Kenya Electricity Generating Company Limited

APPENDIX 1:

EMPLOYER'S REQUIREMENTS /SPECIFICATIONS

Table of Contents

APPENDIX

CONTENTS

TECHNICAL SPECIFICATIONS

SECTION III:

1 GENERAL INFORMATION AND REQUIREMENTS

1.1 INTRODUCTION

1.1.1 Gitaru Hydro Power Station has three generating units with an installed capacity of 225 MW. The Gitaru dam has a capacity of 16 million cubic meters and a spillway capacity of 4500 cumecs. The maximum flow rate for each of the three units is 69.4 cumecs. The station has three intake shafts of dimensions 4.2 m diameter. These intake shafts are opened or closed by a set of three intake gates which are hydraulically operated.

1.1.2 During high water level seasons, the spillway gates must be operated to reduce the water volume in the reservoir for safety of the dam. During such operations, the gates have been frequently malfunctioning sometimes failing to open. This is due to failure of some hydraulic components in the Hydraulic Control System and unwanted shifting of the gates in the horizontal direction causing the gates to jam on the pier.

1.1.3 The intake gates have two HPU's (Hydraulic Power Units) each of which by design can operate all the three gates. During maintenance, the intake is closed as an isolation to allow work to proceed downstream at the Main Inlet Valve (MIV) and the turbine.

1.1.4 Gitaru Power station was commissioned in 1978. Most of the hydraulic components relating to the hydraulic control system of the gates (intake and spillway) are no longer available in the market. KenGen therefore intends to refurbish the hydraulic control systems to update the components to those that can be found in the market in case of any failures.

1.2 DEFINITIONS

Whenever the following terms or words are used in the specifications or any other documents forming part of this tender document, they shall have the following meaning unless otherwise stated:

1. AC: means Alternating Current
2. ACB: means Air Circuit Breaker
3. ADC: means Analogue to Digital Conversion
4. AVR-Automatic voltage regulator
5. BOM-shall mean Bill of materials or list of equipment.
6. CB: -means circuit breaker unless otherwise stated.

7. CT: means current transformer
8. DAS:-Data acquisition system-System whose main function is to acquire, format and transfer to another system for processing
9. D-AVR- Digital Automatic voltage regulator
10. DC: means Direct Current
11. EDG: means Emergency diesel generator
12. ETU: Shall mean electronic trip units commonly used in low voltage circuit breakers
13. FAT: Factory acceptance tests
14. FIDIC - Fédération Internationale des Ingénieurs Conseils (International Federation of Consulting Engineers)
15. GCB-shall mean generator circuit breaker.
16. GSU: Generator step up transformer.
17. HMI- Human machine interface- In this document refers to hardware and/or software required for human user to interface to the systems supplied for control and monitoring purpose.
18. HPU-Hydraulic power unit
19. HV-High Voltage: operating voltage higher than 52.5 Kv
20. HVAC-Heating, ventilation, and air conditioning
21. IED: -Intelligent electronic device refers to programmable microprocessor based electronic devices e.g. numerical protection relays, smart relays etc. used in industrial environment for instrumentation, metering, control or protection purposes.
22. IP xx - Ingress protection: means "Degree of Protection Provided by Enclosure". and shall be according to IEC 60529.
23. LAN-Local Area Network
24. LV-Low Voltage: operating voltage below 1000V. (For transformers, the term Low Voltage Winding is used for the side with lowest rated voltage regardless value)
25. MCCB: means Moulded case circuit breaker.
26. MPCB-Motor protection circuit breaker
27. MCB: means Miniature circuit breaker.
28. MV-Medium Voltage: operating voltage higher than 1000 V and up to 52.5 kV.
29. NC-Normally closed
30. NO-Normally open
31. NSTA- National Standards and Testing Authority
32. OEM-Original Equipment manufacturer

33. OLTC-On Load Tap Changer
34. OPC- Open Platform Communications (OLE for process control)-shall imply the widely accepted communication platform for real-time plant data exchange between control devices from different manufacturers
35. OPC UA -OPC Unified architecture, IEC 62541
36. OPC DA – OPC Data access
37. PC- Personal computer: Refers to IBM PC compatible computers i.e. intel X86/X64 based personal computers running windows operating system.
38. PIMS-Plant information management system
39. PLC-shall mean Programmable Logic Controller unless otherwise defined in the document
40. SAS: Substation Automation System
41. SAT: Site acceptance tests
42. SCADA: -shall mean Supervisory control and data acquisition system. Employer/KenGen SCADA shall mean the existing SCADA at the power plant operated by the employer
43. SDG-SCADA data gateway-multi protocol converter for SCADA communication protocols
44. SLD: - shall mean single line diagram.
45. SOE: - Sequence of events
46. SPST-Single pole single throw
47. SPDT-Single pole double throw
48. **Station/plant**-These words shall predominantly refer to Gitaru power station in the tender unless implied otherwise by the sentence.
49. **System**-Could mean a physical (hardware) system or a software system
50. **Unit**-Shall in many occasions in this document refer to complete generation unit composed of Turbine, generator, GSU transformer, control system and balance electrical and mechanical system. (Gitaru has three units) unless implied otherwise by the sentence
51. VT: means voltage transformer

1.3 GENERAL REQUIREMENTS

1.3.1 These specifications describe the requirements for goods and services to be procured by the procuring entity. Tenderers are requested to submit with their offers the detailed specifications, drawings, catalogues, etc for the products they intend to supply.

1.3.2 Tenderers must indicate on the technical schedules whether the systems offered comply with each specified requirement.

1.3.3 All documents to be submitted shall be in **ENGLISH** language **ONLY**. The SI-system (meter, Newton, second) shall be used throughout the documentation covered by this Specification.

1.3.4 Systems specified in this tender and all associated systems shall be designed to ensure continuity of operation under all working conditions and to facilitate inspection, maintenance and repairs. All reasonable precautions shall be taken in the design of systems to ensure safety of personnel concerned with the operation and maintenance of the systems.

1.3.5 All equipment/components to be supplied MUST have spares available for the next **10 years** after installation.

1.3.6 All the systems to be developed and activities to be carried out in this project will be in accordance with agreeable standards and regulations. There shall be standard pre-commissioning and commissioning procedures that will be agreed upon and approved by employer during this project.

1.3.7 The refurbishment exercise shall be done in such a way that there will be continuity of operation under all working conditions and to facilitate inspection, maintenance, and repairs. All reasonable precautions shall be taken in design of systems to ensure safety of personnel concerned with the operations and maintenance of the systems.

1.3.8 Any reference in the quantity and price schedules, the delivery period schedule or in the various clauses and schedules of the text of either the Specification or the Bid, to any systems shall imply a system that is complete with all software licences, accessories, apparatus and fittings as outlined.

1.3.9 All materials and skilled labour, whether of temporary or permanent nature, required by the Contractor for the design, manufacture, software development, commissioning of the systems etc. shall be supplied and paid for by the Contractor.

1.3.10 If in conflict, the ranking of documents in the technical specifications, in decreasing priority, is as follows:

(a) Particular technical specifications
(b) Existing equipment drawings
(c) Scope of Works
(d) General technical specifications
(e) General specifications
(f) Specification drawings
(g) Preliminary bill of materials
(h) Standards

1.3.11 If the Tenderer is of the opinion that there is conflict or disagreement between the particulars of the documents, standards etc, it must be clearly stated in the tenderer Bid offer document, failure to which, the materials and systems offered shall be deemed to comply in every respect with the current Specification both in manufacture and in performance, and compliance thereof shall be insisted upon without additional cost to the procuring entity.

1.3.12 The bidder shall visit the site and get acquainted with the actual requirements of site if deemed necessary. No claims for inadequate description of the scope shall be entertained later.

1.3.13 Deviations to this specification SHALL NOT be acceptable unless specifically indicated in the offer in the relevant schedule "deviation from technical specifications form". All deviations shall be clearly spelt out by the Bidder Any implied deviation or any deviation mentioned elsewhere in the offer shall not be considered.

1.3.14 It is not the intent of this specification to completely specify all details of design and construction herein. Nevertheless, the systems and installation shall conform to high standards of engineering design and workmanship in all respects and shall be capable of performing continuous operation in a manner acceptable to the employer. Reliability, availability and maintainability are of the utmost importance to the employer in the design of the systems described herein.

1.3.15 The supplied components shall have Original Equipment Manufacturer (OEM) nameplate untampered. The contractor's nameplate if needed shall be added side by side to the OEM nameplate.

1.4 TENDER BID DOCUMENTATION BY TENDERER

Tender bid documentation will guide the employer during the tender evaluation. Documents shall clearly demonstrate the bidders offer compliance to employer requirements.

The following Documents shall be provided.

1.4.1 Bidders' Technical Proposal

1.4.1.1 A proposal containing drawings, data & information elaborate enough to enable the employer to comprehend and assess the vital details, features, capabilities and functioning of the equipment offered and their arrangements shall be included in the bid offer.

1.4.1.2 Bidders' technical proposal shall offer a clear response to the employers' specifications.

1.4.1.3 It shall clearly demonstrate the complete scope of work as defined by the specification and **MUST** include, but not be limited, to the followings: -

(a) **Method statement** -Proposal on how the project shall be implemented. Shall provide a brief response to employer's requirements on project implementation services to be offered, elaborate how they intend to minimize machine outage time for intake gate works and demonstrate their work plan.

The proposal shall **briefly** demonstrate how the bidder proposes to carry out the following:

(i) Refurbishment of gates large hydraulic cylinders
(ii) Performance testing of gates large hydraulic cylinders
(iii) Design, Installation, and commissioning of specified hydraulic control systems.
(iv) Design, Installation, and commissioning of specified electrical systems.

(b) **Implementation program** in Gant chart format. The Gant chart shall illustrate a comprehensive [summary] work programme, showing all the activities and duration required, from tender award stage to full commissioning of the equipment in chronological order. ALL project activities and duration **MUST** be clearly illustrated.

(c) **Quality control plan**, Bidder shall submit a brief(<5pages) quality control plan demonstrating how the project shall be implemented to ensure adherence to employer specifications, approved designs, and standards. The bidder shall borrow from their vast experience in similar projects but considering the conditions at site. It shall include narration of specific quality control mechanisms measures at design, construction, manufacture, erection, installation, testing and commissioning. The presentation shall include method of supervision of the subcontractors/sub suppliers and safety precautions during testing, installation, and commissioning.

Bidders company quality control manuals are not required though they may be referenced and given in soft copy.

(d) **Preliminary Bill of materials (BOM)** dully filled (part of technical schedules) and Bidder's scope of supply if not covered by the provided preliminary bill of materials.

(e) **Preliminary Single line diagrams** for the. Intake gate and spillway LV switchboards.

(f) **Preliminary Hydraulic schematic** for Proposed Intake gate HPU, hydraulic control circuit of the intake and spillway gates. shall show interconnection between hydraulic cylinders and pumping unit.

(g) **Preliminary dimensioned panel arrangement drawings** for all major panels in the offer

(h) **Technical schedules** duly filled.

(i) **Deviation from technical specifications schedule** duly filled if applicable.

1.4.2 Type reports & Product certificates

1.4.2.1 Test reports & product certificates shall be certified by European/USA/Canadian National Standards and Testing Authority (NSTA) or by a third party (not manufacturer or manufacturer subsidiary) Reputable Testing Authority accredited by European/USA/Canadian National Standards and Testing Authority (NSTA).

1.4.2.2 Type Test Reports shall meet the following requirements:

(a) Type Test Reports shall be carried out by a laboratory independent from the manufacturer.

(b) Where a body other than NSTA stated above is used to certify the type-test reports, a copy of the certificate of accreditation shall be attached.

(c) Results of type test shall have been conducted at least 6 months and not more than five years prior to the date of tender submission. The bidder shall submit contact details (Title, email, and fax) of certifying laboratory.

(d) Testing materials and equipment in Type Test Reports shall have the same code/ country / manufacturer and technical parameters as offered materials and equipment. Type tests of non-conforming materials/equipment shall not be accepted.

(e) Type Test Reports shall include all items tested and results confirming that they meet the requirements of applied standards as stipulated in Tender Documents.

(f) Type Test reports shall have Report Numbers for authentication.

(g) Current contact information of the testing and certification authority shall be provided.

1.4.2.3 Type tests reports and certificates for type tests carried out as per IEC 61439 and IEC 60529. less than five years from the date of bid opening for the Low voltage switch board **MUST** be included in the bid.

1.4.2.4 Test reports and product certificates for type tests carried out as per relevant ISO standard less than five years from the date of bid opening for the following equipment specified in the tender **MUST** be included in the bid:

(a) Hydraulic valves
(b) Hydraulic pumps
(c) Hydraulic cylinders

1.4.3 Manufacturing & Testing facilities information

1.4.3.1 Catalogue showing manufacturing and testing facilities proposed to be used for factory testing and training as per requirements of this tender.

1.4.3.2 The catalogue shall show the available testing rigs, test benches and equipment for repair and testing of large hydraulic cylinders.

1.4.4 OEM Technical manuals

1.4.4.1 Comprehensive OEM Technical manual shall be provided for

(a) LV switch boards (for each type of if more than one type is offered)
(b) Directional control valves
(c) Hydraulic pumps
(d) Hydraulic cylinders

1.4.4.2 Each Manual shall as a minimum, cover the following topics:

(a) Detailed description of equipment, including at minimum: the structural description and dimensions, functional descriptions with block diagrams, characteristic curves and logic diagrams, General assembly drawings, control and wiring diagrams, operating conditions, operation description, etc.
(b) Equipment rating: power, insulation, voltage, current, temperature, flow, fault withstand, breaking capacity, various operating characteristic curves, relevant clearances, tolerances, operating temperature etc.
(c) Range of features to be provided.
(d) Range of optional features not provided.
(e) Range of settings provided for all features, both offered and optional.
(f) Operation and maintenance
(g) Statement of performance under reference conditions.
(h) Variation of performance with departure from reference conditions.
(i) Effects of interruptions to dc auxiliary power supply.
(j) Standards the equipment complies to

1.4.4.3 As a minimum, the bidder shall furnish ALL the above documents in in **soft copy** failure to which the bids shall be rejected.

1.4.5 Technical data sheets

1.4.5.1 Technical data sheets and or catalogues briefly describing technical specifications; rated values; operating conditions; physical dimensions, standards of manufacture and testing, photo illustration of the equipment etc. shall be provided.

1.4.5.2 The equipment/item offered shall be clearly marked in the datasheet/catalogue.

1.4.5.3 Datasheets and catalogues shall be provided for but not limited to each of the following:

1. Each type of auxiliary relay (as per clause 3.5 of specifications)
2. Each type of hydraulic valve and component,
3. each type of industrial Ethernet switches,
4. Automatic transfer controller switch,
5. Each type of panel indication meters,
6. Each type of panel multifunctional meters,
7. each type of terminal block,
8. each type of cable,
9. each type of panel/board,
10. each type of push button,
11. each type of selector switch
12. each type of panel indication lamps,
13. each type of miniature circuit breakers,
14. each type of MCCB & MPCB
15. contactors,
16. SCADA interfacing PLC
17. each type of sensor/transducer (flow, pressure, temperature, level etc.) provided,
18. each test equipment,
19. Each Maintenance tool,
20. Each type of power supply unit
21. Voltage monitoring relays
22. Flow control valves
23. Isolation valves
24. Check valves.
25. Filters
26. Hydraulic pipes and fittings
27. Accumulators
28. HPU units
29. Nitrogen cylinders
30. All other proposed hydraulic components

31. Any other device stated in the bidder's offer.

1.4.6 Soft copy of the above documents shall be handed over in a USB flash disk.

1.4.7 In the event of any difference between the Drawings and the Specifications stated, the latter shall prevail. In the event of any difference between scaled dimensions and figures on the drawings, the figures shall prevail.

1.5 PROJECT SCOPE

1.5.1 The scope of works shall cover the following.

(a) Refurbishment of intake gate hydraulic control systems
(b) Refurbishment of existing spillway gate hydraulic cylinders
(c) Refurbishment of existing intake gate hydraulic cylinders
(d) Refurbishment of spillway gate hydraulic control systems
(e) Supply, installation, and commissioning of new LV switchboards for intake gate and spillway gate
(f) Supply of Spares. Tools and maintenance equipment
(g) Provision of training

1.5.2 In fulfilment of the above, the contractor shall carry out the following activities but not limited to:

(a) Studying of existing systems.
(b) Design /Engineering services.
(c) Manufacture,
(d) Factory training at manufacturer's training centre
(e) Factory acceptance testing at the Manufacturer's Factory.
(f) Packing for transport; insuring; shipping & delivering to the port of Kenya.
(g) Customs clearing in conjunction with the employer.
(h) Local Transportation, insuring, delivery to Site, offloading, site storage and Unpacking.
(i) Disassembly/dismantling of existing systems
(j) Erection/Installation
(k) Civil works that may be necessary during site works
(l) On job training during installation and commissioning
(m) Site acceptance Testing and Commissioning.
(n) Maintenance equipment and tools provision and training on use.
(o) Defect reliability period.
(p) Post commissioning site training.
(q) Technical documentation provision and

(r) Warranty

1.6 PROJECT WORK PROGRAM

1.6.1 Work program shall contain refined method statements, quality control program and implementation plan with details as specified in clause 1.4 of specifications. The work program shall be detailed to cover all employer's general specification requirement's and shall define how the whole project shall be carried out.

1.6.2 After the tender award, the approved tenderer shall prepare a draft work program covering the design, manufacture, delivery, installation, testing, training, and commissioning of the Works, in sufficient detail defining the various sections of the Works, including parts to be supplied by the Contractor. The implementation plan shall be prepared in the form of a Critical Path Method Network and a Gantt chart.

1.6.3 The work program shall also Cleary identify the time required for refurbishment and delivery to site of existing hydraulic cylinders.

1.6.4 After tender award and prior to contract signing the employer and Approved tenderer shall meet, discuss, and review the draft work program, the contractor shall subsequently prepare a final work program for employer approval.

1.6.5 The total project duration shall not exceed 24 months; the duration shall be period from commencement date to the date of issuance of the final take over certificate or as otherwise defined in the conditions of contract.

1.6.6 Duration of power plant outage required to implement the project shall not exceed:

1.6.6.1.1 15 days outage time for each unit during installation and commissioning of the intake gate control systems

1.6.6.1.2 4 days of total station outage (in separate days not continuous i.e., 1 or 2 days at a time) for intake gate works. Total outage is to be avoided as much as possible. Total outage shall usually be available at night from 11pm to 5am and on weekends.

1.6.6.1.3 A minimum time gap of 14 days shall be allowed between unit outages. The maximum, however, shall vary depending on the prevailing Kenyan electricity grid condition and climatic conditions.

1.6.7 The bidder shall furnish sequence of activities to be carried out to avoid / minimize the generation loss, likely to occur during the project works. The bidder shall note that work shall be completed within shut down period. The bidder shall also note that there may be uncertainty of Shutdown due to grid exigency. However, no additional cost/ compensation on this account shall be acceptable.

1.6.8 In formulating the work program, the Contractor shall consider the following activities, to be undertaken by the Employer: -

(a) Approval of drawings and designs
(b) Preparations to attend factory training and testing.
(c) Customs Clearance-to be done jointly with the contractor.

1.6.9 Upon approval of the work program by the Employer, it should thereafter be referred to as the Approved Construction Programme and shall become a part of the Contract.

1.6.10 In executing the Approved Construction Program of this Contract, the Contractor shall co-operate with the employer to effect timely completion of the works.

1.7 DOCUMENTATION

1.7.1 General Requirements

1.7.1.1 The Contractor shall prepare and submit to the Project Engineer for approval dimensioned general and detailed design drawings and other pertinent information of all the Plant and equipment specified in the tender documents.

1.7.1.2 All text on documents provided by the Contractor shall be in the United Kingdom ENGLISH LANGUAGE ONLY. Technical Documentation written in any other language SHALL BE REJECTED and presumed not to have been submitted.

1.7.1.3 All drawings and documents shall be dimensioned in millimetres.

1.7.1.4 The Contractor shall, during the total project time, maintain a List of Documentation to be updated by him whenever needed. The List of Documentation shall include the date of original issue of each document submitted as well as the dates of every revision. The List of Documentation shall also include a time schedule for the submittal of the documentation.

1.7.1.5 Symbols used for electrical equipment and components shall be in accordance with IEC 60617. Fluid power schematic symbols shall be as per ISO 1219. Mechanical drawing symbols shall be as latest applicable ISO standards.

1.7.1.6 The Contractor shall establish a coherent system for physical and functional reference designation in accordance with ISO/IEC 81346-1, IEC81346-2, IEC81346-3, and IEC81346-10 (RDS PP). These schemes shall be used throughout on the drawings and documentation and the designation shall be labelled on the components and cables.

1.7.1.7 In addition to what is stated elsewhere in the tender, the following shall apply to all technical documentation handed over to the employer after the project:

1.7.1.7.1 The sizes of all documents and drawings shall conform to the ISO standard, i.e.: A1 (594mm x 841mm), A2 (420mm x 594mm), A3 (297mm x 420mm) & A4 (210mm x 297mm)

1.7.1.7.2 Scales to be used on the drawings shall be 1:10, 1:20, 1:40, 1:50 and multiples of this series.

1.7.1.7.3 All drawings shall be dimensioned in millimetres.

1.7.1.7.4 Technical documentation e.g., manuals, test reports, list of materials, cable lists i.e., all technical documents including ALL drawings shall be provided in A4. Schematic diagrams shall be provided in both A4 and A3. Structural & mechanical drawings shall be provided in A4, A3 and A2/A1 (depending on drawing size).

1.7.1.7.5 All drawings made special for this project shall be compiled on a computer aided drawing system and as part of the as built documentation be handed over on a CD/flash memory with a format readable in latest version of AutoCAD and in any another editable format to be agreed upon and pdf in addition to the paper copies.

1.7.1.7.6 All drawings and technical documentation shall be bound in hard covers as per sample to be provided. NO document shall be folded to fit the book binding, the Binding covers shall be sized according to the containing documents i.e. there shall be A4, A3, and A2/A1 binding covers. Documents of different sizes SHALL NOT be bound together on the same cover. The number of pages per bound volume shall not exceed two hundred (200)

1.7.1.7.7 Any illegible copies of documentation submitted shall be rejected by the employer.

1.7.1.7.8 The SI-system (meter, Newton, gram second) shall be used throughout the works and documentation.

1.7.1.8 The Employer's technical specification drawings attached to the Bid Documents are of informative character. These drawings are intended to illustrate the basic requirements to be satisfied. It is the responsibility of the contractor to prepare a detailed layout/schematic for the new system.

1.7.2 Technical Documentation

1.7.2.1 Technical documentation shall consist of but not limited to: -

(a) Technical manuals

(b) All technical drawings i.e., schematic, wiring, architectural, mechanical & structural assembly drawings etc.

(c) Wiring schedules i.e., cable schedules and terminal diagrams
(d) Functional design specifications and calculations as detailed in clause 1.8.2 of specifications.
(e) Work program containing Method statements, work plans and quality control plans as detailed in clause 1.6 of specifications.
(f) System settings/parameter configurations
(g) Project progress reports
(h) Training programs and materials
(i) FAT and SAT plans/program
(j) SAT and FAT reports
(k) Job safety analysis
(l) Quality control plan

1.7.2.2 Technical manuals shall contain: -

(a) System description consisting of: Introduction/overview of components, functional description, overall system operating philosophy and operating conditions.
(b) System overall design and specific detailed features of design including: Design calculations, descriptive drawings, schematic diagrams, layout diagrams, block diagrams, list of internal materials, connection and terminal list, equipment and components dimensional drawing and control diagram.
(c) Complete operating instructions: included shall be precautions and critical points to be observed, including suggested form to be used in taking periodic readings to maintain an operations record. There shall be a tabulation of possible operating difficulties with the probable causes listed and remedial action to be undertaken for each one. Emergency procedures
(d) Manufacturer/system developer catalogues and technical data sheets for all systems.
(e) Software Manuals for ALL software provided including manuals for Programs and application created for this project e.g. Logic diagrams, HMI application etc. Software manuals to detail: how to use the software, install and un install, license key, support, upgrading & updating, system requirements, troubleshooting etc.
(f) Detailed instructions for programming settings and configuration of all software configurable devices. Instructions for downloading, uploading and backing up settings & configurations,

(g) Complete instructions for ordering replacement parts in a manner that would prevent errors or misunderstanding. Recommended forms for tabulating replacement part information and instructions for returning materials to the factory shall be included.

(h) Trouble shooting instructions

1.7.2.3 The documentation shall leave the operators and maintenance personnel in position to operate the plant in a safe and optimal way and to perform repairs, upgrades and rehabilitation usual to be done by such personnel.

1.7.2.4 The Project Engineer shall approve all technical documents before final submission.

1.7.3 Document Approvals

1.7.3.1 During project execution, the following documents shall be approved as per provision of this clause (1.7.3)

(a) All drawings i.e. Structural, layout, electrical & hydraulic schematics, logic diagrams, wiring schedules, block diagrams, system architecture etc.

(b) Functional design specifications

(c) Setting/parameter configurations and signal list

(d) Training program and syllabus

(e) FAT and SAT plans/program

(f) Work program

1.7.3.2 When the Contractor prepares their work program, as required herein, they shall make allowance for document approval time and indicate it on the program. Claims or extensions of time will not be approved if they are related to the late submission of drawings to the Employer or if they involve delays caused by drawings not being approved by the Employer.

1.7.3.3 During the design stage, the contractor shall send documents to the employer for approval and comments. A copy of each document will be returned to the Contractor marked “Approved”, or “Approved as noted”, or “Not Approved”.

1.7.3.4 Documents submitted by the contractor for approval will be checked / reviewed by the employer and comments, if any, on the same will be conveyed to the contractor. It is the responsibility of the contractor to incorporate correctly all the comments conveyed by the Employer on the Contractor’s documents & drawings. If the Contractor is unable to incorporate certain comments in their design, they shall clearly state in their forwarding letter such non-compliance along with valid reasons and justification.

1.7.3.5 Comment of “not approved” would imply the document must be re done as per comments given; meaning the employer is not in agreement with the content, idea and implications of the document on the overall design and operation of the system.

Comment of "approved as noted" shall imply the employer agrees with the idea or implications of the drawing/document but requires some changes to be implemented before approval.

1.7.3.6 Documents with comments of "Approved as noted", or "Not Approved" shall be reviewed by the contractor as per given comments and resubmitted to the employer for approval. The employer will review the resubmitted document as described in the previous clause. The process shall be repeated until all the submitted documents are approved.

1.7.3.7 Documents requiring revision shall be promptly dealt with and resubmitted as aforementioned. Thereafter, changes shall NOT be made in the Contractor's drawing without written permission of the project Engineer. The above procedure shall be repeated for all authorized changes. It is to be understood, however, that approval of the drawings shall not relieve the Contractor of any responsibility in connection with the work.

1.7.3.8 All documents submitted for approval or sent to the Employer for any other reason may be sent by courier or e-mail

1.7.3.9 Any work performed or material ordered by the contractor prior to receipt of drawings stamped 'Approved' by the employer shall be at the risk of the contractor. After print of any drawing has been returned 'Approved', the contractor may release the parts covered by the drawing, for production / construction.

1.7.3.10 All drawings and data supplied by the Contractor subsequent to the date of contract, which cover changes in the work, extra work, or which supplement existing drawings and data shall, upon approval by the Employer Engineer, form part of the contract documents.

1.7.3.11 If, at any time before the completion of the work, changes are made necessitating revision of approved document, the contractor shall make such revisions and proceed in the same routine as for the original approval.

1.7.3.12 To expedite the delivery and return of the required drawings, scanned drawings shall be used and sent to the following KenGen E-mail addresses–

jmuoka@kengen.co.ke

c.c:-

dwangariria@kengen.co.ke

bimathiu@kengen.co.ke

Or any other email supplied by the employer.

1.7.3.13 System design and deployment shall be in accordance with the approved documents and shall not commence until such approval has been obtained. Subsequent changes contemplated by the Contractor shall be indicated on revised drawings and data resubmitted for approval. The Contractor shall make any changes in the design which

are considered necessary to make the work conform to the provisions and intent of the specification without additional cost to KenGen.

1.7.3.14 Approval of the Contractor's documents shall in no way construe or imply relief of the Contractor from responsibility for any error or omission therein or from any obligation under the Contract.

1.7.3.15 After final approval of documents, the contractor shall send to the employer all the documents stamped/or indicated as "as built".

1.7.4 Final Documentation

1.7.4.1 After project completion i.e. deployment of all systems; complete sets of prints and softcopies of the technical documentation for all new systems shall be furnished as indicated below.

(a) **Soft copies of ALL technical documentation** as defined in section 1.7.2 well organised using document management application program linking all documents (in pdf format) in the project via hyperlinks. The document management application program shall
   (i) Run on any PC without installation or requiring a licence.
   (ii) Enable searching of content easily
   (iii) Organise all technical documentation in chapters or volumes for easy viewing of the contents
   (iv) Document management application based on HTML that can easily be read by standard web browser is preferred.

(b) Soft copies of ALL as built drawings in AutoCAD format and any other CAD software format if used or agreed upon with project engineer.

(c) **Four** Complete sets of bound prints for ALL technical documentation as detailed in section 1.7.2 and ALL as built drawings in **A4**

(d) **Four** Complete sets of bound prints for ALL as built SCHEMATIC drawings in **A3 ONLY**

(e) **Four** Complete sets of bound prints for all as built structural and mechanical drawings in **A3** and **A2/A1**.

(f) All existing employers' drawings interfaced to the new system reviewed and updated by the contractor in two sets one A3 another A4 size sheets.

(g) Soft copies of ALL Logic diagrams in original software format and the software with a licence, used to create the logic diagrams/programs.

1.8 ENGINEERING SERVICES BEFORE INSTALLATION

1.8.1 Studying Existing Systems

1.8.1.1 The contractor shall study the existing intake gate and spillway gate to develop designs for refurbished intake gates

1.8.1.2 It is a requirement that the contractor design Engineer visit the site as soon after the tender award to acquaint himself with the operation of the Units and gather the relevant technical aspects (data, As-Built Control Schematics, cable schedules, etc.) for the design phase.

1.8.1.3 This works includes the engineering of layout of equipment components, cabling & wiring and interface to existing control systems. This will ensure integration of electrical and mechanical equipment to form a well-functioning plant. All the materials and accessories required for the equipment/system to function shall be furnished by the contractor.

1.8.1.4 Drawings, manuals and information relating to the Units will be made available to the contractor. Employer Engineers conversant with the plant operation will be attached to the contractor during formulation and design stages. This will ease correspondence and confirmation of the interface requirements.

1.8.2 Design

1.8.2.1 Systems specified in this tender and all associated systems shall be designed to ensure continuity of operation under all working conditions and to facilitate inspection, maintenance and repairs. All reasonable precautions shall be taken in the design of equipment to ensure safety of personnel concerned with the operation and maintenance of the equipment.

1.8.2.2 All components shall be adequately rated or sized for their most onerous duty and the specified ambient temperature. Due account shall be taken of any heat generated by the equipment therein and the components shall be appropriately selected, rated or de-rated as necessary to suit the most onerous operating temperature within the equipment. A minimum safety factor of 1.2 shall be applied to all systems

1.8.2.3 Design and calculations shall be governed by the design criteria given in the Bid Documents, standards and normal design practice. Necessary safety factors shall be included. The contractor shall assure themself and the employer that the apparatus is suitable for intended use and the environment and stresses to which it will be exposed. Contractor must also ensure that the equipment is compatible with equipment it shall be connected to, or work together with

1.8.2.4 The contractor shall prepare a Functional Design Specification document containing System design parameters to conform to employer requirements. The functional design specification shall contain the following:

(a) A response to the employer's technical specifications and scope of supply describing the equipment to be offered. Description shall include all equipment technical data and the equipment functions. It shall give a clear response to all the employers requirements and shall include a detailed list of equipment/Bill of materials for each system. The list of equipment shall include the manufacturer, model, and quantity.

(b) Tabulation of tests and their reference standards to be carried at factory and site.

(c) Criteria and standards for design and design calculations

(d) Software description and functionality. This to include software licenses requirement, communication protocols, applications hierarchy, system software/firmware description, database structure & design, database applications description, signal list, list of symbols, hardware requirements, Graphical user interface etc

(e) Arrangement (location) drawings of all equipment and all panel layout drawings showing component installation position and dimensions.

(f) Detailed single line diagrams and hydraulic schematic diagrams.

(g) List of inputs and outputs of all types (analogue & digital) for all IEDs, PLC's and other software configurable devices. This list shall contain register/memory addresses and size/type of variables.

(h) OEM technical Specifications of all equipment to be supplied.

1.8.2.5 The functional design specification shall be approved by the employer engineer in similar fashion to drawings as specified in section 1.7.4 of specifications. The functional design specification after approval shall form basis for all tests and shall not be deviated from unless with the written consent of the project engineer. The functional design specification shall conform to all the standards specified in the employer specifications. It shall contain all the calculations and standards used to arrive at the specification.

1.8.2.6 The design shall be reliable and simple. The design shall incorporate every reasonable precaution and provision for the safety of the general public as well as for all those engaged in the operation and maintenance of the equipment itself or equipment connected to or installed in close proximity to it. All apparatus shall be designed to ensure reliable and safe operation under the atmospheric conditions prevailing at the

Site and under such sudden variations of load and voltage as may be met with under working conditions of the system.

1.8.2.7 During design the contractor shall send drawings, functional design specifications, design calculations, FAT & SAT test plans, training syllabus and other documents stated in various sections of the tender for approval by the employer as described in section 1.7 of specifications

1.8.2.8 System design shall ensure easy maintenance of the systems supplied

1.9 MANUFACTURING AND SHIPMENT

1.9.1 Places of Manufacture and Sub-Contractors

1.9.1.1 All equipment offered should be the product of recognised and experienced manufacturers who have been manufacturing specified equipment for the last twenty years. Equipment shall be of basic design and size similar to such that has been in successful continuous operation for at least three years preferably under similar climatic conditions. Proven plant reliability and high availability are of prime importance and the attention of the tenderer is drawn to these particular requirements.

1.9.1.2 The manufacturer's identity and places of manufacture, testing and inspection before shipment for the various portions of the Contract Works shall be specified in the Technical Schedules and shall not be departed from without the agreement of the Project Engineer

1.9.1.3 As soon as practicable after entering into the Contract, the Contractor shall, having obtained the Project Manager's consent in accordance with the Conditions of Contract, enter into the Sub- contracts he considers necessary for the satisfactory completion of the Contract Works.

1.9.1.4 All Sub-contractors and Sub-suppliers of components and materials shall be subject to the approval of the Project Engineer. Information shall be given on each Suborder sufficient to identify the material or equipment to which the sub-order relates, stating that the material is subject to inspection by the Project Manager before dispatch.

1.9.1.5 If the Employer at any stage in the design and production period finds out that the sub-contractor does not fulfil the requirements in the specifications and it is obvious that the required quality cannot be achieved by corrective measure he can request the subcontract to be suspended and the works to be produced elsewhere without extra cost for the Employer.

1.9.1.6

1.9.2 Inspection and Testing

1.9.2.1 General Requirements

1.9.2.1.1 The manufacturer shall be responsible for performing or for having performed all the required tests specified under the specifications. Tenderer shall confirm the manufacturer's capabilities in this regard when submitting tenders. Any limitations shall be clearly specified.

1.9.2.1.2 Full details of type tests performed on equipment identical to that being offered shall be submitted with the offer, accompanied by a proposed schedule of tests to be performed for each item of equipment where applicable.

1.9.2.1.3 In general, type test results shall show that the equipment being proposed for this Contract shall perform in accordance with its design specification in the environments to which it will be subject in its application on this Contract. The environmental factors include climatic (temperature humidity, wind, rain etc.), electromagnetic (radiated and conducted), mechanical (transport vibration, handling knocks, earthquake stresses) and chemical (salt laden atmosphere).

1.9.2.1.4 Where appropriate, the type tests should also demonstrate that the equipment does not exceed accepted standards in terms of its impact on its environment (noise, mains harmonics etc.).

1.9.2.2 Manufacturing quality control, inspection and testing procedures

1.9.2.2.1 All materials used in the Contract Works shall be tested at the factory prior to shipment. Factory tests on equipment shall be made according to the applicable IEC Standards, as specifically specified and as per manufacturer standard testing procedures. Routine tests shall be made on each unit of all equipment before shipment.

1.9.2.2.2 Prior to shipment contractor shall inspect the equipment to ensure:

(a) Correct standards of workmanship and quality
(b) Correct identification labels, cabling, tagging, housing and mounting etc.
(c) Adequate accessibility
(d) Compliance with the Specification and approved documents
(e) Verification of model numbers, quantities of items etc.

1.9.2.2.3 Contractor shall send the inspection report to the employer

1.9.2.3 Factory Inspection, testing and training program.

1.9.2.3.1 The Contractor shall prepare test procedures and result sheets for all tests. He shall also prepare a cross reference listing to show that all of the requirements of the Functional Design Specification have been included in the tests. The Contractor shall prepare and execute a testing program which will establish that specified requirements have been met and that the items furnished and installed will perform as specified and required.

1.9.2.3.2 The Contractor shall submit to the Employer for approval, during or immediately following the submission of drawings, testing plan/ programs describing each test to be performed during factory acceptance tests (FAT), site commissioning and performance tests. The program shall establish the sequence of the tests, the equipment preparation and operation procedures to be followed and the DETAILED PROCEDURE for conducting each test.

1.9.2.3.3 Inspection and test plans (program) may be of any form to suit the Contractor's system, but shall as a minimum:

(a) Contain all tests specified in the particular specifications and all test requirement of the standard stated in the specifications.
(b) Detail inspections in form of check lists to be carried out before testing.
(c) Indicate where subcontract services will be employed
(d) Identify the characteristics to be inspected, examined, and tested at each point
(e) Give detailed procedures, acceptance criteria to be used and the applicable verifying document. Indicate basis of the acceptance criteria i.e. standard or specification applicable.
(f) Indicate mandatory hold points established by the Project Engineer that require verification of selected characteristics of an item of process before this work can proceed.
(g) Define or refer to sampling plans if proposed and where they will be used. Where applicable, specify where lots or batches will be used.
(h) Duration required for each test and all tests for each system

1.9.2.3.4 The program shall also contain performance guarantees, design values, technical particulars, or other criteria for the evaluation of each test. These programs shall be submitted for approval and distributed in the same manner as the drawings.

1.9.2.3.5 Contractor shall submit a Factory training programme as per requirements given in scope of supply and particular technical specifications. All training topics specified in the specifications shall be covered. The program and syllabus shall be approved by employer engineer in similar manner to drawings prior to the FAT. The minimum duration shall be as specified however the contractor

give the necessary time required to cover the training course successfully and include in the bid.

1.9.2.4 **Attendance of Employer's Personnel at Factory Tests and Training**

1.9.2.4.1 The Contractor shall arrange for five (5) Employer's engineers or staff members to witness tests of major items of equipment at the Contractor manufacturing plant/s for a minimum of ten (10) days.

1.9.2.4.2 The Contractor shall submit factory training and factory acceptance tests schedule for approval. After approval by the Employer, the Contractor shall invite the Employer's engineers for training and factory acceptance tests. A period of at least one month shall be provided from date of invitation to the date of departure to the contractor's country of manufacture to allow enough time for travelling preparations.

1.9.2.4.3 Training at manufacturer's plant or a reputable training centre preferably one run by manufacturer in the country of manufacture shall be provided, in order to enable employer engineers, understand the equipment design, operate and maintain the equipment successfully. Factory acceptance testing shall proceed after the training.

1.9.2.4.4 The above two tasks shall be arranged to follow each other; training to precede the factory acceptance tests.

1.9.2.4.5 Contractor shall be responsible for all travel within country of manufacture and all other associated costs of stay by employer engineers other than accommodation and out of pocket expenses which will be catered by the procuring entity. Necessary expenses including internal air ticket cost between Contractor's manufacturing facilities, inland travel charges in the Contractor's country shall be included in the offer. Where manufacturing facilities are located in different countries the contractor shall bear the cost of international travel and visa application between contractor's main factory home country and the other countries

1.9.2.4.6 The procuring entity will be responsible for the round-trip airfares between Kenya and the Contractor's main factory country, accommodation and out of pocket expenses.

1.9.2.4.7 Contractor shall facilitate visa application for the employer engineers by providing necessary support documents required by the contractors' /manufacturer's country government.

1.9.2.5 **FAT**

1.9.2.5.1 Prior to commencement of the tests, the equipment shall be inspected to ensure:

(a) Correct standards of workmanship and quality
(b) Correct identification labels, cabling, tagging, housing and mounting etc.
(c) Adequate accessibility
(d) Compliance with the Specification and reviewed drawings (including compliance with fire safety and materials requirements)
(e) Verification of model numbers, quantities of items etc.

1.9.2.5.2 All factory tests and training requirements detailed in the approved factory acceptance test plan/program and factory training program shall be carried out.

1.9.2.5.3 Valid calibration certificates from a third-party accredited laboratory for test equipment to be used during FAT shall be presented to the employer engineers prior to the beginning of the FAT. Only test equipment with valid calibration certificates from a third-party laboratory credited by NSTA shall be used.

1.9.2.5.4 Conduct of the Tests.

(a) The Contractor shall conduct the tests in accordance with the approved test procedures and shall enter the results in the approved result sheets.
(b) For each test, the Employer will determine whether the test has passed or failed. In general, the test will be considered to have failed if either:
    (i) The result of the test is not in accordance with the expected result described in the test procedure, or
    (ii) The result of the test is in accordance with the expected result described in the test procedure, but some other unexpected or unexplained event occurred which the Employer considers to be a fault
(c) Full use shall be made during the tests of operator manuals and other documentation provided by the Contractor to determine the accuracy of the tests.

1.9.2.5.5 Failures

(a) The Contractor shall correct all faults found during testing and shall arrange for the test to be repeated. The test shall only be repeated when the fault has been remedied and the equipment demonstrated to function correctly.
(b) Where remedial measures involve significant modifications that might, in the Employer's opinion, affect the validity of earlier tests then the Contractor shall repeat the earlier tests and obtain satisfactory results before repeating the test in which the fault was first identified.
(c) The Employer shall have the right to order the repeat or abandonment of any test if results demonstrate that the equipment is significantly non-

compliant with the Contract requirements, without in any way prejudicing his rights under the contract.

(d) The Employer shall have the right to suspend any test if errors or failures have become unacceptable. The Employer shall also have the right to suspend any test in the event of a fault being detected by the Contractor but not reported to the Employer within 24 hours. In this event, the suspension shall remain in effect until reporting has been brought up to date to the satisfaction of the Employer.

1.9.2.5.6 Repeat Tests

(a) The Contractor shall correct and re-test every fault detected during the tests.

(b) Time spent by the Employer witnessing re-tests or waiting at the Contractor's premises or the test site while corrections are made prior to re-test, shall be charged to the Contractor at the standard hourly rate for the personnel concerned.

(c) All other costs incurred by the Employer as a result of such re-tests, including accommodation, subsistence and travel charges, will be charged to the Contractor at cost. If the Employer is required to return to the Contractor's premises or the test site to witness such re-tests then time spent by the personnel concerned in travelling to the site of and witnessing such re-tests, and all charges incurred by them in so doing, including travel and accommodation shall be charged to the Contractor.

1.9.2.5.7 After the tests, detailed test report and employer inspection report shall be signed by the employer engineers and contractor. These documents shall then become part of the contract.

1.9.2.5.8 FAT meeting minutes duly signed by the contractor and the employer representative shall form part of official project documentation and shall be required by the employer to approve payment processing by the bank. As part of the terms of letter of credit.

1.9.2.5.9 Employer will give consent for shipping ONLY after ALL the issues discussed in the minutes and noted in the employer inspection report have been rectified and evidence given to the employer.

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1.9.3 Packing, Transportation and Storage

1.9.3.1.1 The contractor shall provide such packing of the Goods as is required to prevent their damage or deterioration during transit and temporary storage up to their final destination as indicated in the Contract. The packing shall be sufficient to withstand, without limitation, rough handling and exposure to extreme temperatures, salt and precipitation. Packing case size and weights shall take into consideration, the Goods' final destination and the absence of heavy handling facilities at all points in transit. Indoor electrical equipment must be enclosed in welded polythene envelopes inside packing cases and the envelopes shall be evacuated or have a desiccant inside.

1.9.3.1.2 The following information must be clearly stencilled or printed on each packing case, crate, cask, drum, bundle or loose piece, care being taken that the number and other particulars on each package agree with those entered in the packing list accompanying the Invoice:

(a) Employer's Identity
(b) Supplier's Identity
(c) Destination
(d) Project name
(e) Contract No.
(f) Package No.
(g) Item Code
(h) Weight, dimensions

1.9.3.1.3 The marking above shall be durable and upon the body of the package. Marking upon a batten fastened on the case, etc. shall not be used. In the case of bags, bundles and loose pieces, the shapes of which do not permit the marks to be put on the actual package, each bag, bundle or loose piece shall have two metal labels each with two holes securely fastened by independent wires. Each label shall be die-stamped with the above particulars.

1.9.3.1.4 The Contractor shall be responsible for all transportation from manufacturing site to Gitaru power station.

1.9.3.1.5 Employer shall give clearance for shipment of the equipment only after:

(a) all the finalised and approved factory as built Drawings, Instruction and maintenance manuals and any applicable software have been handed over to the employer.
(b) any problems noted during FAT have been rectified and
(c) upon receipt of certified copies of the factory Test Reports

1.9.3.1.6 Contractor will be responsible for equipment and tools handling on site.

1.10INSTALLATION AND COMMISSIONING

1.10.1 Storage at Site

1.10.1.1 The Contractor shall be responsible for proper storage of equipment when delivered until taking over. Care shall be taken to ensure adequate storage to avoid damage to equipment due to rain or strong sunshine.

1.10.1.2 The employer will provide space for contractor to set up a storage facility and site office.

1.10.2 Erection and installation

1.10.2.1 The Contractor shall carry out all erection, testing at site and commissioning of the equipment specified in the Specifications. The Contractor shall perform all electrical, mechanical, civil works and furnish materials that might be necessary during the installation and mounting of the new equipment.

1.10.2.2 All work, methods of work and workmanship, whether fully specified herein or not, shall be of the highest order in all respects; the generally accepted requirements and commonly recognized good practice for first class work of the nature are to be adhered to.

1.10.2.3 The Contractor will make all materials, tools and equipment necessary for installation, testing and commissioning of the works available. This will include heavy lifting equipment i.e., mobile cranes, forklifts, lorries etc. Contractor can hire the equipment available with the employer at the rates to be provided, this however has be agreed at least two weeks to the works and will depend on availability of these equipment then.

1.10.2.4 The Employer will assist if requested in clearing and bonding [with Kenya Revenue Authority] of installation and commissioning tools & equipment on receipt of Airway bill or Bill of Landing, list of tools & equipment with serial numbers, PFI [proforma invoice clearly marked 'Value for 'Customs Purposes Only' and must show the price of each tool & equipment and extension thereof]. This assistance will only be applicable to installation and commissioning tools & equipment not to be supplied under this project and which shall be returned to contractor's country of origin after the project. The Contractor shall meet the cost of shipment and clearing of these tools.

1.10.2.5 Contractor site manager with qualifications stated in qualification criteria schedule of tender document shall manage the works IN PERSON. He/she is expected to be available throughout the project execution or to be represented by an equally qualified person. Works will only proceed when the stated person is present on site. The contractor's design & commissioning engineers and installation supervisors shall meet

qualifications given in the qualification criteria schedule. Evidence of this shall be provided prior to commencement of installation.

1.10.2.6 It shall be Contractor's responsibility to provide all staff, such as engineers, supervisory staff, skilled and unskilled labour necessary to carry out and complete the Contract Works on schedule as specified. Information regarding site staff shall be provided to the project manager.

1.10.2.7 KenGen shall second skilled labour to carry out the works under supervision of the contractor except for specialized works e.g., welding, non-destructive tests, onsite machining, pipework etc. This secondment shall be free of charge to the Contractor for the number of persons and duration specified. The exact number will be agreed upon at contract negotiations and before commencement of installation. In counterpart, the Contractor shall offer proper on the job training to these personnel.

1.10.2.8 It shall be MANDATORY to attach skilled KenGen staff during installation and commissioning who shall be assigned tasks by the contractor for on job training. If some personnel seconded by the Employer does not perform as expected, the Contractor may request the Employer for replacement. Employer's personnel shall be involved in every aspect of the project.

1.10.2.9 Unskilled labour required for installation services shall be sourced from Kenya. Employer shall not allow use of unskilled labour from outside the country. Foreign contractors shall subcontract a portion of the work that can carried out locally to a Kenyan company, bidders shall note it's a mandatory requirement for all foreign bidders to subcontract a portion of the work to a Kenyan registered company.

1.10.2.10 Work shall only be carried out in the time of day approved by the project engineer. No work shall be carried out in the plant in absence of employer personnel.

1.10.2.11 Prior to installation the contractor shall carryout a pre-installation training, the training shall be carried out at site and shall prepare the employer staff for the project. Training shall enable employers' skilled staff to be attached with the contractor during installation to understand contractor's system. During the training, pertinent issues on how the installation shall be carried shall be discussed and agreed upon prior to the start of the project. The content and scope of this training shall be as per requirements of the work to be carried out

1.10.2.12 Prior to machine outage for intake gate works, pre-outage works shall be carried out to minimise the duration of machine outage. Pre-outage works shall include activities such as delivering of equipment to the intake and positioning them for faster installation, marking of old equipment meant for removal and any other logistical works that do not require shutting down the machine.

1.10.2.13 The contractor shall disassemble and remove existing equipment and then store them at a storage facility provided by the employer within the power plant. The contractor shall take due care for the equipment and parts to be reused.

1.10.2.14 Disassembly and removal of old equipment such as panels, cables etc. shall be carried out under supervision of the employer. No equipment shall be removed without the employer representative present and with his/her approval. All existing equipment shall be the property of the employer.

1.10.2.15 Installation & commissioning shall be performed on separate periods for each gate.

1.10.2.16 Employer shall carryout internal modifications to panels not forming part of scope of supply especially unit control panels but shall be interfaced to the new systems. The contractor shall however provide all necessary wiring materials and equipment necessary to carry out modifications on the panels to be modified by the employer.

1.10.2.17 Work on Intake gates.

1.10.2.17.1 Work on the intake gates shall require unit outage and, in some circumstances, total station outage. The Contractor will only be allowed to have only one unit out of operation at a time apart from the works requiring total station outage. All total station outages shall be discussed with the Employer and the Project Manager at least one week before the outage is required No work shall start at the intake before Employer's engineer has authorised the work and all precautions have been put in place to prevent closure or excessive drifting of the two gates that are available.

1.10.2.17.2 Pre -outage works shall be carried out to minimise unit outage. Once unit outage starts the work shall continue until the gate is commissioned without any stoppage or interruption. A maximum of 15 days shall be allowed for works on one gate, within the fifteen days the contractor shall ensure old hydraulic cylinder is removed and a new one or refurbished one is installed and commissioned.

1.10.2.17.3 Prior to the start of outage the employer shall confirm that the contractor has all available materials, tools, equipment and personnel, work shall not commence until the contractor is deemed ready.

1.10.2.17.4 During installation of LV distribution board temporally LV supply distribution board shall be provided by the contractor and shall be used to supply the intake gate pump control panel until the new switchboard is commissioned.

1.10.2.17.5 Installation of HPU's shall be carried out one at a time. one existing HPU shall continue to be in use while the first new HPU is being installed. Gate operations shall be ensured for two gates while installing the HPU. HPU installation works shall be carried concurrently with installation of the first gate hydraulic control

system. All precautions shall be taken to prevent accidental closure of the two gates that must remain open.

1.10.2.17.6 During installation of electrical control panels, operation of the pumps shall be ensured from the LV switchboard. Facility for gate drifting monitoring and restoration by operation of directional control valves and pumps shall be provided by contractor to ensure two gates that are open do not drift and trip a running unit. LV switchboard which will have independent supplies for each pump shall be installed and commissioned first prior to installation of the other control panels.

1.10.2.17.7 Total station outage shall be required for works that will lead to closing of the three gates or shall carry a huge risk of accidental closure of the three gates. Total station outage shall be avoided and minimised as much as possible, however, where one is unavoidable the following that shall be ensured:

(a) Total station outages shall only be available during grid off peak periods of night 11pm to 5am daily and Sundays 5am to 5pm. The longest outage shall be available after Saturday peak time to Sunday evening (18 hours) and shall be utilised for works requiring extended time.

(b) Total station outages shall be well planned to ensure available time is maximised. In this respect the contractor in agreement with the employer shall form work shifts if necessary, to ensure work continues throughout the outage period.

(c) By the end of the outage the two gates that need to remain open shall be open and the risk of them closing shall be minimal

1.10.2.18 While working on the spillway gates, contractor shall ensure two gates remain fully operable throughout the works. Works shall as much as possible be scheduled during the dry season when spilling is not required. Temporary LV distribution board shall be provided for gate operation during installation of the spill way gate LV switchboard.

1.10.2.19 Bidder shall provide a clear method statement on how refurbishment of existing hydraulic cylinders shall be carried out. Refurbished cylinder shall have to be delivered to site prior to the beginning of work on the second and third gate.

1.10.2.20 At the completion of the Contract, the Employer reserves the right, at his discretion, to take over tools, special tools, test equipment (not included in the bid document) and other construction equipment used by the Contractor in connection with the Contract, at depreciated prices to be mutually agreed upon at that time.

1.10.3 Site Acceptance Testing and Commissioning

1.10.3.1 After equipment has been erected and connected to other plant systems on site, the Contractor shall carry out to the satisfaction of Employer such tests as may be required to prove compliance with the Specification, independent of any factory tests. The tests shall be as per the designed standard and as stated in the particular specifications.

1.10.3.2 Prior to site acceptance testing and commissioning the contractor shall carryout a pre-SAT training, the training shall be carried out at site and shall prepare the employer engineers for commissioning. Training shall cover the tests to be carried, how they will be carried out, procedures to be followed, precautions and expected results and. During the training the employer engineers will also advise the contractor engineers on the plant systems that shall be tested together with the new systems. The training shall ensure the employer engineers understand the contractor's tools especially the software tools to enable full participation of employer engineers during the testing. The contractor will take advantage of this training to ensure that the commissioning engineers disseminate all useful information pertaining to the testing to the employer engineers so as to minimise the number queries from the employer engineers thereby reducing commissioning time. The content and scope of this training shall be as per other clauses of this specification.

1.10.3.3 In support of the Site testing activities, the Contractor shall prepare an overall test plan that covers all testing to be carried out on Site. The test plan shall indicate test precedence and dependencies and should be coordinated with the Contractor's general program of work. It shall conform to the relevant requirements for documentation set out in section 1.7 of specifications.

1.10.3.4 The test plan will be subject to the approval of the Employer and should be closely coordinated with the Employer in terms of the availability of plant for testing and the timely provision of the associated permits to work.

1.10.3.5 Inspection and test plans (program) may be of any form to suit the Contractor's system, but shall as a minimum:

1.10.3.5.1 Contain all tests specified in the particular specifications and all test requirement of the standard stated in the specifications.

1.10.3.5.2 Identify the function (performance) tests and operation tests to be carried out

1.10.3.5.3 Detail inspections in form of check lists to be carried out before testing.

1.10.3.5.4 Identify the characteristics to be inspected, examined, and tested at each point

1.10.3.5.5 Give detailed test procedures.

1.10.3.5.6 Give acceptance criteria to be used and the applicable verifying document. Indicate basis of the acceptance criteria i.e., standard or specification applicable.

1.10.3.5.7 Indicate mandatory hold points established by the Project Engineer that require verification of selected characteristics of an item of process before this work can proceed.

1.10.3.5.8 Duration required for each test and all tests for each system.

1.10.3.5.9 show the sequence to follow step by step in all connections, including wet tests and other pertinent factors.

1.10.3.6 Site acceptance testing plans shall be sent to the employer for approval in a similar fashion as drawings as per section 1.7.3 of specifications.

1.10.3.7 The Employer shall have the right, to waive some tests and require additional tests to be carried out if findings on Site indicate additional or alternative tests are required to properly demonstrate that the works comply with the requirements of the Contract.

1.10.3.8 The general requirements for testing and factory testing set out in the preceding Clauses 1.9.2 of this specification are also applicable to Site testing.

1.10.3.9 Testing at site shall be carried out by experienced commissioning engineers as stated in evaluation and qualification criteria. Functional tests shall be inherent in test procedures. The Contractor shall record the test results in the approved test plan in such a manner that the test reports can be used as the basis for future maintenance tests. Test methods, test equipment and test equipment calibration details shall be noted on the test sheets.

1.10.3.10 Commissioning shall be carried out by the Contractor together with Employer's engineers.

1.10.3.11 During site testing and commissioning the factory as built drawings shall be marked/highlighted (to track checks on each circuit) and modified to suite the final installed systems. Two copies of these marked/highlighted and modified drawings shall be made. One copy shall be left at site while one copy shall be used by the contractor to develop final as built drawings and submission as per provision of section 1.7 of specifications.

1.10.3.12 The Site test plans shall be filled by the commissioning engineers and approved by the employer engineer at site. These site test plans shall be copied, and one copy left at site the other copy shall be used to develop final report and submission as per provision of section 1.7 of specifications.

1.10.3.13 Employer shall also handover pen marked modified drawings of power plant systems (not forming part of scope of this project) interfaced to the new installed systems to be updated by the contractor. The employer shall provide pen marked drawings to the contractor who shall provide revised drawings in similar fashion to the drawings of systems supplied by the contractor.

1.10.3.14 Employer commissioning engineers at site shall keep a copy of complete record of the test results. One copy of corrected drawings shall also be kept at site after commissioning.

1.10.3.15 A complete final test report in 4 sets shall be handed over to the Project Manager not later than one month after commissioning.

1.10.3.16 After the performance tests and before Taking Over, reliability shall be undertaken to demonstrate satisfactory operation of the refurbished gate systems. During reliability period multiple operations shall be undertaken to confirm performance of the refurbished systems and their effects on the other plant systems.

1.10.3.17 The period of the reliability run shall be 30 days.

1.10.4 Instruction/Training on Site during installation and commissioning

1.10.4.1 During the installation and commissioning periods, the Contractor's site manager, commissioning engineers/supervisors shall give 'on the job' instruction /training to the employer skilled staff. The Contractor's Engineer/supervisor shall train the employer's staff in such disciplines as.

1.10.4.1.1 Maintenance and test procedures and techniques on the Equipment using test equipment provided by contractor.

1.10.4.1.2 Operational techniques relative to the Equipment both for local and remote operation as appropriate.

1.10.4.1.3 Step by step procedure in pre-commissioning and commissioning of the Equipment into operation.

1.10.4.1.4 Erection, mounting or joining/assembly of the systems supplied under the contract.

1.10.4.1.5 Maintenance, troubleshooting and test procedures and techniques on the fluid power systems.

1.10.4.1.6 Settings configuration on the various IED's and PLC's.

1.10.4.2 To ease on job training, it's a requirement of this tender as specified in other clauses that the installation and commissioning shall be carried out by both contractor and employer personnel. Prior to installation the contractor shall carry out a brief structured training to the employer personnel to bring them to par with contractor's personnel, this will minimise the amount of explaining to be demanded from the contractor's personnel during installation. The Installation Kick-off training shall cover all important aspects of installation and commissioning and shall ease integration of employer staff to the project.

1.10.4.3 Programming and configuration of IED's/PLCs and Computers shall be performed by the contractor for the first system while training the employer engineers. The employer engineers shall then carryout programming and configuration under supervision of contractor engineers for the second system. Contractor shall create software tools e.g., ms office excel/access macros that shall ease programming, configuration and database creation. These tools shall be handed over to the employer and shall be used for future modifications especially of the SCADA systems.

1.10.4.4 The contractor shall document detailed maintenance procedures and checklists for all systems supplied as part of the contract and hand over to the employer for use during plant maintenance.

1.10.4.5 The contractor shall furnish all equipment that is necessary for test and maintenance of the supplied equipment..

1.10.5 Accommodation of Contractor's Personnel

1.10.5.1 Accommodation will be provided to a maximum of four Contractor's employees at matendeni staff camp 6km from Gitaru power station. Cost of meals and other personal expenses will be the responsibility of the Contractor. Meals can be obtained at the Employer's Club located near the site.

1.10.5.2 Transport (including local airport connection) at the site during the works will be the responsibility of the Contractor.

1.10.6 Health, environment and safety

1.10.6.1 The contractor shall forward to the employer during design stage a Safety, Health and Environmental plan –This shall Include a narration of expected safety risks, taking into account local conditions and mitigation measures that will be adopted to ensure that the projects are completed without accidents, with minimum negative impact on the environment.

1.10.6.2 After contract signing, contractor shall provide a job safety analysis for the scope of works.

1.10.6.3 The Contractor shall follow all Kenyan rules and regulations related to workers' safety and health as well as regarding protection of the environment.

1.10.6.4 The Contractor shall be responsible for equipping all their workers and their subcontractors with necessary personal protective equipment such as helmets, eye protection glasses, safety shoes and safety belts and enforcing the use of such. Nobody will be allowed to work in the employer site without proper personal protective equipment.

1.10.6.5 No toxic material (such as Halon, PCB, and Asbestos etc.) shall be utilised neither during construction nor under operation and maintenance.

1.10.6.6 The Contractor shall at all times during the course of work prevent accumulation of debris caused by the work. He shall also remove all debris and temporary structures when finishing the work.

1.10.6.7 All surplus material should be disposed in an environmental satisfying way. Particular attention shall be given to safe disposal of environmentally hazardous substances. Workable equipment shall be handed over to the Employer.

1.11 TRAINING

1.11.1 Overall Requirements

1.11.1.1 All training requirement in this tender shall be offered by the contractor and the bidder shall include all the costs in the bid.

1.11.1.2 The training shall cover both theory and practical aspects of the systems. The content of the trainings shall include theory on the power plant systems, specific theory related to particular equipment supplied and practical lessons on design, installation, operation and maintenance of equipment supplied.

1.11.1.3 The training shall enable employer personnel to design, install, operate and maintain the systems supplied under the project and apply the knowledge to similar plant systems. It shall also enable the employer personnel to design necessary interfaces for the new system to allow interfacing to plant systems. Training shall have an emphasis on preventive maintenance, troubleshooting, repair and upgrades/rehabilitation. Detailed training on repair especially of mechanical systems e.g., hydraulic cylinders and pumps shall be carried by the contractor.

1.11.1.4 Contractor shall engage experienced professional trainers and staff from OEM to carry out training where their personnel do not have the capability to do so. Employer shall require the credentials of the proposed trainers during design stage. Pre-installation, pre-SAT and other on job training shall be carried out by the contractor's staff involved in the project.

1.11.1.5 All trainers shall be experienced, **fluent and have excellent command of English** language. Trainers with poor command of English language SHALL NOT be accepted.

1.11.1.6 The topics listed in the tender (clause 1.11.5) are indicative and the contractor shall develop a detailed syllabus for the trainings. The content of the trainings shall be approved in a similar fashion to drawings as detailed in clause 1.7 of specifications. By the end of site training, all topics listed in clause 1.11.5 shall have been covered exhaustively.

1.11.1.7 Contractor will send to the employer project engineer training aids, presentations and documents to be used for training two weeks prior to the training to ensure it covers the content of the approved training program.

1.11.1.8 A software trainer and training videos shall also be provided where applicable

1.11.1.9 Three kinds of training shall be offered

1.11.1.9.1 Factory training (pre-FAT)

1.11.1.9.2 On job training:

1.11.1.9.3 pre-installation and

1.11.1.9.4 pre-SAT training

1.11.1.9.5 Site training -post commissioning

1.11.2 Factory Training

1.11.2.1 Factory training shall be carried out in the contractors', OEM or other training facilities prior to FAT. The training facilities shall have access to various testing and demonstration equipment and professional trainers. These training facilities shall have training rigs and test benches for the equipment to be supplied under the contract. The demonstration equipment shall be very similar (where applicable same model and make) to equipment to be supplied. Immediately after the training FAT shall be carried out.

1.11.2.2 Content of factory training shall be geared towards understanding the systems design and equipping the employer personnel with detailed understanding of the systems to be supplied. The training shall take employer engineer through the design, manufacture, assembly and testing process in detail.

1.11.2.3 Factory training shall take the employer engineers through the design process to understand how various parameters were arrived at and the calculations and simulations used. The trainer shall demonstrate the design, programming and configurations by carrying out similar designs together with the employer on demonstration equipment. Trainer shall task the employer staff to carryout similar design, programming and configurations on the demonstration equipment on their own to ensure maximum transfer of knowledge and skill.

1.11.2.4 Factory training shall be detailed and cover the engineering processes. In this respect the contractor shall use experienced trainers with in-depth knowledge of the various engineering processes. The contractor shall give basic academic requirements for employer personnel who shall attend this training, the requirements shall however not be above a degree in engineering.

1.11.2.5 Classroom lecturers to be video recorded, and the materials sent to the employer.

1.11.2.6 Factory training programme shall cover the fluid power systems design, installation and maintenance and shall take a minimum of 10 days:

1.11.2.7 The durations given above is the minimum requirement however the bidder shall indicate the necessary duration for successful training and include the cost in the bid. This duration shall however not be less than indicated duration above.

1.11.2.8 Training shall also include detailed training on assembly and repair of the various fluid power systems. Trainer shall disassemble and reassemble various electromechanical/structural components with the employer. This shall also involve disassembly of hydraulic cylinders, reassembly and testing.

1.11.2.9 Practical training on various demonstration equipment shall take precedence over classroom training and emphasis shall be on "learn by doing".

1.11.2.10 Factory training shall include training on how various factory acceptance tests shall be carried and basis for each acceptance criteria. Training shall also describe the various test equipment and test rigs to be used during FAT.

1.11.3 On job training

1.11.3.1 On job training, shall cover both structured and unstructured training to be carried by contractor's personnel during site works. Unstructured training during installation and commissioning shall be carried out by attaching employer skilled personnel to the contractor's' staff to carry out the job while getting instructions from the contractor.

1.11.3.2 On job training for SCADA, PLC and IED configuration and programming shall involve the contractor carrying out the task for one system and supervising the employer as they carry out configurations and programming for the other systems.

1.11.3.3 Two structured trainings shall however be carried out to smoothen the on-job training. These shall be pre-installation training and pre-SAT training.

1.11.3.3.1 Pre-Installation training

(a) This shall be carried out on site prior to commencement of the work
(b) It shall be carried out by contractors' staff who shall carryout installation work
(c) Shall ease integration of attached employer personnel to contractor's staff.
(d) Shall take a minimum duration of two days
(e) To be carried out together with pre-outage works
(f) To cover topics related to how installation shall be carried out, use of contractors' installation tools and equipment, demonstration on how contractor intends to carry out the installation.
(g) Detailed content of this training shall have been approved two weeks prior to site works.

(h) Shall serve to create a good working relationship between employer staff and contractors' staff

(i) Shall address all expected challenges and remedies.

1.11.3.3.2 Pre-SAT training

(a) This training shall be carried out prior to commencement of SAT by the commissioning engineers.

(b) Shall take at minimum of one day

(c) Shall be carried out while installation is ongoing but close to finalisation. Equipment shall be ready for SAT immediately after the training.

(d) Shall be attended by employer engineers to be involved in SAT and commissioning.

(e) Commissioning engineers shall arrive on site earlier (before equipment is ready for SAT) in order to carry out this training.

(f) The training shall serve to create a good working relationship between employer engineers and contractors' commissioning engineers

(g) During the training the harmonised commissioning program for the whole unit shall be discussed between the teams from each subsystem to ensure smooth commissioning the interconnected system.

(h) Various constraints and expected challenges shall be discussed and addressed during this training.

(i) The training shall be interactive between the trainers and the employer engineers.

(j) The training shall cover among other

(k) Step by step SAT procedures

(i) Test plan and acceptance criteria

(ii) Equipment inspection and pre- checks

(iii) Configurations and or programming to be carried out during SAT

(iv) Measuring points and preparations

(v) Necessary modifications to be carried during SAT

(vi) Various equipment limits and precautions to be observed during SAT

(vii) Requirements given in the particular specifications

(viii) Use of test equipment and test set ups

(ix) Any other necessary topic for employer's engineer to fully participate in SAT and commissioning activities

1.11.4 Site training

1.11.4.1 This shall be detailed training to be carried out after the commissioning of the first gate.

1.11.4.2 Shall take a minimum of **three weeks (15 days)** covering fluid power systems design, installation, commissioning, operations, and maintenance.

1.11.4.3 It shall cover topics similar to the factory training but with an emphasis on operation and maintenance. Some of the topics covered in the factory training shall be repeated for the benefit of staff who shall not have attended the factory training. The detailed content shall be agreed upon in the design stage. The bidder shall however note that all topics listed below (clause 1.11.5) **MUST** be covered during site and factory training.

1.11.4.4 Training shall be conducted in employer's facilities and on site using installed equipment, spare equipment supplied will be configured and used for demonstrations. Installed equipment shall be used to carry out practical training; during this period Contactor, shall also carry out identified defects corrections.

1.11.4.5 Contractor shall provide certified and experienced trainers who are **fluent and have excellent command of English language.**

1.11.4.6 Employer will provide projectors and other necessary training facilities.

1.11.4.7 Theory training will be conducted for a group of up to thirty employer personnel or any other number communicated to the contractor two weeks prior to the training. Practical training will be done in small groups to be agreed upon with the employer and will be held in the power plant using installed equipment. Theory training shall include demonstrations using the spares to be supplied.

1.11.4.8 Contractor shall supply training aids including a detailed training guide or document well prepared in advance. Contractor is expected to be well prepared for the training with necessary presentations specific for the training. Contractor will also prepare and present certificates to participants at the end of the training.

1.11.5 Training topics

Training detailed above shall cover a minimum but not limited to the following:

1.11.5.1 Introduction and Fundamentals of Fluid Power

(a) Physics and mathematical fundamentals

(b) Properties of hydraulic fluids including but not limited to viscosity, viscosity index, lubricity/oiliness, types of fluids, synthetic fluids, maintenance of hydraulic fluids etc.

(c) Introduction to various fluid power components i.e., Reservoirs, accumulators, piping, filters, pumps, motors, valves, cylinders

(d) Introduction to the various ISO standards for fluid power systems and their application to design and testing of various fluid power systems.

1.11.5.2 Developing and interpreting hydraulic schematics

(a) How to interpret fluid power symbols established by the International Standards Organization (ISO) 1219-2:2011.
(b) The scope and purpose of the ISO standard. ISO Symbol rules.
(c) The differences between pictorial, cutaway, and graphic symbols.
(d) Symbols for: Transmission lines, Hydraulic reservoirs, Hydraulic pumps, Pressure control valves, Directional control valves, Logic valves, Hydraulic cylinders, Hydraulic motors, Check valves, Quick connect/disconnect couplers, Flow control valves, Accumulators, measuring instruments, Oil conditioners, Air bleed valve/Velocity fuse, Manual shut off valve, Pressure switch etc.
(e) How to use the hydraulic schematic for a given hydraulic system to correctly identify the components.
(f) How to use the hydraulic schematic for a given hydraulic system to determine how the oil flows through the system.
(g) How to use the hydraulic schematic for a given hydraulic system to determine how system components interact with one another.
(h) The defining characteristics of symbols to differentiate one component from another.
(i) The difference between a composite symbol and a simplified symbol.
(j) How to layout and draw a hydraulic schematic.
(k) Drawing Hydraulic circuits using CAD(AutoCAD)
(l) Exercises of drawing hydraulic schematic
(m) Exercise in interpreting hydraulic schematics

1.11.5.3 Detailed training on hydraulic Pumps including but not limited to:

(a) Types of pumps,
(b) Choice of pumps for each typical fluid power application,
(c) Detailed description for each type of pump,
(d) Disassembly and assembly of two common types of hydraulic pumps (gear and piston)
(e) Variable displacement pump principles,
(f) Design principles for fixed displacement and variable displacement pumps
(g) trouble shooting and maintenance.

1.11.5.4 Detailed training on fluid power valves including but not limited to

(a) Types and basic operating principles
(b) Isolation valves-types, operation principles, design criteria, trouble shooting and maintenance.
(c) Check valves- types, operation principles, design criteria, pilot operation, trouble shooting and maintenance.

(d) Directional control valves- types, operation principles, design criteria, pilot operation, electrical operation, trouble shooting and maintenance.
(e) Logic valves- types, operation principles, design criteria, pilot operation, electrical operation, trouble shooting and maintenance.
(f) Flow control valves- types, operation principles, design criteria, trouble shooting and maintenance.
(g) Pressure control valves- types, operation principles, design criteria, trouble shooting and maintenance.
(h) Valve blocks & stacking – types & principles design criteria, trouble shooting and maintenance.

1.11.5.5 Detailed training on proportional valves including but not limited to:
(a) Types and Principles of operation,
(b) Control electronics,
(c) design criteria for open loop,
(d) design criteria for closed loop,
(e) trouble shooting and maintenance.

1.11.5.6 Detailed training on hydraulic cylinders including but not limited to
(a) Types and principle of operation
(b) Servo cylinders (servo motors) principles
(c) Design criteria for various power plant applications
(d) Bearings and seals
(e) disassembly and assembly
(f) performance/functional testing
(g) trouble shooting and maintenance.

1.11.5.7 Detailed training on hydraulic accumulators including but not limited to:
(a) Types and principle of operation
(b) Design criteria and calculations
(c) Selection criteria for typical applications
(d) Safety and isolations
(e) Filling and testing
(f) Nitrogen charging
(g) trouble shooting and maintenance.

1.11.5.8 Detailed training on hydraulic reservoirs including but not limited to:
(a) Types and principles
(b) Sizing criteria and calculations
(c) Selection criteria for typical applications
(d) Cooling and temperature monitoring
(e) Filling and contamination control

(f) trouble shooting and maintenance.

1.11.5.9 Detailed practical training on troubleshooting Fluid power Circuits.

1.11.5.10 Detailed training on fluid power systems safety

1.11.5.11 Design principles for hydraulic power systems

1.11.5.12 Hydraulic oil contamination control and filters

1.11.5.13 Specific training on bulkhead gates operations using hydraulic systems.

1.11.5.14 Electrical control of hydraulic systems design, installation, troubleshooting, testing and maintenance.

1.11.5.15 Fluid power instruments design, installation, troubleshooting, testing and maintenance including but not limited to pressure switches and transmitters, level switches and transmitters, flow switches and transmitters, water in oil detectors, position switches and transmitters etc.

1.11.5.16 Specific training on the intake gate control systems supplied and installed under the contract.

1.11.5.17 Specific training on the spillway gate control systems supplied and installed under the contract.

1.12 WARRANTY

1.12.1 The Contractor shall warrant that goods supplied under the Contract are brand new, unused, of the most recent or current models, and that they incorporate all recent improvements in design and materials unless provided otherwise in the Contract.

1.12.2 The Contractor further shall warrant that all Goods supplied under this Contract shall have no defect arising from design, materials, or workmanship or from any act or omission of the Contractor, or that may develop under normal use of the supplied Goods in the conditions prevailing at Gitaru power station.

1.12.3 The contractor shall warrant that the supplied and commissioned equipment shall have no adverse effect to the spillway and intake gates operation under normal utilisation by the employer as per contractor instructions.

1.12.4 Warranty shall remain valid for twenty-four (24) months after the Equipment, or any portion thereof as the case may be, have been commissioned and take over certificate signed by both parties, or for thirty six (36) months after arrival of equipment at site whichever period concludes earlier. During warranty period contractor shall repair or replace any faulty or mal operating equipment of component due fault under clauses 1-3 above

1.12.5 The bidder guarantees supplying maintenance spares and services as well as repairing of the supplied systems if called upon to do so after expiry of the warranty period at employers' cost for a period of 10 years.

1.12.6 Contractor shall guarantee that all offered items shall have a design life of at least twenty years.

2 SCOPE OF WORKS

2.1 PREAMBLE

2.1.1.1 The Bidder shall examine the scope of works in this section in close connection with the other documents and particulars forming these Bidding Documents. Special attention shall be paid to Particular Technical Specifications and drawings of the existing systems in order to develop the scope of supply by the bidder. The scope of supply summarises the main supply items but does not provide comprehensive requirements, bidder MUST study the particular specifications prior to making their offers.

2.1.1.2 All the functionality and features of the existing system shall be part of the scope of supply whether specifically mentioned in this scope or not. The bidder shall study the existing drawings, carry out a site visit and request all necessary information prior to developing their scope of supply. Where there is a conflict or omission in this scope of works, or conflict between functionality and features of the existing systems and employer's requirements, the bidder shall seek clarification and correction from the employer as stipulated in clause 7 of ITT

2.1.1.3 The tenderer shall indicate proposed make, type, model number and manufacturer of the major equipment in their bid offer.

2.1.1.4 All functions, devices, accessories, or fittings which may not have been specifically mentioned, but which are usual or necessary for the proper and safe completion, operation, and maintenance of the equipment in question, shall be deemed to be included in the scope of supply and shall be supplied.

2.1.1.5 Any alternative/ additional system or device considered necessary for providing complete effective and reliable system shall also be included in the scope of supply by the bidder.

2.1.1.6 In the event of any conflict between the particular specifications and the Scope of works, the particular specifications shall prevail. In the event of any conflict between scaled dimensions and figures on the Drawings, the figures shall prevail.

2.1.1.7 Should the Bidder find discrepancies in or omissions from these Specifications or from the other Documents, or should they be in doubt as to their meaning, they should immediately contact the Project Manager for interpretation, clarification or correction thereof before submitting their Bid.

2.1.1.8 The equipment listed in the subsequent clauses under scope of supply are indicative major components and shall not be assumed to cover the whole scope of supply for each system.

2.1.1.9 All the system and devices listed under scope of supply are to use the station auxiliary DC power supply of 110VDC or 240VAC/415VAC. Where power supply units or power transformers are required to power the devices, they shall be part of scope of supply whether mentioned or not.

2.1.1.10 All the spare listed in the scope of works MUST be quoted for in the schedule of prices. Failure to quote for a stated spare shall render the bid unresponsive.

2.1.1.11 All spares MUST be 100% similar to installed components. Each spare shall be exact type as the equipment installed, shall be complete with all accessories (suitable for plug and play) and shall be tested prior to acceptance by the employer.

2.1.1.12 The bidder shall supply all necessary spares required for operating the equipment for at least 15 years as per manufacturer requirements except the consumables e.g., oil.

2.1.1.13 All spares not listed in the scope of works/particular specifications but are critical to equipment proposed by the bidder or are subcomponents/complementary components of the listed spares MUST be included in the bid offer. Where such spare part / equipment is not listed by the bidder, but it's considered critical it shall be supplied at no extra cost to the employer.

2.1.1.14 All spares shall be tested by the contractor in presence of the employer engineer prior to acceptance. These spares shall be tested at site with the installed systems. Untested spares shall not be accepted by the employer.

2.1.1.15 Spare IED's, PLC modules and other software loaded, and configured devices shall be configured and loaded with the necessary software and then tested prior to acceptance by the employer.

2.1.1.16 It is a condition of this contract that all malfunctioning items during the warranty period – to start after issue date of Take over Certificate – shall be replaced by the Contractor at their own cost.

2.1.1.17 All maintenance and test equipment required to operate the supplied equipment shall be included in the price schedule and shall be handed over to the employer in good order on completion of commissioning tests.

2.1.1.18 Tools and equipment listed in the specifications and scope of works MUST be included in the bid offer and quoted for otherwise the bid shall be considered unresponsive.

2.1.1.19 Installation and testing equipment/tools required for SAT/commissioning but not accepted for supply under the contract shall be shipped to the site and back to contractor's home country by the contractor where requested the employer shall assist in clearing at the port of entry for such equipment.

2.1.1.20 The tools and equipment shall be unused and in new condition at the time of handover.

2.2 GENERAL REQUIREMENTS SCOPE OF WORKS

The requirement under this general scope of works are applicable to all the project sections. The scope of the works shall include but not limited to the listed activities and any other works required to fulfilling all the requirements in this specification:

2.2.1.1 Studying the plant equipment i.e. control systems and other associated equipment and any other system necessary in order to offer a complete solution. In particular, a detailed study of the existing intake gate LV switch board, existing spillway gate LV switch board, intake and spillway gates electrical control circuits, intake and spillway gates hydraulic circuits and intake and spillway gates hydraulic cylinders technical manuals in order to provide a complete solution covering all existing functionality and additional functions as specified in the subsequent specification.

2.2.1.2 Advice the employer on any requirements that are not included in the scope of the project that are necessary for successful implementation of the project.

2.2.1.3 Design of new systems including calculations and drawings and sending designs to employer for approval at each stage of design. Design and development of all software application programs required for operation of systems to be supplied. This shall include preparation of all documentation and review as specified in clause 1.7 of specifications.

2.2.1.4 Manufacture & procurement of all the equipment detailed in the subsequent clauses of this specification and any additional equipment necessary for a complete solution.

2.2.1.5 Factory training for employer engineers at manufacturers training facilities prior to acceptance testing as detailed clauses 1.9 and 1.11 of specifications.

2.2.1.6 Factory acceptance testing witnessed by employer engineers at manufacturers factory for all systems to be supplied as detailed in particular specification and clauses 1.9 of specifications

2.2.1.7 Supply of: factory wired Complete Panels with all components as specified in subsequent chapters of this specification, cables & other free-standing equipment (not mounted on the panels) and all spares as specified in the subsequent chapters of this specification.

2.2.1.8 Supply of cables & conductors, lugs, connectors, screws, nut, bolts, washers, terminal blocks, cable lugs, bootlaces, auxiliary relays and all other installation accessories required for retrofitting the new system and interfacing to the plant systems specified subsequent chapters of this specification.

2.2.1.9 Supply of all accessories which are necessary for satisfactory operation of complete system though not individually or specifically mentioned in the specification.

2.2.1.10 Provision of software's and application programs with licences for all IED's, PLC's, other software-based devices and computers supplied. This shall include software required for interrogating the IED's, PLC's and other software configurable devices via a portable computer, software loaded in the IED's, PLC's & computers and all application programs /configuration files made for the project running on the PLC's, IED's & computers

2.2.1.11 Carry out training on all test equipment and maintenance tools specified.

2.2.1.12 Removal of existing intake gate control systems including the pumping unit, sump tank, hydraulic valves and pipes, gate control panel, LV switchboard and any other existing equipment to be removed and transportation to employer designated storage within the power station.

2.2.1.13 Removal of existing spillway gate control systems including the hydraulic valves and pipes, outdoor cabinets, gate control panel, LV switchboard and any other existing equipment to be removed and transportation to employer designated storage within the power station.

2.2.1.14 Installation of new panels in place of existing panels including shifting from storage with required mounting hardware, blanking plates, Glands, Earthing strip, relevant fabrication and other relevant accessories. Complete wiring and terminations, grounding and also wiring modifications to include all functions as per specifications. Cabling and wiring to interface the new systems to the other plant systems.

2.2.1.15 Installation of the new hydraulic control equipment including carrying out necessary modifications required for the installation. Carrying out of all civil and structural works required for installation of the new equipment.

2.2.1.16 Carry out flushing of the newly installed hydraulic pipework and pressure testing the complete hydraulic circuit.

2.2.1.17 Software configuration and installation on the new systems. Software modification and configuration on employer SCADA equipment in conjunction with the employer engineers as specified in the subsequent chapters of this specification.

2.2.1.18 Site acceptance Testing and commissioning of modified systems as specified in the specifications.

2.2.1.19 On job training during installation & commissioning and post commissioning site training as detailed in section 1.11 of specifications

2.2.1.20 Replacement of any equipment and software found defective during commissioning or defects liability period.

2.2.1.21 Provision of all final documentation as per clause 1.7 of specifications

2.2.1.22 Provision of warranty for supplied Systems.

2.2.1.23 Modification/review and updating of all employer drawings of the plant systems interfaced to the new systems or modified to accommodate the new systems and submission to the employer as specified in clause 1.7 of specifications.

2.2.1.24 Any other services or requirements not mentioned or included in this tender but are critical for the completion of the contract shall be itemized by the bidder in the offer.

2.3 SUPPLY OF HYDRAULIC CONTROL SYSTEMS

2.3.1 Supply of Hydraulic Components for Intake Gates.

Contractor shall supply all the intake gate hydraulic components specified in clause 4.3.2 including but not limited to

2.3.1.1.1 **Three (3)** sets of valves, a set for **each** gate. Each set shall comprise a minimum of the following valves:

(a) Two (2) Flow control valves for the pressure line
(b) One (1) Four by three-way directional control valve
(c) Two (2) Three by two-way directional poppet valves
(d) Two (2) Throttling valves
(e) Two (2) Check valves
(f) Two (2) Pilot operated check valves
(g) One (1) Two-way ball valves (one)
(h) One (1) Normally open gate valve(one).

2.3.1.1.2 **Three (3)** sets of Instruments, a set for **each** gate. Each set shall comprise a minimum of the following instruments/transducers:

(a) One (1) Electronic pressure switch and transmitter
(b) One (1) Mechanical pressure gauge
(c) One (1) linear displacement transducer for accurate measurement of the cylinder piston position retrofitted to the existing cylinders. New cylinders to be supplied with inbuilt linear displacement transducers.
(d) Six (6) Robust IP68 Water resistant gate position Limit switches

2.3.1.1.3 **Three (3)** outdoor cabinet for housing the gate control valves.

2.3.2 Supply of New Intake Gate Hydraulic Power Units

Contractor shall supply **Two (2)** Complete hydraulic power units (HPU) as detailed in clause 4.3.1 each with a minimum of the following components

2.3.2.1.1 One (1) Reservoir with minimum of the following devices

(a) Oil filler port, filter, and strainer
(b) Oil purifier connections.
(c) Breather with an oil moisture vapour filter and dehumidifier.
(d) Dual changeover filter with clogging indicator and electrical contacts on the tank return lines.
(e) Reservoir drain valve with plug.
(f) Mechanical Sight oil gauge (sight glass)
(g) PT100 temperature detector
(h) Electronic float Level switches
(i) Electronic Oil Level transmitter
(j) Oil temperature transmitter

2.3.2.1.2 One (1) complete Pumping set of similar type and rating to the existing mounted outside the reservoir including but not limited to

(a) Motor
(b) Gear pump
(c) Mechanical pressure gauge
(d) Oil Pressure transmitter type Hydac EDS 1700 or equivalent

2.3.2.1.3 One (1) piston accumulator system sized for 300mm travel of one gate including but not limited to the following components.

(a) Piston accumulator
(b) Safety and shutoff block at the top of the accumulator with a minimum of the following devices
    (i) pneumatic pressure relief valve with auxiliary contacts
    (ii) test & charging ports,
    (iii) Pressure transducer ports
    (iv) Pneumatic isolation valve
    (v) Nitrogen bottle connection points
(c) A minimum of the following transducers
    (i) mechanical pressure gauge.
    (ii) Electronic pneumatic pressure switch and transmitter.
    (iii) Accumulator Oil level switches (piston position)
(d) Backup nitrogen bottle/s

2.3.2.1.4 Minimum of the following valves mounted in to **two (2)** manifold valve blocks as described in particular specifications.

(a) At least one (1) Manually operated Flow control valve.
(b) At least Two (2) pressure relief valves each with an auxiliary contact
(c) At least one (1) Pressure actuated (piloted) Unloading valve.

(d) At least one (1) Solenoid actuated Unloading valve.
(e) At least four (4) Solenoid operated directional poppet control valve (or equivalent) with limit switches.
(f) At least Four (4) ball valves with extended handles for isolation
(g) At least two (2) Check valves

2.3.2.1.5 New hydraulic oil to fill all cylinders for each HPU, plus spare capacity equivalent to all oil in the three gates cylinders.

2.3.3 Supply Of New Hydraulic Pipes Clamps and Fittings for Intake Gates

The contractor shall replace all hydraulic pipes at the intake as detailed in clause 4.3.5 with steel plated pipes painted to marine specifications suited for outdoor application (adverse conditions.) and meeting requirements in clause 3.11. Isolation valves specified shall also be included.

2.3.4 Supply Of New Intake Large Hydraulic Cylinder (Servomotor)

The contractor shall supply a new hydraulic cylinder as detailed in clause 4.3.4 with the same specifications, features, sizes, performance, and ratings as the existing cylinders and with all attachment components including but not limited to spherical bearing, transfer tubes, support clamps, valves, linear displacement transducer.

2.3.5 Supply of Hydraulic components for spillway gates.

2.3.5.1 Contractor shall supply and install a minimum of the following devices as detailed in clause 5.3.1, on the existing reservoir.

(a) Breather with an oil moisture vapour filter and dehumidifier.
(b) Dual changeover filter on the tank return line with clogging indicator flag and electrical contacts
(c) Three (3) Pressure line filters one on each pump each with clogging indicator flag and electrical contacts
(d) PT100 temperature detector
(e) Electronic float Level switches
(f) Electronic Oil Level transmitter
(g) Oil temperature transmitter
(h) **four (4)** manifold valve blocks one for each pump each with a minimum of the following:
    (i) Pressure relief valve

(ii) Spring loaded check valve.
(iii) Mechanical pressure gauge
(iv) Electronic pressure switch and transmitter

(i) Twelve (12) 2-way isolating ball valves for the pressure pumps
(j) Two (2) Return line 2-way isolating ball valves.
(k) Return line pressure relief valve rated for continuous duty
(l) new hydraulic oil to fill all the six cylinders while fully closed plus a spare capacity equivalent to half the six cylinders volume.

2.3.5.2 Contractor shall restore the existing open loop control as detailed in clause 5.3.2, this shall include but not limited to supply of.

2.3.5.2.1 Three (3) sets of devices at the pier, one set for **each** gate, each set shall consist of:

(a) Two (2) Two-way ball valve for maintenance isolations
(b) One (1) Flow control valve for the pressure line
(c) One (1) Flow control valves for the return line
(d) One (1) Fine flow control valves for the synchronous control system
(e) One (1) Four by three-way directional control valve
(f) Two (2) Three by two directional poppet valves
(g) One (1) Constant flow divider valves.
(h) Two (2) Mechanical pressure gauge
(i) Two (2) Electronic pressure switch and transmitter

2.3.5.2.2 Three (3) sets of devices at the cylinder base, one set for each gate, each set shall consist of:

(a) Two (2) Three by two poppet valves with solenoid (one for each cylinder)
(b) Two (2) Pilot operated check valves (one for each cylinder.)
(c) Two (2) Two-way ball valve (one for each cylinder).
(d) Two (2) Normally open ball valve (one for each cylinder)

2.3.5.3 The contractor shall also supply a modern **closed loop control** system for synchronising the two gate cylinders movement by utilising the cylinder piston position transducers clause 5.3.2. This shall include but not limited to the following for **each** gate:

(a) At least two (2), one for each cylinder proportional directional control valve suitable for outdoor harsh environments
(b) At least two (2), one for each cylinder, Suitable solenoid directional control poppet valves
(c) Suitable manifold valve block shall be supplied for mounting the valves.
(d) At least two isolation valves for maintenance isolation

2.3.5.4 Contractor shall supply **Three (3)** outdoor cabinets for **each** gate, one at the gate pier (total 3) and the other at the cylinder base (total 6) for housing the gate control valves.

2.3.5.5 Contractor shall supply **six (6)** linear displacement transducer for accurate measurement of the cylinder piston position retrofitted to the existing cylinders. New cylinders to be supplied with inbuilt linear displacement transducers.

2.3.6 Supply of a new accumulator system for the spillway HPU.

Contractor shall supply an Accumulator system sized for **six (6) meters** travel of one gate equivalent to two (2) meters travel of all the three gates including but not limited to the following components as detailed in clause 5.3.5

2.3.6.1.1 One (1) Piston accumulator

2.3.6.1.2 One (1) Safety and shutoff block at the top of the accumulator with a minimum of the following devices.

(a) pneumatic pressure relief valve with auxiliary contacts
(b) test & charging ports,
(c) Nitrogen Charging port,
(d) Pressure transducer ports
(e) Pneumatic isolation valve
(f) Nitrogen bottle connection points

2.3.6.2 Valves manifold block with a minimum of the following devices

(a) At least three (3) solenoid directional control poppet valves or equivalent each with manual override with an extended handle and with an auxiliary contact for open position status
(b) At least three (3) flow control valves for gate pressure supply
(c) One (1) Pressure relief valve with auxiliary contact for operated status
(d) One (1) Manual flow control valve for maintenance pressure discharge
(e) One (1) Oil Pressure transmitter type Hydac EDS 1700 or equivalent

2.3.6.3 At least Four (4) Isolation ball valves with lockable handles

2.3.6.4 Accumulator shall be equipped with a minimum of the following instruments.

(a) One (1) mechanical pressure gauge
(b) One (1) Electronic pneumatic pressure switch and transmitter
(c) One (1) Oil level switches for accumulator oil level (piston position) measurement
(d) One (1) Pneumatic pressure relief valve with auxiliary contacts

2.3.6.5 Set of Nitrogen bottles each equipped with a lockable shut off pneumatic isolation valve.

2.3.7 Supply of new Hydraulic pipes clamps and fittings for spillway gates

The contractor shall replace all hydraulic pipes at the spillway as detailed in clause 5.3.6 with steel plated pipes painted to marine specifications suited for outdoor application (adverse conditions.) and meeting requirements in clause 3.11.

2.3.8 Supply Of Two (2) New Spillway Large Hydraulic Cylinders (Servomotors)

The contractor shall supply Two (2) new hydraulic cylinder as detailed in clause 5.3.4 with the same specifications, features, sizes, performance, and ratings as the existing cylinders and with all attachment components including but not limited to spherical bearing, transfer tubes, support clamps, valves, linear displacement transducer.

2.3.9 Supply Of Spare Hydraulic Components, Pipes & Pipe Fittings, Tools& Equipment.

Contractor shall supply a minimum of the following mandatory spares, tools and equipment.

(a) Two (2) complete sets of control valves of each type used- for every type of control valve (directional, flow, check, pressure relief &. unloading)
(b) Three (3) directional proportional valves for the spillway gate control
(c) Two (2) complete sets of isolation valves of each type used.
(d) One (1) complete intake gate pump including motor, pump, coupling & fittings
(e) Two (2) sets of each type of Hydraulic cylinder seals and fittings.
(f) A set of each type of accumulator fittings
(g) Vacuum dehydration unit – HYDAC Fluid Aqua Mobil FAM 10 or equivalent with aqua sensor for continuous water content monitoring and particle sensor for simultaneous monitoring of particle contamination)
(h) Thermal Camera – Bosch Thermo Camera GTC 400 C or equivalent
(i) Pressure test kit including (SA Gauge set (3 pieces) TKQ, with pressure range 0 up to 5000 psi, Test hoses (1m, 2m & 3m lengths with fittings)), minimess hoses and gauges fittings.
(j) Nitrogen Charging & testing unit – HYDAC FPU-1 or equivalent (including valve body, spindle, check valve, release valve & pressure gauge)

2.4 REFURBISHMENT OF SPILLWAY GATES SERVO MOTORS:

Refurbishment of the existing **Six (6)** intake gate large hydraulic cylinders and carrying out performance testing after refurbishment as detailed in clause 5.3.3.

2.5 REFURBISHMENT OF INTAKE GATES SERVO MOTORS

Refurbishment of the existing **Three (3)** intake gate large hydraulic cylinders and carrying out performance testing after refurbishment as detailed in clause 4.3.3.

2.6 SUPPLY OF ELECTRICAL CONTROL PANELS & SWITCHBOARDS

2.6.1 Supply of Intake gate low voltage supply switchboard and distribution boards

Contractor shall supply a switchboard and a distribution board at the intake with the following incomers and feeder circuits with the indicated switchgear ratings as detailed in clauses 3.9 & 4.5.

	Incomers					
	compartments	Module rating		Type	MCCB/ MPCB rating	Contactor rating
1	Duty incoming supply	300A		Incomer	400A	200KW
2	Reserve incoming supply	300A		Incomer	400A	200KW
3	Control and metering	N/A		Control& metering	N/A	N/A
	Feeders' Withdrawable plug-in modules					
1	Power outlet	125A		Cable feeder	160A	N/A
2	Lighting and small power	125A		Cable feeder	160A	N/A
3	Spare	125A		Cable feeder	160A	N/A
4	Spare	125A		Cable feeder	160A	N/A
5	Screen raking gantry	32A		Cable feeder	32A	N/A
6	Spare	32A		Cable feeder	32A	N/A
7	HPU 1 pressure pump	32A	11KW	motor DOL starter	32A	18.5KW
8	HPU 2 pressure pump	32A	11KW	motor DOL starter	32A	18.5KW
9	Spare	32A	11KW	motor DOL starter	32A	18.5KW

10	Raw water supply	32A	11KW	motor DOL starter	32A	18.5KW
11	Spare	32A	11KW	motor DOL starter	32A	18.5KW
	Lighting and small power 4 Way TP&N distribution board					
	feeder circuit		Type		MPCB rating	MCB rating
1	1		Three phase circuit		32A	N/A
2	2		Three phase circuit		32A	N/A
3	3		Single phase circuit		N/A	32A
4	4		Single phase circuit		N/A	32A
5	5		Single phase circuit		N/A	32A
6	6		Single phase circuit		N/A	16A
7	7		Single phase circuit		N/A	16A
8	8		Single phase circuit		N/A	16A
	Switchboard Basic rating					
1	Main bus bar rating I_n				400A	
2	Distribution bus bar rating I_n				300A	
3	Switchboard short time withstand current (I_{cw})				50KA/1s	
4	Rated operating voltage				433V AC	

2.6.1.1 A complete switchboard with at least two (2) cubicles with all the compartments i.e., bus bar, cable, circuit breaker, Control & metering etc with all internal wiring and mounting accessories e.g., terminal blocks, DIN rails, glanding plates, base plates, internal wires, trunking, doors, frames, bus bars, cable termination accessories, etc. shall be supplied as detailed in clause 4.5.

2.6.1.2 The cubicles shall contain but not limited to the following devices:

2.6.1.2.1 Two (2) 300A incomer circuits with all the components and devices for complete switch board incomers as per clause 4.5., including but not limited to

(a) Two (2) 400A Moulded case circuit breaker and its associated gear

(b) Two (2) 200KW DOL starter contactor

(c) A mechanical interlocking device for the contactors

(d) at least 8(eight) (one per phase for each incomer) current transformers

(e) at least 3(three) three phase voltage transformers

2.6.1.2.2 At least One (1) control and metering compartment containing incomer control and metering devices including but not limited to:

(a) One (1) automatic transfer controller

(b) One (1) Digital panel AC voltmeter

(c) Two (2) Digital panel multifunctional meters

(d) One (1) three pole, three position key operated switch

(e) Three (3) three phase AC voltage monitoring relay

(f) A set of contactor relays for control & interlocks
(g) A set of miniature interface relays with 4 SPDT contacts for interfacing
(h) at least two (2) DC DP Miniature circuit breakers
(i) At least one (1) AC DP Miniature circuit breakers
(j) At least three (3) Motor protection circuit breakers (MPCB)
(k) at least six (6) illuminated push buttons.
(l) At least eight (8) status indication LED lamps
(m) Thermostat, heater and one single phase British type socket outlet

2.6.1.2.3 Five (5) 11 KW standard sized withdrawable motor DOL starter modules meeting requirements of clause 3.9.20 **each** including but not limited to the following main components:

(a) One (1)32A MPCB
(b) One (1) MPCB rotary door operator and knob at the compartment door.
(c) One (1)18.5KW contactor
(d) One (1) set of motor management and control devices.
(e) At least two (2) miniature circuit-breakers for control circuit protection
(f) At least two (2) contactor relays
(g) A set of interface relays with SPDT contacts
(h) At least One (1) current transformer for external panel meter
(i) compartment door with a minimum of the following devices
    (i) Motor management control device HMI display unit
    (ii) Three (3) illuminated pushbuttons (ON/OFF/TRIP RESET)
    (iii) Two (2) status LED lamps (service position and test position)
    (iv) One (1) Running hour's counter.
    (v) One (1) Three pole, three position key-operated switch

2.6.1.2.4 Four (4)125A standard sized withdrawable cable feeder modules meeting requirements of clause 3.9.19 **each** containing but not limited to the following main components:

(a) One (1)160A MCCB
(b) A set of MCCB communication module/s
(c) One (1) MCCB rotary door operator and knob at the compartment door

2.6.1.2.5 Two (2) 32A standard/small sized withdrawable cable feeder modules meeting requirements of clause 3.9.19 **each** including but not limited to the following main components:

(a) One (1)32A MPCB
(b) One (1) Three-phase digital power monitoring device
(c) One (1) MPCB rotary door operator and knob at the compartment door

2.6.1.2.6 A 4-way TPN distribution board module complete with all devices as specified including but not limited to:

(a) Two (2) 32A MPCB

(b) Three (3) 32A AC SP Miniature circuit breakers with Icu ≥10KA @ 400VAC and at least one SPDT auxiliary contacts

(c) Three (3) 16A AC SP Miniature circuit breakers with Icu ≥10KA @ 400VAC and at least one SPDT auxiliary contacts

2.6.1.3 New LV copper power cables shall be installed for any feeder circuit power cable that might require replacement due to the positioning and size of the new switch board.

2.6.2 Supply of Intake gate electrical control panels & cabinets

Contractor shall supply the following.

- Three (3) intake gate control panels for each of the three gates operation
- Three (3) Outdoor cabinets for each of the three gates operation
- Two (2) HPU electrical control cabinet mounted on each HPU.
- SCADA panel housing SCADA interfaces as described in clause 4.4.6.
- Fibre Optic Patch panel cabinet
- DC supply cabinet
- Wiring and wiring accessories

2.6.2.1 Intake gate control panels

Contractor shall supply **Three (3)** intake gate control panels one for each gate as detailed in clause 4.4.3. Each panel shall be complete with enclosure, door, terminal blocks and all wiring and wiring accessories as per clause 3.6. Each panel shall contain but not limited to the following major devices.

(a) Set of contactor relays meeting requirements of clause 3.5.3, for implementation all the gate operations described in clause 4.4.2.

(b) Set of Robust contactor type or equivalent timer relays for implementation all the gate operations described in clause 4.4.2.

(c) Set of interfacing relays for contact multiplication

(d) At least Five (5) LED lamps

(e) At least Five (5) pushbuttons

(f) At least one (1) mushroom head emergency pushbutton

(g) At least one (1) Three pole, Three position key switches

(h) At least One (1) Two pole, Two position selector switches

(i) Two (2) digital panel indication meters as per clause 3.5.8.3

(j) At least Five (5) contactor relays as per clause 3.5.3 for valve control

(k) At least two (2) double pole DC MCB's for 24 V DC and 110V DC supply
(l) At least two (2) AC MCB's shall be provided for AC supplies.
(m) At least one (1) British type socket
(n) At least one (1) LED panel lighting with door switches
(o) Panel heater and hygrostat

2.6.2.2 Intake gate Outdoor control cabinets

Contractor shall supply **Three (3)** intake gate control outdoor cabinets one for each gate as detailed in clause 4.4.3. Each cabinet shall be complete with enclosure, double door, terminal blocks, and all wiring and wiring accessories as per clause 3.6. Panel shall contain but not limited to the following major devices.

(a) At least Three (3) Illuminated pushbuttons (with integrated LED)
(b) At least one (1) mushroom head emergency pushbutton
(c) Panel heater and hygrostat

2.6.2.3 Intake gate HPU control cabinets

Contractor shall supply **Two (2)** intake gate HPU control cabinets as detailed in clause 4.4.4. Each cabinet shall be complete with enclosure, door, terminal blocks, and all wiring and wiring accessories as per clause 3.6. Cabinet shall contain but not limited to the following major devices.

(a) Set of contactor relays meeting requirements of clause 3.5.3, for implementation all the pump operations described in clause 4.4.2.
(b) Set of Robust contactor type or equivalent timer relays for implementation all the pump operations described in clause 4.4.2.
(c) Set of interfacing relays for contact multiplication
(d) At least Four (4) LED lamps
(e) At least Four (4) pushbuttons
(f) At least one (1) mushroom head emergency pushbutton
(g) At least two (2) contactor relays as per clause 3.5.3 for valve control
(h) At least two (2) double pole DC MCB's for 24 V DC and 110V DC supply
(i) At least two (2) AC MCB's shall be provided for AC supplies.
(j) At least one (1) British type socket
(k) At least one (1) LED panel lighting with door switches
(l) Panel heater and hygrostat

2.6.2.4 Intake SCADA panel

Contractor shall supply intake gate SCADA panel as detailed in clause 4.4.6 and 4.6. The panel shall be complete with enclosure, door, terminal blocks, and all wiring and wiring accessories as per clause 3.6. Panel shall contain but not limited to the following major devices.

(a) Set of PLC CPU module/s
(b) Set of PLC external network communication module/s
(c) Set of PLC IO communication module/s
(d) Set of Digital input modules
(e) Set of Digital output modules
(f) Set of analogue input modules
(g) Set of analogue output modules
(h) PLC OPC UA/IEC61850 communication gateway module (optional if CPU inbuilt)
(i) Set of PLC module connectors, termination modules and or mounting back planes
(j) One (1) Operator panel
(k) One (1) Serial devices gateway
(l) Two (2) industrial ethernet switches
(m) Two (2) 240V AC/110V DC to 24V DC power supply units
(n) One (1) 24V DC redundancy diode block.
(o) At least one (1) Two pole, Two position key switches
(p) At least One (1) status signalling tower/s
(q) Set of interfacing relays for all digital outputs wiring
(r) Set of fibre optic patch chords with flexible conduits
(s) Set of double pole DC and AC MCB's for supply protection
(t) Two (2) Panel cooling fans each with Air throughput of at least 750m^3 /h
(u) Four (4) ventilation and filter units
(v) Two (2) thermostats for fans control
(w) At least one (1) British type socket
(x) At least one (1) European type socket
(y) At least one (1) LED panel lighting with door switches
(z) Panel heater and hygrostat

2.6.2.5 Intake Fibre Optic Patch panel cabinet

Contractor shall supply intake gate patch panel cabinet as detailed in clause 4.6. The panel shall be complete with enclosure, door, terminal blocks, and all wiring and wiring accessories as per clause 3.6. Panel shall contain but not limited to the following major devices.

(a) Two (2), twenty-four (24) port fibre optic patch panels, one to be installed at the main control building.
(b) Five hundred (500) meters 24 core OS2 fibre, uni-tube steel wire armoured cable for indoor or outdoor duct or direct buried installation with full rodent protection

2.6.2.6 DC supply cabinet

Contractor shall supply intake gate DC supply cabinet as detailed in clause 4.4.5. The cabinet shall be complete with enclosure, door, terminal blocks, and all wiring and wiring accessories as per clause 3.6. Panel shall contain but not limited to the following major devices.

(a) Two (2) 240V AC/110V DC to 24V DC power supply units
(b) One (1) 24V DC redundancy diode block.
(c) One (1) 110V DC redundancy diode block.
(d) At least ten (10) Double pole 110V DC MCB
(e) At least nine (9) Double pole 24V DC MCB
(f) At least two (2) Double pole 240V AC MCB
(g) One (1) 110V DC supply monitoring relay
(h) At least one (1) LED panel lighting with door switches
(i) Panel heater and hygrostat

2.6.2.7 Wiring and wiring accessories

All control wiring within the intake gate area shall be replaced with new wiring except for wiring to the main control building which shall be re used. All power cabling within the intake gate area that is too short to be reused shall be replaced. Contractor shall supply all cables necessary for the wiring.

2.6.3 Supply of spillway gate low voltage supply switchboard and distribution boards

Contractor shall supply a switchboard and a distribution board at the spillway with the following incomers and feeder circuits with the indicated switchgear ratings as detailed in clauses 3.9 & 5.5.

	incomers				
	Incomer cubicle compartments	Module rating	Type	MCCB	Contactor
1	Duty incoming supply	300A	Incomer	400A	200KW
2	Reserve incoming supply	300A	Incomer	400A	200KW
3	Control & metering	N/A	Control & metering	N/A	N/A
	Feeder Withdrawable plug-in modules				
	Feeder cubicle compartments	Module rating	Type	MCCB /MPCB	Contactor
1	Crane	125A	Cable feeder	160A	N/A

2	Power outlet	125A	Cable feeder		160A	N/A
3	Lighting and small power 4 Way TPN distribution board	125A	Cable feeder		160A	N/A
4	Gitaru central office supply	125A	Cable feeder		160A	N/A
5	Spare	125A	Cable feeder		160A	N/A
6	Spare	125A	Cable feeder		160A	N/A
7	Gatehouse	32A	Cable feeder		32A	N/A
8	Spare	32A	Cable feeder		32A	N/A
9	Pressure pump 1	32A	11KW	motor DOL starter	32A	18.5KW
10	Pressure pump 2	32A	11KW	motor DOL starter	32A	18.5KW
11	Pressure pump 3	32A	11KW	motor DOL starter	32A	18.5KW
12	Return pump	32A	11KW	motor DOL starter	32A	18.5KW
13	Motor supply (spare)	32A	11KW	motor DOL starter	32A	18.5KW
14	Street lighting	32A	11KW	motor DOL starter	32A	18.5KW
15	Spare	32A	11KW	motor DOL starter	32A	18.5KW
16	Spare	32A	11KW	motor DOL starter	32A	18.5KW
	Lighting and small power 4 Way TPN distribution board					
	feeder circuit		Type		MPCB rating	MCB rating
1	1		Three phase circuit		32A	N/A
2	2		Three phase circuit		32A	N/A
3	3		Single phase circuit		N/A	32A
4	4		Single phase circuit		N/A	32A
5	5		Single phase circuit		N/A	32A
6	6		Single phase circuit		N/A	16A
7	7		Single phase circuit		N/A	16A
8	8		Single phase circuit		N/A	16A
	Switchboard Basic rating					
	Main bus bar rating In				400A	
	Distribution bus bar rating In				300A	
	Switchboard short-time withstand current (Icw)				50KA/1s	
	Rated operating voltage				433V AC	

2.6.3.1 A complete switchboard with at least two (2) cubicles with all the compartments i.e., bus bar, cable, circuit breaker, Control & metering etc with all internal wiring and mounting accessories e.g., terminal blocks, DIN rails, glanding plates, base plates,

internal wires, trunking, doors, frames, bus bars, cable termination accessories, etc. shall be supplied as detailed in clause 5.5.

2.6.3.2 The cubicles shall contain but not limited to the following devices:

2.6.3.2.1 Two (2) 300A incomer circuits with all the components and devices for complete switch board incomers as per clause 5.5., including but not limited to

(a) Two (2) 400A Moulded case circuit breaker and its associated gear
(b) Two (2) 200KW DOL starter contactor
(c) A mechanical interlocking device for the contactors
(d) at least 8(eight) (one per phase for each incomer) current transformers
(e) at least 3(three) three phase voltage transformers

2.6.3.2.2 At least One (1) control and metering compartment containing incomer control and metering devices including but not limited to:

(a) One (1) automatic transfer controller
(b) One (1) Digital panel AC voltmeter
(c) Two (2) Digital panel multifunctional meters
(d) One (1) three pole, three position key operated switch
(e) Three (3) three phase AC voltage monitoring relay
(f) A set of contactor relays for control & interlocks
(g) A set of miniature interface relays with 4 SPDT contacts for interfacing
(h) at least two (2) DC DP Miniature circuit breakers
(i) At least one (1) AC DP Miniature circuit breakers
(j) At least three (3) Motor protection circuit breakers (MPCB)
(k) at least six (6) illuminated push buttons.
(l) At least eight (8) status indication LED lamps
(m) Thermostat, heater and one single phase British type socket outlet

2.6.3.2.3 Eight (8) 11 KW standard sized withdrawable motor DOL starter modules meeting requirements of clause 3.9.20 **each** including but not limited to the following main components:

(a) One (1)32A MPCB
(b) One (1) MPCB rotary door operator and knob at the compartment door.
(c) One (1)18.5KW contactor
(d) One (1) set of motor management and control devices.
(e) At least two (2) miniature circuit-breakers for control circuit protection
(f) At least two (2) contactor relays
(g) A set of interface relays with SPDT contacts
(h) At least One (1) current transformer for external panel meter
(i) compartment door with a minimum of the following devices
    (i) Motor management control device HMI display unit

(ii) Three (3) illuminated pushbuttons (ON/OFF/TRIP RESET)
(iii) Two (2) status LED lamps (service position and test position)
(iv) One (1) Running hour's counter.
(v) One (1) Three pole, three position key-operated switch

2.6.3.2.4 Six (6) 125A standard sized withdrawable cable feeder modules meeting requirements of clause 3.9.19 **each** containing but not limited to the following main components:
(a) One (1) 160A MCCB
(b) A set of MCCB communication module/s
(c) One (1) MCCB rotary door operator and knob at the compartment door

2.6.3.2.5 Two (2) 32A standard/small sized withdrawable cable feeder modules meeting requirements of clause 3.9.19 **each** including but not limited to the following main components:
(a) One (1) 32A MPCB
(b) One (1) Three-phase digital power monitoring device
(c) One (1) MPCB rotary door operator and knob at the compartment door

2.6.3.2.6 A 4-way TPN distribution board module complete with all devices as specified including but not limited to:
(a) Two (2) 32A MPCB
(b) Three (3) 32A AC SP Miniature circuit breakers with Icu ≥10KA @ 400VAC and at least one SPDT auxiliary contacts
(c) Three (3) 16A AC SP Miniature circuit breakers with Icu ≥10KA @ 400VAC and at least one SPDT auxiliary contacts

2.6.3.3 New LV copper power cables shall be installed for any feeder circuit power cable that might require replacement due to the positioning and size of the new switch board.

2.6.4 Supply of spillway gate electrical control panels & cabinets

Contractor shall supply the following.

- Three (3) spillway gate control panels for each of the three gates operation
- Three (3) Outdoor cabinets for each of the three gates operation
- HPU electrical control cabinet mounted on the new accumulator system.
- SCADA panel housing SCADA interfaces as described in clause 5.4.7.
- Fibre Optic Patch panel cabinet
- DC supply cabinet
- Spillway gate instruments

- Wiring and wiring accessories

2.6.4.1 Spillway gate control panels

Contractor shall supply **Three (3)** spillway gate control panels one for each gate as detailed in clause 5.4.3. Each panel shall be complete with enclosure, door, terminal blocks, and all wiring and wiring accessories as per clause 3.6. Panel shall contain but not limited to the following major devices.

(a) Set of contactor relays meeting requirements of clause 3.5.3, for implementation all the gate operations described in clause 5.4.2.
(b) Set of Robust contactor type or equivalent timer relays for implementation all the gate operations described in clause 5.4.2.
(c) Set of interfacing relays for contact multiplication
(d) At least thirteen (13) LED lamps
(e) At least six (6) pushbuttons
(f) At least one (1) mushroom head emergency pushbutton
(g) At least one (1) Three pole, Three position key switches
(h) At least Two (2) three pole Two position Key switch
(i) At least One (1) Two pole, Three position selector switches
(j) Five (5) digital panel indication meters as per clause 3.5.8.3
(k) At least Seven (7) contactor relays as per clause 3.5.3 for valve & pump control
(l) At least two (2) double pole DC MCB's for 24 V DC and 110V DC supply
(m) At least two (2) AC MCB's shall be provided for AC supplies.
(n) At least one (1) British type socket
(o) At least one (1) LED panel lighting with door switches
(p) Panel heater and hygrostat

2.6.4.2 Spillway gate Outdoor control cabinets

Contractor shall supply **Three (3)** spillway gate control outdoor cabinets one for each gate as detailed in clause 5.4.3. Each cabinet shall be complete with enclosure, double door, terminal blocks, and all wiring and wiring accessories as per clause 3.6. Panel shall contain but not limited to the following major devices.

(a) At least Five (5) Illuminated pushbuttons (with integrated LED)
(b) At least one (1) mushroom head emergency pushbutton
(c) At least Four (4) LED lamps
(d) Panel heater and hygrostat

2.6.4.3 Spillway gate HPU control cabinet

Contractor shall supply spillway gate HPU control cabinet as detailed in clause 5.4.4. Each panel shall be complete with enclosure, door, terminal blocks, and all wiring and

wiring accessories as per clause 3.6. Panel shall contain but not limited to the following major devices.

(a) Set of contactor relays meeting requirements of clause 3.5.3, for implementation all the accumulator operations described in clause 5.4.2.
(b) Set of Robust contactor type or equivalent timer relays for implementation all the accumulator operations described in clause 5.4.2.
(c) Set of interfacing relays for contact multiplication
(d) At least Four (4) LED lamps
(e) At least Fourteen (14) Illuminated pushbuttons (with integrated LED)
(f) At least One (1) push button
(g) At least Four (4) mushroom head emergency pushbutton
(h) At least three (3) contactor relays as per clause 3.5.3 for valve control
(i) At least two (2) double pole DC MCB's for 24 V DC and 110V DC supply
(j) At least two (2) AC MCB's shall be provided for AC supplies.
(k) At least one (1) British type socket
(l) At least one (1) LED panel lighting with door switches
(m) Panel heater and hygrostat

2.6.4.4 Spillway SCADA panel

Contractor shall supply spillway gate SCADA panel as detailed in clause 5.4.7 and 4.6. The panel shall be complete with enclosure, door, terminal blocks, and all wiring and wiring accessories as per clause 3.6. Panel shall contain but not limited to the following major devices.

(a) Set of PLC CPU module/s
(b) Set of PLC external network communication module/s
(c) Set of PLC IO communication module/s
(d) Set of Digital input modules
(e) Set of Digital output modules
(f) Set of analogue input modules
(g) Set of analogue output modules
(h) PLC OPC UA/IEC61850 communication gateway module (optional if CPU inbuilt)
(i) Set of PLC module connectors, termination modules and or mounting back planes
(j) Three (3) Proportional directional control valves electronic control modules
(k) One (1) Operator panel
(l) One (1) Serial devices gateway
(m) Two (2) industrial ethernet switches
(n) Two (2) 240V AC/110V DC to 24V DC power supply units

(o) One (1) 24V DC redundancy diode block.
(p) At least one (1) Two pole, Two position key switches
(q) At least One (1) Two pole, Three position selector switches
(r) Three (3) digital panel indication meters as per clause 3.5.8.3
(s) Set of interfacing relays for all digital outputs wiring
(t) At least One (1) status signalling tower/s
(u) Set of fibre optic patch chords with flexible conduits
(v) Set of double pole DC and AC MCB's for supply protection
(w) Two (2) Panel cooling fans **each** with Air throughput of at least 750m^3 /h
(x) Four (4) ventilation and filter units
(y) Two (2) thermostats for fans control
(z) At least one (1) British type socket
(aa) At least one (1) European type socket
(bb) At least one (1) LED panel lighting with door switches
(cc) Panel heater and hygrostat

2.6.4.5 Intake Fibre Optic Patch panel cabinet

Contractor shall supply intake gate patch panel cabinet as detailed in clause 4.6. The panel shall be complete with enclosure, door, terminal blocks, and all wiring and wiring accessories as per clause 3.6. Panel shall contain but not limited to the following major devices.

(a) Two (2), twenty-four (24) port fibre optic patch panels, one to be installed at the main control building.
(b) Five hundred (500) meters 24 core OS2 fibre, uni-tube steel wire armoured cable for indoor or outdoor duct or direct buried installation with full rodent protection

2.6.4.6 Spillway gate instruments

Contractor shall supply spillway gate instruments detailed in clause 5.4.5. This shall include but not limited to the following.

(a) Three (3) gate position transducers
(b) Eighteen (18) Robust IP68 Proximity switches

2.6.4.7 DC supply cabinet

Contractor shall supply spillway gate DC supply cabinet as detailed in clause 5.4.6. The cabinet shall be complete with enclosure, door, terminal blocks, and all wiring and wiring accessories as per clause 3.6. Panel shall contain but not limited to the following major devices.

(a) Two (2) 240V AC/110V DC to 24V DC power supply units
(b) One (1) 24V DC redundancy diode block.

(c) One (1) 110V DC redundancy diode block.
(d) At least nine (9) Double pole 110V DC MCB
(e) At least eight (8) Double pole 24V DC MCB
(f) At least two (2) Double pole 240V AC MCB
(g) One (1) 110V DC supply monitoring relay
(h) At least one (1) LED panel lighting with door switches
(i) Panel heater and hygrostat

2.6.4.8 Wiring and wiring accessories

All control wiring within the spillway gate area shall be replaced with new wiring except for wiring to the main control building which shall be re used. All power cabling within the intake gate area that is too short to be reused shall be replaced. Contractor shall supply all cables necessary for the wiring.

2.6.5 Supply of electrical component spares.

Contractor shall supply a minimum of the following mandatory spares, tools, and equipment.

1. Two (2) 400A MCCB
2. Two (2) 200KW/400A contactor
3. 2(two) 160A MCCB
4. 4(four) 32A MPCB
5. 2(two) MCCB/MPCB door-coupling rotary operating mechanism
6. 2(two) 18.5KW/32A contactor
7. 4(four) 32A SP AC MCB
8. 4(four) 16A SP AC MCB
9. 2(two) switchboard current transformers for each CT ratio
10. 2(two) switchboard voltage transformers, for each burden rating
11. 1(one) automatic transfer controller/switch
12. 1(one) Serial device server with at least four Ethernet ports and four serial ports
13. Two (2) Industrial ethernet switches
14. 2(Two) panel digital multifunctional meter
15. 1(one) Digital AC voltmeter with serial output
16. 2(two) three-phase voltage monitoring relays
17. Three (3) Digital panel indication meter
18. Two (2) digital power monitoring devices with serial output, of each type or rating.

19. Two (2) sets of PLC modules- Two modules of each type of PLC module shall be provided.
20. Three (3) Proportional directional control valves electronic control modules.
21. Two (2) Motor management controllers for each rating or type
22. Two (2) Intake gate hydraulic cylinder linear position transducers
23. Three (3) spillway gate hydraulic cylinder linear position transducers
24. Five (5) Intake gate position limit switches
25. Six (6) Robust IP68 spillway gate proximity switches
26. Two (2) Spillway gate position transducers
27. Two (2) Electronic pressure switches & transmitters of each type to be used.
28. Two (2) Electronic level switches & transmitters of each type to be used.
29. Two (2) Electronic temperature switches & transmitters of each type to be used.

3 GENERAL TECHNICAL REQUIREMENTS

3.1 STANDARDS

3.1.1 Ratings, characteristics, tests, and test procedures, etc. for the electrical equipment encompassed by this Specification shall comply with the provisions and requirements of British standards institute (BS) and International Electro-Technical Commission (IEC) standards or International Electrical & Electronic Engineers – IEEE unless otherwise expressly stated in Particular Technical Specifications.

3.1.2 Ratings, characteristics, tests, and test procedures, etc. for the mechanical equipment encompassed by this Specification shall comply with the provisions and requirements of British standards institute (BS) and International standardization organization – ISO standards unless otherwise expressly stated in Particular Technical Specifications.

3.1.3 Where the BS or ISO or IEC or IEEE standards do not fully cover all provisions and requirements for the design, construction, testing, etc. The European Committee for Standardization (EN) standards, rules of CEE (International Commission for the approval of electrical equipment), the standards of CENELEC (Comité Euopeen de Normalisation Elecrotechnique) and other recognised national/international standards LISTED BELOW shall be applied. The other recognized national and international standards are:

(a) German – DIN
(b) American National Standards Institute -ANSI
(c) American Society of Mechanical Engineers – ASME
(d) American Society for Testing and Materials -ASTM
(e) Telecommunications Industry Association (TIA)
(f) International Telecommunication Union (ITU)
(g) International Society of Automation- ISA

3.1.4 Equipment and works shall conform to standards of the bodies indicated clause 3.1.1-3.1.3 ONLY no other standards from other bodies shall be allowed.

3.1.5 The latest revision or edition in effect at the time of Bid Invitation shall apply for all standards used or stated in this tender document. Where references are given to numbers in the old numbering scheme from IEC it shall be taken as to be the equivalent number in the new five-digit number scheme.

3.1.6 The Tenderer shall state the Precise Standard, complete with identification number, to which the various equipment and materials are manufactured. The tender documents do not contain a full list of all standards to be used; the contractor shall give the precise standard which the equipment and work shall conform to.

3.2 GENERAL ELECTRICAL REQUIREMENTS

3.2.1 General

3.2.1.1 The equipment shall withstand without permanent weakening or deformation from short circuit current within the rating of the apparatus (including those due to faulty synchronising) as well as normal atmospheric over voltages taking into account the use of lightning arresters. Special considerations shall be given to pressure rises by short circuits and fire risk. All material and equipment shall be designed and arranged so that over pressure will be relieved in a safe direction and so that fire risk is minimised and consequences of a fire reduced

3.2.1.2 All plastic material used in boxes, panels and boards shall be halogen free and self-extinguishable.

3.2.1.3 The contract supplies shall be designed to facilitate inspection, cleaning and repairs and for operation, in which continuity of service is the first consideration.

3.2.1.4 All conductors' current carrying parts must be dimensioned with ample cross sections so that temperatures are kept within limits in operation and under short circuits. Temperature rises on all equipment shall be kept within limits set in IEC standards provided nothing else is specified. For all current carrying parts the permissible short circuit duration shall be at least 3 second. All electrical connections shall be secured by bolts or set screws of ample size, fitted with locknuts or lock washers of approved types. The equipment shall as far as possible be factory mounted with internal cables and internal equipment installed before shipment. Plug-in components can be shipped separately.

3.2.1.5 Equipment for use in live panels shall not be flammable and shall be self-extinguishable and resistant to flame propagation

3.2.1.6 Equipment for use outdoors or in wet or damp rooms shall be constructed so that water runs off. It shall also have devices draining any inside condensation that may form. Axial bearings on such equipment must be equipped with durable sealing preventing water to ingress.

3.2.1.7 Cast iron shall not be used for chambers of oil-filled apparatus or for any part of the equipment that is in tension or subject to impact stresses. Exception is made where it can be shown that service experience has been satisfactory with the grade of cast iron and the duty proposed.

3.2.1.8 Materials shall be new; the best quality of their respective kinds and such as is usual and suitable for work of like character. All materials shall comply with the latest issues of the specified standard unless otherwise specified or permitted by the Employer.

3.2.1.9 Iron and Steel are generally to be painted or galvanized as appropriate. Indoor parts may alternatively have chromium or copper-nickel plates or other approved protective finish.

3.2.1.10 Workmanship shall be of the highest class throughout to ensure reliable and vibrations free operations. The design, dimensions and materials of all parts shall be such that the stresses to which they may be subjected shall not cause distortion, undue wear, or damage under the most severe conditions encountered in service.

3.2.1.11 All parts shall conform to the dimensions shown and shall be built in accordance with approved drawings. All joints, datum surfaces and meeting components shall be machined and all castings shall be spot faced for nuts. All machined finished shall be shown on the drawings. All screw, bolts, studs and nuts and threads for pipe shall conform to the latest standards of the International Organization for Standardization covering these components and shall all conform to the standards for metric sizes. All materials and works that have cracks, flaws or other defects or inferior workmanship will be rejected by the Employer.

3.2.1.12 Casting shall be true to pattern, of workmanlike finish and of uniform quality and condition, free from blowholes, porosity, hard spots, shrinkage defects, cracks or other injurious defects, shall be satisfactorily cleaned for their intended purpose.

3.2.2 Electrical Equipment Materials

3.2.2.1 All materials supplied under this Contract shall be new and of the best quality and of the class most suitable for working under the conditions specified. They shall withstand the variations of temperature and atmospheric conditions arising under working conditions (including start and stop) without distortion, deterioration or undue stresses in any parts and also without affecting the suitability of the various parts of the Works for which they were designed. The equipment shall be designed for a lifetime of 25 years.

3.2.2.2 No welding, filling or plugging of defective parts shall be permitted.

3.2.2.3 Materials that are susceptible to mould growth under tropical conditions shall be treated to exclude moisture and prevent growth of mould after all machining has been carried out.

3.2.2.4 Cables and bus bars shall be of the highest quality copper. Aluminium conductors shall not be allowed unless specified in particular specifications for a particular component only

3.2.2.5 Small iron and steel parts (other than rustles steel) of all instruments and electrical equipment, the cores of electromagnets and the metal parts of relays and mechanisms shall be treated in an appropriate manner to prevent rusting.

3.2.2.6 Copper and aluminium used as electrical conductors shall be of the electrolytic type and comply with the respective DIN or ASTM Standards.

3.2.3 Bolts, Studs, Nuts, Screws, Washers, etc.

3.2.3.1 All bolts, studs, nuts, etc., shall have a standard metric threading and conform to the relevant standards as regards shape and tolerance. They shall be of Strength Class 8.8 and marked accordingly.

3.2.3.2 All bolts, studs, nuts, washers, screws, etc., used outdoor or in wet or moist environment shall be made of stainless steel.

3.2.3.3 All bolts and nuts shall be hexagonal, either normally or of the round head socket type and secured in an approved manner against becoming loose during operation. The Contractor shall supply the net quantities plus 5% of all permanent bolts, screws and other similar items and materials required for installation of the works at the site. Any such rivets, bolts, screws, etc. which are surplus after the installation of the equipment has been completed shall become spare parts and shall be wrapped, marked and handed over to the Employer.

3.2.3.4 Taper pins shall have threaded stems with nuts where dismantling of the pins is likely to be required.

3.2.3.5 Bolts shall not protrude more than 10 mm beyond the nut but not less than three full threads.

3.2.4 Surface Treatment and Painting of Panels, Support Structures & Electrical equipment

3.2.4.1 Panels, boards, cubicles and cabinets. for indoor use in dry rooms shall have interior surfaces painted with at least one priming and one finishing coat of anti-corrosion paint. Exterior surfaces shall be adequately treated to be substantially corrosion resistant, with one priming coat, and two finishing coats.

3.2.4.2 Outdoor installations and indoor installations in wet and damp rooms shall at least have one priming coat and two layers of paint on zinc powder basis applied after perfect cleaning.

3.2.4.3 Structural supports outdoor and in wet or moist rooms and parts that cannot be readily painted, shall be hot-dip galvanised. All galvanising shall be in accordance with BS 729 or other internationally approved standards. Steel below ground shall in addition to galvanising be protected with Bitumen or a substance of similar quality.

3.2.4.4 The humid and tropical conditions shall be taken into account on selection of the paints and painting procedure.

3.2.4.5 All External surfaces panels, cubicles, cabinets, structural supports etc. shall be painted using RAL7035 colour

3.2.5 Insulating Liquids

3.2.5.1 All electrical equipment requiring insulating oil or other insulating liquids shall be furnished with the first filling including flushing, if required. An excess of 10% of the net amount of oil or liquid required for each component shall also be furnished by the Contractor as spare.

3.2.5.2 The Contractor shall endeavour to employ, as far as practicable, one type and make of insulating oil only for all the electrical equipment.

3.2.6 Sulphur hexafluoride gas (SF6)

3.2.6.1 The SF6 gas shall comply with the requirements of IEC 60376. In addition to the quantity of gas required to fill the equipment supplied, 20% shall be supplied as spare.

3.2.6.2 The high-pressure cylinders for shipment and storage of the SF6 gas shall comply with the applicable national regulations. All the necessary pipes, couplings, flexible tubes and valves for coupling to the switchgear for filling or evacuating all the gases to be used, with all necessary instructions for the storage of this equipment, shall be provided.

3.2.7 Nameplates and signs

3.2.7.1 All nameplates and signs shall be made of non-corrosive weatherproof material such as traffolyte, aluminium or stainless steel.

3.2.7.2 Marking shall be in corrosion resistant material with engraved and coloured lettering. All equipment shall be marked in accordance with standards and local practice. The Contractor must mark all components in a clear and unambiguous way so that it can be related to the documentation.

3.2.7.3 Letters shall be white and engraved on black background. For aluminium and steel signs black letters on metallic background shall be used. For warning signs, red background shall be used.

3.2.7.4 All panels, cubicles, switchboards, switchgear compartments, outdoor equipment and structures and all devices & equipment mounted in the panels shall be labelled

with name plates. All operating mechanisms as pushbuttons, switches and handles must be marked in a precise way and necessary warning signs must be supplied.

3.2.8 Equipment Working Stress and Reliability

3.2.8.1 The design, dimensions and materials of all parts shall be such that they will not suffer damage under the most adverse conditions nor result in deflections and vibrations, which might adversely affect the operation of the equipment.

3.2.8.2 Mechanisms shall be constructed to avoid sticking due to rust or corrosion. The equipment and apparatus shall be designed and manufactured in the best and most substantial and workmanlike manner with materials best suited to their respective purpose and generally in accordance with up-to-date recognized standards of good practice.

3.2.8.3 The equipment shall be designed to cope with 0.20g seismic acceleration on their centres of gravity.

3.2.8.4 All equipment shall be designed to minimize the risk of fire and consequential damage, to prevent ingress of vermin and dust and accidental contact with electrically energized or moving parts.

3.2.8.5 Panels and switch boards shall be capable of continuous operation with minimum attention and maintenance in the exceptionally severe conditions likely to be obtained in a tropical climate

3.2.9 Degree of Protection

3.2.9.1 Enclosures for electrical equipment shall offer the following degree of protection at minimum (ref. IEC 60034, IEC 60059, IEC 60529 and IEC 60947) where it's not stated in the particular specifications:

3.2.9.1.1 Motors/Motor Terminal boxes: IP 54/IP 65

3.2.9.1.2 Dry Transformers: IP 2x

3.2.9.1.3 Limit switches: IP 65

3.2.9.1.4 Indoor switches: IP 5x

3.2.9.1.5 Outdoor switches: IP 65

3.2.9.1.6 Low voltage switchgear and control cabinets:

(a) Indoor IP 3x

(b) Outdoor IP 55

(c) Junction boxes IP 65

3.2.9.1.7 Light fittings

(a) Outdoor and wet areas IP 44

(b) Indoor IP 2x

3.2.9.2 Printed circuit boards SHALL NOT be mounted on the panels. All printed circuit boards shall be contained in enclosures with an ingress protection of at least IP30 with terminal blocks and ports on the enclosures for interface.

3.2.10 Earthing

Contractor shall take the necessary measures and furnish the required material for the safe Earthing of:

3.2.10.1 All steel structures, metal parts and overhead ground wires.

3.2.10.2 All metal parts, even if these do not constitute a conducting part of an electric system of the plants, such as machinery, operating desks, piping, sewers, rails, metal tanks, lighting, fixtures, cable racks, etc.

3.2.11 Locking Devices and Padlocks

3.2.11.1 All panels, cubicles, switchboards, switchgear compartments and Facilities for applying safety isolation i.e., circuit breaker operating mechanisms, disconnectors & switches operating handles, control switches, bus bar shutters etc. shall be provided with locks. Locks with at least three keys will be provided. Padlocks will only be used where other locks are not appropriate

3.2.11.2 Three keys with labelled trafolyte holder shall be provided for each lock, key operated devices and padlocks.

3.2.12 Tool Rack for switchgear operations

3.2.12.1 A tool rack shall be installed in a cubicle/compartment close the switchgear for each switchboard. It shall house all the handles and tools required for operation of the switchgear. The rack shall be easily accessible to operators and not cause obstruction to operations.

3.2.12.2 Three key cabinets shall be supplied and installed for storing all the keys supplied under the project.

3.3 GENERAL MECHANICAL REQUIREMENTS

3.3.1 Materials

3.3.1.1 Quality

3.3.1.1.1 All materials incorporated in the equipment shall be of first-class commercial quality, as customarily used for this type of equipment, having regard to strength, durability, best engineering practice and the particular service to which the equipment will be subjected, free from defects and imperfections, of recent manufacture, new and unused, and where indicated, of the grades and classifications designated herein. Materials not specifically described herein shall be the most suitable for the purpose and shall comply with the latest specifications of the British Standards Institution (BS) or an approved relevant international standard.

3.3.1.1.2 If the Contractor desires for any reason to deviate from or use materials not covered by existing specifications of the British Standards Institution, he shall state the exact nature of the deviation from existing BS specification or exception for which no BS specification exists and shall submit for the approval of the Engineer complete descriptions and details of the materials which he proposes to use. All materials, supplies, and articles not manufactured by the Contractor shall be the products of recognised reputable manufacturers and, so far as the provisions of this Specification are covered, shall be considered equally to have been manufactured by the Contractor.

3.3.1.2 Applicable Standards

Materials for equipment furnished shall conform to the latest issue of the following standards.

3.3.1.2.1 Steel Castings: shall conform to the requirements of BS EN 10293: 2005 "Steel Castings for General Engineering Uses" and the following shall apply:

(a) Identification of casting with origin of cast shall be preserved.

(b) No castings shall be repaired or welded without written sanction from the Engineer.

3.3.1.2.2 Iron Castings: shall conform to the requirements of BS EN 1561: 1997 "Founding. Grey Cast Irons". A signed certificate stating that the castings comply in all respects with the appropriate provisions of this Specification and the results of all the specified tests shall be provided. The full nature and

properties of any special cast irons proposed by the Contractor shall be submitted to the Engineer for approval.

3.3.1.2.3 Steel Forgings: Steel forgings shall have physical properties at least equal to those required by BS EN 10250-2: 2000 "Open steel die forgings for general engineering purposes. Non-alloy quality and special steels". The provisions of BS EN 10250-2: 2000 shall apply in full and the Contractor shall inform the Engineer of any forging to be carried out after heat treatment.

The full nature and properties of any special alloy steels proposed by the Contractor shall be submitted to the Engineer for approval.

3.3.1.2.4 Structural Steelwork: Structural Steelwork shall conform to the latest BS requirements of BS EN 10029, BS 7668 and BS EN 10113 and BS EN 10210-1.

3.3.1.2.5 Steel Plates: Important stress carrying parts shall conform to the requirements of BS EN 10028 and BS EN 10029.

Plate used for general structural purposes shall conform to the requirements of BS EN 10029, BS 7668, BS EN10113 and BS EN 10210-1, provided that the Contractor shall submit the proposed method of Steel Manufacture for the approval of the Engineer.

3.3.1.2.6 Corrosion Resisting Steel Plates: shall conform to the latest requirements of BS EN 10028 Parts 1 to 3 and BS EN 10028 and BS EN 10029, as appropriate.

3.3.1.2.7 Corrosion Resisting Steel: bars, billets or forgings for bolts, nuts, pins, etc., shall conform to the latest requirements of BS EN 10277 Parts 1 to 5 and BS EN 10278. Specific requirement of the material shall conform to "Chromium Rust Resisting Steels - 12 to 14 per cent Chromium". Grade shall be submitted by the Contractor, for approval of the Engineer.

3.3.1.2.8 Chrome Nickel Steel: bars, billets or forgings for bolts, nuts, pins, etc., shall conform to BS EN 10277 Parts 1 to 5 and BS EN 10278. Specific requirements of the material shall conform to "Martensitic Chromium - Nickel Rust Resisting Steel".

3.3.1.2.9 Chrome-Molybdenum Steels: with a minimum Brinell Hardness Number of 300 shall conform to BS EN 10277 Parts 1 to 5 and BS EN 10278. Grade shall be submitted by Contractor, for approval of the Engineer.

3.3.1.2.10 Chromium Steel: with a minimum Brinell Hardness Number of 250 shall conform to BS EN 10277 Parts 1 to 5 and BS EN 10278. Grade EN18. "One per cent Chromium Steel".

3.3.1.2.11 Chromium Plating of Pins: shall be generally in accordance with BS EN 1254.

3.3.1.2.12 Where the chromium plated pins or axles bear upon special bearing materials the Contractor shall comply with the bearing manufacturer's instructions for the surface finish and machining tolerances.

3.3.1.2.13 Self-lubricating bearings and washers: shall be of PTFE, tenmate or equivalent. Manufacturer and specification shall be to the approval of the employer Engineer.

3.3.1.2.14 Corrosion Resistant Steel for Castings: shall conform to the latest requirements of BS EN 10293 and shall be suitable for welding without subsequent heat treatment.

3.3.1.2.15 Bronze Castings: shall conform to BS EN 1982 provided that all rubbing bearings whether ferrous to non-ferrous, or nonferrous to non-ferrous, are mutually compatible both with regard to freedom from metallic pickup and electrolytic action, and only virgin metals are used. The various copper alloys proposed by the Contractor shall be submitted for the approval of the employer Engineer.

3.3.1.2.16 Brass and Bronze Bars and Rods: shall conform respectively to BS EN 12163 and BS EN 12167.

3.3.1.2.17 Copper, Brass and Bronze Sheet Plate and Strip: shall conform respectively to BS EN 172, BS EN 1652, BS EN 1653, and BS EN 1654.

3.3.1.2.18 White Metal Bearing Alloys: shall conform generally to BS 3332:1987 "White Metal Bearing Alloy Ingots", but proprietary alloys may be used provided always that they are entirely suitable for the use envisaged; that they are entirely compatible for firm bonding to the backing material; that full technical details and information are submitted by the Contractor for approval of the Engineer and that only virgin metals are used.

3.3.1.2.19 Steel Pipework: shall conform to the requirements of BS EN 13480 Parts 1 to 5. All steel piping shall be seamless and manufactured by the solid pierced and drawn process.

3.3.1.2.20 Copper Pipework: shall be to the requirements of BS 1306:1975, "Copper and Copper Alloy Pressure Piping Systems".

3.3.1.2.21 Galvanising: of steelwork for structures shall conform to BS 4921:1988 "Sherardized Coatings on Iron and Steel Articles".

3.3.2 Design Stresses

3.3.2.1 General

Liberal Factors of Safety shall be used throughout the design, and especially in the design of all parts subject to alternating stresses, repetitive stresses or shock. Upon request from the Engineer, the Contractor shall furnish complete information regarding the maximum unit stresses and loading and condition criteria used in the design. Design calculation sheets shall be made available to the Engineer, upon request.

3.3.2.2 Stresses and Factor of Safety

The stresses and factor of safety used for Normal operating conditions shall be as follows: -

3.3.2.2.1 Structural steel, bolts, weld steel stresses shall not exceed the lesser of those given in BS 5400, "Steel, Concrete and Composite Bridges" or BS 449, "The Use of Structural Steel in Building".

3.3.2.2.2 Self-lubricating bronze bushings bearing stress not to exceed 21,000 KN/m^2.

3.3.2.2.3 Wire ropes, shafts, gearing etc. The minimum factor of safety shall be: -

(a) Wire ropes -6
(b) Roller lifting chains- 5.
(c) Shafts subject to combined bending and twisting- 5
(d) Steel gears and pinions- 6
(e) Cast iron gears, pinions, and other components - 8.
(f) Other items 5

3.3.2.3 Maximum Unit Stresses under Normal Operating Conditions

3.3.2.3.1 Principal carbon and low alloy steel materials shall conform to the requirements of BS EN 10028 Part 1 and Part 2. The maximum allowable design stresses shall not exceed those laid down in Section Two, sub-section B of BS 5500:1997 "Unfired Fusion Welded Pressure Vessels". For other materials specified in these Documents, the maximum unit stresses shall not exceed the values given in the following table: -

Material	In Tension	In Compression	In Shear
Cast Irons	10% U.S.	68.95 NN/m^2	20.68 MN/m^2
Cast Steels	20% U.S. or 35% YS, whichever least	20% U.S. or 35% YS, whichever least.	25% YS.
Steel Plates	25% U.S. or 45% YS, whichever least	25% U.S. or 45% YS, whichever least	35% YS.
Other Materials	20% U.S. or 35% YS, whichever least.	20% U.S. or 35% YS, whichever least.	25% YS.

Key: **MN/m2**- Mega Newtons per square metre; **YS** - yield strength; **U.S.**- min ultimate tensile strength

3.3.3 Tests of Materials

3.3.3.1 General

All materials, parts and assemblies thereof comprising the work to be executed under these Specifications shall be tested unless otherwise directed, according to the relevant British Standard Specification for the materials concerned as described elsewhere in this Specification. For materials where no British Standard or ISO standard Specification exists, tests are to be made according to the best modern commercial methods and to the approval of the Engineer having regard to the particular type and application of the material concerned. The Contractor shall prepare specimens and perform tests and analyses to demonstrate conformance of the various materials with the applicable specifications. Should the Contractor propose to use stock materials not manufactured specifically for the equipment covered by these Specifications, he shall submit satisfactory evidence to the Engineer that such material conforms to the requirements stated herein, in which case tests of material may be partially or completely waived. Certified mill test reports of plates will be acceptable.

3.3.3.2 Additional Tests

Tests in addition to BS tests are required as follows: -

3.3.3.2.1 Copper Alloy Castings: for shaft and pin bushes, wear and bearing sleeves are to be proved sound by pressure testing after rough machining. No sealing process will be permitted.

3.3.3.2.2 White Metal Bearing Alloys: the firmness of bonding of white metal bearing alloys to the backing material shall be completely proved by ultrasonic testing or other approved method after final machining of the bearing surfaces.

3.3.3.3 Test Reports and Acceptance

Certified copies of test reports shall be furnished in triplicate to the Engineer as soon as possible after the tests are made. The result of these tests shall be in such form as to provide means of determining compliance with the applicable specifications for the material tested. When requested, all tests or trials shall be made in the presence of a duly authorised inspector representing the Engineer. The Contractor shall keep the Engineer informed in advance of the time of starting and the progress of the work in its various stages so that arrangements can be made for inspection. No materials shall be

shipped until all tests, analyses and shop inspections have been completed and certified copies of test reports have been accepted. Acceptance of materials, parts and assemblies, or the waiving of the inspection thereof by the Engineer, shall in no way relieve the Contractor of the responsibility for furnishing equipment conforming to the requirements of these Specifications.

3.3.4 Manufacturing

3.3.4.1 Manufacturers and Samples

The Contractor shall furnish to the Engineer for his approval the names of the manufacturers of all machinery and equipment which he contemplates incorporating in the work, together with the performance, capacities, and other significant information pertaining to the equipment. Samples of materials shall be submitted for approval when so directed. Equipment, materials, and articles installed or used without such approval shall be at the risk of subsequent rejection by the Engineer.

3.3.4.2 Workmanship

Workmanship shall be of the highest calibre, and in accordance with the best modern practice for the manufacture of high-grade machinery, notwithstanding any omissions from these Specifications or Drawings. All work shall be performed by workmen skilled in their various trades. The machining of renewable or interchangeable parts shall be accurate and to specified dimensional tolerances so that replacements made according to the drawings may be readily installed with minimum of hand fitting. The Contractor shall provide and maintain in storage for at least 20 years, at his own expense, sufficient patterns, templates, jigs, gauges, drawings, or other necessary records to enable him to make and repair replacement parts. Prior to disposal of any of the above patterns, templates, jigs etc., the Employer shall be given the option to take over the item in question. All special gauges and templates necessary for field erection shall become the property of the Employer and shall be handed over in good and accurate condition. Patterns for castings shall remain the property of the Contractor.

3.3.4.3 Connections

As much of the work of fabrication and assembly, as is reasonably practicable, shall be completed in the Manufacturer's workshops. Connections shall be made by means of rivets, bolts or welds. In connections containing more than one type of fastening only

rivets and fitted bolts may be considered as acting together to share the load. In all other composite connections sufficient of the type of fastening shall be provided to carry the entire load for which the connection is designed.

3.3.4.4 Tolerances

3.3.4.4.1 All tolerances and allowances shall be subject to the Engineer's approval and shall conform to BS 4500:1970 "ISO Limits and Fits".

3.3.4.4.2 Finished contact and bearing surfaces shall be true and exact to secure full contact. Journal surfaces shall be polished and all surfaces shall be finished with sufficient smoothness and accuracy to ensure proper operation when assembled. Parts entering any machine shall be carefully and accurately machined. All drilled holes for bolts shall be accurately located and drilled from templates.

3.3.4.4.3 All tolerances intended to be used for the finishes of machined surfaces shall be selected with due consideration being given to the special nature and function of the parts and to the corresponding accuracy required to ensure proper operation.

3.3.4.5 Finished Surfaces

Surface finishes shall be indicated on the shop drawings and shall be assessed as indicated in BS 1134: Parts 1 and 2 "Centre-line-average-height method for the assessment of Surface Texture".

3.3.4.6 Unfinished Surfaces

So far as practicable all work shall be laid out in the manufacturer's workshops to secure proper matching of adjoining unfinished surfaces which shall be true to the lines and dimensions shown on the drawings and shall be chipped or ground free of all projections and rough spots. When there is a large discrepancy between adjoining unfinished surfaces, they shall be chipped and ground smooth or machined to ensure proper alignment. Depressions or holes not affecting the strength or usefulness of the parts may be filled in an approved manner.

3.3.4.7 Screw Threads

3.3.4.7.1 All threads for bolts, nuts, screws, and pipes shall be generally in accordance with British Standard Handbook No.18 ISO Metric Screw Threads (BS 3643) and Pipe Threads (BS 21:1985). The precise standard of screw thread adopted

shall be mutually agreed between the Contractor and the Engineer at the commencement of the Contract and must thereafter remain uniform.

3.3.4.7.2 Exceptionally large threads for specific purposes may, with the approval of the Engineer, be of special form. Smaller nuts, bolts and screws shall be turned all over from bright bar stock; larger nuts and bolts shall be turned from forgings. Threads of smaller bolts and nuts may be die cut; threads of larger bolts shall be screw cut. Impact or roll forming of threads will not be permitted but, subject to the approval of the Engineer, large threads may be finished rolled at the root.

3.3.4.8 Special Workshop Processes

The Contractor shall submit for the approval of the Engineer details of all special processes used in the manufacture of the equipment covered by these specifications. Such processes include, but are not limited to, cold metal deformation processes, thread root rolling, surface shot peening or rolling, metal spraying, electro-deposition, and other processes. The Contractor shall inform the Engineer of any proposals to mark off and/or machine any components using the co-ordinate system and machining of components by profile machines.

3.3.4.9 Drawings Symbol Coding

3.3.4.9.1 All drawings submitted to the Engineer for approval shall contain details of any heat- treatment during final manufacture; dimensional tolerances; clearance and interference fits; surface finish and special workshop processes.

3.3.4.9.2 Fluid power schematic drawings shall strictly use the standard ISO 1219 Fluid power systems and components —Graphical symbols and circuit diagrams.

3.3.4.9.3 Mechanical drawings shall adhere to ISO ICS 01.100.20 standards for Mechanical engineering drawings and all other applicable ISO standards such as ISO 81714, ISO 129, ISO 7083ETC.

3.3.4.9.4 Functional reference designation shall be in accordance with ISO/IEC 81346

3.3.5 Welding

3.3.5.1 General

Welding of structural steelwork shall be by an electric arc process. The procedure to be followed, plant and equipment to be used and the testing and inspection to be applied, shall all be to the satisfaction of the Engineer and shall conform generally to the relevant British Standard Specifications.

3.3.5.2 Parent Metal

The grade of steel shall be to the approval of the Engineer for each particular work to be constructed and shall conform to clause 3.3.1.2

3.3.5.3 Welding Electrodes

3.3.5.3.1 Electrodes for manual metal-arc welding shall be in accordance with BS EN 499: 1995 except that hydrogen-controlled electrodes only shall be used for manual metal-arc welding of mild steel, Grades 43A and 43B, when the steel thickness is 40 mm or more.

3.3.5.3.2 Hydrogen controlled electrodes shall be used for manual metal-arc welding of steels to grades 43C, D and E, and grades 50A, B and D.

3.3.5.3.3 The electrodes to be used for metal-arc welding of steels to grades 55C and E shall be subject to agreement.

3.3.5.4 Terms and Symbols

On all drawings, welding procedure sheets, etc., terms and symbols relating to the welding and thermal cutting of metal shall be in accordance with BS 499.

3.3.5.5 Shop and Site Welding

3.3.5.5.1 Shop welding shall be carried out in workshops under the specified conditions of temperature, materials, welding procedure, workmanship, welding operations, supervision, and inspection. Machine welding will be allowed where approved machines are in use correctly controlled by qualified operators.

3.3.5.5.2 Careful attention must be given to the preparation of the surfaces of the parent metal prior to site welding and the welding shall be carried out in accordance with this Specification. Details of the proposed surface treatment shall be submitted with details of the connections to be made by site welding.

3.3.5.5.3 Site welding shall not be carried out when the plate temperature is 0˚C or below, welding shall only be allowed when special precautions approved by the Engineer are taken to prevent too rapid a rate of cooling and loss of heat.

3.3.5.5.4 Pre-heating shall comply with BS 1856, BS 2642 and the recommendations given in the Appendices to those Standards shall be adopted where relevant to the welding conditions and procedures.

3.3.5.5.5 The welding plant and equipment employed on the Works shall be of sufficient capacity to carry out the procedure laid down and suitable for the

types of electrodes in use. The Contractor shall provide all necessary staging and screens for the welders; the supervisors and the inspectors shall maintain all plant and equipment in an efficient condition. Suitable tong test ammeters shall be provided by the Contractor for measuring the current except only when efficient means of so doing are incorporated as part of the welding plant.

3.3.5.6 Welding Current

The welding current shall be within the range recommended by the manufacturer of the particular electrode being used and shall be towards the upper limit of the range rather than the lower.

3.3.5.7 Tack Welds

Where a tack weld is to be incorporated in a welded joint, the welding procedure used shall correspond in all respects to that specified for the joint as a whole and the shape of the tack shall be suitable for incorporation in the finished weld.

3.3.5.8 Weld Joints Preparation

3.3.5.8.1 The forms of weld joint preparation shall be in accordance with the relevant British standard unless modified by the standard details accompanying this Specification.

3.3.5.8.2 Fusion faces, angle of bevel, root radius, etc., shall be properly prepared to give the approved weld forms. The fusion faces shall be carefully aligned, and the correct gap and alignment maintained during the welding operation. In the preparation of the fusion faces shearing shall be limited to metal thicknesses not greater than 8 mm. All fusion faces shall be prepared by machining and 3 mm of material shall be allowed for this purpose, or, where approved, by machine flame cutting. Faces shall be kept clean and protected.

3.3.5.9 Peening

Strict instructions shall be issued to all welders that no peening shall be done.

3.3.5.10 Preheating and Temperature Conditions of Welding

3.3.5.10.1 Welding shall not in any circumstances be carried out when the ambient or plate temperature is 0°C or below. Where the combined plate or section thickness is equal to 50 mm or over and the ambient temperature is under 10°C,

welding shall only be allowed where special precautions are taken to prevent a too rapid rate of cooling and loss of heat.

3.3.5.10.2 Preheating shall comply with BS 1856, BS 2642 and the recommendations given in the Appendices to those Standards shall be adopted where relevant to the welding conditions and procedures.

3.3.5.11 Intermittent Welds

Intermittent welds shall be used only where indicated.

3.3.5.12 Post-Welding Distortion and Shrinkage

The Contractor shall take every reasonable precaution to avoid post-welding distortion and shrinkage occurring in welded assemblies, and shall inform the Engineer immediately during fabrication in the event of such distortion or shrinkage proving to be uncontrollable. Special attention shall be paid to prevent distortion of the box construction of the gate structure and the embedded metalwork.

3.3.5.13 Butt Welded Joints

3.3.5.13.1 All main butt welds shall have complete penetration and, except where it is impracticable, shall be welded from both sides, the back of the first run being suitably gouged out to clean metal before the backing run is deposited.

3.3.5.13.2 The ends of the welds shall have full throat thickness. This shall be obtained on all main welds by use of extension pieces adequately secured on either side of the main plates. Additional metal remaining after the removal of the extension pieces shall be removed and the ends and surfaces of the welds shall be smoothly finished.

3.3.5.14 Assembly of Joints

In the fabrication of plate girders and built-up members generally, all joints in each component part shall be made before such component part is welded to other parts of the members.

3.3.5.15 Welding Position

No welding operator shall be permitted to undertake work in welding positions other than those for which he has been tested.

3.3.5.16 Welding Design and Procedure

3.3.5.16.1 The design of welds and the allowable stresses shall be in accordance with BS 449 Part 2 and relevant British Standards.

3.3.5.16.2 Details, of the proposed welding procedure accompanied by diagrams showing the build-up of all main welds, together with the details of the manufacture, classification, code and size of electrodes to be used, shall be submitted to the Engineer for his written approval.

3.3.5.16.3 Welding procedure shall be such that distortion is reduced to a minimum, and local distortion is rendered negligible in the final structure.

3.3.5.16.4 Butt welds in flange plates and/or web plates shall be completed before the flange and web are welded together.

3.3.5.16.5 Approval of the welding schedule and procedure shall not relieve the Contractor of his responsibility for correct welding and for the minimising of distortion in the finished structure.

3.3.5.16.6 All welds shall be finished full and made with the correct number of runs, the welds being kept free from slag and other inclusions, all adhering slag being carefully removed from the exposed faces immediately after each run is completed, and before any additional run is started.

3.3.5.16.7 For all welds, except those on tubular work, the minimum cross section, area of run, and maximum run length per electrode shall comply with the requirements of the relevant Codes of Practice.

3.3.5.17 Qualifications of Welding Operators

The Contractor shall be responsible for ensuring that each and every welding operator employed on the fabrication and/or site work is an efficient and dependable welder.

3.3.5.18 Testing of Welding Operators

3.3.5.18.1 Operators, other than those engaged on tube welding, shall be tested as detailed in BS 4872 Part 1 and appropriate to the corresponding weld position and using specimens of the parent metal to be employed.

3.3.5.18.2 Only welding operators who satisfy the appropriate tests shall be employed on welding. Should an operator fail in a first test, two further tests shall be undertaken immediately and the operator to qualify must satisfactorily pass both these tests.

3.3.5.18.3 The provisions of BS 449, Part 2, Clause 79, shall apply with regard to types of work for which welders are qualified.

3.3.5.18.4 The names of all operators qualified as aforesaid, and particulars of the tests passed by each shall be recorded by the Contractor and agreed by the Engineer and shall subsequently be made available as and when required. The Engineer shall have the right to require the immediate suspension by the Contractor of any operator who's standard of workmanship is unsatisfactory, but the Contractor may submit the operator for re-test if he has received further instruction.

3.3.5.19 Re-Testing of Operators

3.3.5.19.1 Routine re-testing of all operators shall be carried out every 6 months.

3.3.5.19.2 he Engineer reserves the right to have any welding operator re-tested at any time during the Contract.

3.3.5.20 Test Plates

The Engineer will require test plates on all main butt welds in flange members. Test plates shall be incorporated at the side and continuous with the main weld. These test plates shall be cut from extensions of the main plates and fixed as extension pieces at the butt joint so that the metal lies in the same direction as that of the main plate. Each test plate shall be clearly marked to be identified with the flat and the end from which it has been cut. (Test plates shall be prepared in accordance with BS 709 Part 3, transverse bend).

3.3.5.21 Additional Tests by the Contractor

The following additional tests shall be carried out by the Contractor when directed by the Engineer.

3.3.5.21.1 Fillet weld inspection tests in accordance with BS 709 Chapter 6 and tension tests in accordance with BS 709 Chapter 2.

3.3.5.21.2 Test plates and tests on butt welds other than main butt welds in flange members as previously described.

3.3.5.21.3 Radiographic or other non-destructive examinations on butt or fillet welded joints and/or the test specimens. Preparation of etched sections of welds may be required for examination.

3.3.5.21.4 Charpy V-notch tests in accordance with BS 709 Chapter 4.

3.3.5.22 Independent Non-Destructive and Special Testing

3.3.5.22.1 The Engineer may also require independent radiographic or other non-destructive examinations of butt and fillet welds to be undertaken. These examinations will be carried out by or under the supervision of the Engineer.

3.3.5.22.2 The frequency of independent examinations will depend on the results obtained. Preparation of etched sections of welds may be required for examination.

3.3.5.22.3 Tensile and bending tests may also be carried out by the Engineer in accordance with BS 709.

3.3.5.23 Non-Destructive Examination of Welds

The Contractor shall satisfy themself as to the quality of all butt welds and shall carry out radiographic or ultrasonic tests on butt welded joints and/or on the test specimen referred to in clause 3.3.5.20. The extent of these tests shall not be less than 10% of the total number of butt welds stressed in compression. All butt welds stressed in tension shall be tested. The non-destructive examination of welds shall be delayed after completion of the welding for a period of 12 hours minimum to avoid the risk of protracted weld cracking not being detected.

3.3.5.24 1.2.8.24 Sub-Standard Workmanship and/or Incorrect Welding Procedures

Should the tests on the minimum percentage of butt welds stressed in compression and described in clause 3.3.5.23 or any of the tests described in clause 3.3.5.21 show, in the opinion of the Engineer, unacceptable or substandard welds resulting from bad workmanship or incorrect welding procedures, then the extent of these tests shall be increased to a percentage decided by the Engineer to ensure acceptable standards of workmanship and/or procedure, the additional cost to be borne by the Contractor.

3.3.5.25 Record of Tests and Examination on Welds

The Contractor shall record evidence and results of all destructive or non-destructive tests and examinations and shall submit radiographs and records for examination by the Engineer or his authorised representative.

3.3.5.26 Works Supervision by Contractor

3.3.5.26.1 The Contractor shall be responsible for ensuring that all materials, welding, fabrication, and workmanship comply with this Specification and he shall provide the necessary supervision and testing to fulfil this requirement.

3.3.5.26.2 They shall, when more than one supervisor is employed, provide adequate means of identification either by means of an identification stamp or other approved means, to enable the supervisor of the work to be identified.

3.3.5.27 Correction of Weld Faults

The correction of weld faults shall be carried out under the supervision and to the entire satisfaction of the Engineer.

3.3.5.28 Acceptance of Welded Structures

The acceptance of the welded work shall depend upon correct dimensions and alignment and absence of distortion in the structure, upon satisfactory results from the examination and testing of the joints in accordance with the instructions given on the drawings, and the soundness of the welds and upon general good workmanship.

3.3.5.29 Cleaning

All welds, slag, splatter and flux residues shall be removed from the steelwork.

3.3.6 Nuts and Bolts.

3.3.6.1 Washers shall be provided under nuts and bolt heads where required.

3.3.6.2 Each bolt and stud shall show at least one full thread beyond its nut after assembly and all studs shall be screwed home by at least one diameter.

3.3.6.3 All nuts, bolts, and other fastenings on any part of the equipment shall, where required, be securely locked by a means approved by the Engineer.

3.3.7 Lubrication

3.3.7.1 Except where self-lubricating bearings are specified all moving parts, bearings, journals, etc. shall be provided with adequate means of lubrication. Where suitable, pressure gun lubrication and the necessary guns shall be supplied by the Contractor as part of the equipment. Lubricants shall be to the approval of the Engineer and with a specification the same as used at the plant.

3.3.7.2 Adequate seals shall be provided where necessary and the works shall be designed to prevent lubricants from leaking away or splashing out during normal use.

3.3.7.3 All items of plant, oil bath lubricated, shall be provided with sighting oil level gauges positioned to allow easy access for reading and subsequent filling.

3.3.7.4 All grease nipples, and oiling points, shall be accessible without removing cover plates etc. The works shall be handed over to the Employer in running order with all moving parts properly lubricated with approved lubricants. The Contractor shall supply the first filling of lubricants plus 20% to be held in suitable containers on Site.

3.3.8 Termite Resistant Materials

3.3.8.1 Wooden cable drums, timber used for shoring trenches and other purposes and any other fibrous material used during construction shall be treated with creosote or other approved preservative to prevent action by termites. Where any material is found to be infested it shall be removed immediately and burnt.

3.3.9 Corrosion

3.3.9.1 Metals

3.3.9.1.1 Iron and steel shall in general be galvanised or painted as appropriate in accordance with the Specification. Indoor parts may be chromium or copper nickel-plated or protected by an approved anti-corrosion finish to the satisfaction of the Engineer.

3.3.9.1.2 Small iron or steel parts (other than stainless steel) of all instruments and electrical equipment, the cores of electro-magnets, the metal parts of relays and mechanisms shall be treated by an approved anti-corrosive finish to prevent rust.

3.3.9.1.3 Laminated cores or other pieces of mechanism which cannot for any reason be treated against corrosive action shall have all exposed parts thoroughly cleaned and heavily coated with enamel, lacquer or compound.

3.3.9.1.4 Where it is necessary to use two dissimilar metals in contact, (a) they shall be so selected that the potential difference between them in the electro-chemical series is not greater than 0.5 volts (b) the potential difference shall not exceed 0.5 volts when the contact area is either immersed in water or exposed to condensation. If this is not possible, the contact surface of one or both of the metals shall be electro-plated or otherwise finished in such a manner that the potential difference is reduced to within the required limits or, alternatively the two metals shall be insulated from each other by means of an approved insulating material or by a coating or approved varnish compound to the satisfaction of the Engineer.

3.3.9.2 Screws, Nuts, Springs, Pivots, etc.

The use of iron and steel shall be avoided in instruments and electrical relays wherever possible. Steel screws, where used, shall be zinc, cadmium or chromium plated, or where plating is not possible owing to tolerance limitations, of corrosion resisting steel. All wood screws shall be of dull nickel-plated brass or other finish to be approved by the Engineer. Instrument screws (except for those forming part of a magnetic circuit) shall be of brass or bronze, springs shall be of non-rusting material e.g., phosphor bronze or nickel silver, as far as possible. Pivots and other parts for which non-ferrous material is unsuitable shall be of an approved stainless steel where possible.

3.3.9.3 Metalwork and Pipes

All metal parts and pipes such as supports, which will be submerged or come into contact with water shall be adequately protected against corrosion to the approval of the Engineer.

3.3.10 Painting and Protective Treatment

3.3.10.1 General

3.3.10.1.1 The intent of this section of the Specification is to give maximum protection to all items of plant to ensure long term safe operation and to minimise plant outage.

3.3.10.1.2 Particular attention shall be given to the underwater parts.

3.3.10.1.3 Painting shall be completed, except for cleaning and repair at site, prior to shipment. The finish paint of surfaces which are fully accessible and in an environment fully suitable for completion of painting may be completed at site before the end of the maintenance period provided that no delays to or interference with plant usage can arise. Such surfaces shall however be fully protected against deterioration that could occur in transit and during storage at site.

3.3.10.2 Standards & Workmanship

3.3.10.2.1 All steelwork is to be protected as specified below and to the requirements of the relevant British Standard, or equivalent, including the following where relevant. BS 3981, 282, 389, 388, 729, 1070, 1133, 2521-4, 2525-32, 2569, 3189, 3416, 3698, 3699, 3900, 4129, 4232 & 4592, CP 2008.

Full details of paints to be used are to be submitted for approval including the names of suppliers, and the Contractor is responsible for ensuring that the paints are compatible and that they are applied in accordance with the requirements of BS EN ISO 12944.

3.3.10.2.2 Wet and dry film thicknesses shall be checked in accordance with BS EN ISO 12944 to ensure that the specified dry film thicknesses are met. The specified thicknesses shall be regarded as minimum.

3.3.10.2.3 Nothing in this Specification shall limit the Engineer's power to require that faulty or otherwise obviously thin or uneven paintwork shall be recoated, repaired or replaced.

3.3.10.2.4 The maximum amount of paint treatment shall be completed in the manufacturer's works. Site work shall be limited to finishing coats and to repair of damage suffered during transport, storage, and erection, and making good at site connections, bolts and welds.

3.3.10.2.5 The painted steelwork shall be stored at works and on Site so that it is clear of the ground and laid out and stacked in an orderly manner that will ensure that no pools of water can accumulate on the surfaces. Suitable packing should be laid between layers of stacked material. Where temporary covers are used, proper ventilation shall be provided.

Special care shall be taken with steelwork stored outside, with an "interior" finish or incomplete exterior finish, to ensure that the protective system is not adversely affected by the environment or prolonged storage periods.

Before any steelwork is placed into store, it shall be examined for continuity and uniformity of the paint system. It shall also be inspected from time to time and maintenance painting carried out as necessary to restore the paint system to its specified condition.

The following provisions shall be made to reduce to a minimum, damage to the paint system during handling, transport, and erection.

(a) An adequate drying period after completion of painting shall be allowed to ensure that the paint has hardened and is resistant to damage.
(b) Special slings or lifting points or both shall be provided for handling and loading or unloading in the fabrication shops, during transit and at the Site.
(c) Methods of loading and off-loading on transit vehicles and ships, which will reduce the handling at Site to a minimum.

(d) Special supports, packing and lashings on vehicles or trucks to prevent chafing

3.3.10.2.6 In cases where site welding is to be carried out, no protective measures beyond the primer shall be carried within 100 mm of welds, until completion of the welding.

3.3.10.2.7 All contact surfaces for High Strength Friction Grip Bolts shall be treated as specified hereafter for each particular painting system.

Special care shall be taken after assembly to paint all edges and corners near the joints, together with the bolt heads, nuts, and washers to prevent the ingress of water.

The complete painting scheme, as applied to the main body of the structure, shall be given to the joints after treatment as above.

3.3.10.2.8 After erection, the steelwork shall be examined for continuity and uniformity of the paint system and where necessary it shall be cut back, cleaned, and recoated as specified.

3.3.10.2.9 The Contractor shall provide adequate supervision and inspection so as to ensure that all stages of work are carried out to the required high standard and shall comply with all the requirements laid down in BS EN ISO 12944.

Full facilities shall be afforded to the Engineer and his appointed inspectors to examine the work at all stages. Similar facilities shall also apply to the paint manufacturers.

3.3.10.2.10 All coatings are to be applied under covered conditions. Coatings may only be applied outside with the prior permission of the Engineer.

This requirement shall also apply to the surface preparation of steelwork prior to treatment.

3.3.10.2.11 All blast cleaning and coating shall be done under favourable ambient conditions which must continue throughout the drying time of the coatings.

(a) Operations at Works shall be carried out under the following conditions:
   (i) Temperature of the ambient atmosphere shall lie between the ranges 7˚ to 32°C.
   (ii) The ambient relative humidity shall be below 90 per cent.

(b) Operations on Site shall be carried out when the ambient conditions are favourable and are likely to continue during the drying time of the paint.

(c) Painting shall be suspended under the following conditions:
   (i) When the temperature of the ambient atmosphere falls below 7°C or its relative humidity rises above 90 per cent. Painting may be carried

out outside these conditions by warming the steel surface and/or by erecting some form of temporary shelter to the approval of the Engineer.

(ii) For outdoor work, during periods of inclement weather, e.g., rain, fog, or mist.

3.3.10.2.12 The Manufacturer's instructions are to be strictly adhered to.

3.3.10.3 Materials

3.3.10.3.1 Red lead primer shall be type B in accordance with BS 2523 with a dry film thickness of 0.040 mm.

3.3.10.3.2 Calcium plumbate primer shall be in accordance with BS 3698 with a minimum dry film thickness of 0.025 mm.

3.3.10.3.3 Zinc chromate primer shall have a water-resistant medium, i.e., oleoresinous or alkyd medium, pigmented with zinc chromate/red oxide, and shall have a minimum dry film thickness of 0.040 mm.

3.3.10.3.4 Etch primer shall consist of solutions of polyvinyl butyral resins in alcohol and pigmented with zinc chromate to which is added (before use as a paint) an alcoholic solution of phosphoric acid. The minimum dry film thickness shall be 0.012 mm.

3.3.10.3.5 Zinc rich primer shall consist of not less than 85% by weight of metallic zinc in an epoxide resin medium. The minimum dry film thickness shall be 0.025 mm.

3.3.10.3.6 Black bitumen paint shall be in accordance with BS 3416 and shall have a minimum dry film thickness of 0.075 mm.

3.3.10.3.7 Micaceous iron oxide paint shall be of the phenolic resin type with a minimum dry film thickness of 0.075 mm.

3.3.10.3.8 "Undercoat" paint shall be highly pigmented with a matt or eggshell sheen, oleo resinous or alkyd base paint, and shall have a minimum dry film thickness of 0.025 mm.

3.3.10.3.9 "Gloss" paint shall consist of a mixture of drying oils and alkyd resins containing finely dispersed agents, and shall have a minimum dry film thickness of 0.025 mm.

3.3.10.3.10 Galvanising shall be in accordance with the requirements of BS EN ISO 1461 with a minimum coating of 60 gm/m2.

3.3.10.3.11 Coal tar epoxy paint shall be in accordance with BS 3900. The minimum total dry film thickness for two coats shall be 0.23 mm with the thickness of each coat being as recommended by the manufacturer.

3.3.10.4 Mechanically & Hand Cleaned Steel

3.3.10.4.1 The steel is to be thoroughly cleaned at works and all dirt, oil and loose particles removed, full use being made of power-driven tools, such as carborundum grinding discs, chipping hammers and needle guns. Excessive burnishing of the metal through prolonged application of rotary wire brushes is to be avoided. Wire brushes with steel bristles should be used as the bristles of other metals may leave deposits that cause electrolytic corrosion.

3.3.10.4.2 Surfaces shall be protected within 4 hours of having been cleaned and shall not be exposed to outside atmospheres during this period.

3.3.10.4.3 Before applying a protective finish, the surfaces shall be free from moisture, grease, dirt, weld slag and loose scale and rust.

3.3.10.4.4 In cases where site welding is required, the provisions of clause 3.3.5 shall be observed.

3.3.10.4.5 In cases where site connections are to be made using black bolts, the contact faces of the related parts shall be painted with the red lead primer only. After the site connection has been made all edges and corners near the joint together with the bolt's heads, nuts and washers shall be treated to ensure that the protection to the whole of the joint is to the standard of the adjacent members.

3.3.10.4.6 In cases where site connections are to be made using high strength Friction Grip Bolts, the contact surfaces shall be thoroughly cleaned and protected during storage and transport. Prior to erection the dry metal surface shall be inspected and if necessary re-cleaned.

3.3.10.5 **Blast Cleaning**

3.3.10.5.1 The steelwork is to be blast cleaned at the works in accordance with BS 7079:1989 and BS EN ISO 8503: 1995, second quality standard with an optimum profile of 0.065-0.090 mm high as specified.

3.3.10.5.2 Surfaces for preparation to Second Quality standard shall correspond with the pictorial standard SA 2 in the Swedish Standard SIS.055900 - 1967 taking due account of the initial condition of the steel as specified in the Standards.

3.3.10.5.3 After blasting, the surface is to be freed from abrasive residues by high pressure air dusting and/or vacuum cleaning. Any "rogue" peaks are to be reduced by rubbing over the surface with a mechanical grinder and the surface dusted down before painting.

3.3.10.5.4 Surfaces shall be protected within 2 hours of having been blast cleaned and shall not be exposed to outside atmospheres during this period.

3.3.10.5.5 A prefabrication primer may be used after blast cleaning to suit a fabricator's facilities, etc. subject to the following: -

(a) The prefabrication primer is to be applied within 1½ hours of blast cleaning ensuring that the metal is in perfectly dry condition.

(b) The prefabrication primer shall be a two-pack type zinc-rich primer, containing about 90% and not less than 85% finely divided metallic zinc in epoxide resin or other approved primer. It should be suitable for continuous spray application, dry rapidly, and be touch dry within 10 minutes or less, with a dry film thickness of 0.012 mm to 0.025 mm. It should comply with BS 4129 and have the following properties.

(i) It should not interfere with fabrication by welding or other means.

(ii) It should be non-toxic and give rise to no objectionable fumes when heated during welding and cutting.

(iii) It should not affect the strength of the welds.

(iv) The primer should protect the steel effectively throughout the desired period of fabrication.

(v) The primer should form a suitable basis for the final protective paint scheme.

(c) After fabrication, areas of bare steel, welds, etc. shall be wire brushed to remove rust and weld spatter and shall be patch primed as above. The steel is to be thoroughly cleaned to remove oil, grease and other dirt from the surface and to the satisfaction of the Engineer.

3.3.10.5.6 The steelwork shall then be treated with one coat of zinc-rich primer bound in a medium of epoxide resin to yield paint suitable in all respects for brush application with a dry paint film, 0.025mm to 0.040 mm thick, containing not less than 85% by weight of metallic zinc.

3.3.10.5.7 In cases where site welding is required, the provisions of clause 3.3.5 shall be observed.

3.3.10.5.8 In cases where site connections are to be made using black bolts, the contact surfaces of the related parts shall be painted with the prefabrication primer and the primer only.

3.3.10.5.9 After the site connection has been made all edges and corners near the joint together with the bolt heads, nuts and washers shall be treated to ensure that the protection to the whole of the joint is to the standard of the adjacent members.

3.3.10.6 Acid Dipping

Acid dipping shall be by the "Footner" pickling process or an equivalent procedure, and the steelwork shall be treated as soon as it has dried and whilst it is still warm.

3.3.10.7 Painting Systems

System No.	Surface Preparation	Paint System	Where Applied
I	Mechanically or Hand Cleaned.	Zinc Chromate Primer	Factory/shop
		Undercoat.	Factory/shop
		Gloss Coat.	Site
2	Mechanically or Hand Cleaned.	2 coats Red Lead Primer	Factory/shop
		Undercoat	Factory/shop
		Gloss Coat	Site
		Gloss Coat	Site
3	Blast Cleaned 2nd Quality.	2 Coats of Red Lead or Calcium Plum bate Primer Undercoat	Factory/shop
		Undercoat	Factory/shop
		Gloss Coat of Oil Resistant Paint	Site
4	Blast Cleaned 2nd Quality	3 Coats Red Lead Primer	Factory/shop
5	Blast Cleaned 2nd Quality	2 Coats Coal Tar Epoxy	Factory/shop
6	Blast Cleaned 2nd Quality.	1 Coat Zinc Rich Epoxy Primer	Factory/shop
		1 Coat Coal Tar Epoxy	Factory/shop
		1 Coat Coal Tar Epoxy	Factory/shop
7	Blast Cleaned 2nd Quality.	1 Coat Zinc Rich Epoxy Primer	Factory/shop
		1 Coat Coal Tar Epoxy	Factory/shop
		2 Coats Coal Tar Epoxy	Site
8	Acid Pickling	Dipped in Bitumen	Factory/shop
9	Galvanized	Etch Primer	Factory/shop
		Dipped in Bitumen	Factory/shop
10	Galvanized	Etch Primer	Factory/shop
11	Blast Cleaned 2nd Quality	2 Coats of oil resistant Enamel	Factory/shop
12	Pickle	Protective Grease	Factory/shop
		All pipes plugged at ends. Flush out	Site
13	Remove loose scale & rust	One coat cement wash	Factory/shop
14	Machined Surfaces	Protective coating	Factory/shop
		Coat with grease	Site
15	Stainless steel surfaces	Protective coating	Factory/shop
		Clean as necessary	Site
16	Sheet steel control cubicles (exterior)	Stove enamel	Factory/shop.
17	Sheet steel Control cubicles (interior)	Semi-matt white	Factory/shop

3.3.10.8 Schedule of Protective Treatment for Spillway & Intake Gates

In the table below "System No." refers to the surface treatments specified in clause 3.3.10.7

Item/Surface	System No.
Stainless steel faces on embedded frames	
Sealing faces	15
Guide faces	15
Wheel bearing surfaces	15
Machined finished surfaces	
Gate wheel treads and axles	14
Radial gate, pivot assemblies	14
Gate bearing surfaces	14
Exposed embedded steelwork	
All gate and stoplog embedded parts	7
Radial gate pivot anchorage beams	6
Gate Structures	
All gates and stoplog sections	6
Hoisting Equipment – Intake & Spillway Gates	
Oil reservoirs – indoor	11
Oil reservoirs – outdoor	3
Hydraulic panels-Outdoor	2 or 16
Steel piping for oil – indoor	12
Hydraulic cylinders & piping - Outdoor	3
Sheet Steel Control panels	
Interior	17
Exterior	16
Surfaces embedded in concrete	13
Lifting Beams and lifting rods	6
Screen Panels and raking Equipment	9
Raking Gantry	2
Mobile Crane	2
Stoplog Gantry Crane	2
Draft Tube Gate Hoist	2
Intake Gate platform supports	9
Spillway Stoplog Covers	6

3.3.10.9 Colours, Identification

The colour schemes will be as specified or as directed by the Engineer.

3.4 AUXILLIARY POWER SUPPLY EQUIPMENT

Auxiliary power for the purposes of this clause shall mean power supply powering plant control, metering and protection devices.

3.4.1 General Auxiliary Power Supply Requirement

3.4.1.1 The electricity supplies for auxiliary supply will be as follows:

3.4.1.1.1 415 volts 3-phase 50 Hz 4-wire for heavy power application such as OLTC motors.

3.4.1.1.2 240 volts' single phase 50 Hz for light power application such as lighting, indication, anti-condensation heaters and oil pumps.

3.4.1.1.3 110 volts DC for control, metering, indication and protection devices and all power circuit breakers closing, tripping and spring charging supplies.

3.4.1.1.4 110 volts DC for power operated isolators and earthing switches.

3.4.1.1.5 24V DC for electronics supply where specified.

3.4.2 Alternating Current (AC)

3.4.2.1 All mains auxiliary supplies shall be switched and protected with a circuit breaker. Double-pole circuit breakers shall be used to break single-phase ac mains supplies. For multi-phase supplies, each phase shall be switched simultaneously.

3.4.2.2 Miniature circuit breakers shall be used in auxiliary AC power circuits rated 63 amps and below unless otherwise stated in particular specifications. They shall be approved as circuit breakers and have a breaking capacity sufficient to break the short circuit at the place of use (i.e., no upstream backup fuses for reduction of fault level shall be necessary).

3.4.2.3 Except where prior approval is obtained, wires external to the equipment shall be colour coded as stated elsewhere this specification.

3.4.3 Direct Current (DC)

3.4.3.1 All DC circuits shall be switched and protected by appropriately rated circuit breakers, the circuit breakers must be approved for the relevant DC voltage and current, fuses to be used for ratings of 1A and below only unless otherwise specified in the particular specifications.

3.4.3.2 Double pole circuit breakers shall be used for switching and protection of all DC supply circuits rated above 1A, they shall be rated appropriately to break DC short circuit without the necessity of upstream backup fuses.

3.4.3.3 Where found necessary, backup fuses shall be used to prevent tripping of main DC supplies

3.4.3.4 If electronic equipment or system require the use of local internal batteries approval must be obtained. Where approval is given, batteries used inside

equipment shall be: totally sealed, leak-proof type, have no possibility of explosion even at ambient temperature above 40˚C, available in the local market and rated below 5V. Use of internal batteries shall be avoided unless where specified

3.4.3.5 Equipment supplied under this contract shall be rated for direct use 0f 110VDC without external power supply units. Where this is not possible or appropriate 24VDC auxiliary supply shall be used. Other than 110VDC, only 24VDC shall be allowed for auxiliary DC supply for control, metering and protection equipment.

3.4.4 Fuses

3.4.4.1 Carriers and bases for fuses and links shall be in accordance with IEC 269 standard and colour coded to permit identification of the circuit rating.

3.4.4.2 The contacts of the fixed portion of the fuse or link shall be shrouded so that accidental contact with live metal cannot be made when the moving portion is withdrawn.

3.4.4.3 Main supply fuse links shall, unless otherwise specified, be of the high rupturing capacity cartridge type. Where fuse carriers are mounted vertically, the incoming (supply) circuit shall be connected to the top terminals. Where fuses are used, the Contractor shall ensure that proper discrimination between main and sub-circuits is maintained.

3.4.4.4 Where LV power fuses above 63 amps are specified, they shall be of high rupturing capacity cartridge, type NH gl, according to DIN VDE 0636 and IEC 60269. All fuse bases shall have a load switching capacity and a thermal rating equal to the rating of the largest fuse it can accommodate. Fuse replacement shall be possible without use of special tools and with IP 20 protection against live parts.

3.4.4.5 Fuse holders shall be equipped with at least 1SPDT auxiliary contacts for fuse blown indication.

3.4.4.6 Fuses embedded in devices e.g., terminal blocks etc shall have a fuse blown LED indication.

3.4.5 Miniature Circuit Breakers

3.4.5.1 Miniature circuit breakers shall be designed and tested in accordance with IEC 60947 and supplementary requirements of this specification.

3.4.5.2 They shall be suitably rated for both the continuous and short circuit loadings of the circuits they are protecting under all service and atmospheric conditions stated in the specification and ensure that correct discrimination is maintained between main and sub-circuits.

3.4.5.3 Where circuit breakers are used in circuits containing inductive loads, e.g. operating coils, it is essential that they are suitable for satisfactory operation in the circuit in which they are used, i.e. account is taken of the circuit time constant.

3.4.5.4 MCB used for DC circuits shall be double pole and rated for DC applications.

3.4.5.5 All MCB's shall be provided with two auxiliary contact(s) for remote indication of circuit breaker operation and interlocking purposes.

3.4.5.6 Means shall be provided to prevent the circuit breakers being inadvertently switched to the 'OFF' position.

3.4.5.7 Circuit breakers shall be mounted in such a manner so as to give easily visible indication of breaker position and shall be grouped and spaced.

3.4.6 Motor Protection Circuit breaker, MPCB

MPCB's shall be special kind of MCCB's for three phase loads rated below 100A. They shall meet the following requirements.

3.4.6.1 Designed for motor and other three phase loads protection. They shall be used for protection of all three phase control circuits/supplies such as such as VT inputs and outputs, voltage monitoring relays input etc.

3.4.6.2 The MPCB's shall be suitably rated for the application, with overload settings as low as 0.1A for metering & control circuits protection.

3.4.6.3 Shall have an adjustable overload setting, with a dial on the front side for adjustment. Overload shall be settable from at least 70% to 100% MPCB rating.

3.4.6.4 The current ratings given in the specifications consider that the Overload shall be settable from at least 70% to 100%. Overload setting and trip classes shall be computed during design.

3.4.7 Power Supply Units (PSUs)

3.4.7.1 PSUs shall be of approved design and such that they do not impose parasitic or harmonic voltages on the station battery system or electronic equipment.

3.4.7.2 Protection circuits incorporated into PSUs shall be such that any overload of the output or short circuit current does not damage any components within the PSU.

3.4.7.3 PSUs shall incorporate over-voltage and overcurrent protection devices to protect the components that comprise the output load.

3.4.7.4 All PSUs shall have at least one SPDT alarm contact to annunciate failure of the PSU.

3.4.8 Electrical Sockets

3.4.8.1 Single phase electrical sockets installed for lamps, hand tools, measuring equipment etc., shall be the British standard, BS 1363, type with 3 square pin sockets and with earth connection.

3.4.8.2 Single phase sockets shall be rated at least 16A (lower rating shall not be used).

3.4.8.3 Three phase sockets shall be according to IEC 60309 (CEE type).

3.4.8.4 Contractor shall use sockets available in the local market.

3.5 CONTROL DEVICES GENERAL REQUIREMENTS

3.5.1 Instruments/Transducers

3.5.1.1 General Requirements

(a) Pressure sensors and transmitters shall be of corrosion proof material, degree of protection IP 54, and vibration class I (ISO 2372). Their scale shall indicate bar. The measuring pipe shall be equipped with stop chock. If the indicator is exposed to vibration, it shall be filled with damping liquid (glycerine).

(b) Limit switches for pressure, temperature and flow (even if combined with the indicators) shall be of class 1, conforming to IEC 60536 without noticeable hysteresis. Where more than one limit is required, each limit shall be independently settable. Set points shall be easily readable.

(c) Limit switches not mounted in enclosures shall be of the proximity type without need for separate power supply and equipped with light emitting diodes to indicate position where necessary.

(d) Flow meters shall be graded in litres/s or M3/s from zero to 150% above required value. They shall be electronic without moving mechanical parts.

(e) Electronic transmitters shall be rated for 24V DC unless otherwise specified

3.5.1.2 Resistance temperature detectors (RTD)

(a) They shall be industrial grade PT 100 type protected to suit the environment where there are to be used.

(b) They shall conform to the IEC 60751: 2008 Standard

(c) They shall meet accuracy class B as per IEC 60751 i.e Class B = ± (0.30 + 0.005* t) for (-50 to 500°C). Accuracy of ±0.80C at 1000C

(d) Shall have an operating range of at least –2000C to + 5000C

(e) Shall be wire wound with good vibration resistance

(f) They shall either be four wire or three wire connection type. Two wire types SHALL NOT be accepted for any application.

3.5.1.3 **Pressure transmitters**

The digital pressure transmitters shall be provided with a minimum of the following features: -

(a) The pressure switch instrument shall be microprocessor based with key programming facility.

(b) The instruments shall have relays with switching points (set point where the relay is activated) and switch-back points (set point where the relay is deactivated). The instruments should also have precise pressure adjustments of 0.1bar.

(c) Integrated pressure sensor with strain gauge on stainless steel membrane.

(d) An accuracy of 0.5 % - 1 % full scale.

(e) 4-digit digital display for pressure value display to one decimal place.

(f) The instruments shall have either

(i) Four (4) switching points & relays.

(ii) Two (2) switching points & relays.

(iii) Analogue 4 to 20mA output pressure signal

(iv) Combination of (i) & (iii)

(v) Combination of (ii) & (iii)

(vi) Analogue 4 to 20mA output signal & one (1) switch point CO relay

(g) It shall be possible set to display values in bars as unit of measurement.

(h) Instruments shall be ideal for frequent switching.

3.5.2 Indicating lamps and Push buttons & Selector switches

3.5.2.1 All status and position indication lamps shall be of the light emitting diode type and be replaceable without use of soldering or special tools. A switch for lamp test shall be put in all panels, neighbouring panels can be grouped together with one test switch.

3.5.2.2 All indication contacts shall be galvanic isolated and potential free.

3.5.2.3 Indicating lamp assemblies shall be of the switchboard type, insulated for 110 V DC service, with appropriately coloured lens and integrally mounted resistors for 110-volt service. The lens shall be made of a material, which will not be softened by the heat from the lamps.

3.5.2.4 For the Circuit Breakers, isolators and motors status indications, Red indicating lamps shall be used for "ON/CLOSED" position, green lamps for "OFF/OPEN" position Indication and Amber for Transition

3.5.2.5 For alarms/warnings, yellow indicating lights shall be used while for trips/faults, red indicating lamps shall be used

3.5.2.6 All semaphores SHALL be of LED type.

3.5.2.7 Emergency push buttons shall meet the following.

(a) Shall have a large red mushroom head.
(b) Shall be protected from accidental operation by a glass cover.
(c) Emergency push button shall remain latched when operated until reset.
(d) Resetting shall be done by twisting or rotating the button.

3.5.2.8 Illuminated pushbuttons shall consist of a command push button and a status LED lamp. The LED lamp shall indicate the status of the device/primary circuit commanded by the push button.

3.5.2.9 Discrepancy switches shall be used for operation of switchgear, they shall have the following specifications

(a) They shall be operated by Push, turn and control
(b) They shall have an integrated LED for position indication
(c) Shall be rated for 110V DC or 24 V DC depending on application
(d) Shall have a big knob made of transparent polycarbonate completely illuminated by a coloured LED inside.
(e) LED shall be lit depending on the position of the switch and the controlled device
(f) Each discrepancy switch shall at minimum have four (4) SPDT contacts

3.5.3 Control Contactor Relays

3.5.3.1 These relays shall be used for control and tripping purposes

3.5.3.2 They MUST meet ALL the following specifications:

(a) **Manufacturer**: Siemens/ABB
(b) **Model/series**: 3RH2/3RH1/NFZ contactor relays
(c) **Number Contacts**: 4poles 4 SPST OR 8 poles 8 SPST depending on application
(d) **Contacts current rating at 110VDC**: At least 3A
(e) **Magnetic coil voltage rating**: 24VDC/110VDC with a range of +/- 20%
(f) **Magnetic coil maximum power rating for closing and holding**: 4W

(g) **Structure**: Relays shall be a single unit i.e. without a separate base for mounting and shall have a capability to plug an auxiliary unit on top with 4 contacts poles (4 SPST)

(h) **Base unit**: Relay base unit shall have four contacts poles (4 SPST) and the operating coil

(i) **Auxiliary plug in unit**: relays shall have an auxiliary plug in unit with four contacts poles (4C/O)

(j) **Connection type**: screw-type terminals

(k) **Type of connectable conductor cross-section** (for auxiliary and control current circuit): at least 2X4mm2 solid conductors or 2X2.5mm2 stranded cores with bootlace.

(l) **Mounting type**: Snap-on mounting on a DIN rail

(m) **Size of relays**: S00

(n) **Resetting**: Relays shall be self-resetting

(o) **Protection class on the front**: IP20

(p) **Degree of pollution**: 3

(q) **Insulation voltage**: 690 V

(r) **Surge voltage resistance:** 6kV

(s) **Mechanical service life (switching cycles):** at least 30,000,000

3.5.3.3 These relays shall be provided with voltage free contacts for operating with associated circuits. The contacts shall be amply rated for their A.C or D.C duty with snap action where possible and magnetic blow – out devices. Surge suppressor devices shall be provided across relays coils and contacts.

3.5.4 Coupling/Interfacing relays

3.5.4.1 These relays shall be used to isolate two systems at the same voltage or different voltages. Digital inputs and output Signals from and to the plant control system shall be coupled to the new systems via these relays where specified in the particular specifications

3.5.4.2 There shall be two types of coupling relays

(a) Highly compact micro-relay modules with 1 SPDT or solid state micro plug in relays

(b) Miniature interface auxiliary relays modules with 4 SPDT electromechanical plug in relays

3.5.4.3 ***Highly compact micro-relay modules (optocouplers)***

(a) Highly compact micro-relay modules shall be used to interface contact outputs or inputs between two systems using different common supply, for

circuit isolation or wherever else it may be necessary as per design or particular specification

(b) They shall consist of a power terminal block and a plug in micro relay

(c) The power terminal block shall have the following general features:

- Integrated filter to protect against interference voltages or currents
- The housing shall be made of Polyamide PA non-reinforced
- Shall permit operating voltages of up to 250VAC
- Shall accommodated a solid state or electromechanical relay
- Permit a continuous current of 10 A
- Safe isolation according to DIN EN 50178 between coil and contact
- Screw connection terminals
- Support wide range of input voltages from 12 V DC to 230 V AC
- Shall have Integrated yellow LED and interference suppression circuit on the input circuit
- Output circuit Protection against polarity reversal and surge protection
- Support conductor cross section of 0.2 mm² ... 4 mm² for solid / stranded connections
- Contact material- AgNi
- Dimensions W / H / D - 6.2 mm / 80 mm / 94 mm or equivalent
- Insulation - input/output 4 kV (50 Hz, 1 min.)
- Ambient temperature (operation) - 20 °C ... 55 °C
- Mechanical service life - min 2 x 107 cycles
- Standards/regulations - IEC 60664, EN 50178, IEC 62103
- DIN rail mounting

(d) Plug-in micro relays (electromechanical) shall have the following general features:

- Typical input current at rated voltage shall be within range of 3-7mA
- Shall have a response time of less than 5ms at rated voltage
- Contact material shall be made of silver nickel AgNi
- The contacts shall be double throw (SPDT)
- Switching voltage up to 250V AC/DC depending on the application
- Power contacts up to 16 A
- High degree of protection IP67
- Safe isolation according to DIN EN 50178 between coil and contact

- Dimensions W / H / D - 5 mm / 28 mm / 15 mm or equivalent
- Insulation - input/output 4 kV (50 Hz, 1 min.)
- Ambient temperature (operation) - 40 °C ... 85 °C
- Mechanical service life - min 2 x 10^7 cycles
- Standards/regulations - IEC 60664, EN 50178, IEC 62103

(e) Plug-in solid state relays shall have the following general features:

- Typical input current at rated voltage shall be within range of 3-7mA
- Shall have a typical switch-on time of 20µs at rated voltage
- Contact material shall be made of silver nickel AgNi
- Switching voltage up to 250V AC/125V DC depending on the application
- Contacts continuous current of up to 5 A
- High degree of protection IP67 and Vibration and shock-resistant
- Dimensions W / H / D - 5 mm / 28 mm / 15 mm or equivalent
- Insulation - input/output 2.5 kV (50 Hz, 1 min.)
- Ambient temperature (operation) - 25 °C ... 60 °C
- Standards/regulations - IEC 60664, EN 50178, IEC 62103

3.5.4.4 ***Miniature interface auxiliary plug-in relay modules***

(a) These relays shall be used for interface circuits where contact multiplication is required and other interfacing functions as per particular specification or design requirements

(b) The relay module shall consist of a plug-in relay, socket and a holder

(c) The relays shall have 4 c/o (4 SPDT) contacts rated 6 A continuous current

(d) Rated coil voltage shall be 110VDC 0r 24VDC depending on application

(e) Relay shall have gold contacts Cadmium-free

(f) Shall have an integrated LED and freewheeling diode

(g) Shall have Integrated test button for manual actuation and locking of output contacts

(h) Relay Shall have clearly visible mechanical status indication

(i) The socket shall have screw connection terminals.

(j) The relay shall be held in place by a wide thick plastic holder

(k) The Holder shall have Snap-on mounting on DIN rail

(l) The socket shall not be wider than 27mm

(m) Basic ratings:

(i) **Plug in relay**

Rated control supply voltage, Ur	24VDC or 110VDC
Coil Operating voltage	Ur ±20%
Coil power consumption	<1W
Output circuits	11-12/14, 21-22/24, 31-32/34, 41-42/44
Contact material	AgNi/Au 5 µm
Maximum switching voltage	250 V DC / 250 V AC
Contacts rated operational current	6A
Maximum switching (breaking) power	1500 VA
Contact resistance	≤ 100 mΩ
Mechanical lifetime	> 2 x 10^7 switching cycles
Electrical lifetime	> 10^5 switching cycles
operating time	<16ms
rated insulation voltage	>250VAC
Rated impulse withstand	
between coil and contacts	2.5 kV AC
between open contacts	1.5 kV AC
between c/o (SPDT) contacts	≥ 2 kV AC
Clearance between coil and contacts	≥ 1.6 mm
Creepage distance between coil and contacts	≥ 3.2 mm
Degree of protection	IP 40
Ambient temperature range	-40...+70 °C
Product standard	EN 60810-1, EN 60255-23, IEC 61810-7

(ii) **Socket**

Rated current	12A
Degree of protection	IP 20 B (EN 60529)
Temperature range	-40...+85 °C
Connection type	screw connection
Maximum number of wires per connecting terminal	2
Wire size with wire end ferule	2 x 1.5 mm^2
Wire size without ferule	2 x 2.5 mm^2
Mounting	DIN rail (EN 50022)
Socket Material	PA 6+GF - V2
contacts Material	CuZn33
contact surface	5 µ tinned
terminals	8 µ galvanized
combi screw M3	8.8 Steel, 5µ nickelized
Insulation voltage	> 3 kV
Isolation between coil and contacts	EN 61984
Clearance and creepage distance	EN 61984

3.5.5 Trip circuit/coil supervision relays.

3.5.5.1 Trip circuit/coil supervision relays shall be provided for circuit breakers trip circuit/coil supervision and Lockout trip relay circuit/coil supervision.

3.5.5.2 Trip circuit supervision relays shall have a time delayed drop off (100 millisecond minimum) and shall be provided with self-resetting indicators or approved equipment.

3.5.5.3 Monitoring of breaker trip coil in both open and close position shall be provided.

3.5.5.4 Relays will have green LED which will light when circuit is okay

3.5.5.5 Relays shall have a minimum of two SPDT heavy duty contacts with at least 3A continuous current rating at 125V for interface to existing control and automation system.

3.5.5.6 The relay shall be designed and have rugged construction for reliability / dependability over a wide temperature range, even under extreme environmental conditions.

3.5.5.7 The supervision current shall always be less than 1.5 mA to avoid unwanted operation of the trip coils.

3.5.5.8 Shall be panel mounted, flush mounted on the front of the panel with connections from the rear.

3.5.6 DC Supply supervision relay

3.5.6.1 The relay shall be capable of monitoring the DC supply to which it is connected and indicating failure. It shall have at least 4NC potential free contacts

3.5.6.2 The relay shall have a `time delay on drop-off' of not less than 100 milliseconds and be provided with operation indicator/flag/LED clearly visible. Green LED shall be lit on the relay when supply is available and okay

3.5.6.3 The relay shall detect supply DC failure after DC voltage falls below 70–90% (dependent on application) rated or exceeds 120% rated for a time period exceeding 100ms.

3.5.6.4 Green colour supervision lamps of clustered LED type shall be provided on the panel to indicate availability of healthy DC supply.

3.5.7 AC Voltage monitoring relays

3.5.7.1 They shall monitor under and over voltage in each phase for a three-phase relay. There shall be a dial for setting the under-voltage level and another dial for setting the over voltage level.

3.5.7.2 They shall detect Phase failure from over or under voltage as described above or from frequency failure and output an alarm

3.5.7.3 They shall monitor Phase sequence and output an alarm in case of failure

3.5.7.4 They shall have an Adjustable hysteresis for output contact drop off or pick up

3.5.7.5 They shall have an Adjustable time delay for output contact drop off or pick up

3.5.7.6 Shall have at least four (4) SPDT contacts

3.5.7.7 Shall have at least three status indication LED's. They shall have a green LED for healthy status, yellow LED status for unhealthy status and a blinking LED for time delay.

3.5.8 Panel Indication meters

3.5.8.1 General requirements

(a) All Panel mounted instruments and meters shall be flush-mounted, back-connected, dust-proof and heavy-duty. They shall have a removable cover, either transparent or with a transparent window.

(b) Panel indication shall be of digital type unless where specified in particular specifications.

3.5.8.2 Analogue panel indication meters

Where Analogue panel meters are specified, they shall have at minimum the following features:

(a) scale plates shall be of a permanent white circular or rectangular finish with black pointer and markings,

(b) shall have a clear transparent non-reflective window and clearly readable long scale.

(c) Shall be of accuracy class 1.5 or better, the maximum error shall be not more than one and a half (1.5) percent of full-scale range.

(d) Their cut out shall be DIN standard 1/4DIN, or 1/8 DIN.

3.5.8.3 Digital Panel Indication Meters

(a) There shall be four types of digital panel meters depending on inputs, these are:

(i) Digital indication meter for Instrument/process signals with a 4-20mA DC current input

(ii) Digital DC voltmeter/Ammeter with a DC input voltage whose range is selectable and an external shunt for DC current ammeter.

(iii) Digital AC ammeter with an AC current input from a CT

(iv) Digital AC voltmeter with an AC voltage input (phase-phase or phase-neutral)

(b) The meters shall site programmable/configurable for scaling, range set up etc. They shall have at least three buttons on the front for this purpose.

(c) Indication meters shall meet or exceed accuracy Class 1, according to IEC 62053-11.

(d) Display **MUST** be 5-digit LED with characters sized at least 14mm for all digital meters.

(e) They shall be panel mounted, flush mounted on the front of the panel with connections from the rear.

(f) They shall have buttons and menu for configuring their parameters such as

(i) Input range

(ii) Output range

(iii) VT/CT ratio

(iv) Scaling factor

(g) They shall meet the following minimum specifications.

(i) Inputs and accuracy range

Input Range	Resolution	Input Resistance	Error at 25°C
DC Current for digital Instrument/process signals indication meters			
±20.000 mA	1.0 µA	10 Ω	0.01% FS ± 2 counts
DC Voltage for digital DC voltmeter/Ammeter			
±200.00 mV	10 µV	1 GΩ	0.01% FS ± 2 counts
±20.000 V	1 mV	10 MΩ	0.01% FS ± 2 counts
±300.00 V	10 mV	10 MΩ	± 0.4 V
AC Current for digital AC ammeters			
0-5.000 A	1 mA	0.01 Ω	± 20 mA
AC Voltage for digital AC voltmeter			
0-300.0 V	100 mV	1 MΩ	± 0.8 V
0-600.0 V	100 mV	1 MΩ	± 0.8 V

(ii) Display

Readout Range	5 LED digits, 7-segment, 14.2 mm (.56"), red or -99999 to 99999
Indicators	Minus sign, decimal point,2 red LED lamps (configurable)
Display update rate	3 per second

(iii) A-to-D Conversion

A-to-D rate	>50 per second
Output update rate	
Signals > 50 Hz	>50 per second
Signals >3 to 50Hz	Signal frequency
Signals > DC to 3 Hz	3 per second

(iv) Maximum input Signal

Max applied voltage	600 VAC for 20, 200 and 300 V ranges, 125 V AC for other ranges
Current protection	8x for 20 mA, 1x for 5 A

(v) Power supply

Voltage range	85-264 VAC or 90-300 VDC
nominal	110VDC ± 20%,
Consumption	less than 3VA

(vi) Excitation Output (if specified in particular specifications)

level	24 VDC ± 5%, 50 mA
Output isolation	50 VDC to meter ground

(vii) Analog Output (if specified in particular specifications)

Output levels	4-20 mA, 0-20 mA, 0-10V, -10 to +10V (jumper selectable)
Scaling	Zero and full scale adjustable from -99999 to +99999
Resolution	16 bits (0.0015% of full scale)
Isolation	250V RMS working, 2.3 kV RMS per 1 min test

(viii) Relay Outputs (if specified in particular specifications)

Relay types	Two independent SPDT relays
Current ratings	8A at 250 VAC /24 VDC
Output common	Isolated commons for each SPDT relay
Isolation	250V RMS working, 2.3 kV RMS per 1 min test

(ix) Serial Data I/O (if specified in particular specifications)

Interface	RS485, RJ45 or terminal block connection.
Protocols	Modbus RTU
Data rates	300 to 19200 baud
Isolation	250V RMS working, 2.3 kV RMS per 1 min test

(x) Environmental

Operating temperature	0°C to 55°C
Storage temperature	-40°C to 85°C
Relative humidity	95% at 40°C, non-condensing
Ingress Protection	IP65

(xi) Dimensions

panel Cut-out	1/8 DIN 92mm X 45mm OR 1/4 DIN 92mm X 92mm depending on particular specifications or design requirement
Front dimensions	96mm X 48mm OR 96mm X 48 mm depending on particular specifications or design requirement
Device overall depth	less than 125mm without the connections

(xii) Connections

Type	Screw type
wire size	2X2.5mm2

3.5.9 Digital Panel Multi-Function Meters

3.5.9.1 Panel multifunctional meters shall be power transducers with an integrated display flush mounted on the panel used to indicate AC power parameters and transmit to remote equipment.

3.5.9.2 They Sshall be panel mounted, flush mounted on the front of the panel with connections from the rear.

3.5.9.3 The meters shall be site programmable/configurable for scaling, range set up etc. They shall have at least three buttons on the front for this purpose.

3.5.9.4 Shall meet accuracy class 0.2 as per IEC 61557-12

3.5.9.5 Shall have a fast Ethernet port 100base-T and support Modbus TCP

3.5.9.6 Shall have a large graphical LCD backlit display (at least 72 mm x 54 mm)

3.5.9.7 Shall be interfaced to SCADA system via Ethernet communication.

3.5.9.8 They Shall have the following specifications

(a) Measuring inputs

Measurement rate	continuous
AC input voltage range	
Phase-to-neutral L-N	3~ 400 V AC (+ 20 %)
Phase-to-phase L-L	3~ 690 V AC (+ 20 %)

voltage input type	Direct connection or voltage transformers
Rated Input current	3 phase AC 1A/5A selectable
Continuous current rating	10A
Current input type	from current transformers
Surge withstand capability	100 A for 1 s
Connection type	3P4W i.e., 3 phases, 4 conductors

(b) Measuring accuracy

Measured variable	Accuracy class acc. to IEC 61557-12
RMS Voltage	0.2
RMS current	0.2
Apparent power	0.5
Active power	0.2
Reactive power (VAR)	1.0
Cos φ	0.20%
Power factor	2
Phase angle	+/-1°
Frequency	0.1
Apparent energy	0.5
Active energy	0.2
Reactive energy	2.0

(c) Power supply

Rated range	95 … 240 V AC (50Hz) or 110 … 340 V DC
Nominal	110VDC ± 20%
Power consumption	< 10 VA

(d) Display & controls

Type	Monochrome, graphical LCD, light backlighting, dark text and digits
Resolution	128 x 96 pixels
Size W X H	at least 72 mm x 54 mm
Display refresh rate	0.33-3/sec adjustable
keyboard	at least four keys for Parameterization and viewing
Parameterization	Menu-driven parameterization and operation with plaintext display.

(e) Digital inputs and outputs

Number	at least 2 Digital Inputs & 2 Digital outputs
Digital Input rating	24VDC/7mA
Digital output rating	24VDC/100mA

(f) Communication

Interface	Ethernet 10/100 base-TX (fast Ethernet)
protocol	Modbus TCP/IP

(g) Connections

Type	Screw terminals
measuring and power supply terminals	Solid 1 x 0.5 ... 4,0 mm² 2 x 0.5 ... 2,5 mm² Finely stranded with end sleeve 1 x 0.5 ... 2,5 mm² 2 x 0.5 ... 1.5 mm²
Digital inputs & outputs	Solid 1 x 0.2 ... 2.5 mm² 2 x 0.2 ... 1.0 mm² Finely stranded with end sleeve 1 x 0.2 ... 2.5 mm² 2 x 0.2 ... 1.5 mm²
Ethernet	RJ45(8P8C)

(h) Enclosure

Housing design	Switching panel housing to IEC 61554
Housing dimensions W x H	96 mm x 96 mm
Overall depth	<60 mm
Mounting position	vertical
Degree of protection according to IEC 60529	Front: IP65 Rear: IP20

(i) Environmental conditions

Temperature range	Operating temperature - 10 °C to + 55 °C Storage and transport temperature, - 25 °C to + 70 °C
Relative humidity	95% at 25°C without condensation (normal conditions)
Operating altitude above sea level	up to 2000m or higher
Degree of pollution	2

(j) Functions and Features

Measurement values	Derivation of various RMS power parameters from the basic measured variables with maximum and minimum values, as well as mean values for phase-to-neutral voltages, phase-to-phase voltages and currents. Phase-to-phase voltage, Phase-to-neutral voltage, Current, Apparent power per phase, Active power per phase import/export, Reactive power per phase positive/negative, Total apparent power, Total active power import/export, Total reactive power positive/negative, Power factor, Total power factor, Line frequency, THD voltage, THD current, Active energy import / export, Reactive energy positive4 / negative, Apparent

	energy
	accessible registers for all measured values
Counters and power demand	A total of 10 energy counters capture active energy, reactive energy, apparent energy for off-peak and on-peak, import and export Counters and power demand Calculation and storage of the last demand period mean value for active power and reactive power for simple generation of load profiles using software. Programmable demand period from 1 to 60 mins. Configurable universal counter for counting limit violations and status changes at the digital input or output, or for indicating the active power or reactive power of a connected pulse encoder Working hours' counter for monitoring the runtime of a connected load.
Monitoring functions	Monitoring of 6 limit values. The limit values can be combined according to logic AND/OR. A group message that indicates the violation of at least one limit value can be generated using an OR operation. Phase sequence monitor. Status monitoring of the digital input. Monitoring the operating status of the meter
Input & outputs	Multifunctional digital input for tariff changing, demand period synchronization, status monitoring or acquisition of energy pulses from third-party devices. Multifunctional digital output, programmable as energy pulse output for active energy or reactive energy pulses, for showing the direction of rotation, indicating the working hours of the meter, outputting limit violations, or as a switching output for remote control via PC.
Standards	
Electromagnetic compatibility	EMC for industrial sector: IEC 61000-6-2 respectively IEC 61326-1:2005, table 2 EMC against unloading: IEC 61000-4-2: 2001-04 EMC against high frequency fields: IEC 61000-4-3: 2006-02

	EMC against conducted LF disturbance variables (industry): IEC 61000-6-4 EMC against conducted disturbance variables via HF fields: IEC 61000-4-6: 2001-12 EMC against magnetic fields with power engineering frequencies: IEC 61000-4-8: 2001-03 EMC against quick, transient electrical disturbances: IEC 61000-4-4: 2005-07 EMC against voltage drops and interruptions: IEC 61000-4-11: 2004-03 EMC against surge voltages: IEC 61000-4-5: 2001-12
other	pulse emitter: according to IEC62053-31
Mechanical dynamic stress	Low-temperature test: DIN EN 60068 Part 2-1:1995-03 Vibratory load (conditions of use): IEC 60068 Part 2-6:1995-03 / EN 60068 Part 2-6:1996-05 Vibratory load (transport conditions): IEC 60068 Part 2-6:1995-03 / EN 60068 Part 2-6:1996-05 Seismic conditioning (conditions of use) in accordance with IEC 60068 Part 3-3:1991-02/ EN 60068 Part 3-3:1993-09 Shock load (conditions of use): IEC 60068 Part 2-27:1987 / EN 60068 Part 2-27:1995-03 Shock test, withstand strength (conditions of use): IEC 60068 Part 2-27:1987 / EN 60068 Part 2-27:1995-03 Continuous shock (transport conditions): IEC 60068-2-29:1987 / EN 60068 Part 2-29:1995-03 Mechanical stability against bump and impact (conditions of use): IEC 60068-2-75:1997-08 Free fall of the unpacked device (transport conditions): IEC 60068-2-32:1975

3.5.10 Serial device server

A serial (EIA RS485, RS422, RS232) to Ethernet TCP/IP communication converter/gateway/server with an integrated Ethernet switch allowing multiple hosts on the TCP/IP network to communicate to multiple legacy serial devices. Shall have the following features.

3.5.10.1 Serial Device Server features

(a) 4 (four) RJ45/terminal block serial port interfaces

(b) Full Modbus RTU support on the serial ports with baud rates up to 230 kbps

(c) Convert Modbus RTU to Modbus TCP/IP
(d) Transparent Modbus TCP Client or Server mode
(e) Support at least 16 (sixteen) Modbus TCP masters in slave (server) mode
(f) Support at least 32 (thirty-two) Modbus TCP slaves in master (client) mode
(g) Fully compliant EIA/TIA RS485, RS422, RS232 serial ports (software selectable)
(h) Raw socket mode allowing conversion of any serial protocol.
(i) Transmit serial data over an IP network.
(j) Support for Modbus TCP, DNP3, WIN, TIN, and Microlock serial protocols
(k) Point-to-point and multi-point serial modes
(l) Baud rates up to 230 kbps

3.5.10.2 Integrated Ethernet Switch features

(a) 4-8 (four to eight) fast /gigabit Ethernet ports
(b) Support various 10/100/1000BaseTX or 100BaseFX port options:
(c) RJ45 for 10/100baseTX ports and LC/SC/ST ports for 100 base FX ports
(d) High performance and throughput Ethernet switching
(e) Full IEEE 802.3 compliance: 802.3-10BaseT; 802.3u-100BaseTX, 100BaseFX; 802.3x-Flow Control; 802.3D-MAC Bridges; 802.1D-Spanning Tree Protocol; 802.1p-Class of Service; 802.1Q-VLAN Tagging; 802.1w-Rapid Spanning Tree Protocol; 802.1x-Port Based Network Access Control; 802.1Q-2005 MSTP;
(f) Non-blocking, store and forward switching with Switching latency not exceeding 5 µs at 100Mbps.
(g) Switching bandwidth: 1.2 Gbps
(h) MAC addresses: 2048
(i) MAC address table size: 16kbytes

3.5.10.3 Cyber Security Features

(a) Multi-level user passwords
(b) SSH/SSL/SFTP (128-bit encryption)
(c) Enable/disable ports, MAC based port security.
(d) Port based network access control (802.1x)
(e) VLAN (802.1Q) to segregate and secure network traffic.
(f) RADIUS centralized password management
(g) SNMPv3 authentication and 56-bit encryption

3.5.10.4 Fully managed switch with the following software features

(a) Simple plug and play operation – automatic learning,
(b) negotiation, and crossover detection
(c) MSTP (802.1Q – 2005, formerly 802.1s

(d) RSTP (802.1D-2004) and Enhanced Rapid Spanning Tree
(e) (eRSTP) network fault recovery (<5ms)
(f) Quality of Service (802.1p) for real-time traffic
(g) VLAN (802.1Q) with double tagging and GVRP support
(h) Link aggregation (802.3ad)
(i) IGMP snooping for multicast filtering.
(j) Port rate limiting and broadcast storm limiting.
(k) Port configuration, status, statistics, mirroring, security
(l) SNTP time synchronization (client and server)

3.5.10.5 Device Management/configuration

(a) HTTPS graphical web-based, SSL (128-bit encryption) interface
(b) SNMP v1, v2c, v3 (56-bit encryption)
(c) Telnet, VT100, SSH/SFTP (128-bit encryption)
(d) Command Line Interface (CLI)
(e) RSA Key Management (1024 bit key)
(f) Authentication and Accounting – TACACS+ (encrypted),
(g) RADIUS client, PPP

3.5.10.6 Rugged Rated for Reliability in Harsh Environments

(a) Immunity to EMI and heavy electrical surges
    (i) Meets IEEE 1613 (electric utility substations)
    (ii) Exceeds IEC 61850-3 (electric utility substations)
    (iii) Exceeds IEC 61800-3 (variable speed drive systems)
    (iv) Exceeds IEC 61000-6-2 (generic industrial)
(b) Fully independent 2kV (RMS) isolated serial ports
(c) -40°C to +85°C operating temperature (no fans)
(d) Contain no moving parts such as fans
(e) galvanized steel enclosure at least 18 AWG thick

3.5.10.7 Mounting and enclosure:

(a) DIN or panel mount
(b) Ingress protection: at least IP40
(c) galvanized steel enclosure

3.5.10.8 Power Supply.

(a) Fully integrated power supply (no external adaptors)
(b) Universal high-voltage range: 88-300VDC
(c) Screw connection terminal blocks
(d) Shall be connected to 110 ± 20% VDC station supply

3.5.10.9 Environmental Testing.

shall be tested to the same standards as protective relays including IEC 60255-21-1, IEC 60255-21-2, IEC 60255-21-3, IEC 60255-26:2013, EN 61000-4-2, EN 61000-4-4, and IEEE C37.90.1.

3.5.10.10 Alarm Output.

There shall be an alarm contact output to signal internal errors and device malfunctions. The alarm contact shall be fail safe

3.5.10.11 Warranty: 5years

3.5.11 Industrial Ethernet switches

Shall meet the following requirements.

3.5.11.1 Rugged Rated for reliability in harsh environments

(a) Immunity to EMI and heavy electrical surges
(b) Zero-Packet-Loss Technology
  (i) Meets IEEE 1613 Class 2 (electric utility substations)
  (ii) Exceeds IEC 61850-3 (electric utility substations)
  (iii) Exceeds IEC 61000-6-2 (generic industrial)
(c) -40° C to +85° C operating temperature (fan less)
(d) Ingress Protection of at least IP40
(e) 18 AWG (1.27mm) galvanized steel enclosure
(f) Shall not contain moving parts e.g. fans

3.5.11.2 Shall be DIN or panel mounted.

3.5.11.3 Shall have 24V DC supply With terminal block screw terminal connections

3.5.11.4 Shall have a critical alarm relay with at least one SPDT contact

3.5.11.5 Compliant with IEC 61850-9-2 Sampled Values and IEC 61850-8-1 GOOSE Message

3.5.11.6 Compliant with IEE 802.3, 802.3u, 802.3x, 802.3ab, 802.1d, 802.1p, 802.1Q, 802.1Q-2005, 802.1w', Link Aggregation etc.

3.5.11.7 Store & Forward switching method with Switching latency not exceeding10.5 µs

3.5.11.8 Shall be a managed switch with a Rugged Operating System (ROS®) supporting the following features.

(a) Simple plug-and-play operation – automatic learning, negotiation, and crossover detection
(b) MSTP 802.1Q-2005
(c) RSTP (802.1w) and Enhanced Rapid Spanning Tree
(d) eRSTP network fault recovery
(e) Quality of service (802.1p) for real-time traffic
(f) Port rate limiting
(g) Port configuration, status, statistics, mirroring, security

(h) SNTP time synchronization (client and server)
(i) Web-based, Telnet, CLI management interfaces
(j) SNMP v1/v2/v3
(k) Remote monitoring (RMON)
(l) Rich set of diagnostics with logging and alarms

3.5.11.9 Rugged Operating System (ROS®) shall support the following Cyber security features

(a) Multilevel user passwords
(b) Secure File Transfer Protocol (SFTP) using SSH
(c) Web-based management using SSL
(d) RADIUS-Authentication service for device management
(e) 1024-bit RSA encryption for key management and key exchange
(f) Integrated router/firewall/VPN;
(g) Full IPsec virtual private networking;
(h) VPN with 3DES, AES128, AES256 support;
(i) Enable/disable ports,
(j) MAC-based port security;
(k) Port-based network access control (802.1x);
(l) VLAN (802.1Q) to segregate and secure network traffic;
(m) SNMPv3 encrypted authentication

3.5.11.10 Precision Time Protocol (PTP) support.

(a) Shall support time synchronisation on all the ports at an accuracy exceeding 1µs
(b) All ports shall support transparent clock, slave clock or master clock time synchronisation features as per IEE1588 v2.

3.6 CONTROL PANELS AND CABINETS REQUIREMENTS

3.6.1 General requirements

3.6.1.1 Panels and cabinets shall be of robust construction, formed of a steel frame and covered with smooth steel plate. The steel plate shall be folded sheet steel of not less than 2.0mm thick and properly stiffened to prevent distortion. Panels shall normally be covered at their rear with hinged doors. The frames of the boards and panels shall be designed to permit firm anchoring on the floor. The frames shall permit easy erection, and allowance shall be made for extension of the board by similar additional panels. All enclosures shall be ventilated so that the temperature

inside the enclosure does not rise more than 50C above ambient even with possible heaters connected.

3.6.1.2 All Equipment and materials for use in Switchboards, panel and cabinets shall not be flammable and shall be self-extinguishable and resistant to flame propagation. All plastic materials to be used in the panels shall have flammability rating of at least V-0 as per UL 94.

3.6.1.3 Outdoor-cabinets and cabinets for moist environments shall be provided with thermostat-controlled heaters to inhibit collection of moisture. The heater must be arranged not to overheat any cables or equipment. Openings for drainage of condense shall be provided at the lowest point in the cabinets.

3.6.1.4 Panels and other enclosures shall be designed with an ingress protection suitable for the equipment mounted inside. However, as a minimum all outdoor panels and cubicles shall have IP rating of 55 or higher and for indoor panels and cubicles IP rating of 54 and higher.

3.6.1.5 All major or important compartments containing electrical equipment shall be provided with a single phase 16 A square pin socket and internal LED lighting facilities switched off by a door switch.

3.6.1.6 Unless otherwise specified or agreed upon, all instruments, apparatus and devices on the panel fronts shall be provided for flush mounting. Panels with flush mounted devices shall be provided with transparent cover. The cover shall be a hinged to allow resetting and adjustment. All terminals and all equipment shall be accessible without dismantling other components. Equipment shall not be mounted in swing-out doors. However, proper swing out frames may be used provided they can be opened will full load without twisting or distorting the panel. Windows shall be provided in front of rack mounted equipment.

3.6.1.7 All panels shall be provided with LED Lamp lighting fixture rated for 240V AC/110V DC/24VDC supply, controlled by panel door switch and fuse. The number of such LED lighting fixtures shall be at least two per panel.

3.6.1.8 All panels, boards and cabinets doors shall be provided with handles and key operated locks. All doors and removable covers shall be gasketed all round with neoprene gaskets, ventilating louvers with screen and filters.

3.6.1.9 The panel shall be provided with 240V, 50Hz. 15 A, 3 pin British type universal socket with switch. The socket with switch shall be mounted inside the panel at convenient location.

3.6.1.10 The new panels, cabinets and switchboards shall be constructed to fit in the existing space where the current panels, boards & cabinets are located with cable entry from bottom.

3.6.1.11 They shall have easy access to the wiring inside through the rear side of the panel.

3.6.1.12 The panels shall be factory wired with the reception terminal blocks for connection to the instrumentation transformers, circuit breakers tripping coils, alarm circuits and plant equipment.

3.6.1.13 The panels shall be mounted on approved form of anti-vibration mounting.

3.6.1.14 Relays, electronic cards and devices shall be identified with labels permanently attached to the device.

3.6.1.15 All relays shall be firmly supported on their bases to avoid mal-operation due to vibrations when the unit is running.

3.6.1.16 Printed circuit boards SHALL NOT be mounted on the panels. All printed circuit boards shall be contained in enclosures with an ingress protection of at least IP20 with terminal blocks and ports on the enclosures for interface.

3.6.1.17 The bottom of the panels shall be sealed by means of removable gasketted steel plates. Gland plates for the bottom entry shall be at 100mm above the floor

3.6.1.18 A base plate for each panel shall be provided not exceeding 10cm in height.

3.6.1.19 All panels shall incorporate a common internal copper Earthing bar onto which all panel earth connections shall be made. Suitable stud or holes with the right screws shall be provided for connection to the main earth.

3.6.1.20 Appropriate eye bolts shall be provided to facilitate for easy lifting of the panels.

3.6.1.21 Panels and switchboards shall be labelled on the front and back at the top.

3.6.1.22 Marshalling cabinets, panels or boxes containing terminal blocks only shall be at least 400mm wide with a hinged door/s.

3.6.1.23 Device tagging shall be as per ISO/IEC 81346 and VGB RDS PP standards.

3.6.1.24 Terminal identification shall be as per IEC 61666.

3.6.2 Wiring

3.6.2.1 All panel internal wiring shall be stranded flexible copper conductor with, suitable for operation at voltages below 1000 V and in compliance with the provisions of the applicable IEC Recommendations. Conductors shall not be smaller than 2.5 mm^2 for current & voltage transformer circuits and 1.0mm^2 for all other control circuits. The selection of conductor sizes for current transformer circuits shall be supported by calculations.

3.6.2.2 Wire runs shall be neatly arranged in trunks and properly clamped Wiring shall be securely supported, neatly installed by lacing and tying, readily accessible and connected to equipment terminals and terminal blocks. Flame retardant, plastic wiring channels/troughs with strap on plastic covers shall be used for this purpose. Sufficient space in channel for modification of wiring shall be kept. For

wiring within boards, the "bunch" pattern shall be adopted. Ample space shall be provided for running of cable within the enclosures.

3.6.2.3 The screens or screened pairs of multicore cables shall be earthed in accordance with a coherent Earthing philosophy to be worked out by the Contractor and approved by the Project Engineer. The screen and earth wires shall be terminated in terminals dedicated for this use. All free conductors in connecting cables shall be terminated in terminals that shall be temporarily connected to earth and special marked as specified in proceeding clauses.

3.6.2.4 All conductors cross section must be checked against max load current, allowable burden on measuring transformers, short circuit values, voltage drop, protection requirements and selectivity. Conductors however shall have minimum cross sections as follows:

(a) Measuring cables from VT & CT output - 2.5 mm^2
(b) Control and other measuring cables - 1.0 mm^2
(c) PLC wiring - 0.5 mm^2
(d) Power cables according 120 % max load current with a minimum of 2.5 mm^2
(e) Analogue signal cable-shielded twisted pairs-0.75mm^2
(f) Networking cables- shielded twisted pairs -cat6A.

3.6.2.5 The standard phase colours for AC supply conductors including CT & VT output are: Brown for L1 phase, Black for L2 phase, Grey for L3 phase, blue for neutral and Green with yellow stripe for Earth/ground wires as per relevant recent IEC standard.

3.6.2.6 For auxiliary DC Supply, Red for Positive and White for negative. Conductors for instrumentation and control signals shall be coloured according to DC voltage, source, and function. To differentiate DC wiring a coherent method of wire colour identification shall be developed for the project and approved by the employer. Colours specified for AC circuits shall not be used for DC circuits.

3.6.2.7 Multi-stranded conductor ends shall be fitted with a suitable crimped thimble (bootlace ferrule type). The thimble shall be of correct type and length according to the core size and crimple tools shall be specially adapted to the thimble and cross section used. Each wire shall be separately terminated unless otherwise approved.

3.6.2.8 All connections shall be made at numbered terminal blocks; joints, splicing or paralleling of wires will not be accepted.

3.6.2.9 Accidental short circuiting of certain wires is likely to result in malfunction of equipment, such as closing or tripping of a breaker or positive and negative wires, these wires shall not be terminated on adjacent terminal blocks.

3.6.2.10 It shall be possible to work on small wiring for maintenance or test purposes without making a switchboard/panel dead.

3.6.2.11 Wire termination shall be made with solder less crimping type of tinned copper lugs which firmly grip the conductor. Insulation sleeves shall be provided at all the wire terminations.

3.6.2.12 Engraved core identification plastic labels, factory marked to correspond with panel wiring diagram shall be fitted at both ends of each conductor. Wire labels shall fit tightly on the wire and shall not fall off when the wire is disconnected from terminal blocks. These markers shall be of an approved type attached to the conductor insulation.

3.6.2.13 The wire numbers shall be a combination of source device tag: terminal and destination device tag: terminal.

3.6.2.14 The wire labels shall be factory numbered, indelibly marked by engraving with black letter on a white background PVC casting. All wires directly connected to trip circuit breaker or devices shall be distinguished by white letter on a red background PVC casting.

3.6.2.15 The method of wire labelling shall be subject to approval by the Employer; Wire label shall contain both origin device/terminal block terminal Number and destination device/terminal block terminal. If single numeric digit ferrule is to be used Number 6 and 9 shall not be used

3.6.2.16 The unused space on the front or rear of the panels shall be kept clear of wiring to facilitate addition of devices without rewiring associated portion of the panels.

3.6.2.17 The contractor shall be responsible for the completeness and correctness of the internal wiring and for the proper functioning of the connected equipment.

3.6.3 Phase arrangement

3.6.3.1 The standard phase arrangement when facing the front of the panel shall be L1-L2-L3-N, and L-N from the left to right, from top to bottom, and front to back for A.C three-phase and single-phase circuits. For DC circuit it shall be N-P from left to right, P-N from top to bottom and front to back. All relays, instruments, other devices, buses and equipment involving three-phase circuit shall be arranged and connected in accordance with the standard phase arrangement wherever possible.

3.6.4 Terminal blocks

3.6.4.1 **General requirements**

(a) All panel wiring shall terminate at terminal blocks, the terminal blocks shall be of the moulded type and provided with barriers to separate power from control cables. It shall be possible to replace a single terminal block

without dismantling a whole column. They shall be clearly marked, the designations being those entered in the respective wiring diagrams. ALL terminal blocks shall be capable of receiving 2.5mm2conductors.

(b) Only one conductor shall be connected to each side of a terminal block and the branch-offs shall be made by interconnecting the necessary number of neighbouring blocks by means of shorting plugs.

(c) Terminal blocks using screws acting directly on the wire (conductor) as well as spring type terminal blocks are NOT acceptable. To avoid squeezing of the wire the screw pressure shall be applied by a pressure plate having smooth edges. 'OBA' terminal blocks are not acceptable. Only terminal blocks that are operated using screw drivers are acceptable.

(d) Terminal blocks for different voltages SHALL NOT be mixed between one another. All conductors in a multi-core cable shall be terminated on the same terminal block column if they are of the same voltage. The blocks shall be grouped for each voltage and they shall be clearly marked for easy identification of the system voltage. Terminations on T.B. shall be grouped function wise on one region of T.B. (may not be full T.B)

(e) There shall be at least 20 % spare terminal blocks on each block.

(f) All spare contacts/terminals of the panel mounted equipment and spare cores/conductors of cables terminated in a panel shall be wired up to terminal blocks with ferrule numbers starting with U.

(g) Moulding materials making up the terminal blocks shall be self-extinguishing or resistant to flame propagation, substantially non-hydroscopic and shall not carbonized when tested for tracking. The insulation between any terminal and framework between adjacent terminals shall with stand test of 2kV RMS for one minute. The moulding shall be mechanically robust to withstand handling while making terminations.

(h) Terminal blocks shall be located at least 300mm from the bottom of the panel and shall be easily accessible. All terminal blocks shall be vertically oriented in a panel; horizontally aligned terminal blocks shall NOT be accepted. Marshalling Panels containing terminal blocks only shall be at least 400mm wide.

(i) Each Individual Terminal Block shall be marked with a distinctive Number, which shall be the same Number used in the drawings, for identification purposes. The TB number shall be engraved in black numbers in white background.

(j) Each set of terminal Block shall be identified by a label to distinguish it from another set of terminal blocks with similar Numbers for the individual terminal blocks. The labels used will match those used in the drawings.

3.6.4.2 **Terminal blocks for control circuits**

(a) Shall be used for all control/metering/protection circuits (all other circuits apart from those described in clause 3.6.4.2 rated up to 125V DC wiring:

(b) Shall be rated as follows:

i. Voltage: ≥600V AC,

ii. Continuous current rating @ 40oC ambient: ≥16 A,

iii. Rated impulse withstand voltage: ≥6KV

iv. Cross sectional area: ≥6mm2

(c) Shall have a Knife disconnect/isolator between the wire terminals

(d) Shall have two slots on both sides of the knife disconnect for inserting shorting plugs or "banana" test plugs.

(e) Each terminal block shall have two terminals for wire connections on each side of the terminal block i.e four connections per terminal block

(f) Shall be suitable for connecting multi-stranded conductors of cross-sectional area of 1 mm2 – 4mm2 with edge processing (bootlace)

3.6.4.3 **Power terminal blocks**

(a) Shall be used for single phase and three phase power feeder circuits rated below 150A.

(b) Shall be rated as follows:

i. Voltage: ≥1000V AC,

ii. Continuous current rating @ 40˚C ambient: 75–250 A,

iii. Rated impulse withstand voltage: ≥8KV

(c) Shall be flame resistant and suitable for operating voltages of 1kV.

(d) Shall consist of threaded studs and nuts M4-M12, partition plates and covers. Cable lugs (eye/horse shoe) shall be used to terminate the cables to the power terminal blocks

(e) Nuts shall be locknut, locking nut type that can resist vibrations

(f) The conductors shall be attached to the terminals using crimped cable lugs. Each connection shall be secured by tightening the hexagonal nut. The cable lugs shall be put between the washers on the clamp support.

(g) The terminals shall have an integrated hinge cover, with a high degree of finger safety. When closed, the cover shall lock onto the terminal and protect the contact from accidental contact.

(h) Neighbouring terminals shall have Shock protection provided by partition plates. The cover strips shall be locked into the guides of the partition plates and held with clips to prevent them slipping to the side.

(i) Shall be suitable for connecting conductors of cross-sectional area 2.5mm^2 – 50mm^2.

(j) Circuits rated over 150 A shall use bus bar connections and not terminal blocks.

3.6.5 Labelling

3.6.5.1 All Panels, switch boards, cubicles and all front mounted equipment as well as equipment mounted inside the panels shall be provided with individual labels with equipment designation engraved for identification. The labels or escutcheon plates shall be mounted directly above the respective equipment with English description and also where appropriate the Device tag as per ISO/IEC 81346 and VGB RDS PP standards

3.6.5.2 The Device Name/Number shall correspond to the Name/Number used in the drawings. All panel devices shall also be provided tag numbers corresponding to the ones shown in the panel internal wiring drawing to facilitate each tracing of wiring. These labels shall be mounted directly by the side of the respective equipment and shall not be hidden by the equipment wiring.

3.6.5.3 Labels shall be made of Aluminium anodized plate P.V. Castings. The entries on the plates shall be indelibly marked by engraving with black letter on a white background. The plates shall be made of weatherproof and corrosion-proof materials and shall not be deformed under the service conditions at the site.

3.6.5.4 All devices e.g., relays, timers, MCB's, instruments etc. shall be given tags as per ISO/IEC 81346 and VGB RDS PP standards with name of device, corresponding to the ones shown in the panel internal wiring drawings.

3.6.5.5 Major equipment shall be provided with a rating plate containing the necessary information specified in the relevant IEC standards.

3.6.6 Auxiliary Supply

3.6.6.1 Contractor shall reconnect the existing AC / DC supply for Switches, Panel illumination, space heater etc. and supplies for control and protections of existing panels. Where deemed necessary a fresh connection shall be made from the power distribution boards, the contractor shall be expected to supply cables and associated switchgear e.g. circuit breakers where necessary.

3.6.6.2 Devices and equipment shall be suitable or adopted for 110V (±20%) DC supply and 240V/415V (±10%) AC supply which is existing at the station.

3.6.7 Earthing (Grounding)

3.6.7.1 There shall be exposed and accessible earthing bars in all panels connected to the existing station Earthing/grounding system. Cables shall be earthed and shielded in accordance with earthing philosophy worked by contractor. All connections between equipment and the Earthing network shall be exposed (not embedded) and easily accessible for checking of the transition points.

3.6.7.2 Contractor shall take the necessary measures and furnish the required material for the safe Earthing of:

(a) All steel structures, metal parts and overhead ground wires.
(b) All metal parts, even if these do not constitute a conducting part of an electric system of the plants, such as machinery, operating desks, piping, sewers, rails, metal tanks, lighting, fixtures, cable racks, etc.
(c) All operational electric systems such as power and instrument transformers, lightning arresters etc.

3.7 CABLES AND CONDUCTORS

3.7.1 General Requirements

3.7.1.1 ALL Electric CABLES SHALL BE STEEL-WIRE ARMOURED (SWA).

3.7.1.2 The cables shall be marked with item designation in both ends as well as by entrances in enclosures. The cable marking shall be fire proof

3.7.1.3 Cable markers shall be installed at the beginning and end of the cable

3.7.1.4 Cables shall be neatly arranged, well supported and labelled at the glanding or termination point

3.7.1.5 No joints shall be allowed.

3.7.1.6 Cables shall be wound on strong drums arranged to take a round spindle of a section adequate to support the loaded cable drum during installation and handling. The drums shall be lagged with closely fitting battens that shall be securely fixed to prevent damage to the cable. Wooden drums shall be constructed of seasoned timber to prevent shrinkage of drums during shipment and subsequent

storage at site. Each drum shall be clearly marked including indication of direction of rolling.

3.7.1.7 The ends of the cables shall be suitably sealed to prevent ingress of moisture. The end of the cable left projecting from the drum shall be securely protected against damage by mishandling during transport and storage.

3.7.1.8 All control wiring shall be carried out with 1100V grade multi strand flexible copper conductor wires with HRPVC insulation and shall be flame retardant, vermin and rodent proof. Cables with twisted pairs for analogue signals (4-20mA,0-10V etc.) shall be shielded to reduce EM interference.

3.7.1.9 All conductors shall be multi-stranded copper. The conductor shall be new, clean, uniform in size, shape and quality, smooth and free from scale, splits, sharp edges and other harmful defects. The conductor shall be in accordance with IEC 60228. The conductor shall be filled with swelling powder to stop axial ingress of moisture.

3.7.1.10 The maximum continuous current carrying capacity and maximum permissible continuous conductor temperature, and the factors for determining such rating and temperature shall be based on recommendations found in BS 7671 requirements for industrial installations and IEC 60287, subsequent amendments and all conditions prevailing on the Site

3.7.1.11 All conductors cross section must be checked against max load current, allowable burden on measuring transformers, short circuit values, voltage drop, protection requirements and selectivity. Conductors however shall have minimum cross sections as follows:

(a) Measuring cables from VT & CT output - 2.5 mm2
(b) Control and other measuring cables - 1.0 mm2
(c) Power cables according 120 % max load current with a minimum of 2.5 mm2
(d) Analogue signal cable-shielded twisted pairs-0.75mm2
(e) Networking cables- shielded twisted pairs -cat6

3.7.1.12 The standard phase colours for AC supply conductors including CT & VT output are: Brown for L1 phase, Black for L2 phase, Grey for L3 phase, blue for neutral and Green with yellow stripe for Earth/ground wires as per relevant recent IEC standard.

3.7.1.13 For auxiliary DC Supply, Red for Positive and White for negative. Conductors for instrumentation and control signals shall be numbered clearly along the whole cable length for easy identification. To differentiate DC voltages and sources a coherent method of wire colour identification shall be developed for the project

and approved by the employer. Colours specified in clause 3.7.1.12 shall not be used for DC circuits.

3.7.2 Cable Laying and Routing

3.7.2.1 The final routing of HV and LV cables in indoor and outdoor installations shall be determined by the project engineer, from the directives given in Particular Specifications, and the principles shown in the layouts on the drawings. All cable routing must adapt to obstacles as tubes and ventilation channels. All penetrations of fire zone separations shall have the same fire classification as the separation itself.

3.7.2.2 Cables shall be laid on corrosion resistant (aluminium or hot dipped galvanised) cable trays and racks and by raising cables fixed to cable ladders. The trays shall be dimensioned and fixed so that it allows one man to climb on it in addition to the cable load. Each tray shall have at least 15 % spare capacity. The distance between each tray shall at least be 300 mm. For exposed outdoor installations cables shall be laid in covered cable trenches, plastic or steel ducts, depending on the available space.

3.7.2.3 Branch offs to individual equipment shall be fixed and supported all the way to the connection box. Cables and cable supports shall be properly fixed and secured against movement under short-circuit and strain caused by erection work. Particular attention shall be given to termination in confined areas where personnel may climb under erection and maintenance. Flexible tubes of “spiral type” shall not be used whereas tubes of “plica” type can.

3.7.2.4 Low power cables, i.e. cables for control, metering, etc. shall not be run in close parallel to high power cables or earth wires but shall be run at the greatest possible separating distance. The minimum distances are:

3.7.2.5 High and medium voltage versus control and measuring cables 800 mm

3.7.2.6 Low voltage power cables versus control and measuring cables 400 mm

3.7.2.7 Necessary EMC consideration shall be taken in accordance with EMC standards.

3.7.2.8 Additionally, cables for extra low power, i.e. mA and mV circuits and cables connected to low power solid state electronic circuits, shall be laid in separate sheet steel trays with covers.

3.7.2.9 Single-phase power cables shall be run in trefoil configuration, single-phase AC power cables shall be run in parallel. Special care shall be taken so that closed magnetic circuits do not form around single-phase cables.

3.7.2.10 Cables shall be laid in full runs and not spliced unless approved by Project Engineer. Termination of multi-stranded conductor ends shall be with a suitable crimped thimble as specified above. All other cable lugs or similar shall be of crimped type adapted to the cable type and cross-section used. The tools used should be special approved for the lugs and cable type used.

3.7.2.11 All cables shall be well marked with heat and oil resistant markers

3.7.2.12 The cable supplier's instructions regarding handling and bending radius shall be followed.

3.8 SOFTWARE

3.8.1 Submission

3.8.1.1 One copy of each different type of Software in a CD Rom, for Protection Relays, excitation controller, communication gateways, SCADA/HMI systems and other measuring and Control Devices whose Configuration and Settings is Software based and the connection Cable (Two for each type of device) shall be provided to employer when equipment is shipped to site

3.8.1.2 Logic diagrams/programs, PLC application programs, HMI/SCADA application programs, document management application and all other programs developed by the contractor or his supplier or subcontractor for operation of any device supplied under this project shall be provided to employer in editable format when equipment is shipped to site

3.8.1.3 Software used to develop Logic diagrams/programs, PLC application programs, HMI/SCADA application programs, document management application and all other programs required for operation of any device supplied under this project shall be provided for installation into at least two portable computers with all necessary licences

3.8.1.4 Intellectual property rights for IED/ controller Logic diagrams/programs, PLC application programs, HMI/SCADA application programs, document management application and all other programs developed by the contractor or his supplier or subcontractor specifically for operation of any device supplied under this project/contract SHALL BE CEDED to the employer after commissioning

3.8.1.5 All the software required for configuring or programming IED's, PLC's industrial PC's or any other programmable device whether explicitly mentioned in the specifications or not shall be supplied for installation to two portable PC's. The software shall also be capable of downloading and analysing data from the IED/measuring device.

3.8.1.6 It shall be possible to load the configuration/programming software into at Least two different Laptop Computers without requirement for additional licenses, to

facilitate Operations. Where additional licenses are required, the cost shall be considered to have been included in the bid.

3.8.1.7 All software/programs running on any of the supplied devices which may be required for installation/reinstallation into the device at any point in the lifetime of the device e.g. after changing some parts or repairing shall be supplied

3.8.1.8 One set of hard cover manuals for each type of software Supplied providing detailed

3.8.2 Software Configuration Management Plan

3.8.2.1 A Software Configuration Management (CM) Plan shall be produced defining the manner in which the changes to software are controlled and logged during the lifecycle of the project.

3.8.2.2 The Contractor shall identify the CM procedures to be applied to software development.

3.8.2.3 Specifically, the Contractor shall ensure that procedures exist to identify, document, control and maintain all software design changes. The procedures shall include a method for:

(a) Program and/or module version identification, registration and updating
(b) Obtaining approval to implement a modification
(c) Producing build documents at baseline
(d) Ensuring that modifications are properly integrated
(e) Keeping secure masters at separate locations
(f) The provision of validated copies
(g) The proper marking, storage and handling of software media
(h) The control of the identification inspection status
(i) The control of support software
(j) Ensuring that non-conforming software is identified and segregated.

3.9 SWITCHBOARD CUBICLES & EQUIPMENT SPECIFICATIONS

3.9.1 LV AC Switchboard Cubicles Structure

3.9.1.1 The switchboard shall be made of steel.

3.9.1.2 Switch boards shall be built up of separate metal clad- compartmented cubicles with earthed metal partitions. Partition steel plates, fastened to the structure, shall divide the cubicles into compartments.

3.9.1.3 The cubicle frames shall be made of steel bars at least 2.5 mm thick while Partition plates shall be of mild steel at least 2 mm thick. Steel shall be thoroughly cleaned by shot blasting or other approved methods before applying protective coating.

3.9.1.4 The position of the partition steel plates shall be adjustable to easily adapt the height of the compartments in steps of 25mm.

3.9.1.5 Each compartment shall be closed by an individual practicable steel door on the front, and by independent steel covers on the sides and back.

3.9.1.6 Fully independent compartments shall be provided for:

(a) Bus bars
(b) Cabling
(c) Switch-gear (circuit breakers, isolators, switches)
(d) Metering, control and protections.

3.9.1.7 Extensions of the switchboard, by addition of similar structures, shall be possible both to the right and to the left of the initial structure.

3.9.1.8 The switchboards shall be constructed to IP54 degree of protection to external environment in accordance with IEC 60529. A type test report for the degree of protection of the switchgear panels from a third party reputable testing laboratory certified by the National Standards and Testing Authority (NSTA) or a laboratory accredited to the NSTA shall be submitted with the tender for evaluation purposes.

3.9.1.9 The complete switchgear shall be such that the complete switchboard is of flush-front design.

3.9.1.10 The panels shall be equipped with eye bolts for lifting purposes.

3.9.1.11 The cubicles shall be tropical vermin proof

3.9.2 LV AC Switchboard Cubicles Covers and doors

3.9.2.1 All accessible parts of the switchboard shall be conveniently earthed by their assembly means, and shall not require any supplementary specific Earthing lead.

3.9.2.2 When installed, covers and doors shall ensure a minimum IP54 degree of protection according to IEC 60529.

3.9.2.3 Cover and doors shall be made of steel plates at least 2mm thick

3.9.2.4 Side- and back-covers

(a) Side- and back-covers shall be flush-mounted on the structure by means of spacers and self-tapping screws, which shall ensure the Earthing of the covers.
(b) For ease of maintenance, the covers shall be interchangeable and re-usable on any compartment of the same dimensions.

3.9.2.5 Doors

(a) Covers and doors shall be made of stainless steel sheet at least 2mm thick to ensure stability

(b) The doors shall be provided with internal hinges, ensuring the Earthing of the door.

(c) The doors shall be capable of withstanding the effects of maximum internal arcing fault without being blown off and causing danger to other equipment/personnel.

(d) The minimum opening angle of the door shall be 130 to 180 degrees.

(e) The doors shall be pre-punched to accommodate at any time:

i. Door locks

ii. Meters and other control components

iii. Plates for auxiliary components

(f) Doors for switchgear compartments shall be provided with an interlock, avoiding the opening of the door without previously switching-off the voltage supply to the compartment.

(g) All doors shall be equipped with at least two locks to avoid unauthorised access

(h) Circuit breakers knobs on compartment doors shall be provided with provisions for padlocking.

(i) ACB compartments doors shall have provision for padlocking the ACB: in isolated position and in off position to prevent un authorised operation.

3.9.3 LV AC Switchboard Cubicles Compartments

3.9.3.1 All compartments shall be able to withstand arching without flashover to neighbouring compartments as per IEC 61641 standard. The different compartments formed by the partition plates, shall comply with the following conditions:

3.9.3.2 **Bus bar compartments**

(a) The bus bar compartments shall be separated from the other compartments by finger-proof & fire proof shrouds.

(b) Bus bar compartment shall be located at the rear or top of the switchboard. But not at the bottom part of the switchboard

(c) The Bus bar compartment shall contain all phase and Neutral conductors, duly marked L1, L2, L3, and N.

(d) Protective conductors shall be located in a separate compartment, and shall be duly marked PE.

(e) All fixed connections shall be maintenance-free.

(f) The Bus bars shall be supported by insulators, made of flameproof and leakage-proof material

3.9.3.3 **Cable compartments**

(a) The cable compartment shall contain the out-going terminals for power and control circuits.

(b) Cable compartments shall be located either in the front or back of the cubicles depending on the available space as long as they isolated from the bus bars as per specified form of internal separation.

(c) Compartments MUST be at least 400mm wide for ease of working.

(d) All external control and power cables shall be terminated in the cable compartments.

(e) Form of internal separation 4b shall be adhered to. In that respect:

i. The cable compartment shall be separated from the other compartments by metallic shutters providing a degree of protection of minimum IP20 according to Standard BS EN 60529, to avoid the accidental downfall of parts from upper compartments.

ii. Out-going feeders shall have a degree of protection of minimum IP20 according to Standard BS EN 60529, to avoid accidental contacts

(f) Out-going feeders copper bars shall be provided as terminals, to allow the connection of several cables in parallel.

(g) All connection terminals and cables shall be mounted in such a way as to avoid any traction or compression forces being exerted on them.

(h) The bars and cable supports shall be designed to withstand the rated short circuit withstand current of the switchboard.

(i) Incoming and outgoing cables shall enter the compartment by the top or the bottom, with front or rear access provided to the connections.

(j) The cable compartments should have an anti-vermin guard plate giving protection against rats, rodents etc.

(k) The control cable terminations and power cable terminations shall be separated using a transparent arc barrier, to allow safe working on the control wiring termination while the switchboard is live

3.9.3.4 **Switch-gear and control compartments**

(a) Switch-gear and metering/control compartments shall be equipped with universal fixing plates, with holes in fixed steps allowing for the mounting of the different switch-gear and metering and protection components

(b) The air circuit breakers compartments shall have an inbuilt carriage for where ACB shall be mounted to facilitate isolation and withdrawal of the air circuit breaker.

(c) Switching device (ACB, MCCB and withdrawable modules) compartment doors shall be interlocked to the circuit breaker open /off position. The compartment doors shall not open unless the circuit breaker is switched off

(d) ACB's compartment door shall have openings be covered by a transparent clear cover for viewing ACB status,

(e) ACB compartments will have provision for padlocking the ACB in isolated or on/off position for safe isolations and operations

(f) Withdrawable modules compartments shall have mechanism to allow installation of plug in modules described in this specification. It shall have provision to place a padlock at the front of module racks to prevent unauthorised insertion of plug in modules.

(g) All the Protection Relays, Auxiliary Relays, power Meters Indication Lamps, Instruments, Control and selection switches and any other associated accessories shall be mounted in the Protection and Control compartments.

(h) Meters, switches, push buttons & signal lamps shall be mounted on the hinged door of the compartment, which shall be pre-punched to accommodate them.

3.9.4 Protection and finish

3.9.4.1 Protection against corrosion

(a) A zinc coating, providing protection against corrosion according to Standard EN10142, shall protect all steel parts forming the structure.

(b) All ferrous parts e.g. hinges, mounting parts, shall be protected by an electro galvanic zinc coating.

(c) Protection shall be verified in accordance with Standard BS EN 50298. Following tests shall be made:

i. "Wet heat", 6 cycle 24hours with 95% relative humidity at 40°C, according to Standard IEC 68-2-30

ii. "Salt fork", 2 cycle 24hours at 35°C, according to Standard IEC 68-2-11

3.9.4.2 Finish

(a) All edges shall be bent-over to avoid sharp edges

(b) All external doors and covers shall be flush-mounted to the structure.

(c) No hinges, fixing screws or bolts shall be visible from the front of the switchboard

(d) All external parts shall be given a primary coat of epoxy powder of minimum 75-micron thickness and two coats of contrasting colour of durable and weather resisting paint. The top coat shall be of uniform colour, preferably RAL 7035 or as shall be specified by the project engineer at design stage.

(e) The final thickness of the paint shall not be less than 80 Microns at any point within the switchgear panel

(f) External mounted equipment shall be flush mounted and shall be suitably labelled with permanent labels, black lettering on a white background, to the approval of the Engineer.

3.9.5 Arc Resistance & Protection

3.9.5.1 Switchboards shall meet requirements of IEC TR 61641

3.9.5.2 Main bus bars shall be Insulated to prevent the occurrence of arcing. Distribution bus bars shall have arc barriers to restrict the effects of arching

3.9.5.3 Switchboard shall be designed to have arc protection limiting arcing fault effects to the place of origin ONLY.

3.9.5.4 In addition, all possible Arc protective measures to limit the effects of an arc shall be employed such as:

(a) Arc barriers for limitation of arcs arc resistance to one section

(b) high-quality insulation of live parts

(c) provision of arc-resistant hinge and locking systems,

(d) provision for safe operation of withdrawable units or circuit breakers behind a closed door

(e) arc barriers on ventilation openings at the front

3.9.5.5 All possible protection of limiting the effects of internal arcing faults inside the switchboard shall be employed. In a worst-case scenario:

(a) Opening of doors and covers must be impossible

(b) Parts must not fly off

(c) No holes must form in the enclosure

(d) Indicators must not ignite

(e) PE conductor circuit for touchable cubicle parts must be functioning

3.9.5.6 A type test report for the switchboard arc testing in accordance with IEC TR 61641 from a third party reputable testing laboratory certified by the National Standards

and Testing Authority (NSTA) or a laboratory accredited to the NSTA shall be submitted with the tender for evaluation purposes

3.9.6 Bus bars specifications

3.9.6.1 The bus bars shall be single and air insulated. The bus bars and connections shall be made of high conductivity, high grade copper, and shall be in unit lengths.

3.9.6.2 Bus bars, connections and their support shall be rated for the rated continuous current under ambient conditions and capable of carrying the short-time current rating specified in the switchboard requirements

3.9.6.3 Provision shall be made for locking main bus bar and cable termination bus bars shutters separately in the circuit Breaker compartment.

3.9.6.4 The Bus bar shall be made of flat copper bars, of the same cross-section (for the same rating) over the whole width of the switchboard.

3.9.6.5 Main bus bars shall allow extensions of the switchboard both left and right with minimum possible disturbance to the existing bus bar.

3.9.7 Cubicles Wiring

3.9.7.1 Each cubicle shall have a terminal block at the cable compartments where all external cables such as Auxiliary DC supply, and control signals shall be terminated. All circuits for connection to external cables such DC & AC auxiliary supplies, control and Indications shall be wired up to the terminal Block at the cable compartments where external cables shall be connected. At least 10% spare terminals shall be provided on the terminal board for any future requirements.

3.9.7.2 Power cables to feeder and incomer circuits shall be terminated on the cable compartment to cable termination bus bars

3.9.7.3 Anti-condensation heaters shall be provided inside each cubicle. They shall be located so as not to cause injury to personnel or damage to equipment. The heaters shall be controlled by a hygrostat with a variable humidity and temperature setting. The Heaters shall be dimensioned to ensure that condensation cannot occur within the switchgear panel.

3.9.7.4 The 240V AC supply, for the heaters shall be controlled by a suitably rated single pole miniature circuit Breaker. All the switchgear panels shall be rodent and vermin proof.

3.9.7.5 The metal cases of all devices and equipment shall be connected to the earth bars with green/yellow insulated copper conductors of minimum 2.5 mm2 cross-section area.

3.9.7.6 All the Compartments including the hinged doors and all the Earthing points of the equipment installed/mounted in the cubicle shall be connected to the cubicle grounding conductor for external connection to the station Earthing System.

3.9.7.7 Earthing conductors shall be of annealed high conductivity copper. The earthing conductor on the primary equipment such as the Earth Switch and also for inter-cubicle earth-bonding as well as for external connection to the substation Earthing – grid shall be adequate to carry the rated switchgear short-circuit current

3.9.8 Withdrawable plug in modules Specifications

3.9.8.1 Withdrawable plug in modules shall contain switch gear and control circuits for feeder circuits.

3.9.8.2 There shall be two kinds of withdrawable plug in modules;

(a) Standard sized modules- one unit along the width of the feeder cubicle and
(b) Small sized modules- multiple units along the width of the feeder cubicle.

3.9.8.3 All the plug-in modules shall contain an MCCB or an MPCB with a door-coupling rotary operating mechanism, for breaker closing and manual opening. The shaft/handle shall be joined to a knob at the compartment door. The Knob shall have provisions for locking the circuit breaker in off position for isolation purposes

3.9.8.4 Module's frame shall be made of stainless (protected against corrosion) steel plates at least 2mm thick.

3.9.8.5 The plug-in modules shall have a special contact mechanism that allows changing their position while the compartment door is closed. The mechanism shall control the connection of the withdrawable module unit to the switchboard compartment bus bar and feeder power contacts. The following positions shall be possible:

(a) Idle (disconnected) mode - Main circuit open & auxiliary circuit open
(b) Test mode- Main circuit open & Auxiliary circuit closed
(c) Operating mode-Main circuit closed & Auxiliary circuit closed

3.9.8.6 The module contact mechanism shall have the following features:

(a) Shall be operated by a key (rod) that shall be inserted into the plug-in module while the compartment door is still closed.
(b) The Key shall be operated in a rotary motion using a small force, a maximum rotatory force of 10 Nm.
(c) Module shall have two positions for inserting and operating the key switch. The first position shall move the module from operating to idle mode or vice versa, the second shall move the module from test to idle mode or vice versa

3.9.8.7 The following control elements for the contact mechanism shall be on the compartment door:

(a) the two key insertion positions;

(b) a display window showing the operating mechanism mode with the following colours green for idle mode, blue for test mode and red for operating mode.

(c) Contact mechanism service opening cover with locking provision to prevent unauthorised contact mechanism operation.

3.9.8.8 A mechanical interlock shall prevent opening the compartment door when the contact mechanism is in operating mode.

3.9.8.9 Module shall have a mechanical interlock preventing withdrawal of the module when it's in operating or test mode. Module shall have mechanical locking/unlocking latches for locking the plugin module in place in the compartment. Mechanical unlocking latches shall have to be pressed by user before removing the unit from the compartment.

3.9.8.10 Modules shall have provisions for pressing the mechanical unlocking latches before removing the module. Modules shall also have provisions (handles) at the front side to ease carrying the module out of the compartment.

3.9.8.11 Modules shall have a 'pull out lock' to prevent it from falling down when you pull it out. The pull-out lock shall make sure you can pull out the module only as far as necessary before lifting up.

3.9.8.12 Modules shall have steel plate separating the bus bar & cable terminals contacts at the back of the module from the switchgear and associated circuitry on the front side of the module. Control and switchgear devices and the circuitry shall be mounted on the front side (facing compartment door) of this plate.

3.9.8.13 Bus bar contacts and outgoing feeder contacts shall be separated at both ends

3.9.8.14 MCCB & MPCB shall only be actuate-able from the compartment door only if the compartment door is closed.

3.9.8.15 Module shall have a control plug at the side or front of the module

3.9.8.16 Modules shall be withdrawable and insert-able while the bus bars are energized.

3.9.8.17 Modules shall be positioned to test or operating mode only if the MCCB/MPCB is off.

3.9.8.18 Control plug extension cable at least three meters long shall be provided for testing of the modules outside the switchboard. The cable shall plug in to the compartment control plug port and the plugin module control plug port

3.9.9 Distribution/panel board specifications

3.9.9.1 There shall be a three-phase distribution/panel board located in one compartment of the switch boards or mounted separately as specified in the switchboard requirements.

3.9.9.2 The distribution boards if mounted on a switchboard compartment shall not be connected to the distribution bus bars of the switch board and it shall be completely isolated from the switch board bus bars. It shall be supplied by one withdrawable plugin module.

3.9.9.3 MCB's/MPCB's shall be mounted on DIN rails. The MPCB's/MCB's shall be linked to the board's bus bar and to the feeder cables using insulated copper strips/bars

3.9.9.4 It shall be possible to easily replace an MCB/MPCB without shutting down the whole board.

3.9.9.5 The distribution board, bus bars shall be insulated or shall have shutters or any other proper mechanism of covering bus bars to prevent users from coming into contact with the bus bars while replacing the MCB's. The bus bars shall be insulated or have an IP protection of 4X

3.9.9.6 For distribution boards mounted on a switchboard compartment, copper strips/bars shall be used to terminate the panel boards' outgoing feeder cables at the cable compartment. Power terminal blocks meeting requirements of clause 3.6.4.3 may be used terminate power cables in the cable compartment.

3.9.9.7 The board's bus bar shall have Neutral and protective earthing (PE) connection terminals .

3.9.9.8 Shall have the following basic ratings.

(a) All distribution boards bus bars rated continuous current rating at 40˚C ambient temperature.: ≥125A.
(b) Rated short time withstand current (Icw): ≥25KA/1s
(c) Rated operational voltage Ue: 433 VAC
(d) Rated insulation voltage: ≥800VAC
(e) Rated impulse withstand voltage Uimp: ≥6KV

3.9.10 Switchboards Basic Ratings

3.9.10.1 The following ratings shall apply to all switchboards. i.e.

(a) Intake gates control centre
(b) Spillway gates control centre

3.9.10.2 The above boards shall meet the following primary ratings and features:

(a) Rated short time withstand current: 50 kA /1s (29 KA /3s)
(b) Nominal frequency: 50 Hz

(c) Cooling: Natural
(d) Ambient air temperature: 40 °C
(e) Relative humidity (@40 °C): 80 %
(f) Rated altitude: ≥1000m ASL
(g) form of separation as per IEC 61439-2: form 4b
(h) IP degree of protection as per IEC 60529: IP 54
(i) Rated insulation voltage: 1000 V
(j) Rated operating voltage: 433 V AC
(k) Rated impulse withstand voltage: 6 kV
(l) Over voltage category: III
(m) Pollution severity: 3
(n) cable entry: from the bottom

3.9.11 Moulded case circuit breakers, MCCB

3.9.11.1 Moulded case circuit breakers shall be used for all three phase low voltage circuits rated above 100A where an ACB is not necessary.

3.9.11.2 MCCB's rated 160A and above shall meet all the following requirements.

No.	Type (Basic rating)	160A	250A	400A	630A	800A
(a)	Rated continuous current, In, at 50°C [A]	160	250	400	630	800
(b)	Rated continuous current, In, at 70°C [A]	128	200	320	504	640
(c)	Rated ultimate symmetrical breaking current, Icu, at 415VAC as per IEC 60947-2, [kA]	55	55	55	55	70
(d)	Rated Service symmetrical breaking current, Ics, at 415VAC as per IEC 60947-2, [kA]	55	55	55	55	70
(e)	Rated insulation voltage, Ui, in accordance with IEC 60947-2 [V AC]	1000	1000	1000	1000	1000
(f)	Rated impulse withstand voltage, Uimp (Main current paths/Auxiliary circuits) [kV]	8/4	8/4	8/4	8/4	8/4
(g)	Rated operating voltage, Ue, at IEC 50 / 60 Hz [V AC]	433	433	433	433	433
(h)	Maximum DC contact resistance at 40°C [mΩ]	0.55	0.35	0.2	0.15	0.15

(i)	Maximum power loss with a balanced load at rated current, In, and at 40°C [W]	40	60	90	160	250
(j)	Utilization category as per IEC 60947-2	A	A	A	A	A
(k)	Permissible ambient Operating temperature [°C]	-25 to +70	-25 to +70	-25 to +70	-25 to +70	-25 to +70
(l)	Trip mechanism	ETU	ETU	ETU	ETU	ETU
(m)	Modbus RTU/TCP communication	YES	YES	YES	YES	YES
(n)	Number of poles	3/4	3/4	3/4	3/4	3/4
(f)	Number of auxiliary SPDT (CO) contacts	≥4	≥4	≥4	≥4	≥4
(g)	Current metering error (up to 120% rated)	≤1%	≤1%	≤1%	≤1%	≤1%

3.9.11.3 MCCB's mounted in the withdrawable plug-in units shall have a door-coupling rotary operating mechanism with a knob attached to the compartment door.

3.9.11.4 All MCCB's shall have at least two SPDT (CO) contacts for ON/OFF status and two SPDT (CO) contacts for tripped status.

3.9.11.5 All MCCB's shall have an electronic trip unit and support Modbus RTU (RS 485) serial communication or Modbus TCP ethernet communication.

3.9.11.6 There shall be two types of electronic trip units (ETU) for all MCCB's.

(a) Line protection ETU for cable feeder modules MCCB
(b) Motor protection ETU for motor DOL starter modules MCCB

3.9.11.7 Line protection electronic trip unit shall have the following functions and features:

(a) Overload protection (settable from at least 30% to 100% MCCB rating)
(b) Short-time and long-time delayed short-circuit protection.
(c) Instantaneous short-circuit protection.
(d) Neutral conductor protection
(e) Ground-fault protection
(f) Dials for setting the pickup and time delay settings.
(g) Two signalling LED's for ETU status and protection trip/alarm
(h) A reset push button and remote hardwired trip reset input.
(i) Metering function providing measurement of current, voltage, power, energy, power factor and frequency and transmission to SCADA.
(j) SCADA communication via Modbus RTU or TCP

3.9.11.8 Motor protection electronic trip unit shall have the following functions and features:

(a) Overload protection with thermal image function to reduce trip time following an overload trip. Overload shall be settable from at least 30% to 100% MCCB rating.
(b) Over current protection with motor start time and permitted starts set up
(c) Instantaneous short-circuit protection.
(d) Phase failure/phase unbalance protection
(e) LCD display
(f) Direct, user-friendly, menu-driven setting of the absolute values of the protection parameters in absolute ampere values via buttons and LCD display
(g) A reset push button and remote hardwired trip reset input.
(h) Metering function providing measurement of current, voltage, power, energy, power factor and frequency and transmission to SCADA.
(i) SCADA communication via Modbus RTU or TCP

3.9.11.9 Data from MCCB ETU shall be transferred via Modbus RTU/TCP to plant control system. The following data and functions shall be available:

(a) Switching MCCB on or off (in conjunction with a motorized operating mechanism)
(b) MCCB ON or OFF status
(c) Tripped signals
(d) Tripped signals with cause of tripping operation, tripping current and time stamp.
(e) Alarm (e.g., overload)
(f) Alarms with time stamp (e.g., overload, phase unbalance current, etc.)
(g) Max. phase current of a phase
(h) Phase currents with max. value and time stamp
(i) Neutral conductor current with min./max. value and time stamp
(j) Read/write to ETU.
(k) Number and type of tripping operations: Long-time delay, Short time delay, Instantaneous, or Ground fault
(l) Number of switch operations under load
(m) Operating hours
(n) Type of trip unit (functions supported)
(o) 3/4-pole switch
(p) Current sensor rating
(q) Serial no. of the trip unit
(r) Software version of the trip unit
(s) Time synchronization

(t) Zone Selective Interlocking functionality
(u) Delete trip memory.
(v) Delete max. measured values.
(w) Delete maintenance information.

3.9.11.10 A minimum of the following measurements shall be available to SCADA via Modbus from the MCCB ETU and measurement module: All phase currents, neutral current, L-N voltage all phases, L-L voltage all phases, active power each phase and total, reactive power each phase and total, apparent power each phase and total, power factor each phase and total, frequency, average current and voltage values, total active energy import and export , total reactive energy import and export and total apparent energy import and export

3.9.11.11 The following features shall be offered if necessary or stated in the switchboard requirements:

(a) The motorized operating mechanism for remote switching
(b) Under voltage release to trip the moulded case circuit breaker when the voltage fails. The under-voltage level shall be settable.
(c) Shunt release for remote tripping of the moulded case circuit breaker.

3.9.12 Automatic Transfer Controller (ATC)

3.9.12.1 **Function**: To control the transfer between two switchboard incomer power supplies automatically, while talking into consideration the set limit values and delay times.

(a) Shall detect fluctuations occurring in the main power supply quickly and switch to the standby power supply.
(b) The ATC only switches to the standby power supply after it has ensured that the standby supply is delivering the required power supply quality.
(c) Shall have a digital input for external initiation of transfer between the two power supplies.

3.9.12.2 **Incomer supply inputs:** Shall have two three phase four wire voltage inputs for direct connection to 433 V L-L AC supplies.

3.9.12.3 **Digital inputs & outputs:**

(a) Shall have at least 8 (eight) digital inputs, 6 (six) of which are programmable and 7 (seven) relay outputs, 5 (five) of which are programmable.
(b) Digital outputs shall be rated at least 8A @125 V DC.
(c) Shall have a digital input for setting the line priority (initiating changeover)

(d) Shall have two digital outputs configured for Main incomer and reserve incomer supply status (healthy/unavailable)

3.9.12.4 **Operation features:**

(a) Shall have an LED or LCD display for display of incomer voltages and for device parameterisation.

(b) Shall have the following parameters settable on the device display:

(i) Time delay before the circuit breaker on the main supply side opens

(ii) Time delay before the circuit-breaker on the standby supply side closes.

(iii) Time delay before the circuit-breaker on the standby supply side opens.

(iv) Time delay before the circuit-breaker on the main supply side closes

(v) Under and over voltage thresh holds

(vi) Frequency limits

(vii) Main and standby supply input (priority)

(c) Shall monitor the voltage of the main and standby supply for the following parameters.

(i) Under and over voltage

(ii) Under and over Frequency

(iii) Phase rotation/symmetry

(iv) Voltage imbalance

(v) Frequency imbalance

(d) Shall have 4 (four) selectable operating modes: off, manual, automatic, test.

(e) Have a non-volatile memory(flash) for storing Data, parameter and logged events (e.g., power failure, faults)

(f) Display the status of the circuit breakers or contactors.

(g) Real time clock

3.9.12.5 **Power supply:** Shall have a DC power supply.

3.9.12.6 **Communication:**

(a) Shall have an RS485 port/terminals.

(b) Shall support Modbus RTU.

(c) Shall transmit all logged events and alarms via communication. A minimum of the following signals shall be available.

i. Circuit breaker/contactor status

ii. Incomer supply available/unavailable.

iii. Supply status alarms e.g. Over voltage, under voltage, over/under frequency, phase rotation etc.

iv. Time delay and incomer priority settings

(d) Shall be configured for device parameterisation via communication.

(e) Shall be configured for circuit breaker closing/opening commands via communication.

3.9.12.7 **Voltage & insulation ratings**

(a) Rated operational voltage Ue: 433VAC.

(b) Rated insulation voltage: 1000V AC

(c) Rated impulse withstand voltage Uimp:≥4KV

3.9.13 Motor Protection Circuit breaker, MPCB

MPCB's shall be special kind of MCCB's for three phase loads rated below 100A. They shall meet the following requirements.

3.9.13.1 Designed for motor and other three phase loads protection. Shall be used for protection of three phase loads rated below 100A.

3.9.13.2 Shall have an adjustable overload setting, with a dial on the front side for adjustment. Overload shall be settable from at least 70% to 100% MPCB rating.

3.9.13.3 Shall have a short-circuit current breaking capacity (Icu) of at least 50KA at 400V AC (three phase)

3.9.13.4 Shall have the following minimum ratings and features.

(a) No of poles: 3(three)

(b) Rated operating voltage: 433 V AC

(c) Rated impulse withstand voltage, Uimp: ≥6KV

(d) Overcurrent & short circuit release: thermomagnetic

(e) short-circuit current breaking capacity (Icu) @400VAC: ≥50KA

(f) Auxiliary contacts: At least 3(three) SPDT(CO) contacts

(g) Terminals: screw type

(h) Conductor size on main terminals: up to 2X 25 mm² stranded conductor

(i) Rated ambient Operating temperature: -20 to +60 °C

3.9.13.5 All MPCB's shall have at least two SPDT (CO) contacts for ON/OFF status and one SPDT (CO) contacts for tripped status.

3.9.13.6 MPCB's rated below 3A with overload adjustable to less than 1A shall be used for protection of three phase control circuits such as VT inputs and outputs, voltage monitoring relays input etc.

3.9.13.7 The current ratings given in the specifications consider that the Overload shall be settable from at least 70% to 100%. Overload setting and trip classes shall be computed during design.

3.9.14 Digital Power Monitoring Device (PMD)

3.9.14.1 Shall be three-phase power meter meeting requirements of IEC 61557-12

3.9.14.2 Shall have the following interfaces.

3.9.14.2.1 At least One (1) optically isolated digital input

3.9.14.2.2 At least One (1) optically isolated digital output

3.9.14.2.3 RS485 port supporting Modbus RTU or ethernet port supporting Modbus TCP for SCADA interface

3.9.14.3 Shall be used for three phase circuits and shall have four primary wire connections (3P4W). Shall be capable of direct measurements of current, voltage, frequency, and energy.

3.9.14.4 Voltage measurement ratings (direct connection)

(a) Nominal Voltage Un (L-N / L-L):230 V / 400 V AC, 50 / 60 Hz

(b) Max. measurable voltage

(i) Voltage L-N: 276 V 3AC

(ii) Voltage L-L: 480 V 3AC

(c) Min. measurable voltage

(i) Voltage L-N: 20 V 3AC

(ii) Voltage L-L: 34.6 V 3AC

(d) Zero-point suppression level

(i) Voltage L-N: 7 V

(ii) Voltage L-L :10 V

(e) Impulse withstand voltage: 6.5 kV (1.2 / 50 µs)

(f) Measuring category: CAT III (acc. to IEC 61010-2-030)

3.9.14.4.2 Current measurement ratings

(a) Rated for direct connection to the AC system.

(b) Max. input current Imax: ≥65 A

(c) Reference current Iref (acc. to EN 50470-1): 10 A

(d) Current impulse overload capability: ≥1990 A for 10 ms

(e) Measuring range: 0.5 ... 65 A

3.9.14.4.3 Auxiliary Power supply rating

(a) Design of the power supply: Wide range AC power supply

(b) Work area :100 V - 230 V +/- 20%

(c) Power consumption: ≤ 5 VA

(d) Overvoltage category: OVT III

3.9.14.4.4 Measuring accuracy

(a) Applicable standards: IEC 61557-12, IEC 62053-21, IEC 62053-22, IEC 62053-23, EN 50470-3:

(b) Minimum measured variable Accuracy class acc. to IEC 61557-12 (K55)

(i) Voltage: Class 0.5
(ii) Current: Class 0.5
(iii) Apparent power: Class 1
(iv) Active power: Class 1
(v) Reactive power: Class 1
(vi) Total apparent power over all phases: Class 1
(vii) Total active power over all phases: Class 1
(viii) Total reactive power VAR1 over all phases: Class 2
(ix) Cumulated active power: Class 1
(x) Cumulated reactive power: Class 2
(xi) Total power factor: Class 0.5
(xii) Line frequency: Class 0.05
(xiii) Active energy: Class 1
(xiv) Reactive energy: Class 2
(xv) Active energy according to IEC62053-21: Class 1
(xvi) Reactive energy according to IEC62053-23: Class 2
(xvii) Measurement accuracy according to EN50470-3: Class B

3.9.14.4.5 A minimum of the following measurements shall be available to SCADA via Modbus: Phase currents all phases, neutral current, Voltage L-N voltage all phases, L-L voltage all phases, active power each and all phases, reactive power each and all phases, apparent power each and all phases, power factor each and all phases, frequency, average current and voltage values, total active energy, total reactive energy, total apparent energy, energy values for each four quadrants, device status and diagnostics and statistical values i.e. maximum, minimum & average for all measurements i.e. voltage, current, power factor, active power, reactive power, apparent power, frequency

3.9.14.4.6 Environmental conditions

(a) Temperature range:

(i) Ambient temperature during operating phase -25 °C … +55 °C
(ii) Ambient temperature during transport and storage -25 °C … +70 °C

(b) Installation altitude above sea level max. 2000 m
(c) Degree of pollution 2
(d) Environmental tests according to

(i) EN 60068-2-27
(ii) EN 60068-2-6

3.9.15 Current transformers, CT

3.9.15.1 Current transformers shall be dry, cast resin type and shall be accommodated inside the cubicles, in the cable/switchgear compartment.

3.9.15.2 The current transformers shall be in accordance with the requirement of IEC 61869-1&2 and shall have the specified accuracy under load conditions and shall be able to withstand the effect of short-circuit fault current rating of the switchboard.

3.9.15.3 Current transformers shall have a rated burden calculated for sufficient operation of the numerical relays and the highest accuracy for meters and instruments.

3.9.15.4 Copies of Type Test certificates and routine Test Reports/Certificates as per IEC 61869-2 shall be provided.

3.9.15.5 Current transformers shall meet a minimum of the following requirements.

(a) CT ratio: as specified.
(b) Number of cores: at least 1(one) metering core
(c) Accuracy class: 0.5 or better for metering
(d) Instrument security factor (ISF): 120%
(e) Burden: at least 3VA (to be determined at design stage)
(f) Rated short time withstand current (Icw): ≥50KA/1s
(g) Rated operational voltage Ue: 433VAC.
(h) Rated insulation voltage: 1000VAC
(i) Rated impulse withstand voltage Uimp: 12KV
(j) Meets requirements of IEC 61869-2

3.9.16 Voltage transformers, VT

3.9.16.1 Voltage transformers shall be dry cast resin type and shall be accommodated inside the cubicles, in the cable/metering compartment.

3.9.16.2 The voltage transformers shall be in accordance with the requirement of IEC 61869-1&3 and shall have the specified accuracy under load conditions and shall be able to withstand the effect of short-circuit fault current rating of the switchboard.

3.9.16.3 Copies of Type Test certificates and routine Test Reports/Certificates as per IEC 61869-3 shall be provided.

3.9.16.4 Low voltage switchboard VT's shall meet a minimum of the following requirements.

(a) VT ratio: 415V/110V

(b) Burden: 5-50VA (dependent on application/load)
(c) Accuracy class: 0.5
(d) Rated operational voltage Ue: 433VAC.
(e) Rated insulation voltage: 1000VAC
(f) Rated impulse withstand voltage Uimp: 12KV
(g) Meets requirements of IEC 61869-3

3.9.17 Motor Management & Control Devices (MMC)

3.9.17.1 MMC shall be compact, with remote LCD display, shall be directly connected to the motor primary circuit and shall have serial communication interface to SCADA.

3.9.17.2 It shall provide the following protection functions and features:

(a) Protection against over-currents
(b) Protection against thermal overloads, settable and with choice of trip class
(c) Protection against ground faults
(d) Protection against phase imbalances
(e) Protection against mechanical jams during or after the start-up phase.
(f) Protection against idling
(g) Protection against excessive starts
(h) Power factor monitoring
(i) Phase sequence recognition
(j) Overvoltage and under voltage protection
(k) Undercurrent detection
(l) Active power monitoring

3.9.17.3 Shall have a minimum of two (2) contacts for hardwired signalling of trip and relay faulty alarm.

3.9.17.4 Shall have a digital input for trip reset.

3.9.17.5 Shall have an interface to the motor primary circuit (busbars) rated at least 200A and 690 V AC. Shall be able to measure motor currents up to 200A and voltage up to 690V AC.

3.9.17.6 Shall have a remote HMI panel for installation in control cabinet door which shall have: system interface for connecting a PC, at least seven (7) LEDs for status indication and user-assignable buttons for controlling the motor, and a display for indication of measured values, status information, fault messages, settings/parameters etc.

3.9.17.7 Shall have a precise and accurate ground-fault current detection interface for ground fault protection and motor condition monitoring.

3.9.17.8 Shall Measure and display motor currents, motor operating hours, number of motor starts & trips/stop, cause of motor trip.

3.9.17.9 Shall have a serial port supporting **Modbus RTU** or ethernet port supporting **Modbus TCP.**

3.9.17.10 Shall be interfaced to the serial device server and transfer a minimum of the following information to SCADA via Modbus RTU/TCP.

(a) Motor switching state (on, off, jammed etc),
(b) Current in phases 1, 2 and 3 and maximum current in A
(c) Voltage in phases 1, 2 and 3 in V
(d) Real power in W
(e) Reactive power in VAR
(f) Apparent power in VA
(g) Energy in WH
(h) Power factor in %
(i) Phase unbalance in %
(j) Switching ON/OFF command
(k) Tripped signals with cause of tripping operation, tripping current and time stamp.
(l) Alarms with time stamp (e.g., overload, phase unbalance current, etc.)
(m) Number of motor operating hours, also resettable)
(n) Motor stop times, also resettable
(o) Number of motor starts, also resettable
(p) Number of permissible starts remaining.
(q) Number of overload tripping, also resettable

3.9.17.11 Software for configuration of the MMC's shall be provided with licences for installation into at least two laptops.

3.9.18 Contactors

3.9.18.1 All contactors shall be DC controlled type, with coils rated 110VDC ±20%

3.9.18.2 Contactors shall comply with provisions of IEC 60947-4

3.9.18.3 The contactors shall be well supported on their bases to avoid malfunctioning during operation due to vibrations.

3.9.18.4 Pick-up and drop-off voltages for electricity held-in contactors shall comply with IEC 60947-4-1. Latched contactors shall pick-up and latch-in between 80% and 115% of nominal control supply voltage and shall trip between 75% and 115% of nominal control supply voltage.

3.9.18.5 All contactors shall have minimum of 2NO and 2NC voltage free SPST auxiliary contacts.

3.9.19 Withdrawable Cable Feeder Modules

3.9.19.1 Cable feeder modules shall be used to supply switchboards and other mixed loads. The number of devices contained in the cable feeder module shall be dependent on the rating of the module. The cable feeder modules shall be used for circuits not requiring frequent switching.

3.9.19.2 All cable feeder modules shall meet withdrawable module requirements in clause 3.9.8

3.9.19.3 Withdrawable cable feeder modules rated above 125A shall contain an MCCB with the following features:

(a) The MCCB's shall have line protection ETU and Modbus RTU/TCP communication interface.

(b) The MCCB serial/ethernet output shall be connected to a serial device server for data transmission to SCADA system.

3.9.19.4 Withdrawable cable feeder modules rated below 100A shall contain an MPCB and a power monitoring device.

3.9.19.5 630A rated cable feeder modules shall contain the following:

(a) 800A MCCB meeting requirements in clause 3.9.11

(b) At least 1(one) current transformer meeting requirements in clause 3.9.15 for the digital AC ammeter

(c) At least 1(one) Digital panel AC ammeter meeting requirements of clause 3.5.8

(d) MCCB isolating switch joined to a knob at the compartment door.

3.9.19.6 250A rated cable feeder modules shall contain the following:

(a) 315A MCCB meeting requirements in clause 3.9.11

(b) At least 1(one) current transformer meeting requirements in clause 3.9.15 for the digital AC ammeter

(c) At least 1(one) Digital panel AC ammeter meeting requirements of clause 3.5.8

(d) MCCB isolating switch joined to a knob at the compartment door.

3.9.19.7 125A rated cable feeder modules shall contain the following:

(a) 160A MCCB meeting requirements in clause 3.9.11

(b) MCCB isolating switch joined to a knob at the compartment door.

3.9.19.8 63A rated cable feeder modules shall contain the following:

(a) 63A MPCB meeting requirements in clause 3.9.13

(b) Three-phase digital power monitoring device meeting requirements in clause 3.9.14, with the serial output wired in a multi droop bus to the serial device server.

(c) MPCB isolating switch joined to a knob at the compartment door.

3.9.19.9 32A rated cable feeder modules shall contain the following:

(a) 32A MPCB meeting requirements in clause 3.9.13

(b) Three-phase digital power monitoring device meeting requirements in clause 3.9.14, with the serial output wired in a multi droop bus to the serial device server.

(c) MPCB isolating switch joined to a knob at the compartment door.

3.9.19.10 For each cable feeder module, Potential free contacts shall be provided for a minimum of the following signals.

- MCCB/MPCB ON
- MCCB/MPCB OFF
- MCCB/MPCB protection trip
- Module in test position
- module in withdrawn position
- module in service position

3.9.20 Withdrawable Motor DOL (Direct online) starter feeder modules

3.9.20.1 Motor DOL starter modules shall be used to supply motors and other inductive loads requiring frequent switching. The number of devices contained in the motor DOL feeder module shall be dependent on the rating of the module.

3.9.20.2 All motor DOL starter feeder modules shall meet withdrawable module requirements in clause 3.9.8

3.9.20.3 55KW standard sized withdrawable motor DOL feeder modules, shall meet the following minimum requirements:

(a) Shall have 160A MCCB meeting requirements in clause 3.9.11

(i) The MCCB shall have a motor protection electronic trip unit with an LCD display.

(ii) The MCCB serial/ethernet output shall be connected serial device server for data transmission to SCADA system.

(iii) MCCB LCD display shall be configured to indicate the motor currents and motor status.

(b) Shall have a 75KW contactor.

(i) Rated for DOL starting of 100hp (75KW) motors.

(ii) Rated continuous current of 160A at 400C ambient temperature.

(iii) Insulation rated at 1000V AC.

(iv) With at least 4NO and 4NC potential free contacts

(c) Shall have motor management and control device meeting requirements in clause 3.9.17, with the Modbus RTU serial output wired in a multi droop bus to the serial device server or ethernet output wired to SCADA panel.

(d) Shall the following devices

(i) At least 2(two) miniature circuit-breakers for control circuit protection

(ii) At least 2(two) contactor relays

(iii) A set of interface relays with SPDT contacts

(iv) A current transformer meeting requirement in clause 3.9.15 for panel meter

3.9.20.4 32KW standard sized or small sized withdrawable motor DOL starter modules, shall meet the following minimum requirements:

(a) Shall have 63A MPCB meeting requirements in clause 3.9.13

(b) Shall have an 37KW contactor

(i) Rated for DOL starting of 50hp (37KW) motors

(ii) Rated continuous current of 80A at 400C ambient temperature

(iii) Insulation rated at 1000V AC

(iv) With at least 2NO and 2NC potential free contacts

(c) Shall have motor management and control device meeting requirements in clause 3.9.17, with the Modbus RTU serial output wired in a multi droop bus to the serial device server or ethernet output wired to SCADA panel.

(d) Shall the following devices

(i) At least 2(two) miniature circuit-breakers for control circuit protection

(ii) At least 2(two) contactor relays

(iii) A set of interface relays with SPDT contacts

(iv) A current transformer meeting requirement in clause 3.9.15 for panel meter

3.9.20.5 11KW standard sized or small sized withdrawable motor DOL starter modules, shall meet the following minimum requirements:

(a) Shall have 32A MPCB meeting requirements in clause 3.9.13

(b) Shall have an 18.5KW contactor

(i) Rated for DOL starting of 25hp (18.5KW) motors

(ii) Rated continuous current of 38A at 40˚C ambient temperature

(iii) Insulation rated at 1000V AC

(iv) With at least 2NO and 2NC potential free contacts

(c) Shall have motor management and control device meeting requirements in clause 3.9.17, with the Modbus RTU serial output wired in a multi droop bus to the serial device server or ethernet output wired to SCADA panel.

(d) Shall the following devices

(i) At least 2(two) miniature circuit-breakers for control circuit protection

(ii) At least 2(two) contactor relays

(iii) A set of interface relays with SPDT contacts

(iv) A current transformer meeting requirement in clause 3.9.15 for panel meter

3.9.20.6 7.5 KW standard sized or small sized withdrawable motor DOL starter modules, shall meet the following minimum requirements:

(a) Shall have 16A MPCB meeting requirements in clause 3.9.13

(b) Shall have a 7.5KW contactor.

(i) Rated for DOL starting of 10hp (7.5KW) motors

(ii) Rated continuous current of 16A at 40˚C ambient temperature

(iii) Insulation rated at 1000V AC

(iv) With at least 2NO and 2NC potential free contacts

(c) Shall have motor management and control device meeting requirements in clause 3.9.17, with the Modbus RTU serial output wired in a multi droop bus to the serial device server or ethernet output wired to SCADA panel

(d) Shall the following devices

(i) At least 2(two) miniature circuit-breakers for control circuit protection

(ii) At least 2(two) contactor relays

(iii) A set of interface relays with SPDT contacts

(iv) A current transformer meeting requirement in clause 3.9.15 for panel meter

3.9.20.7 The Motor DOL starter Withdrawable plug-in modules shall have a minimum of the following devices mounted on their compartment doors

(a) Motor management control device HMI display unit

(b) 3(three)illuminated pushbutton (ON/OFF/TRIP RESET)

(c) 2(two) status LED lamps (service position and test position)

(d) 1(one)Running hour's counter

(e) 1(one) 3-position key-operated switch for motor start/stop interlock MANUAL/AUTO/SCADA

3.9.20.8 The Motor DOL starter Withdrawable plug-in modules shall have a minimum of the following features implemented.

(a) Emergency stop from the field shall prevent pump start and stop the pump by a hardwired circuit. It shall interlock starting relay coil circuit.

(b) There shall be a contactor relay for grouped starter failure/fault with at least 4NO contacts.

(c) There shall be a contactor relay for switching on the main contractor.

3.9.20.9 Potential free contacts shall be provided for a minimum of the following signal outputs for each motor DOL starter module.

- Motor/lights ON
- Motor tripped (protection)
- module in withdrawn position
- Module in test position
- Local selection
- Switchboard selection
- Motor/lights OFF
- MCCB/MPCB OFF
- MCCB/MPCB ON
- MCCB/MPCB tripped
- module in service position
- SCADA selection

3.9.20.10 The following inputs/ commands with a 24/110VDC common supply shall be provided for each motor DOL starter module.

- Motor/lights ON
- MCCB trip reset
- Motor/lights OFF
-

3.10 MOTORS

3.10.1 General

3.10.1.1 All motors shall comply with the current issue, at date of tendering, of the following:

(a) IEC 60034 Rotating Electrical Machines.

(b) IEC 60085 Electrical Insulation: Thermal Classification.

(c) BS 3979 Dimensions of Electrical Motors (Metric Series).

(d) BS 529 Steel Eyebolts.

(e) BS 822 (Part 6) Terminal Markings of Rotating Electrical Machinery.

3.10.1.2 All motors shall be insulated to Class 'B' of IEC 60085.

3.10.2 Operating Conditions

3.10.2.1 Under normal operating conditions, all motors shall be capable of two consecutive starts and three starts per hour.at nominal voltage.

3.10.2.2 AC motors shall be capable of operating continuously at rated torque for this application at any frequency between ± 5% of nominal.

3.10.2.3 They shall be capable of operating at rated torque for five minutes at 75% nominal voltage and rated frequency. They shall also recover normal operation in the event of loss of supply for three seconds followed by restoration to 80% nominal voltage.

3.10.2.4 Induction motors shall be suitable for direct online starting at full voltage when the starting current shall be guaranteed not to exceed six times full load current subject to the tolerances in IEC 60034.

3.10.2.5 DC motors shall be capable of operating at normal duty at any voltage between +10% and -20% of the nominal value.

3.10.3 Enclosures

3.10.3.1 Motors shall be totally enclosed, fan cooled with a removable plug to drain accumulated condensation, unless otherwise recommended by the Contractor and approved by the employer Engineer.

3.10.3.2 Motor enclosure shall provide IP55 ingress protection as IEC 60529.

3.10.3.3 Appropriate eyebolt fixing holes and eyebolts shall be provided as necessary for lifting heavy parts during erection and overhaul.

3.10.3.4 Base plates and coupling guards shall be supplied and flexible couplings used wherever appropriate.

3.10.3.5 A diagram plate shall be affixed giving the connections for the required direction of rotation, in addition to the rating plate.

3.10.3.6 All motors shall be supplied with integral anti-condensation heaters with external wiring connections, unless they are to be mounted in a controlled environment, e.g., a heated cubicle.

3.10.4 Bearings

3.10.4.1 The preferred motor speed is 1500 rpm, with roller bearings below 375 kW and plain bearings above. For speeds above 1500 rpm, plain bearings must be used above 150 kW. Vertical motors shall have guide and thrust bearings to approval.

3.10.4.2 All bearings shall be provided with adequate means for lubrication, readily accessible without removal of guarding. Grease nipples shall be to BS 1486 and standardised throughout the plant in respect of type, size, spacing etc.

3.10.4.3 The temperature of lubrication oil shall not exceed 71°C and this shall be capable of being tested by provision of thermometer pockets. Oil level indicators shall be provided. Where oil levels vary when motors are stationary and running, both levels shall be indicated. Lubrication shall be adequate for starting up after prolonged shut down or for a prolonged running down period.

3.10.4.4 Provision shall be made to prevent damage to bearings by shaft currents.

3.10.5 Terminal Boxes

3.10.5.1 Terminal boxes shall be substantially designed for the short circuit duty applicable. They shall be complete with terminals designed for the current and fault ratings of the motor supply circuit. Porcelain or natural rubber is not acceptable for insulation.

3.10.5.2 The terminals and the terminal boxes shall be suitable for accepting cables with either copper or aluminium conductors, i.e., the spacing and dimensions shall be large enough to accept the appropriate sweated type terminating lugs. The cable glands and terminating lugs or ferrules shall be provided as part of the motor.

3.10.5.3 Minimum clearances shall be as follows:

415-volt motors	Clear (mm)	Creep (mm)
up to 7.5 kW	6.5	11
7.5 kW to 40 kW	8.0	12.5
40 kW to 75 kW	10.0	12.5
Over 75 kW	12.5	19

3.10.5.4 Terminals shall be clearly labelled with coloured plates with markings for busbar side and neural side as follows U1, V1, W1; U2, V2, W2; U-Brown, V-Black, W- Grey. Labelling shall be large and clear.

3.10.5.5 All the three phase six motor connections shall be brought out to the terminal box. Internal star or delta connection shall not be accepted.

3.10.5.6 Motor terminal box shall be sealed to provide IP65 ingress protection as per IEC 60529.

3.11 PIPES AND PIPEWORK

3.11.1 General requirements

3.11.1.1 All pipes shall be cold drawn seamless high tensile hydraulic tube according to DIN **2391C E 355N (ST52.4 NBK).**

3.11.1.2 Pipe connections shall use non-weld connection technologies (fittings, flanges etc.)

3.11.1.3 The pipes shall be electroplated.

3.11.1.4 Pipe characteristics such as wall thickness, material and paint work shall be as per recommendations of the 'hydraulic piping standard handbook'.

3.11.1.5 The maximum allowable flow rate in pipes shall as per of the hydraulic piping standard handbook tables, higher velocities shall not be acceptable.

3.11.1.6 All piping, flanges, sockets, joints, seals, gaskets, etc. shall be made of materials to withstand pressure and temperature conditions involved in the operation of the equipment and provide a positive seal under all operating conditions and shall incorporate an ample factor of safety. Requirements in the hydraulic piping standard handbook and applicable standards shall be met and exceeded.

3.11.1.7 Provision shall be made allowing for full expansion that can take place under all conditions of operation.

3.11.1.8 Where necessary, provision shall be made for the draining and release of air in systems using valves and in addition plugged drain and air release bosses should be welded to pipes at appropriate points to facilitate hydraulic testing.

3.11.1.9 All pipework and fittings shall be of the same materials or similar unless otherwise specified or agreed by the Engineer.

3.11.1.10 All pipes shall be pressure tested at twice maximum working pressure.

3.11.2 Piping work requirements

3.11.2.1 All piping shall be routed to provide a neat and economical layout having the shortest possible run and requiring the minimum number of fittings. Piping shall be arranged so that full access for the maintenance of equipment can be achieved with the minimum dismantling of piping. All piping shall be installed as closely as possible to walls, ceilings, columns, etc. to occupy the minimum space. Existing piping routes shall be followed as much as possible.

3.11.2.2 Pipes shall not be solidly embedded in concrete but shall be run in trenches and ducts with adequate supports and restraints. Whenever possible, sleeves shall be provided where pipes pass through walls, floors, beams or columns. The internal diameter of sleeves shall be adequate to allow sections of the piping to be removed through them.

3.11.2.3 Pipes shall be cut accurately to proper lengths and shall be worked into place without springing or forcing. Proper allowances shall be made for expansion and contraction of pipes.

3.11.2.4 All pipes, pipe bends and tees shall be truly circular in the bore and uniform in wall thickness, with the number of joints kept to a minimum necessary for efficient maintenance of the equipment. Tees and bends shall be to standard dimensions. Hot bending with packing may be used for larger sizes according to facilities available, but not bends in alloy or stainless steels, which may be made after permission by the Engineer. Where bends are formed, no crimping or flattening of the pipe will be accepted.

3.11.2.5 All pipework shall be shop-welded and shall be assembled and tested before dispatch. An adequate number of loose flanges and trimming allowances shall be provided to facilitate site erection. All pipes shall be fitted with temporary blank flanges or plugs before dispatch to site, and these shall not be removed until just before coupling up.

3.11.2.6 As much as possible existing piping supports shall be re used. For piping crossing ceiling or supporting walls and where existing supports cannot be reused, shall be provided with welded- on anchor collars for embedding in the concrete.

3.11.2.7 Pipes shall be thoroughly cleaned and flushed, during installation and immediately before setting to work, with the same type of oil to be used in the system. Necessary precautions shall be taken to ensure that contaminates do not enter pumps, filters and other sensitive equipment.

3.11.3 Welding

3.11.3.1 Welded butt joints shall be of the full penetration type. For the pipes special provisions shall be taken to ensure a high quality of the root side.

3.11.3.2 Branches shall be welded to the main pipe by means of full penetration welds.

3.11.3.3 All pipework shall be shop-welded and shall be assembled and tested before dispatch to site. Site welding of pipes shall not be allowed except for special circumstances approved by the employer engineer.

3.11.4 Pipe Supports, Clamping and Hangers

3.11.4.1 All pipework and accessories shall be mounted and supported in a safe and neat manner.

3.11.4.2 Pipe and valve support systems will be of corrosion-resistant material and will be galvanically isolated where the support system and associated piping are of dissimilar metallic materials.

3.11.4.3 All brackets, stays, frames, hanger and supports for carrying and staying the pipes, including their fasteners, shall be included in the supply and completed by the

Contractor at the site. All supports clamps, brackets, stays frames hangers shall be metallic either made of aluminium or stainless steel.

3.11.4.4 All clamps shall of the aluminium stauff type. Spacing for the clamps shall be according to recommendations in the 'hydraulic piping standard handbook'.

3.11.4.5 Supports and hangers shall be designed and arranged so that any pipe can be withdrawn without disturbing the others.

3.11.4.6 All heavy valves, and others, where necessary, shall be supported independently of the pipes to which they connect, to the satisfaction of the Engineer.

3.11.4.7 The Contractor shall supply drawings showing the location of each major anchor and support and the weight to be carried by that support.

3.11.5 Pipe Jointing

3.11.5.1 Choice of coupling shall be as per the hydraulic standard handbook.

3.11.5.2 Welded joints SHALL NOT be used.

3.11.5.3 All coupling together of pipes and valves larger 12mm in diameter shall be by flange joints.

3.11.5.4 Flanges shall be machined across the full-face diameter and shall be square with the bore of the pipe. Edges shall be machined, and the back shall be cutter-faced or spot-faced so that boltheads, washers and buts will bed down appropriately. In general, all flanges shall comply with the relevant requirements of the ISO standards.

3.11.5.5 Jointing material shall be so proportioned that when the joint is tightened-up no part of it will protrude into the pipe bore.

3.11.5.6 For flange joints two plain washers will be used for each bolt and the washer material will be the same as the flange material.

3.11.5.7 Gasket materials for flanged connections will be suitable for the temperature, pressure, and corrosiveness of the fluid conveyed in the pipeline.

3.11.5.8 Gasket thickness will not exceed 2 mm unless otherwise stated.

3.11.5.9 Bolts, studs, and nuts will be lubricated.

3.11.5.10 Where threaded joints occur, such as for pressure gauges, instrumentation, pipe plugs, etc., they will meet the following requirements:

(a) Pipe threads will be ISO unless otherwise specified.

(b) Pipe threads will be cut full and will be free from torn or ragged surfaces; minimum thread engagement will be according to DIN ISO 228 or equivalent standard.

(c) Threaded joints will be made up with joint compound. Stainless steel threaded joints will be made using an accepted anti-seize compound

specifically manufactured for use on stainless steel pipe threads to eliminate galling; and

(d) the use of thread cement or caulking of threaded joints to stop or prevent leakage is not acceptable.

3.11.6 Painting

3.11.6.1 All pipes shall factory painted with standard hydraulics golden brown colour.

3.11.6.2 Painting shall meet requirements of clause 3.3.10.

3.11.6.3 Wet and dry film thicknesses shall be checked in accordance with BS EN ISO 12944 to ensure that the specified dry film thicknesses are met. The specified thicknesses shall be regarded as minimum. During FAT coat thickness shall be checked and verified.

3.11.6.4 The maximum amount of paint treatment shall be completed in the factory/contractor's shop as per requirements in clause 3.3.10.Site work shall be limited to finishing coats and to repair of damage suffered during transport, storage, and erection, and making good at site connections, bolts and welds. All precautions shall be made to prevent paint damage as indicated in the general mechanical requirements.

3.12VALVES

3.12.1 General requirements for all Valves

3.12.1.1 All valve bodies shall have surface corrosion protection via surface coating technologies.

3.12.1.2 Valves shall be tested in the factory to twice the maximum working pressure which will occur in service, and the test pressure shall be legibly and permanently marked on the valve.

3.12.1.3 The contractor shall provide a valve schedule summarizing the duties of all valves provided under the Contract and quoting the relevant mechanical and electrical device numbers, the associated drawing number, and the class, working pressure and test pressure.

3.12.1.4 All valves shall be rated for ambient temperature range of -20°C to +60 °C.

3.12.1.5 All valve models to be used in the project shall have been tested and certified by a third-party reputable testing laboratory certified by the National Standards and

Testing Authority (NSTA) or a laboratory accredited to the NSTA in the EU, USA or Canada. Certificates and test reports shall be submitted with the tender for evaluation purposes.

3.12.1.6 All valves shall have the OEMs (Original Equipment Manufacturer's) nameplate un-tampered. Contractors' nameplate if needed shall be installed side by side to the OEM one.

3.12.1.7 All valves shall be clearly labelled using anodized aluminium plates or oil resistant PVC castings, label marking shall be as per IE81346-10 (RDS PP) codes. The name plates shall be clearly visible.

3.12.2 Control & Regulating Hydraulic Valves

3.12.2.1 Shall be Manganese phosphate/zinc plated/zinc-nickel plated.

3.12.2.2 All control & regulating hydraulic valves shall have solid steel Casting Body/housing rated at least twice the valve rated working pressure.

3.12.2.3 Solenoid driven valves shall have removable high-performance solenoid coil, for ease of replacement. The coil shall be rotatable 360° for flexible installation.

3.12.2.4 All control valves that are power actuated will have adjustable limit switches to indicate both the open and closed positions.

3.12.2.5 All solenoid operated valves shall be rated for station 110V DC unless otherwise specified.

3.12.2.6 Control valve Interface shall be according to DIN 24340 Form A6, ISO 4401-03

3.12.2.7 The porting pattern shall be according to the standards ISO 4401-5, NFPA T3.5.1M R1 and ANSI B93.7 D 05.

3.12.2.8 All solenoid valves shall have a protection class of at least IP66 accordance with IEC 60529 with correctly installed electrical connections.

3.12.2.9 All solenoid valves shall have a yellow LED operation indicator rated the same as coil voltage and with a suppression diode.

3.12.2.10 Where solenoid driven valves are used to perform a control function, they shall be spring loaded such that upon loss of power the valve moves to the safest position.

3.12.2.11 The valves shall have part numbers certified by a national standards body in the EU, USA or Canada.

3.12.2.12 All solenoid valves shall have concealed manual override pin.

3.12.3 Pipeline Isolation and Non return Hydraulic Valves.

3.12.3.1 Isolation Valves shall be readily accessible for both operation and maintenance, and where necessary for ease of operation the spindles shall be extended. An appropriate lockable handle shall be provided for all isolation valves.

3.12.3.2 Isolation valves are to be of the same size as the pipe run in which they are installed except where explicitly specified otherwise.

3.12.3.3 Valves will be installed so that they are easily removable without significant disassembly of other equipment or cutting of pipe or welds.

3.12.3.4 Valves of same make, size and type shall be interchangeable.

3.12.3.5 As far as possible, valves shall not be fitted in an inverted position. An indicator of approved type shall be fitted to each valve and each extended spindle shall clearly show the position of the valve.

3.12.3.6 Shut-off valves shall be suitable for opening and closing against full unbalanced pressure, including closure against free discharge.

3.12.3.7 Special attention shall be given to the operating mechanism and correct lubrication of all valves to ensure a minimum of maintenance and ease of operation.

3.12.3.8 All Isolation valves shall be provided with means for padlocking. Exception shall be to the approval of the Engineer. They shall be lockable, in both the open and closed position, by an acceptable method. The locking method will permit visual checking of the position of the valve while locked.

3.12.3.9 Isolation valves shall be installed at all locations necessary to operate and maintain equipment, and any other additional locations required to protect Workers during maintenance or assembly/disassembly of equipment.

3.12.3.10 Valves shall be made of steel.

3.12.3.11 All isolation valves shall be ball type or globe designed for hydraulic applications over 200 bars.

3.12.3.12 The direction of flow should be permanently marked on the valve body.

3.12.3.13 Non-return valves shall be of the non-slamming type preferably incorporated with means of adjusting the closure rate with damping towards the “close” end of the stroke. If appropriate, provision shall be made for draining the pipework on each side of non- return valves.

3.12.3.14 All valves shall be arranged so that movement to the clockwise direction shall close the valve. The face of each valve shall be permanently and clearly marked with the words” open” and “close” and shall be provided with an arrow to indicate the directions for opening and closing.

3.12.3.15 All brackets, stays, frames, supports, etc. necessary for carrying and steadying valves shall be included in the supply and completed by the Contractor at the Site.

3.13 PRESSURE VESSELS/ACCUMULATORS

3.13.1 Pressure vessels shall be designed, constructed, tested, and otherwise comply with European union Pressure Equipment Directive PED 2014/68/EU issued on 19.07.2016.

3.13.2 All vessels with a volume grater that 1 litre **MUST** have a CE mark as per European union directive PED 2014/68/EU.

3.13.3 Pressure vessels must be made from materials that meet PED specifications for traceability.

3.13.4 Vessels shall be manufactured under an approved quality system, like ISO 9001.

3.13.5 All hydrostatic testing to be witnessed by an approved supervisory body certified in the EU. Safety tests shall be repeated at site by a licensed local inspector to ensure the vessels meet local regulations. Cost of inspection and tests shall be borne by the contractor.

3.13.6 All pressure vessels burst pressure shall be at least 2.8 times the rated pressure.

3.13.7 All pressure vessels shall have safety pressure relief valves designed to meet EU directives and applicable ISO standards. For systems with working pressure exceeding 100 bar, the system pressure circuit shall have at least two other safety pressure relief valves at different points in the system other than the safety valve on the pressure vessel.

3.13.8 All pressure vessels shall be designed for ambient temperature of 40˚degress Celsius and altitude of over 1000 meters above sea level.

3.13.9 All hydraulic accumulators shall utilise compressed Nitrogen gas for energy storage. They shall all have at least one backup nitrogen bottles sized to meet the flow/storage requirements specified in particular specifications.

3.13.10 Nitrogen gas to be used in pressure vessels shall have purity of at least 99.995% filtered at below 3µm.

3.13.11 Pressure vessels sizing calculations shall be provided during design stage, the vessels shall provide enough energy storage to provide the load and travel specified in particular specifications.

3.14 GITARU POWER PLANT OPERATING CONDITIONS

3.14.1 Gitaru power plant consists of three vertical Francis turbines driving generators of the salient type.

3.14.2 The generators are operated in a network with other generators and are connected to the supply Kenyan power system network via generator step-up transformers.

3.14.3 Gitaru generators are among the biggest in the Kenyan grid and play a big role in grid frequency and voltage regulation.

3.14.4 Temperature and Humidity

3.14.5 The equipment shall withstand, without impairing the component function, the following ambient conditions:

(a) Temperature range: -1^{0}C to $+45^{0}$C

(b) Relative humidity: 85 % at 40^{0}C

3.14.6 The dewpoint shall not be reached. If necessary, special measures shall be taken [cooling, fanning].

3.14.7 Other environmental conditions

(a)	24-hour average temperature:	+10°C — +35°C
(b)	Relative humidity:	90 -100%
(c)	Height above sea level:	930 m
(d)	EMC Class (IEC 61000):	Industrial environments
(e)	Seismic coefficient:	Not available
(f)	Rainfall conditions Average:	500-800 mm/year
(g)	Indoor Pollution degree:	III
(h)	Earthquake acceleration-Horizontal acceleration:	not available
(i)	Earthquake Acceleration-Vertical acceleration:	not available
(j)	!32kV bus bar estimated fault level	2627MVA
(k)	220kV bus bar estimated fault level	2698MVA
(l)	Estimated fault level main LV switchboard	20kA

4 INTAKE GATE CONTROL SYSTEM PARTICULAR SPECIFICATIONS

4.1 EXISTING SYSTEM

4.1.1 Equipment Data

4.1.1.1 Gates

(a) Number: 3 intake gates
(b) Height: 5,980mm
(c) Width: 4,200mm
(d) Seal: Rubber/Stainless steel

4.1.1.2 Hydraulic System Specifications

(a) Operating pressure – 190 bars
(b) Pressure limitation – 220 bars
(c) Time required for total hoist – 10.5 minutes.
(d) Lowering time – 10.5 minutes
(e) Quick closing time – 1.6 minutes
(f) Emergency shutdown lowering speed – 4 meters/minute.
(g) Necessary hoisting force – 700 kN
(h) Crack open – 100 millimeters
(i) Pump type IPH 3-16, discharge 15.8 cubic centimetres per revolution, maximum pressure 300 bars, pump rpm -3000.
(j) Capacity of existing reservoirs: 734 litres as max oil level.
(k) Number of pumping units: 2 pumping units

4.1.1.3 Intake Gates Cylinder Details:

(a) Bore – 250 mm.
(b) Rod Diameter – 125 mm
(c) Stroke – 6300 mm
(d) Pull – 700 kN
(e) Operating Pressure – 190 bar
(f) Lifting Speed – 0.6 m/min
(g) Lowering Speed – 0.6 m/min
(h) Hoisting time – 10.5 min
(i) Lowering time – 10.5 min
(j) Emergency Lowering Speed – 4 m/min.
(k) Travel for leak oil – 100 mm
(l) Oil volume for lift – 238 Liters
(m) Oil volume for closed position – 316 liters

4.1.1.4 **Voltages used in existing electrical controls:**

(a) Control Panel Supply Voltage: **3-phase 415 VAC at 50Hz**

(b) Pump Motors operating voltage: **3-phase 415 VAC at 50Hz**

(c) Cabinet heating and shutdown heating of the pump motors: **240 VAC at 50Hz.**

(d) Control voltage: **110 VDC**

(e) Remote Control Voltage: **50 VDC**

(f) Auxiliary voltages for transducers: **110 VAC at 50Hz**

(g) Auxiliary voltages for pressure indicators: **24 VDC**

4.1.2 Existing Intake Low Voltage Switchboards

4.1.2.1 The existing switchboards were installed in 1978. They have feeders and incomers as described below.

4.1.2.2 Intake gates control centre

CELL	CIRCUIT	RATING
	INCOMER CUBICLE	
1	Changeover contactor	200A
2	Duty incoming supply	200A
3	Reserve incoming supply	200A
	Feeder Circuits	
4	Gates control unit	100A
6	Spare	35A/7.5KW DOL
7	Raw water supply	35A/7.5KW DOL
10	Lighting and small power 4 Way TP&N distribution board	30A
11	Lighting and small power	63A
12	Spare	32A
13	Power outlet	100A
14	Screen raking gantry	32A

4.2 OVERALL SYSTEM REQUIREMENTS

4.2.1 The new intake gate control system shall provide all existing functions and all other new functions detailed in this specification. All existing gates operation functionality shall be provided and restored irrespective of what is detailed in this specification.

4.2.2 Not all components, parts and works necessary for the complete intake gate control system have been detailed in this specification. Bidder shall visit the site and study existing equipment drawings and manuals to ensure their offer covers all the components, parts and works required for the refurbishment.

4.2.3 The offered equipment shall not have any adverse effect on the current intake gate system operations and maintenance.

4.2.4 Each intake gate shall have independent electrical and hydraulic control components with hydraulic and electrical isolations at all critical points to enable isolation of each gate for maintenance without affecting the other two gates. Each gate shall have its own set of instruments and valves for the hydraulic cylinder operations. New hydraulic components and transducers shall be supplied for intake gate controls. All the existing intake gate (position, flow, pressure etc) transducers shall be replaced with new ones. Existing robust waterproof limit switches for gate position shall also be replaced with new robust IP68 waterproof limit switches ones.

4.2.5 Two redundant hydraulic power units (HPU) shall be supplied for providing the hydraulic power to hoist the three gates. Each HPU shall have its own motor-pump, set of valves, tank, accumulator, nitrogen bottles, filters, monitoring instruments, electrical control panel etc. One HPU system shall be able to operate all the three gates. It shall be possible to carryout pro longed maintenance on one HPU system without affecting intake gate operations. There shall be a duty standby selection to set the active HPU. All HPU components shall be supplied none of the existing HPU parts shall be re used.

4.2.6 Appropriate control valves shall be provided on each HPU to enable operation of all the three gates from each HPU. Redundant control valves and isolation valves shall be provided on each HPU such that It shall be possible to carry out prolonged maintenance on any one of these control valves without affecting operations of the gate. All required valves shall be supplied, none of the existing valves shall be re used.

4.2.7 Each HPU shall have a hydraulic accumulator system for automatic restoration of the gates to fully open position after they drift without running the pumps. Accumulator shall be able to restore all the three gates, appropriate control valves to be provided. Appropriate control and isolation valves shall be provided to ensure that it shall be possible to carry out extended maintenance on the accumulator without affecting any of the three gates operation. Each accumulator shall be sized for 300mm travel of one gate equivalent three (3) 100mm restorations (3X100mm) on any gate without running the pumps e.g., when AC supply is unavailable.

4.2.8 All Hydraulic piping and supports shall be removed and replaced with new piping and pipe support. None of the existing piping and supports shall be re-used. All piping shall be completely factory made i.e., bending, welding, and painting of pipes shall be done at the factory.

4.2.9 All the existing hydraulic cylinders (servo motors) shall each be removed, tested shipped to a repair centre, refurbished, tested, shipped back to site, and reinstalled in another gate. A new hydraulic cylinder (servomotor) shall be installed for the first gate to be worked on. The existing cylinder on the last gate to be worked on shall be removed refurbished and shipped back to site as a spare. Stripping down of the existing cylinder shall be witnessed by the employer, during strip down the refurbishment options of replacing or repairing a part of the cylinder shall be identified and agreed upon.

4.2.10 New outdoor IP 55 cabinets shall be provided for housing valves, control pushbuttons, instruments, and indication devices.

4.2.11 Hydraulic pressure system shall be designed for working pressure of 200 bars and test pressure of 400 bars. All the components on the pressure line shall be tested to 400 bars during site acceptance testing.

4.2.12 All hydraulic components shall be of CETOP type with the OEMs (Original Equipment Manufacturer's) nameplate un-tampered. Contractors' nameplate if needed shall be installed side by side to the OEM one.

4.2.13 The contractor shall test and commission the functionality of the entire intake gates hydraulic system. This shall involve opening and closing of all the gates with and without load.

4.2.14 Electrical control circuit/logic for the pumps and gate operation **shall hardwired** using contactor relays meeting specifications in clause 3.5.3. All interlocks and commands for pump and gate control shall be hardwired, local operation using pushbuttons, indicator lamps and panel instruments shall be the primary mode of gate operation. Pumps starting and stopping shall be automated by a hardwired circuit. PLC or any other IED's shall only be used for remote interfaces to SCADA and for protective functions if any.

4.2.15 PLC/PAC system shall be supplied and installed for SCADA interfacing. Remote operation of gates and pumps through PLC shall be provided as a backup operation mode with a remote selection interlock.

4.2.16 Independent intake gates electrical control circuits shall be provided for each gate and preferably housed in different cabinets. Circuits shall be isolated to ensure maintenance work can be carried out in one gate without affecting the other two gates and to ensure a failure in one electrical component does not affect operation of more than one gate. If the functions are to be housed in one cabinet, the cabinet shall be compartmentalised/ or demarcated to ensure isolation of circuits for each gate.

4.2.17 Low voltage AC switchboard shall be supplied, installed and commission to provide AC supply to all intake gate systems. DOL starters shall be provided for each HPU pump on the switchboard, existing common pump starter cabinet shall be removed. Wall mounted LV AC distribution board shall be provided for lighting and small power distribution.

4.2.18 All control wiring within the intake gate area shall be replaced with new wiring except for wiring to the control building which shall be re used. All power cabling within the intake gate area that is too short to be reused shall be replaced.

4.2.19 All systems and components shall be clearly labelled using anodized aluminium plates or oil resistant PVC castings, label markings shall be as per IE81346-10 (RDS PP) codes. The name plates shall be clearly visible.

4.3 INTAKE GATE HYDRAULIC SYSTEM REQUIREMENTS

4.3.1 Hydraulic Power Unit (HPU) Requirements

4.3.1.1 System requirements

4.3.1.1.1 Contractor shall design, supply, install and commission **two (2)** new Hydraulic Power Units (HPU's) which shall provide power to hoist the three intake gates.

4.3.1.1.2 Each HPU shall consist of reservoir and its accessories, pump, valves, Accumulator, back up nitrogen bottle/s, instruments, and an electrical control panel.

4.3.1.1.3 Each HPU shall be able to operate any of the three gates.

4.3.1.1.4 Pumps, Filters, and pump control blocks shall all be mounted outside of the reservoir tank, they **SHALL NOT** be immersed into the sump tank like the current HPU'S.

4.3.1.1.5 System shall be designed for 200bar working pressure.

4.3.1.1.6 New hydraulic oil shall be supplied for the new HPU's plus spare capacity equivalent to all oil in the three gates cylinders. The oil shall be the same as the existing oil and shall meet employers' standard hydraulic oil requirements to be provided to the contractor.

4.3.1.1.7 Electrical control cabinet meeting requirements in clause 4.4.4 shall mounted on each HPU. All control and instrumentation wiring for the HPU shall be done on this cabinet.

4.3.1.1.8 The compete HPU composed of all the parts above shall preferably be structurally jointed as one compact system for easy testing, delivery and mounting at site.

4.3.1.2 Hydraulic Reservoir (sump tank)

4.3.1.2.1 Each HPU shall have a reservoir with capacity of at least 130% of all the oil in the hydraulic system (cylinder & pipes) of the three gates and the accumulator under normal operating conditions.

4.3.1.2.2 The tank shall be made of EN 1.0038 steel and shall comply to DIN 24339 standard.

4.3.1.2.3 The tank sheet steel thickness shall be suitable for the application as specified, however, at minimum, the sheet metal thickness **MUST** be at least **6mm.**

4.3.1.2.4 The surface of the reservoir (tank) shall be designed to be sufficiently large to transfer the total heat resulting from losses to the environment without the need of further cooling accessories. Contractor shall size and provide sizing calculations to employer for approval during design. Sizing shall factor in 130% oil capacity and natural cooling of the tank without cooling accessories.

4.3.1.2.5 Reservoir shall be designed to support the motor driven oil pumps and shall be provided with a manhole for access to the interior.

4.3.1.2.6 Reservoir shall have a minimum of the following devices each with an appropriate port on the tank.

(a) Oil filler port, filter, and strainer
(b) Oil purifier connections.
(c) Breather with an oil moisture vapour filter and dehumidifier.
(d) Dual changeover filter with clogging indicator on the tank return lines.
(e) Reservoir drain valve with plug.
(f) Mechanical Sight oil gauge (sight glass)
(g) PT100 temperature detector to monitor the oil temperature.
(h) Electronic float Level switches with at least three switching points & relays for too low level (stop pumps), low level (alarm) and high oil level (alarm).
(i) Electronic Oil Level transmitter with digital display and 4-20mA analogue output
(j) Oil temperature transmitter with digital display, two contacts and 4-20mA analogue output

4.3.1.2.7 Baffle plates (separator plates) shall be mounted in the reservoir to prevent the dirt from the returning fluid from being carried over to the suction chamber. The baffle plate (separator) shall also aid in the removal of air trapped in the fluid and prevent cavitation of the pumps caused by sloshing of oil and suction of oil with air bubbles. The suction and return lines on the sump tank shall be mounted as far apart as possible to allow any trapped air in the hydraulic oil to escape.

4.3.1.2.8 Pipe terminations in the reservoirs shall be below the oil level in the tank to prevent foaming and aeration of the hydraulic oil as well as suction of air by the pump.

4.3.1.2.9 The sump tank shall be used as the supporting structure for the motor driven pump set and some of the control valves & instruments (hydraulic valves and their mounting, transducers and gauges etc.) and the pump control panel. The tank shall thus be stiffened and reinforced to accommodate the weight of all components mounted on top of the tank. The process of reinforcement should not create dirt traps in the tank and the tanks interior shall be easy to clean.

4.3.1.2.10 The steel tank shall be hot galvanized and not spray-galvanized to prevent corrosion. Additionally, the steel tanks shall be sand- blasted and the interior primed with a zinc-rich paint before the cover is welded on. This paint shall be resistant to the hydraulic fluid and shall offer adequate protection against corrosion.

4.3.1.2.11 Any necessary opening through the tank such as pipe, filter and pump connections shall be carefully sealed and tightened to prevent any dirt from contaminating the hydraulic oil. Suitable sealing materials shall be used to compensate for any un-evenness in the sealing surfaces and shall be resistant to the hydraulic oil.

4.3.1.2.12 A pumping unit and its motor as well as its directional control and flow control valves shall be mounted on top the sump tanks and not inside.

4.3.1.2.13 The reservoir shall have a changeover inline return filter with clogging indicator on the tank return lines. The clogging indicator shall have both a mechanical indicator and an electrical output contact to be interfaced with the electrical control panel.

4.3.1.2.14 The sump tank shall be designed such that the flow velocity of the hydraulic oil inside the tank is as low as possible to allow any dirt suspended in the fluid to settle at the bottom of the tank. Access holes of adequate size shall be provided on the tanks so that the inside of the tank can be inspected and cleaned.

4.3.1.2.15 The HPU's Control manifolds shall be custom built to meet specified requirements of the existing hydraulic system. The customizing ensures that the hydraulics perfectly fit into the given application without losses in performance.

4.3.1.2.16 Reservoir testing: Leak test, coating

4.3.1.2.17 Reservoir protective treatment shall meet the following:

(a) Surface preparation: Blast cleaning at least Sa 2½ (ISO 8501) V2A / V4A sandblasted

(b) Reservoir prime coat: Epoxy zinc phosphate nominal Dry Film Thickness (DFT) 80 µm

(c) Reservoir intermediate coat: Epoxy paint nominal DFT 40 µm

(d) Reservoir final coat: Epoxy paint nominal DFT 40 µm

(e) Reservoir total nominal DFT: 160 µm

(f) Reservoir handling: Welded lifting lugs

(g) Reservoir cleaning cover: RD350 or RD475

4.3.1.3 **Pumping system requirements:**

4.3.1.3.1 Oil pumping set with pump motor shall be provided and mounted on each sump tank. Each pump shall be self-priming at any time after commissioning.

4.3.1.3.2 The pumping set shall be complete with, electric driven gear pump including, monitoring devices, duplex filters (with pressure differential alarm), all necessary piping and all other parts necessary to integrate the pump system into the control system.

4.3.1.3.3 New pump motors shall be supplied meeting requirements in clause 3.10. The pump motors shall be rated for continuous operation and direct online starting at full voltage. Unloading of the pumps during start-up shall be achieved mechanically or electrically. The contractor shall give a detailed description on how this shall be achieved.

4.3.1.3.4 The pumps shall be powered via the three phase pump starters located at the new intake gate LV switchboard with a capacity of 415Vac, 50Hz & 11KW. If the pumps supplied are of a higher capacity than what is specified in the LV switchboard requirements, the contractor shall supply a higher rated DOL starter as specified in clause 3.9.20 to suit the new motors.

4.3.1.3.5 Pumping set shall be designed for 200bar working pressure.

4.3.1.3.6 Pump shall be of similar type and rating to the existing.

4.3.1.3.7 Pump shall be sized to provide enough flow for raising of gate as per the existing system working principle. At minimum 50 litres per minute

4.3.1.3.8 Mechanical pressure gauge shall be provided for pump pressure monitoring during maintenance.

4.3.1.3.9 Pump line shall have a port for pressure monitoring and bleeding with an appropriate check valve.

4.3.1.3.10 Oil Pressure transmitter type Hydac EDS 1700 or equivalent meeting specification in clause 3.5.1.3; with four (4) switching point relays,4-20 mA signal output, digital display and full-scale pressure range of 0 to 250 bars shall be provided and mounted on the HPU. Pressure transducer shall be connected to the main pressure line using an appropriate minimess hose.

4.3.1.4 **Hydraulic accumulator system**

4.3.1.4.1 Each HPU shall have a hydraulic accumulator for restoration of the three gates.

4.3.1.4.2 Accumulator system shall consist of a piston accumulator and at least one Nitrogen bottle.

4.3.1.4.3 Accumulator shall meet all requirements in clause 3.13.

4.3.1.4.4 Accumulator shall be sized for 300mm travel of one gate equivalent three100mm restorations (3X100mm) of any gate without running the pumps.

4.3.1.4.5 The accumulator shall meet the following minimum requirements.

(a) **Type**: Piston accumulator
(b) **Design Working pressure**: 350 Bar.
(c) **Test pressure (p x 1.5):** 525 Bar
(d) **Seals:** "Viton" seal suitable for fluids HAS to HSD among others, Working temperature: -10˚C to 80˚C.
(e) **Bores** hard chromium surfaced.
(f) Use only nitrogen on the gas-side.

4.3.1.4.6 The piston accumulator and its nitrogen bottle/s shall be mounted next to the sump tank or as appropriate to maximise on the space available at the intake gate. The compete HPU shall preferable be structurally jointed as one compact system for easy, testing, delivery and mounting at site.

4.3.1.4.7 Accumulator shall be equipped with a safety and shutoff block at the top of the accumulator with a minimum of the following devices.

(a) pneumatic pressure relief valve for accumulator safety pressure release
(b) test port,
(c) Nitrogen Charging port,
(d) Pressure transducer ports -for connecting mechanical pressure gauge and electronic pressure transmitter.
(e) Pneumatic isolation valve
(f) Nitrogen bottle connection points

4.3.1.4.8 The pressure accumulator shall be designed such that the level of oil in the accumulator is monitored for indication when the nitrogen bottles need to be refilled.

4.3.1.4.9 Each accumulator shall be equipped with a minimum of the following instruments.

(a) mechanical pressure gauge displaying its operating pressure for maintenance. The maximum permissible excess operating pressure must be clearly marked on the gauge.
(b) Electronic pneumatic pressure switch and transmitter meeting specification in clause 3.5.1.3 with at least two programmable contacts ,4-20mA output

and display for nitrogen pressure indication which shall be wired to the control panels.

(c) Oil level switches for oil level (piston position) measurement in the accumulator shall be provided for oil level low and high alarms and connected to the control panel.

(d) Pneumatic pressure relief valve shall be provided equipped with auxiliary contact for connection to the control system to annunciate when the relief valve is operated.

4.3.1.4.10 The nitrogen bottle/s shall each be equipped with a lockable shut off pneumatic isolation valve.

4.3.1.4.11 The contractor shall also provide nitrogen charging devices, filling and testing equipment for use when re-filling the nitrogen bottles.

4.3.1.4.12 The pressure accumulator shall be firmly mounted with mountings that must be able to withstand shocks in case of pipe break.

4.3.1.5 Control & Regulating valves.

4.3.1.5.1 Valves and associated equipment shall preferably be assembled from standard CETOP components and mounted on a valve block on top of each HPU sump tank.

4.3.1.5.2 Control valves shall be Manganese phosphate/zinc plated/zinc-nickel plated.

4.3.1.5.3 Valves and valve blocks shall be designed to meet isolation and redundancy requirements given in clause 4.2.

4.3.1.5.4 There shall be at least two manifold valve blocks. One for pump control and the other for fluid power supply to the gates

4.3.1.5.5 Pump control block shall be provided with a minimum of the following Rexroth or equivalent valves.

(a) Check valve.

(b) Pressure actuated (piloted) Unloading valve.

(c) Solenoid actuated Unloading valve.

(d) Pressure relief valve

4.3.1.5.6 Valves manifold block for gate fluid power supply shall be provided with a minimum of the following Rexroth or equivalent valves.

(a) At least four solenoid directional control poppet valves or equivalent

(b) Pressure relief valve

(c) Needle valve for pressure discharge

4.3.1.5.7 The two relief valves shall have slightly different pressure setting for safety redundancy. All Pressure relief valves shall have a limit switch wired to control system for alarming when the valve operates.

4.3.1.5.8 To minimise pressure loss on the accumulator, control valves for gate cylinders fluid supply shall only be actuated to supply the hydraulic cylinder when gate operation is required otherwise the pipeline to the cylinder shall not be continuously supplied with pressure. The control valves shall have poppet valves or equivalent sealing method to ensure perfect sealing when valve is in off/closed position. The control valves shall each have a limit switch for position monitoring wired to the control panel.

4.3.1.5.9 There shall be at least four Isolation valves with extended handles on the pipelines connected to the valve block for isolation of each cylinder pressure lines and the accumulator. The isolation valves shall enable maintenance and replacement of each control valve without affecting gate operations.

4.3.1.5.10 Each control valve line (each valve port line) shall have a port for pressure monitoring and bleeding with an appropriate check valve.

4.3.1.5.11 A manually operated needle valve shall be provided on each HPU for discharging the accumulator pressure and the main pressure line for maintenance.

4.3.1.5.12 All valves necessary for each HPU operation as described in the preceding clauses shall be provided. The contractor shall however ensure a minimum of the following Rexroth or equivalent valves are included in the scope of supply for each HPU.

(a) At least Two (2) Common manifold valve block,
(b) At least one (1) Manually operated Flow control valve for de pressuring the HPU.
(c) At least Two (2) pressure relief valves each with an auxiliary contact wired to control system.
(d) At least one (1) Pressure actuated (piloted) Unloading valve.
(e) At least one (1) Solenoid actuated Unloading valve.
(f) At least four (4) Solenoid operated directional poppet control valve (or equivalent) with manual override for supplying fluid power to the three gates cylinders. Each valve to have limit switch for position indication wired to control system.
(g) At least Four (4) ball valves with extended handles for isolation
(h) At least two (2) Check valves

4.3.2 Hydraulic Cylinder Components.

4.3.2.1 The contractor shall replace all the hydraulic components on the intake gate hoisting cylinders. These components can be found in drawing number 251-14057. They include but not limited to following per cylinder:

(a) Flow control valves (two) for the pressure line
(b) Four by three-way directional control valve (one)
(c) Three by two-way directional poppet valves (two)
(d) Throttling valves (two.)
(e) Check valves (two).
(f) Pilot operated check valves (two).
(g) Two-way ball valves (one)
(h) Normally open gate valve(one).
(i) pressure switch (one)
(j) Mechanical pressure gauge
(k) Robust Limit switches for gate position indication (five)

4.3.2.2 Contractor shall supply all hydraulic control components necessary for gate hoisting function. The supplied components shall be rated for outdoor use at the climatic conditions at site. The components shall have a design life exceeding 25 years and suitable for use in harsh environments.

4.3.2.3 Contractor shall supply and install an outdoor cabinet at the gate structure for housing the gate control valves. The valves shall have however rugged and sealed for outdoor application irrespective of being housed at the cabinet.

4.3.2.4 Contractor shall design the new components to ensure the gate travel limits, speed (flow rates), pressure, oil flow during lifting and lowering are maintained as per plant commissioning requirements. Design shall ensure all safety factors are incorporated in the design. The new valves shall ensure the gate operations and oil flows remain as per gate design.

4.3.2.5 The new valves shall be configured and tested to ensure the gate operation is within the intake gate operating limits and all safety functions are provided.

4.3.2.6 Contractor shall supply new Rexroth or equivalent valves to carry out all the functions carried out by the existing valves. The new valves shall be standard CETOP components and mounted on a common valve manifold block.

4.3.2.6.1 The valves shall include but not limited to directional control valves, flow control valves, check valves, pilot operated check valves or logic valves and isolation valves.

4.3.2.6.2 An isolation valve shall be mounted at the end of the pipeline and at the cylinder ports for maintenance isolations.

4.3.2.6.3 Each control valve line (each valve port line) shall have a port for pressure monitoring and bleeding with an appropriate check valve.

4.3.2.7 Contractor shall supply and install the following new instruments.

4.3.2.7.1 Mechanical pressure gauge displaying operating pressure for maintenance. The maximum permissible operating pressure must be clearly marked on the gauge.

4.3.2.7.2 Electronic pressure switch and transmitter meeting specification in clause 3.5.1.3 with at least two programmable contacts,4-20mA output and display for cylinder pressure indication which shall be wired to the control panels.

4.3.2.7.3 A linear displacement transducer for accurate measurement of the cylinder piston position with 4-20mA output and at least four (4) programmable contacts wired to the control panels. The transducer shall be factory installed for the new cylinder and retrofitted into the existing cylinders during refurbishment. The transducer shall be appropriate for large cylinder application and shall not have any adverse effect on the cylinder. The transducer **shall not** utilise **external** cables or wires and **shall not** utilise a rod. The transducer port shall be totally sealed with appropriate rugged seals to ensure no oil leakage during gate operations.

4.3.2.7.4 Six (6) Robust IP68 Water resistant Limit switches for each gate for position indication and each with at least Two contacts. The limit switches shall be sturdy and robust enough to withstand the forces involved with the gate movement. It shall meet the following requirements:

(a) Shall have at least one NO and one NC contacts (two contacts)
(b) Contact Ratings: 10A @ 500 V AC, 0.4 A @220 V DC
(c) Nominal Insulation Voltage Ui: 500VAC, 600VDC
(d) Protective class: IP68, completely water resistant, shall withstand being submerged in a fluid to a depth of 1.5m for thirty minutes.
(e) Mechanical life: 30 million operations
(f) Switching Frequency: 150 operations per minute (30 million lifetime operations)
(g) Temperature range: -20˚C to +70˚C
(h) Switching characteristics: according to DIN 43694, form A, B, C, D and E. To meet DIN requirements for switching characteristics, the round mounting holes must be used.
(i) Standards: Meets the requirements of the following norms: Insulation group C per VDE 0110 VDE 0660 and DIN 43694.
(j) Construction:
    (i) Reliable head and cover sealing.
    (ii) Capacitive head and cover screws.

(iii) Robust die cast aluminium housing

(iv) Easily accessible earthing screw in accordance with DIN requirements. The earthing screw should be placed near the cable entry. This ensures that if the cable is pulled out forcibly, the earth lead is last to be disconnected so that shock hazard is minimized.

(v) Mounting by means of two round holes 5.3mm in diameter or two elongated holes 5.3mm x 7.3mm.

(vi) Roller levers: aluminium lever with steel roller for slide operation. Should offer a 90˚-total travel in each direction protecting the switch mechanism from the effects of machine overrun.

4.3.3 Servicing of Existing Hydraulic Cylinders

4.3.3.1 The contractor shall service and test all the intake gates hydraulic cylinders. This shall include supply and installation of new rod and piston seals. Testing shall be done to guarantee no leakage in any of the seals. The contractor shall submit the test results which the employer will conduct due diligence to verify.

4.3.3.2 The servicing of the servo motors (cylinders) shall include the following:

4.3.3.2.1 Complete stripping of each unit in a clean environment.

4.3.3.2.2 Inspection of all the components after cleaning to measure up in accordance with standard cylinder tolerances to determine if they are required to be re-used, re-worked or replaced.

4.3.3.2.3 The Rod and its Chrome surface shall be inspected for damage, deep scoring, and signs of underlying corrosion below the chrome surface as well as the thickness of the chrome which should not exceed.

4.3.3.2.4 The barrel bore shall be inspected for deep scoring and measured up for tolerance regarding the bore as well as any ovality in the barrel bore. The barrel can then be determined if it needs a polishing hone (on a proper honing machine) or if it needs to be replaced if damage cannot be repaired to standard repair tolerances.

4.3.3.2.5 Gland (Head) and rod piston shall also be measured against international standards to determine if re-use, repair or replace.

4.3.3.2.6 Valves mounted directly onto the servo motors shall be replaced and the mounting surface ground and polished.

4.3.3.2.7 Transfer tubes shall be replaced. Pipe support Clamps must be replaced by aluminium stauff clamps.

4.3.3.2.8 All seals shall be replaced. The replacement seals must be of equivalent or better quality.

4.3.3.2.9 All fasteners shall be replaced to the correct specification.

4.3.3.2.10 Spherical Bearings shall be replaced to the correct specification with the correct material, lubrication and sealing against the environment. This shall be from a well-known International Bearing manufacturer like SKF, NTN, Timken or NSK.

4.3.3.2.11 Hydraulic Hoses shall be replaced together with all port adapters and fittings.

4.3.3.2.12 Assembly shall be done in a clean environment and all fasteners torqued to the required rating in the correct sequence as per standard practices.

4.3.3.2.13 Testing procedure shall be advised and witnessed by a KenGen person. The test shall include the following:

(a) Pre-testing procedure
(b) Low pressure end-of-stroke testing in both directions without leaks. (minimum pressure required to stroke the cylinder)
(c) Full test pressure end-of-stroke testing in both directions (at least 20% above the working pressure).
(d) Open and closed centre measurements as well as stroke length to a 1mm tolerance.
(e) Mid-stroke bypass tests conducted a 1m intervals.

4.3.3.2.14 A detailed tamper proof test report must be produced and shall include the following:

(a) Open and closed Centres
(b) Stroke length
(c) Low pressure end-of-stroke tests with minimum pressure recorded.
(d) Full test pressure for end-of-strokes recorded.
(e) Test Oil temperature and specifications recorded.
(f) ISO Cleanliness level of test oil recorded.
(g) Water content of test oil recorded as a percentage of saturation.
(h) Details of the person who carried out the test.
(i) Photos of the unit on test for record purposes.

4.3.3.2.15 Preparation for painting shall include shot blasting of the barrel and gland external surfaces.

4.3.3.2.16 The cylinder shall be hard stamped with a job reference number for traceability and future repairs. This job number shall be clearly marked by a different colour paint on top of the final coat for ease of finding the number.

4.3.3.2.17 Painting of the cylinder to marine specification and as detailed in clause 3.3.10

4.3.4 Supply of New Hydraulic Cylinder

4.3.4.1 The contractor shall supply a new hydraulic cylinder with the same specifications, features, sizes, performance, and ratings as the existing cylinders and with all attachment components including but not limited to spherical bearing, transfer tubes, support clamps, valves, linear displacement transducer. The body and rod material and their finishing of the new cylinders shall be the same as existing.

4.3.4.2 The Cylinder shall be large cylinder type designed for civil engineering applications in hydro power applications with a design life of over 25 years.

4.3.4.3 Shall meet all the specifications of the existing cylinders as provided for in the manuals and drawings.

4.3.4.4 Bidder shall study the existing cylinder specifications and drawings before making their offer. Drawing of existing cylinders is attached in the appendix.

4.3.5 Piping Requirements

4.3.5.1 The contractor shall replace all hydraulic pipes at the intake with steel plated pipes painted to marine specifications suited for outdoor application (adverse conditions.)

4.3.5.2 Piping shall meet all the requirements in clause 3.11.

4.3.5.3 A pressure line and tank line shall be supplied for each gate cylinder from the HPU's to the cylinder. Tank line piping shall not be jointed outside the gate control room.

4.3.5.4 Ball valve isolation valves shall be connected on each gate cylinder pipeline from the HPU's. Valves shall be mounted on the cylinder end and on the HPU end for maintenance isolations.

4.3.5.5 A manually operated needle valve shall be provided on each gate cylinder pressure line for discharging the pressure line during maintenance.

4.3.5.6 The pipe clamps shall all be of Aluminium Stauff type. The clamps shall be installed with a spacing of 1m between adjacent clamps, clamps shall be installed directly behind threaded pipe connectors and couplings. Pipe bends shall be supported by clamps as near to the bending curve as possible. In places with valves, the clamp support shall be provided both in front and behind the valves.

4.3.5.7 The contractor shall pressure test the piping system at 400 bars as recommendations in the Hydraulic Piping Standard Handbook and applicable ISO standards. All equipment necessary for pressure testing shall be provided by the contractor. Piping shall be observed to withstand 400bar test pressure for at least 30 minutes without leakages and mechanical strength of the system is observed to be sufficient for the test to be successful.

4.3.5.8 The contractor shall flush the piping system to remove any contaminants according to the recommendations of the 'Hydraulic Piping Standard Handbook revision 1' or newer. An equivalent or better standard shall be accepted.

4.4 INTAKE GATE ELECTRICAL CONTROL REQUIREMENTS

4.4.1 General Requirements

4.4.1.1 The Bidder shall study the existing gate control scheme and make a proposal based on that and the scope and specifications provided in this document.

4.4.1.2 The bidder shall ensure that all the existing functions of the gate control scheme are maintained in the offer. All the existing operation modes of the intake gates shall be maintained.

4.4.1.3 Electrical control circuit/logic for the pumps and gate operation shall hardwired using contactor relays meeting specifications in clause 3.5.3. All interlocks and commands for pump and gate control shall be hardwired, local operation using pushbuttons, indicator lamps and panel instruments shall be the primary mode of gate operation. Pumps starting and stopping shall be automated by a hardwired circuit. PLC or any other IED's shall only be used for remote interfaces to SCADA and for protective functions if any. Remote operation of gates and pumps through PLC shall be provided as a backup operation mode with a remote selection interlock.

4.4.1.4 All control wiring within the intake gate area shall be replaced with new wiring except for wiring to the main control building which shall be re used. All power cabling within the intake gate area that is too short to be reused shall be replaced.

4.4.1.5 The hardwired control scheme shall include all necessary controls, interlocks, protection functions and indications to ensure safe and reliable operation of the intake gates.

4.4.1.6 All the components of the gate control scheme shall be housed in panels that meets the specifications in clause3.6

4.4.1.7 Contractor shall supply the following control panels.

(a) Three (3) intake gate control panels for each of the three gates operation
(b) Three (3) Outdoor cabinets for each of the three gates operation
(c) Two (2) HPU electrical control cabinet mounted on each HPU.
(d) SCADA panel housing SCADA interfaces as described in clause 4.4.6.
(e) DC supply cabinet

4.4.1.8 The intake gate control panels with all the necessary switches, wiring and electrical items as specified shall be housed in the existing intake control room. The existing electrical equipment shall be dismantled and removed by the Contractor.

4.4.1.9 The gate control supplies, and the motor-pump supplies shall be supplied from the intake gate low voltage switchboard.

4.4.1.10 Each gate shall have the following levels of control:

(a) Operation through pushbuttons in the gate control panel at the intake gate control building.
(b) Local operation through pushbuttons located at the hydraulic cylinders.
(c) Operation from SCADA panel
(d) Emergency close from unit automation system

4.4.1.11 The following operations of the intake gates shall be provided for:

(a) Raising or opening the gate
(b) Lowering or closing the gate
(c) Stopping in any position of travel
(d) Emergency- shutdown operation

4.4.1.12 The intake gate control panel shall have control circuits for each of the operations mentioned above for each of the gates.

4.4.2 Gate Operation Description

4.4.2.1 Raise Operation:

4.4.2.1.1 The raise pushbutton shall give the pulse that is required to start the raise operation. The control circuit shall be implemented in such a way that only a pulse is required to open the gate completely and not continuous operation of the raise pushbutton.

4.4.2.1.2 After the raise pushbutton is pressed, the hardwired control shall check all the pre-conditions including but not limited to: no motor starter failure, HPU selection, HPU grouped failure, sump tank oil level, gate position and other condition deemed necessary for proper functioning of the intake gate before starting the motor pump, energizing solenoid directional control valve at the HPU (duty/standby) and energizing the solenoid directional control valve at the hydraulic circuit for raising the gate.

4.4.2.1.3 The control scheme shall monitor and display the pressure of the oil at the hydraulic cylinder pressure line after the motor pump has been started. In case a minimum pressure of **100 Bars** is not attained after a time delay of

approximately **5 Seconds**, from either duty HPU and standby HPU, solenoid valves are de-energized, and the gate remains in its current position.

4.4.2.1.4 When the gate is raised by approximately **100mm**, which is the penstock filling position, a limit switch is actuated which shall hold the intake gate in position awaiting the penstock to be filled.

4.4.2.1.5 The control scheme shall have a transducer for indicating that the penstock has been filled indicating the end of the "crack opening" phase. Once the penstock is filled, the control scheme shall resume opening the intake gate to its fully open position. A timer relay with a setting of time required to fill the penstock shall also interlock resumption of gate opening operation.

4.4.2.1.6 Once the gate is fully open as indicated by a limit switch mounted on the hydraulic cylinder, the control scheme shall switch off the pump and de-energize the solenoid valves associated with opening the gate. The gate shall be held in the open position.

4.4.2.1.7 If during gate operation the duty HPU is not able to provide pressure the control scheme shall automatically switch to standby HPU if no other operation is in progress or stop the gate operation. If operation is stopped a manual raise command shall be required resume raise operation.

4.4.2.2 **Lowering Operation:**

4.4.2.2.1 The lower pushbutton shall give the pulse that is required to start the lower operation. The control circuit shall be implemented in such a way that only a pulse is required to lower the gate completely and not continuous operation of the lower pushbutton.

4.4.2.2.2 The control scheme shall energize the respective solenoid valves in the hydraulic circuit allowing the gate to lower by gravity. The solenoid valves necessary for directing the pressurized oil to the upper part of the hydraulic cylinder shall also be energized.

4.4.2.2.3 The control scheme shall monitor and display the pressure of the oil at the hydraulic cylinder resulting from the weight of the gate. In case a minimum pressure of **100 Bars** is not attained after a time delay of approximately **5 Seconds**, the solenoid valves are de-energized, and the gate remains in its current position.

4.4.2.2.4 Once the gate reaches the closed position, a limit switch shall be actuated, and the lowering solenoid valves are de-energized.

4.4.2.3 **Stop operation:**

4.4.2.3.1 The stop operation shall interrupt the raise and lower operations but not the emergency stop operation. The stop operation shall be initiated by a push button in the gate control panel.

4.4.2.3.2 When the gate is in the open operation, the stop operation shall stop the running motor pump and de-energize the solenoid hydraulic valves that are actuated by the raise operation. The gate shall come to a standstill.

4.4.2.3.3 When the gate is in the lower operation, the stop operation will de-energize the solenoid hydraulic valves that are actuated by the lower operation and the gate shall come to a standstill.

4.4.2.3.4 The gate control scheme shall be implemented such that subsequent gate operations either lowering or raising shall have to be initiated again by pressing their respective pushbutton after the stop operation has been executed.

4.4.2.4 **Emergency shutdown:**

4.4.2.4.1 In case of emergencies, the gate shall be closed quickly a speed higher than the normal lowering speed. This operation mode shall be initiated by pressing the emergency shutdown pushbutton at the intake and at the powerhouse.

4.4.2.4.2 The control circuit shall be implemented in such a way that only a pulse is required to lower the gate completely.

4.4.2.4.3 The gate control scheme shall energize the respective emergency shutdown solenoid valves lowering the gate at a velocity higher than the normal lowering.

4.4.2.4.4 When the gate reaches the fully closed position, a limit switch shall be actuated de-energizing the emergency shutdown solenoid valves.

4.4.2.5 **Gate Restoration Control:**

4.4.2.5.1 The gate control scheme shall have a gate restoration functionality that shall restore any of the open gates back to the fully open position in case they drift and move downwards by **100mm** from the gate fully open position.

4.4.2.5.2 There shall be a limit switch that is actuated once the gate drifts by **100mm** from the gate fully open position. Once this switch is activated, the gate control scheme will energize the necessary solenoid hydraulic valves to allow pressurized oil to flow from the HPU to the hydraulic cylinder of the gate that has drifted.

4.4.2.5.3 The gate shall be lifted back up until the gate fully open position limit switch is actuated. The gate fully open limit switch shall de-energize all the actuated solenoid valves and the gate shall remain in the fully open position.

4.4.2.5.4 In case the system is unable to restore the drifted gate due to any system failure and continues to drift further, the gate control scheme shall trigger an emergency closure of the intake gate. To achieve this, the gate control scheme shall have a limit switch mounted on the gate's hydraulic cylinder below the

gate restoration limit switch that shall be actuated when the gate continues to drift. A dry contact shall be provided and wired to the unit control system for tripping the unit when restoration fails, or gate drift position limit switch is actuated.

4.4.2.6 **Simultaneous Raising of two gates:**

4.4.2.6.1 The intake control scheme shall allow simultaneous raising of two gates at time. The third gate shall be electrically interlocked and cannot be opened if the other two gates are being raised. The closing of the third gate shall be possible at any time.

4.4.2.6.2 Once a raise command from one gate has started a pump, the gate control scheme shall isolate subsequent open commands from the other gates to that pump until the gate reaches the fully open position, receives a stop command or receives an emergency closing command.

4.4.2.6.3 Thus, the gate control scheme shall only allow two gates to be simultaneously opened. The third gate shall be electrically interlocked (using a hardwired scheme) as long as the two other gates are being raised.

4.4.2.6.4 Gate control panel shall have selector switch for setting the duty and standby HPU.

4.4.2.6.5 The Duty HPU shall provide pressurized oil for raising the first gate. When the raise command for the second gate is issued, the other HPU shall be switched on providing pressurized oil to raise the second gate. The necessary solenoid valves shall be energized to enable raising of the gates.

4.4.2.7 **In case of AC power failure:**

4.4.2.7.1 If the gate is opening, the gate shall stop and remain in position.

4.4.2.7.2 If the gate is stopped, it will remain in position.

4.4.2.7.3 If the gate is closing, gate will continue closing but may be stopped.

4.4.2.7.4 If the gate is open it shall be possible to close it as required.

4.4.2.8 **Hydraulic Power Unit (HPU) Pump Operations**

4.4.2.8.1 Intake gate control system shall have two HPU's and each HPU shall be complete system with reservoir, pump, control valves, accumulator, and instrumentation.

4.4.2.8.2 Pump shall be operated either manually or automatically. There shall be selector switch on the switchboard for manual/auto/SCADA operation. Manual operation shall be via push buttons on the switchboard or at the HPU control panel or SCADA panel. HPU control panel shall house the pump auto control circuit.

4.4.2.8.3 A pressure transducer as described in the HPU requirements shall be used for automatic starting and stopping of pumps when no gate opening is in progress to charge the accumulator.

4.4.2.8.4 In auto operation mode, the pump shall automatically start when pressure falls below set pressure of the accumulator or when gate raise operation is initiated from gate control. Pump shall stop automatically when the pressure reaches the set system pressure or when pump stop is initiated from gate control.

4.4.2.8.5 Pump shall run continuously when a gate raise operation is in progress irrespective of accumulator pressure, unloading valve shall unload the pump to prevent pressure from rising above working pressure.

4.4.2.8.6 The pump control scheme shall be implemented such that:

(a) One gate is always opened with the aid of one HPU.

(b) Every gate can be opened with the aid of every HPU.

(c) Only two gates can be opened simultaneously with both HPU pumps running

(d) When two gates are being raised, the third gate is electrically interlocked.

4.4.2.8.7 The HPU that is selected duty shall be responsible for providing the pressurized oil for raising any of the three gates whose raise pushbutton is first pressed.

4.4.2.8.8 The pump control scheme shall monitor the pressure of the duty motor-pump after a start pump command has been issued. The start command for the duty motor pump from the gate control panel shall simultaneously start a timing relay. If after the expiration of the set time (approximately 5-7 Sec) a minimum pressure of 100 Bar is not available, the motor pump is unable to build pressure. The pump control scheme shall:

(a) Shut down the duty motor pump.

(b) Annunciate pump failure to the pump control panel and the SCADA panel.

4.4.2.8.9 Solenoid operated unloading valve shall be actuated to unload the valve during pump start up. The unloading shall be timed.

4.4.3 Gate Control Panels

4.4.3.1 Three gate control panels shall be provided for gate control. Each gate shall have a separate control panel. Due to the limitation of space at the intake gate control room a single enclosure with three distinct partitions may be used, and each gate control to be housed in a separate compartment.

4.4.3.2 The gate control panel shall implement a hardwired control scheme, using contactor relays meeting requirements of clause 3.5.3, for all the gate operations described in

clause 4.4.2. All gate operations described in clause 4.4.2 and any other existing function necessary for gate operation shall be implemented.

4.4.3.3 Robust contactor type or equivalent timer relays shall be provided as per operating description and existing system requirements. Timers shall not be plug in type of relays.

4.4.3.4 A minimum of the following instruments and signals shall be wired to **each** gate control panel/compartment.

4.4.3.4.1 The gate positions limit switches as detailed in clause 4.3.2.7.4

(a) shall be wired for each of the following positions:

(i) Closed Position

(ii) Filling (Crack open) Position

(iii) Trip Position

(iv) Gate Restore Position

(v) Gate fully open Position

(b) All the above contacts shall be multiplied using a **contactor control relay** meeting requirement in clause 3.5.3 for use in gate control panel and wired to unit automation panel (powerhouse) and SCADA panel.

4.4.3.4.2 Hydraulic cylinder linear displacement transducer as detailed in clause 4.3.2.7.3

(a) 4-20mA output shall be wired to digital panel indication meter and to SCADA panel through signal multiplication and isolator or using a meter with 4-20mA output. Series wiring of the analogue signal to meter and SCADA without isolation shall not be accepted.

(b) Contact outputs shall be used to back up the limit switches contact i.e., wired in parallel.

4.4.3.4.3 Hydraulic cylinder pressure switch & transmitter as detailed in clause 4.3.2.7.4

(a) 4-20mA output shall be wired to digital panel indication meter to SCADA panel through signal multiplication and isolator or using a meter with 4-20mA output. Series wiring of the analogue signal to meter and SCADA without isolation shall not be accepted.

(b) Contact outputs shall multiplied for control circuits and wiring to SCADA panel.

4.4.3.4.4 HPU 1 pressure okay contact from pressure switch & transmitter as detailed in clause 4.3.1.3.10 to be used in gate control circuits. Contact to be multiplied at the pump panel for use on the three gates control.

4.4.3.4.5 HPU 2 pressure okay contact from pressure switch & transmitter as detailed in clause 4.3.1.3.10 to be used in gate control circuits. Contact to be multiplied at the pump panel for use on the three gates control.

4.4.3.4.6 Penstock full transducer (switch). Existing transducer to be replaced. Contacts of the transducer to be multiplied for SCADA and control panel use.

4.4.3.4.7 HPU 1 reservoir oil level low from Electronic float Level switches at the reservoir

4.4.3.4.8 HPU 2 reservoir oil level low from Electronic float Level switches at the reservoir

4.4.3.4.9 Grouped HPU 1 pump starter fault from LV switchboard.

4.4.3.4.10 Grouped HPU 2 pump starter fault from LV switchboard.

4.4.3.4.11 All other transducers and signals necessary for gate control as described in clause 4.4.2 and as per existing scheme shall be provided and wired to the control panel.

4.4.3.5 A minimum of the following LED lamps shall be mounted on **each** gate control panel/compartment door for gate operations.

(a) Gate fully open status
(b) Gate fully closed status
(c) Gate cracked open.
(d) Gate below leakage oil position (Trip Position)
(e) Gate Moving (restoration point)

4.4.3.6 A minimum of the following pushbuttons shall be mounted on **each** gate control panel/compartment door for gate operations.

(a) Gate raise command.
(b) Gate lower command
(c) Stop command.
(d) Emergency close (button as per clause 3.5.2.7)
(e) Alarm reset.
(f) Lamp check-lamp check circuit to be provided.

4.4.3.7 A minimum of the following selector switches shall be mounted on **each** gate control panel/compartment door for gate operations.

(a) Three pole, Three position key switches for GATE/CONTROL ROOM/SCADA location of gate operation interlock
(b) Two pole, Two position selector switches for duty HPU selection

4.4.3.8 A minimum of the following digital panel indication meters meeting requirements of clause 3.5.8.3 shall be mounted on **each** gate control panel/compartment door for gate operations.

(a) Hydraulic cylinder pressure with 4-20mA output
(b) Hydraulic cylinder position with 4-20mA output

4.4.3.9 A minimum of the following solenoid valves shall be actuated from **each** gate control panel/compartment to carry out gate operations described in clause 4.4.2. All the

solenoid valves shall be actuated using a **contactor control relay** meeting requirement in clause 3.5.3. The relay contacts shall be wired to SCADA panel for monitoring.

(a) Cylinder open solenoid
(b) Cylinder normal close solenoids
(c) Cylinder emergency close solenoid
(d) HPU 1 Cylinder fluid power supply solenoid for the specific gate
(e) HPU 2 Cylinder fluid power supply solenoid for the specific gate

4.4.3.10 A minimum of the following electrical supplies devices shall be installed on **each** gate control panel or compartment.

(a) At least two (2) double pole DC MCB's for 24 V DC and 110V DC supply
(b) At least two (2) AC MCB's shall be provided for AC supplies.
(c) At least one (1) British type socket
(d) At least one (1) LED panel lighting with door switches
(e) Panel heater and hygrostat

4.4.3.11 All existing signals and functions from the unit control systems at the powerhouse shall be restored for **each** gate this shall include but not limited to

(a) Gate fully open status
(b) Gate below restoration position (trip position) status
(c) Gate filling position status
(d) Gate closed status.
(e) Gate moving (restoration) position status.
(f) Gate emergency trip status
(g) Gate emergency trip command

4.4.3.12 **Outdoor Electrical Control Panel:**

4.4.3.12.1 For operation of the intake gates from the gate's hydraulic cylinders, illuminated pushbuttons with integrated feedback LED lamps for the manual operation (raising, lowering, and stopping) and an emergency close mushroom head push button shall be mounted in an outdoor panel.

4.4.3.12.2 Panel shall have a minimum ingress protection rating of IP 66. The panel shall have double doors with the pushbuttons mounted in the inner door ensuring that the pushbuttons are not exposed to the environment. The pushbuttons shall, however, be ruggedized and able to withstand the outdoor environmental conditions.

4.4.3.12.3 The pressure gauge and its indicator that monitor the pressure in the hydraulic cylinder shall also be mounted in the outdoor electrical control panel.

4.4.3.12.4 Each gate shall have its own outdoor control panel that shall be mounted next to the gate's hydraulic cylinder for convenient operation.

4.4.4 HPU Control Panels

4.4.4.1 An electrical panel shall be supplied for each HPU. The HPU electrical control panels shall be mounted on the HPU and shall be supplied as a compact unit together with the HPU.

4.4.4.2 The HPU panel shall implement a hardwired pump auto control scheme, using contactor relays meeting requirements of clause 3.5.3, for all the automatic pump operations described in clause 4.4.2. All pump operations described in clause 4.4.2 and any other existing function necessary for pump operations shall be implemented.

4.4.4.3 A minimum of the following the HPU instruments described in clause 4.3.1 shall be wired to **each** HPU electrical panel for pump control and interfacing to the SCADA panel and gate control.

(a) Clogging indicator on each tank return line filter.
(b) PT100 temperature detector to monitor the oil temperature.
(c) Electronic float Level switches with at least three switching points & relays for too low level (stop pumps), low level (alarm) and high oil level (alarm).
(d) Electronic Oil Level transmitter with digital display and 4-20mA analogue output
(e) Oil temperature transmitter with digital display, two contacts and 4-20mA analogue output
(f) Oil Pressure transmitter type Hydac EDS 1700 or equivalent meeting specification in clause 3.5.1.3; with four (4) switching point relays and 4-20 mA signal output.
(g) Electronic pneumatic pressure switch and transmitter meeting specification in clause 3.5.1.3 with at least two programmable contacts ,4-20mA output and display for nitrogen pressure indication.
(h) Oil level switches for oil level (piston position) measurement in the accumulator for oil level low and high alarms
(i) Pneumatic pressure relief valve auxiliary contact for accumulator pressure relief valve operated status.
(j) Pump pressure relief valve operated auxiliary contact.
(k) Main HPU pressure relief valve operated auxiliary contact.
(l) Gate 1 Cylinder fluid power supply valve open auxiliary contact.
(m) Gate 2 Cylinder fluid power supply valve open auxiliary contact.

(n) Gate 3 Cylinder fluid power supply valve open auxiliary contact.

4.4.4.4 The following instruments contacts shall be multiplied for pump control, wiring to gate control panel and SCADA on **each** HPU.

(a) Oil level too low level (stop pumps) level switch.
(b) Oil level low level (alarm) from the reservoir level switch.
(c) Oil temperature too high alarm from temperature transmitter
(d) Oil pressure normal from Oil Pressure transmitter type Hydac EDS 1700 or equivalent
(e) Pneumatic pressure relief valve auxiliary contact for accumulator pressure relief valve operated status.
(f) Pump pressure relief valve operated auxiliary contact.
(g) Main HPU pressure relief valve operated auxiliary contact.
(h) Gate 1 Cylinder fluid power supply valve open auxiliary contact.
(i) Gate 2 Cylinder fluid power supply valve open auxiliary contact.
(j) Gate 3 Cylinder fluid power supply valve open auxiliary contact.

4.4.4.5 The following alarms shall be created for annunciation and gate operations on **each** HPU.

(a) Pump failure – If pump fails to build pressure 10-15 secs after starting (to latch until reset). Robust contactor type timer relay to be used.
(b) Pressure very high fault – If any of the three-pressure relief valve is actuated. (to latch until reset)
(c) Grouped HPU fault– if any of the following is actuated-Pump failure, pressure very high fault, oil level too low trip, temperature to high alarm.

4.4.4.6 Pressure switch contacts to be utilised as follows **on each** HPU.

(a) Contact 1 HPU pressure too low alarm.
(b) Contact 2 HPU pressure low start pump.
(c) Contact 3 HPU pressure normal (ok)
(d) Contact 4 HPU pressure too high stop pump.

4.4.4.7 The following shall be interfaced to DOL starter on the switchboard for **each** HPU.

(a) Pump start and stop on the switchboard and on the HPU control panel shall be interlocked by manual selection at the switchboard. In manual selection starting or stopping of pump shall be possible at the switchboard and at the HPU
(b) Pump starter on the switchboard be wired in failsafe (series) to the following devices on the pump control panel for Pump to start. Emergency push button reset, DC MCB on, Oil level too low trip off, pressure very high off.

(c) Auto operation of pump shall be interlocked to switchboard auto selection.

(d) Main contactor ON and OFF status and starter fault status shall be wired to the HPU electrical control panel for indications, alarms and pump control.

4.4.4.8 A minimum of the following LED lamps shall be mounted on **each** HPU.

(a) Pump failure

(b) Pump starter fault

(c) Pressure very high fault

(d) Grouped HPU fault

4.4.4.9 A minimum of the following pushbuttons shall be mounted on **each** HPU.

(a) Pump start

(b) Pump stop

(c) Fault reset.

(d) Emergency stop (button as per clause 3.5.2.7)

(e) Lamp check-lamp check circuit to be provided.

4.4.4.10 A minimum of the following solenoid valves shall be actuated from **each** HPU panel/compartment to carry out gate operations described in clause 4.4.2. All the solenoid valves shall be actuated using a **contactor control relay** meeting requirement in clause 3.5.3. The relay contacts shall be wired to SCADA panel for monitoring.

(a) Pump unloading valve during start up.

(b) accumulator isolation solenoid

(c) Any other solenoid valve applicable to pump control

4.4.4.11 A minimum of the following electrical supplies devices shall be installed on each gate control panel or compartment.

(a) At least two (2) double pole DC MCB's for 24 V DC and 110V DC supply

(b) At least two (2) AC MCB's shall be provided for AC supplies.

(c) At least one (1) British type socket

(d) At least one (1) LED panel lighting with door switches

(e) Panel heater and hygrostat

4.4.5 DC supply

4.4.5.1 Contractor shall supply and install a DC distribution cabinet for supply of all intake gate systems.

4.4.5.2 Panel shall distribute both 110V DC and 24V DC.

4.4.5.3 The panel shall have two 110V DC incoming circuits and one 240V AC UPS supply

4.4.5.4 A diode shall be provided for paralleling the two DC incoming circuits.

4.4.5.5 Two (2) redundant power supply units one for 240V AC supply input and another for 110V DC supply input for providing the SCADA cabinet with 24V DC supply shall be installed.

4.4.5.6 24V DC supply from the two power supply units shall paralleled using a diode block.

4.4.5.7 A minimum of the following 110V DC circuits shall be provided.

(a) LV switchboard
(b) SCADA panel
(c) Gate control panel/compartment 1
(d) Gate control panel/compartment 2
(e) Gate control panel/compartment 3
(f) HPU 1
(g) HPU 2
(h) Other
(i) Spare 1
(j) Spare 2

4.4.5.8 A minimum of the following 24V DC circuits shall be provided.

(a) LV switchboard
(b) Gate control panel/compartment 1
(c) Gate control panel/compartment 2
(d) Gate control panel/compartment 3
(e) HPU 1
(f) HPU 2
(g) General instruments supply
(h) Spare 1
(i) Spare 2

4.4.5.8.2 A DC supply supervision relay shall be wired on the 110V DC bus. Its auxiliary contact shall be wired to the employer's common PLC at the main control building/.

4.4.6 SCADA Interface

4.4.6.1 Contractor shall supply, install, and commission a SCADA panel at the spillway control room meeting requirements in **clause 4.6** and implementing the gate control functions in the subsequent clauses.

4.4.6.2 Contractor shall Implement all the control schemes as described in clause 4.4.2 on the SCADA panel automation system. The SCADA selection at the gate control panels and at

the switchboard shall allow operation of equipment from the operator panel on the SCADA panel at the intake gate. At the SCADA panel local/ remote selection shall interlock remote SCADA operations and operator panel operations

4.4.6.3 Requirements for SCADA panel and all associated equipment are described in clause 4.6.

4.4.6.4 A minimum following signal shall be wired from each gate control panel/compartment to the SCADA panel.

(a) Gate Closed Position
(b) Gate Filling (Crack open) Position
(c) Gate Trip Position
(d) Gate Restore Position
(e) Gate fully open Position
(f) Hydraulic cylinder linear displacement transducer 4-20mA output
(g) Hydraulic cylinder pressure switch & transmitter 4-20mA output
(h) Two (2) contacts of Hydraulic cylinder pressure switch & transmitter
(i) Penstock full contact
(j) Gate emergency stop
(k) Gate raise in progress.
(l) Gate lower in progress
(m) Gate stopped.
(n) Gate raise fault.
(o) Gate lower fault
(p) Gate raise locked out (No HPU available for raise)
(q) Gate operation location selection- GATE
(r) Gate operation location selection- CONTROL ROOM
(s) Gate operation location selection- SCADA
(t) HPU 1 duty
(u) HPU 2 duty
(v) 110V DC MCB trip
(w) 24V DC MCB trip
(x) Grouped fault (to reset)

4.4.6.5 A minimum following command shall be wired to **each** gate control panel/compartment from SCADA panel.

(a) Gate raise
(b) Gate lower
(c) Gate stop.
(d) Gate emergency close

(e) Reset alarms.

4.4.6.5.2 A minimum following signal shall be wired from **each** HPU to the SCADA panel.

(a) Two (2) Clogging status contacts, one on each tank return line filter
(b) PT100 temperature detector to monitor the oil temperature.
(c) Three (3) Electronic oil Level switches contacts
(d) Electronic Oil Level transmitter 4-20mA analogue output
(e) Two (2) Oil temperature transmitter contacts
(f) Oil temperature transmitter 4-20mA analogue output
(g) Four (4) Oil Pressure transmitter contacts
(h) Oil Pressure transmitter 4-20 mA signal output.
(i) Two (2) Accumulator pneumatic pressure contacts
(j) Accumulator pneumatic pressure,4-20mA output.
(k) Two (2) accumulator Oil level switches contacts
(l) Accumulator Pneumatic pressure relief valve operated auxiliary contact.
(m) Pump pressure relief valve operated auxiliary contact.
(n) Main HPU pressure relief valve operated auxiliary contact.
(o) Gate 1 Cylinder fluid power supply valve open auxiliary contact.
(p) Gate 2 Cylinder fluid power supply valve open auxiliary contact.
(q) Gate 3 Cylinder fluid power supply valve open auxiliary contact.
(r) 110V DC MCB trip
(s) 24V DC MCB trip

4.4.6.6 A minimum following command shall be wired to **each** HPU from SCADA panel.

(a) Fault reset.

4.4.6.7 All SCADA panel and its interface wiring shall be supplied and installed by the contractor.

4.4.6.8 Program development shall be carried as described in clause. 4.6.1.3

4.5 LOW VOLTAGE INTAKE GATE SWITCHBOARD

4.5.1 General LV Switchboards Requirements

4.5.1.1 Gitaru power station has several LV switchboards for supplying various station loads. All the switch boards are supplied from the main station switch board located at the control building; main station switch board has four incoming supplies from the station transformers and diesel generator. The main switch board has two bus sections a duty bus section and reserve bus section each with two incomers, only one incomer is connected to the bus bar at any one time.

4.5.1.2 There is a gate control centre at the gates control building that is supplied from the main station switch board. KenGen wishes Install new gate control centre at the gates control building.

4.5.1.3 Bidder shall study the existing switch boards and make a proposal based on that and the scope and specifications provided in this document. The switchboards and their components shall conform to ALL the specification given in the subsequent sections and other parts of this document.

4.5.1.4 The new boards and equipment must ensure continuous supply for FOURTY YEARS Without interruptions. They MUST withstand the prevailing environmental conditions prevailing at site and as provided in the plant equipment data section 3.14 of specifications.

4.5.1.5 Any alternative / additional equipment considered necessary for providing complete, effective, and reliable switchboards but not indicated in the specifications shall also be included in the bid.

4.5.1.6 Project involves design, installation, and commissioning of intake gate control supply 3Φ switchboard & 1Φ AC distribution board.

4.5.1.7 The switch board and its components shall be designed, constructed, and tested in accordance with IEC 61439, IEC 60947 and IEC 60529. The boards shall be complete with all the relevant components including, bus bars, circuit breakers; cable compartment; instrument transformers; protection & control relays; instruments, meters and other control devices. Three phase connections shall ALL be 4 WIRE and DC connections 2 WIRE.

4.5.1.8 The new switchboards shall cover all the functionality of the existing switchboards plus the new requirements. Bidders must study the existing switchboard before making their offer. Necessary drawings and equipment data will be supplied during the site visit.

4.5.1.9 Components, devices or parts of the switchboard not mentioned in the specification but required for complete working of the switchboard or for providing functionality of the existing switch boards and new requirements shall be included in the bid and shall form part of equipment to be supplied.

4.5.1.10 Power cables for incomer and feeder cables shall be reused except where cables are too short to be re-used due to changes in the switchboard.

4.5.1.11 Auxiliary supply, Control, metering, and protection cabling within the intake shall be replaced with new cables.

4.5.2 Switchboard Particular Requirements

4.5.2.1 The switchboard shall have two incomer supplies from the main station switchboard duty bus section and reserve bus section.

4.5.2.2 The following incomers and feeder circuits with the indicated switchgear ratings shall be provided in the new switch board:

	Incomers					
	compartments	Module rating		Type	MCCB/ MPCB rating	Contactor rating
1	Duty incoming supply	300A		Incomer	400A	200KW
2	Reserve incoming supply	300A		Incomer	400A	200KW
3	Control and metering	N/A		Control& metering	N/A	N/A
	Feeders' Withdrawable plug-in modules					
1	Power outlet	125A		Cable feeder	160A	N/A
2	Lighting and small power	125A		Cable feeder	160A	N/A
3	Spare	125A		Cable feeder	160A	N/A
4	Spare	125A		Cable feeder	160A	N/A
5	Screen raking gantry	32A		Cable feeder	32A	N/A
6	Spare	32A		Cable feeder	32A	N/A
7	HPU 1 pressure pump	32A	11KW	motor DOL starter	32A	18.5KW
8	HPU 2 pressure pump	32A	11KW	motor DOL starter	32A	18.5KW
9	Spare	32A	11KW	motor DOL starter	32A	18.5KW
10	Raw water supply	32A	11KW	motor DOL starter	32A	18.5KW
11	Spare	32A	11KW	motor DOL starter	32A	18.5KW
	Lighting and small power 4 Way TP&N distribution board					
	feeder circuit			Type	MPCB rating	MCB rating
1	1			Three phase circuit	32A	N/A
2	2			Three phase circuit	32A	N/A
3	3			Single phase circuit	N/A	32A
4	4			Single phase circuit	N/A	32A
5	5			Single phase circuit	N/A	32A
6	6			Single phase circuit	N/A	16A
7	7			Single phase circuit	N/A	16A
8	8			Single phase circuit	N/A	16A

	Switchboard Basic rating	
1	Main bus bar rating In	400A
2	Distribution bus bar rating In	300A
3	Switchboard short-time withstand current(Icw)	50KA/1s
4	Rated operating voltage	433V AC

4.5.2.3 Switchboard and switchgear shall be compliant with specifications in clause 3.9.

4.5.2.4 Intake gates control centre switchboard shall meet basic ratings and features as per clause 3.9.10plus the following:

(a) Rated continuous current of the main bus bars: 400A.

(b) Rated continuous current of the distribution bus bars: ≥250A.

4.5.2.5 Switch board shall contain four bus bars for each phase and neutral. Both main and distribution bus bars shall consist of four bus bars

4.5.2.6 The switchboard shall have at least two cubicles with compartments for bus bar; cable connection; incomer and feeder modules and Protection, metering & control.

4.5.2.7 The switchboard shall conform to the IEC 61439-2 Form 4b form of separation and external ingress protection IP54 according to IEC 60529. Switchgear and metering compartments shall be separated from each other by finger-proof partitions (IP2X). Bus bar and cable compartments shall be separated from the switchgear and metering compartments by finger-proof partitions (IP2X).

4.5.3 Incomers

4.5.3.1 The switchboard shall have two incomers each on a separate compartment and connected to each bus section of the main station switch board.

4.5.3.2 Each incomer compartments shall have the following devices.

(a) MCCB compliant with all specifications in clause 3.9.11 and each with the following features:

(i) Continuous current rating, In: 400A

(ii) Line protection electronic trip unit

(iii) Shunt current release (remote trip input)

(iv) Communication interface configured and interfaced to the serial device server.

(v) Neutral current transducer and input

(vi) MCCB shall be withdrawable with service, test and disconnected positions or the complete incomer shall be withdrawable meeting requirements of clause 3.9.8

(b) Shall have a 200KW contactor.

(i) Rated for DOL starting of 270hp (200KW) motors.
(ii) Rated continuous current of 400A at 40°C ambient temperature.
(iii) Insulation rated at 1000V AC
(iv) With at least 4NO and 4NC potential free contacts

(c) Mechanical interlocking between the two incomer contactors shall be provided.

4.5.3.3 Neutral link rated at least 400A shall installed for each incomer linking the neutral bus bars to the incomers neutral.

4.5.3.4 Each incomer shall have at least 4(four) (one per phase) 300/1 A current transformers meeting requirements of clause 3.9.15

4.5.3.5 Each incomer shall have at least 1(one) three phase voltage transformers meeting requirements of clause 3.9.16

4.5.4 Control, Metering and Protection

4.5.4.1 A minimum of the following control, metering & protection devices and functions shall be provided.

(a) 2(Two) Digital Panel multi-function meter meeting all requirements of clause 3.5.9 one for each incomer
(b) Local manual incomer operation via push buttons shall be provided for each incomer, Auto changeover control shall be provided by the automatic transfer controller and SCADA control circuit shall be provided and interfaced to SCADA interface PLC.
(c) At least three Motor protection circuit breakers (MPCB) suitably rated for protection of the three-phase control circuits.
(d) An emergency pushbutton for emergency tripping of the MCCB's
(e) At least six illuminated pushbuttons for contactor local opening, Contactor closing and MCCB trip reset with integrated LED indication lamps for each incomer.
(f) A set of contactor relays for circuit breaker control & interlocks
(g) A set of miniature interface relays with 4 SPDT contacts for interfacing
(h) At least eight (8) status indication LED lamps for the following status of each incomer.

DC supply ok	Incoming Supply unavailable
MCCB/incomer in service position	MCCB/incomer in test position

(i) At least two DC DP Miniature circuit breakers
(j) At least one AC DP Miniature circuit breakers

4.5.4.2 A digital AC voltmeter shall be connected to the switchboard main bus bar via a three-phase voltage transformer for measurement of bus bar voltage.

(a) The digital AC voltmeter shall be as per requirements of clause 3.5.8.3
(b) The digital AC voltmeter shall be flash mounted on the incomer cubicle.
(c) The digital AC voltmeter shall have an EIA 485, Modbus RTU communication output, which shall be wired to the serial device server
(d) The digital AC voltmeter shall be wired to a voltage transformer line-line output.
(e) three-phase voltage transformer meeting requirements of clause 3.9.16 shall be connected to the main bus bar.

4.5.4.3 An automatic transfer controller (ATC) meeting requirement in clause 3.9.12 shall be flash mounted on the control compartment for automatic change over control.

(a) The ATC communication port shall be wired to the serial device server.
(b) The transfer digital input and two digital outputs for incomer status shall be wired to the common PLC.
(c) The ATC three phase inputs shall be wired directly to the incomer cables or via the voltage transformers.

4.5.4.4 A three-position key operated changeover operation LOCAL /AUTO /SCADA mode selector switch shall be provided for interlocking contactor operation.

4.5.4.5 An AC voltage monitoring relay shall be connected to the busbar for monitoring of total loss of supply to the switchboard. The relay shall meet requirements of clause 3.5.7 and shall have at least two NC contacts.

4.5.4.6 Potential free contacts shall be provided for wiring to plant common PLC. A minimum of the following binary signals shall be hardwired to the common PLC at the control room using existing cables to control room:

Total loss of AC supply	Loss of DC supply
Duty Incomer supply available	Reserve Incomer supply available

4.5.5 Feeder Modules

4.5.5.1 Five (5) 11 KW standard sized withdrawable motor DOL starter modules meeting requirements of clause 3.9.20 shall be installed.

4.5.5.2 Four (4)125A standard sized withdrawable cable feeder modules meeting requirements of clause 3.9.19 shall be installed.

4.5.5.3 Two (2) 32A standard/small sized withdrawable cable feeder modules meeting requirements of clause 3.9.19 shall be installed.

4.5.6 Lighting and Small Power 4 Way TPN Distribution Board

4.5.6.1 A 4-way TP&N distribution board shall be mounted on one switch board compartment or on a nearby depending on space availability.

4.5.6.2 The board shall meet requirements of clause 3.9.9

4.5.6.3 A minimum of the following circuit breakers shall be mounted on the board.

(a) 2(two) 32A MPCB meeting requirements in clause 3.9.13

(b) 3(three) 32A AC SP Miniature circuit breakers with Icu ≥10KA @ 400VAC and at least one SPDT auxiliary contacts

(c) 3(three) 16A AC SP Miniature circuit breakers with Icu ≥10KA @ 400VAC and at least one SPDT auxiliary contacts

4.5.6.4 The board's bus bar shall have continuous current rating of at least125A at 40˚C ambient temperature.

4.6 INTERFACING TO SCADA SYSTEM

4.6.1.1 SCADA cabinet shall be provided for interfacing all gate functions to SCADA. An Automation PLC/PAC system shall be utilised for SCADA interface and local gate operations. The automation system shall consist of a PLC/PAC system, Operator panel and communication interfaces to IED's and to KenGen SCADA system.

4.6.1.2 The SCADA cabinet shall contain a minimum of the following devices.

(a) PLC/PAC system including but not limited to

(i) Set of PLC CPU module/s

(ii) Set of PLC external network communication module/s

(iii) Set of PLC IO communication module/s

(iv) Set of Digital input modules

(v) Set of Digital output modules

(vi) Set of analogue input modules

(vii) Set of analogue output modules

(viii) PLC OPC UA/IEC61850 communication gateway module (optional if CPU inbuilt)

(ix) Set of PLC module connectors, termination modules and or mounting back planes

(b) Two (2) redundant power supply units one for 240V AC supply and another for 110V DC supply input for providing the SCADA cabinet with 24V DC supply.

(c) Operator panel for local SCADA operations

(d) A serial device server meeting requirement of clause 3.5.10

(e) Two (2) industrial ethernet switches meeting requirement of clause 3.5.11

(f) Three pole, two position LOCAL/REMOTE selection key switch for SCADA operations interlock

(g) Set of DC and AC MCB's for supply protection
(h) Two (2) Panel cooling fans each with Air throughput of at least 750m^3 /h
(i) Four (4) ventilation and filter units
(j) Two (2) thermostats for fans control
(k) At least one (1) British type socket
(l) At least one (1) European type socket
(m) At least one (1) LED panel lighting with door switches
(n) Panel heater and hygrostat

4.6.1.3 Programmable logic controller (PLC)or Programmable automation controller (PAC) shall meet the following.

4.6.1.3.1 It **MUST** be either of the following brands.
(a) Schneider Modicon: M580
(b) Siemens S7-1500
(c) ABB AC 500 /AC 800M
Schneider Modicon M580 is preferred

4.6.1.3.2 It shall be wired to all the specified signals for gate control (as detailed in clauses 4.4.6 & 5.4.7) and switchboard (clause 4.6.1.4). IO modules required to connect all the specified signals and signals required to implement the control functions specified shall be provided.

4.6.1.3.3 PLC/PAC shall be sized appropriately for the function, however at minimum the PLC shall meet the following performance parameters:
(a) minimum program memory of **8MB**
(b) Minimum data memory of **32MB**
(c) Support over 2000 discrete IO's and 500 analogue IO channels
(d) Shall be able to handle 24 simultaneous Modbus connections.

4.6.1.3.4 At least, Sixteen (16) spare digital inputs, eight (8) spare digital outputs, four (4) 4-20mA spare analogue inputs and Four (4) 4-20mA spare analogue outputs, shall be provided for future use.

4.6.1.3.5 PLC/PAC shall have a minimum of two (2) 10/100/1000 base-TX Ethernet ports or 100 base-FX Ethernet ports or 1000 base-X fibre optic Ethernet ports connected to the SCADA network. PLC Shall be connected to the two SCADA Ethernet switches

4.6.1.3.6 PLC/PAC shall have non-volatile memory capable of storing all program and data in case of DC power loss **without** use of internal battery backup. PLC shall also be supplied a removable flash memory of at least 128MB for easy back up, upload and download of PLC program and data.

4.6.1.3.7 Shall be capable of real time communication to all the MCCB's, power monitoring devices, multifunction power meters, Motor management and control devices, panel indication meters and ATC in the switchboard using Modbus and availing the data to employer SCADA. Other real time fieldbus protocols may be used if simultaneously supported by the switchboard devices (i.e., if the switchboard devices support Modbus and the other field bus protocol)

4.6.1.3.8 Shall communicate with employer SCADA via Modbus TCP and either OPC UA or IEC61850 (Modbus TCP+OPCUA or Modbus TCP + IEC61850). A gateway shall be provided if the PLC does not support Modbus TCP and OPC UA /IEC61850. External gateway if needed shall be an independent device i.e., gateway function shall not be implemented in the operator panel. If a gateway is used all necessary configuration shall be carried out for interfacing SCADA system to the PLC/PAC

4.6.1.3.9 Shall be programmed in IEC61131-3 function block diagram language or continuous functional chart (CFC) language only. Any function which must be programmed in a non-graphical language shall contained in a block and linked to other blocks in a graphical method.

4.6.1.3.10 The PLC/PAC program shall be based on function blocks library (custom or otherwise) for the applications required. Basic logic functions shall be grouped into function blocks. Each function block shall have description of the inputs, outputs and its internal functions and data. Multiple applications shall utilise an instance of the same function block. The program shall be well structured for easy modification and reading. Use of basic/elementary logic blocks in the main program shall be avoided to ease program readability. A detailed description of each of the function blocks used shall be provided.

4.6.1.3.11 PLC program shall provide for remote control of devices at the gate from SCADA system and local control from the operator panel at the SCADA interface cabinet. Remote/local operations shall be interlocked by a selector switch mounted on the cabinet.

4.6.1.3.12 The automation system shall provide some data to employer common PLC at the control building. Contractor shall configure the automation system to write and read the common PLC via Modbus TCP on the registers to be provided by the employer.

4.6.1.3.13 Variables/data objects tags shall be coded as per IEC81346-10 RDS-PP but with an easy-to-understand English variable description.

4.6.1.3.14 All external digital inputs/outputs and other outputs of logical operations shall be configured as events or alarms and shall have a time stamp on change of status. PLC time stamp all discrete events to 10ms accuracy. Time stamped events shall be accessible to employer SCADA via OPC UA or IEC61850 and to the local operator panel.

4.6.1.3.15 PLC shall be time synchronised to 1ms accuracy via NTP or PTP to the station grandmaster clock at the control room.

4.6.1.3.16 All program variables shall be contained in a program section (parameter section) that can easily be accessed to monitor status and set the value. A window shall also be created on the operator panel for viewing and setting the parameters. Editing/setting of parameters on the operator panel may be restricted or unavailable depending on the program and equipment security, however all parameter status should be available. The number and type of the above parameters shall cover all points considered necessary for troubleshooting and testing by the employer.

4.6.1.3.17 During design stage the contractor shall send the logic diagrams (PLC program) for review. The logic diagrams shall be accompanied by programming notes/manuals to enable the employer to easily interpret the program. The notes shall describe the functions of all the blocks, inputs and outputs of program section and function of all program sections. The employer on receiving the programs may add parameters necessary for operations and troubleshooting. The employer may also add events and alarms deemed necessary for effective monitoring of the system if not included.

4.6.1.3.18 At least two digital outputs shall be configured for hardware and software failure/watchdog output (closed when system is healthy). The contact shall be hardwired to the common PLC at the control building using the existing wiring.

4.6.1.3.19 PLC/PAC program/logic diagrams **MUST** be submitted to the employer in an editable format.

4.6.1.3.20 Software tools necessary for editing the PLC program shall be supplied for installation into **at least two** laptops with all the licences provided for each installation. Software licenses will not be required if Schneider Modicon M580 PLC is utilised.

4.6.1.4 The following binary inputs and outputs shall be wired to the SCADA interface PLC from the source device contacts or coils of the LV switchboard. Potential free contacts shall be provided.

(a) For the Incomers *(1)*

Duty incomer MCCB ON	Reserve incomer MCCB ON
Duty incomer MCCB OFF	Reserve incomer MCCB OFF
Duty incomer MCCB ETU trip	Reserve incomer MCCB ETU trip
Duty incomer MCCB in test position	Reserve incomer MCCB in test position
Duty incomer MCCB withdrawn	Reserve incomer. MCCB withdrawn
Duty inc. MCCB in service position	Reserve inc. MCCB in service position
Duty Incomer supply available	Reserve Incomer supply available
Duty Incomer MCCB open command	Reserve Incomer MCCB open command
Duty Incomer MCCB ETU trip reset	Reserve Incomer MCCB ETU trip reset
Duty Incomer emergency trip	Reserve Incomer emergency trip
Duty Incomer 3ø control supply fail	Reserve Incomer 3ø control supply fail
Incomer operation selected MANUAL	Incomer operation selected SCADA
Grouped MCB trip	Incomer operation selected AUTO

(b) for **each** DOL motor starter *(5/8).*

- Motor/lights ON status
- Motor tripped (protection)
- MCCB/MPCB tripped
- module in withdrawn position
- Module in test position
- Switchboard selection
- Motor/lights ON command
- MCCB trip reset command
- Motor/lights OFF status
- MCCB/MPCB OFF
- MCCB/MPCB ON
- module in service position
- SCADA selection
- Local selection
- Motor/lights OFF command
-

(c) for **each** Cable feeder module *(6/8)*

- MCCB/MPCB ON
- MCCB/MPCB protection trip
- module in withdrawn position
- MCCB/MPCB OFF
- Module in test position
- module in service position

(d) For the lighting and small power distribution board *(1)*

Group 1 MCB trip

Group 2 MCB trip

4.6.1.5 A serial device server meeting requirement of clause 3.5.10 with four (4) EIA 485 serial ports and four (4) 10/100 base TX Ethernet ports shall be supplied and installed in the SCADA cubicle for Modbus RTU to Modbus TCP/IP protocol conversion.

4.6.1.5.1 The serial device server shall be connected to a minimum of the following on the serial ports.

(a) All feeder module MCCB's *(4/6)*

(b) Incomer MCCB's *(2)*

(c) All the feeder power monitoring devices *(2)*

(d) Automatic transfer controller *(1)*

(e) The main bus bar AC voltage digital AC voltmeter *(1)*

(f) Motor management controllers for each DOL starter *(5/8)*

4.6.1.5.2 Contractor shall supply and configure all software necessary to handle communication between the LV switchboard devices and the SCADA system.

4.6.1.5.3 All software required for configuring the switchboard devices shall be supplied and installed into two employer laptops with all the necessary licenses if required.

4.6.1.6 Contractor shall supply and install a fibre optic cable with at least twelve (12) pairs of single mode (OS2) fibre from the control room to the gate building for remote communication to SCADA.

4.6.1.6.1 Two (2), twenty-four (24) port fibre optic patch panels shall be provided and installed one at the control room and the other at the gate building.

4.6.1.6.2 A patch panel cabinet shall be supplied and installed at the intake gate building for housing the patch panel.

4.6.1.6.3 The patch panels shall be factory pre-populated and tested fibre patch panel with factory pre-loaded Twenty-four LC or SC adapters connected to pigtails. The fibre optic cable shall be spliced to the patch panel pigtails.

4.6.1.6.4 Fibre optic cable shall be laid on the existing cable trenches from control building to the Gates The distance form control building to gates along cable trenches is approximately **500m**.

4.6.1.6.5 The fibre optic cable shall be a 24 core uni-tube steel wire armoured cable for indoor or outdoor duct or direct buried installation with full rodent protection. Fibre optic cable shall have following features: 24 individual-coloured fibres type OS2, Gel filed PBT loose tube with optical fibres, Water-blocking E-glass yarn separator, Galvanized steel wire armour and FR (Fire Retardant) - LSZH (Low Smoke Zero Halogen) UV Stable Outer Sheath

4.6.1.7 Two (2) Industrial ethernet switches meeting requirements of clause 3.5.11 shall be installed at the SCADA cabinet.

4.6.1.7.1 Each switch shall be connected to the following:

(a) Employer SCADA LAN A or B
(b) PLC/PAC
(c) Serial device gateway
(d) Operator panel/HMI
(e) Communication gateway if applicable

4.6.1.7.2 Each Switch shall have at least one fibre optic port supporting both multimode and single mode fibre, with LC or SC connector, supporting Gigabit ethernet 1Gbps and supporting fast ethernet 100Mbps.

4.6.1.7.3 Switches shall have enough ports to connect all the ethernet devices at the gate including the two digital panel multifunction meters and any other switchboard device utilising ethernet port instead of serial port.

4.6.1.7.4 Each ethernet switch shall be connected to the SCADA LAN at the control building via a single mode (OS2) fibre.

4.6.1.7.5 Fibre optic connections to the patch panel shall be carried out by the All fibre terminating devices and components shall be provided.

4.6.1.8 An operator panel/ HMI display shall be flash mounted on the SCADA interface panel. Shall have all HMI functions to be able to operate, monitor and trouble shoot the switchboard devices and the gate systems locally.

4.6.1.8.1 Shall meet the following minimum hardware features.

(a) Display: TFT widescreen, 16 million colours, LED backlight 100% dimmable, viewing angle 170°
(b) Size (in inches): ≥12“
(c) Resolution (W x H in pixels): ≥1280 x 800
(d) MTBF of backlight (at 25 °C in hours) :>80,000
(e) Input method: Touch screen
(f) USB ports: ≥three (3)
(g) Application data memory:>12MB
(h) Program memory: ≥2MB
(i) Flash memory: ≥4GB
(j) Ethernet: 2 x RJ45 10/100 Mbps (two fast Ethernet ports)
(k) Power supply rated voltage: 24V DC
(l) Real time clock: hardware, battery backed and synchronically (NTP)
(m) Operating temperature: 45˚C
(n) Front Ingress protection: IP65

4.6.1.8.2 Shall meet the following minimum software features.

(a) Shall contain a commercially available operating system.
(b) Shall Support Ethernet/internet protocols such as TCP/IP, HTTP, DHCP, SNMP, DCP, LLDP and SNTP

(c) Shall support many tags, at minimum **2000**.

4.6.1.8.3 A minimum of the following HMI screens shall be configured.

(a) Switchboard Single line for status indications and operating switchboard devices
(b) Gate operations and monitoring for each gate
(c) Operations and monitoring for each HPU
(d) Closed loop gate operations.
(e) Accumulator monitoring
(f) Switchboard devices monitoring and diagnostics.
(g) Power consumption monitoring
(h) Events screen- Discrete variables from DI, DO and calculated process variables shall be configured either as alarms, faults, or events. Event screen shall display event, alarm or fault when configured variables change state either from 0 to1 or from 1 to 0. Events shall be coloured as per standard colours to be provided by the employer.
(i) Alarm screen-Shall display all active and unacknowledged alarms/trips.
(j) Trend window- trending analogue variables

4.6.1.8.4 A status signalling tower/s shall be installed on top of the panel with the following units.

(a) Siren with adjustable volume
(b) Red light unit
(c) Green light unit
(d) Blue light unit
(e) Yellow rotating beacon

4.6.1.8.5 Operator panel program/project **MUST** be submitted to the employer in an editable format.

4.6.1.8.6 Operator panel Configuration Manager software with all necessary licenses shall be provided for installation into at **least two** laptops.

5 SPILLWAY GATE CONTROL SYSTEM PARTICULAR SPECIFICATIONS

5.1 EXISTING SYSTEM

5.1.1 Equipment Data

5.1.1.1.1 Hydraulic System Specifications

(a) Cylinder diameter – 300 mm
(b) Piston Rod diameter – 150 mm
(c) Ring area – 530 cm2
(d) Piston area – 707 cm2
(e) Total Hoist – 5.5 m
(f) Oil Volume for total hoist – 292 liters.
(g) Gate Hoisting Force – 937 kN
(h) Operating pressure – 190 bars
(i) Pressure limitation – 220 bars
(j) Time for total hoist – 44 minutes
(k) Hoisting speed of the drive – 0.13 m/minute
(l) Hoisting speed of the gate – 0.3 m /minute

5.1.1.1.2 Cylinder Details:

(a) Bore – 300 mm
(b) Rod – 150 mm
(c) Stroke -5,500 mm
(d) Hoist Capacity – 937 kN
(e) Operating pressure – 190 bar
(f) Lifting speed of the Hoist – 0.13 m/min
(g) Lifting speed of the gate – 0.3 m/min
(h) Hoisting Time – 44 min
(i) Oil volume for total hoist – 292 Liters

5.1.2 Operating Description

5.1.2.1 All the functionality and features of the existing control system are described in the attached existing equipment drawings and documents.

5.1.2.2 Each of the gates has its own control which is hardwired. The gates can be controlled from the spillway control room or from spillway pier using pushbuttons mounted in an outdoor control panel.

5.1.2.3 The control scheme was designed to accomplish the following operating functions:

(i) Normal hoisting
(ii) Normal Lowering
(iii) Stopping the gate when hoisting
(iv) Stopping the gate when Lowering
(v) Emergency operation

5.1.2.4 The existing system was designed to have an automatic mode that maintained the dam level between 924.00 and 925.50 meters above sea level. The system used float switches to control the opening and closing of the spillway gates. This system shall be restored in the SCADA panel. Dam level and overflow rate shall be obtained remotely existing float switches shall not be required.

5.1.2.5 The system was also designed with a remote-control option where the Spillway gates could be opened and closed from the powerhouse this feature shall be provided via SCADA.

5.1.2.6 The oil is supplied from a common high-pressure unit. The high-pressure unit (HPU) for the spillway gate control has a common sump tank and three motor-pumps. Each pump supplies pressurized oil to the two hydraulic cylinders of a specific gate. However, using manually operated isolating valves, the pumps can be re-directed to supply pressurised oil to the hydraulic cylinders of the other gates.

5.1.2.7 Each radial gate has two hydraulic cylinders that are used for hoisting or lowering the gates.

5.1.2.8 The existing control scheme detects and corrects tilting of the gates due to different friction ratios at the rollers or due to unequal flow of oil to the hydraulic cylinders. This function is referred to as **synchronous control** of the spillway gates. The system uses electrical and hydraulic components to detect tilting and restore the gates. **The distance between each gate and the gate guide is 5mm in each direction**.

5.1.2.9 Position transducers were mounted on each of the three gates. They are used to detect and signal inclination of the gates during gate movement. The position indicators detect the following inclinations as viewed in the direction of flow:

(i) Inclination of the gate to the left
(ii) Inclination of the gate to the right
(iii) Lateral movement of the gate on the left
(iv) Lateral movement of the gate on the right

5.1.2.10 During an inclination to the left, the lower right edge of the gate moves closer to the right-hand side gate guide. Inclination to the left is detected when the gate moves towards the right-hand side gate guide by 3mm.

5.1.2.11 During an inclination to the right, the lower left edge of the gate moves closer to the left-hand side gate guide. Inclination to the right is detected when the gate moves towards the left-hand side gate guide by 3mm.

5.1.2.12 Two position transducers mounted on middle of the gates, one of the right-hand side and one on the left hand side. The two transducers are used to detect lateral movement when the gate moves by 2mm from the centre position in the gate guides on either the left or the right-hand side.

5.1.3 Existing Spillway Low Voltage Switchboards

5.1.3.1 The existing switchboards were installed in 1978. They have feeders and incomers as described below:

CELL	CIRCUIT	RATING
	INCOMER CUBICLE	
1	Changeover contactor	200A
2	Duty incoming supply	200A
3	Reserve incoming supply	200A
	FEEDER CIRCUITS	
4	Gates control unit	125A
5	Crane	125A
6	Motor supply (spare)	35A/7.5KW
8	Lighting and small power 4-way TP&N distribution board	30A
9	Power outlet	100A
10	Lighting and small power	63A
11	Gatehouse	16A

5.2 OVERALL SYSTEM REQUIREMENTS

5.2.1 The new spillway gate control system shall provide all existing functions and all other new functions detailed in this specification. All existing gates operation functionality shall be provided and restored irrespective of what is detailed in this specification.

5.2.2 Bidder shall visit the site and study existing equipment drawings and manuals to ensure their offer covers all the components, parts and works required for the refurbishment.

5.2.3 The offered equipment shall not have any adverse effect on the current spillway gate system operations and maintenance.

5.2.4 The existing spillway gates HPU system motors, pumps and tank shall be re used. However, all the control valves and electrical controls shall be replaced.

5.2.5 New hydraulic components and transducers shall be supplied for spillway gate controls. Each gate shall have its own set of instruments and valves for the hydraulic cylinder operations. All the existing spillway gate position, flow, pressure etc transducers shall be replaced with new ones. Existing robust IP68 limit switches for gate position shall also be replaced with new ones. New cylinder position transducers shall be provided to indicate position of each cylinder on the gate.

5.2.6 Each of the existing hydraulic cylinders (servo motors) shall be removed, tested, shipped to a repair centre, refurbished, tested, shipped back to site, and reinstalled in another gate. New hydraulic cylinders (servomotors) shall be installed for the first gate to be worked on. The existing cylinders on the last gate to be worked on shall be removed, refurbished and shipped back to site as spares. Stripping down of the existing cylinders shall be witnessed by the employer, during strip down the refurbishment options of replacing or repairing a part of the cylinder shall be identified and agreed upon.

5.2.7 The spillway gates have a synchronous control system that prevents the gates from tilting during hoisting or lowering. This results from different friction ratios at the gate rollers and unequal flow of oil to the servo motors. Synchronous control is achieved by an open loop control system of electrical and hydraulic equipment. Currently this system has failed. The contractor shall be required to design a robust synchronous control system and implement using new valves and instruments. Contractor shall supply new proximity switches on the gate for the synchronous control function.

5.2.8 New closed loop control of the cylinders shall be implemented to ensure synchronised travel of the cylinders and automatic positioning of the gates at the desired opening. This shall be achieved by use of proportional directional control valves and installation of new linear displacement transducers on the existing cylinders for cylinder piston position measurement. Contractor shall restore the existing open loop control of the cylinders with new valves plus the additional closed loop control valves with a selector valve and switch for switching between open and closed loop. Both open loop and closed loop control functions shall be provided.

5.2.9 A hydraulic accumulator system shall be provided for emergency operation of the gates without running the pumps. The accumulator system shall be pressurised by any of the three pumps, duty pump to take precedence. Accumulator shall be able to operate all the three gates, appropriate control valves to be provided. The use of accumulator shall be manually activated in case of loss of supplies during operation and hence the accumulator shall remain isolated until required. Appropriate solenoid operated isolation poppet valve with manual override shall be connected to the accumulator to

ensure no pressure is lost from the accumulator while it is not in use and for allowing pressure recharge. Appropriate control and isolation valves shall be provided to ensure that it shall be possible to carry out extended maintenance on the accumulator without affecting any of the three gates operation. Accumulator shall be sized for **6m travel of one gate or 2m travel of all the three gates** without running the pumps e.g., when AC supply is unavailable. Nitrogen backup bottles shall be provided to achieve the required pressure and oil volume.

5.2.10 Appropriate control and isolation valves shall be provided to enable operation of all the three gates from each pump. Control valves and isolation valves shall be designed to enable carrying out prolonged maintenance on each of these control valves without affecting operations of more than one gate. During maintenance of these valves only one gate may be affected while the other two will remain totally unaffected. All required control & regulating valves shall be supplied, none of the existing valves of this type shall be re used.

5.2.11 All Hydraulic piping and supports to the gates shall be removed and replaced with new piping and pipe supports. None of the existing piping and supports shall be re-used. All piping shall be completely factory made i.e., bending, welding, and painting of pipes shall be done at the factory.

5.2.12 Hydraulic pressure system shall be designed for working pressure of **200 bars** and test pressure of **400 bars**. All the components on the pressure line shall be tested to **400 bars** during site acceptance testing.

5.2.13 All hydraulic components shall be of CETOP type with the OEMs (Original Equipment Manufacturer's) nameplate un-tampered. Contractors' nameplate if needed shall be installed side by side to the OEM one.

5.2.14 The contractor shall test and commission the functionality of the entire spillway gates hydraulic system. This shall involve opening and closing of all the gates with and without load.

5.2.15 All the hydraulic valves required for the operation of the gates i.e., raising and lowering the gates, **MUST BE MANUALLY OPERABLE**. All Directional Control valves installed in this system shall have manual override with extended handles to allow for deployment manually whenever needed in emergency situations. The system shall be designed to be operable in a total power loss emergency.

5.2.16 New outdoor IP55 cabinets shall be provided for housing valves, control pushbuttons, instruments, and indication devices at the pier and at the cylinder base.

5.2.17 Open loop electrical control circuit/logic for the pumps and gate operation **shall be hardwired** using contactor relays meeting specifications in **clause 3.5.3.** All interlocks and commands for pump and gate control shall be hardwired, local operation using

pushbuttons, indicator lamps and panel instruments shall be the primary mode of gate operation. Pumps starting and stopping shall be automated by a hardwired circuit. PLC or IED's shall only be used for remote interfaces to SCADA and for protective functions if any.

5.2.18 PLC/PAC system for SCADA interface shall be provided. Remote operation of gates and pumps through SCADA PLC shall be provided as an operation mode with a SCADA selection interlock. PLC shall also implement closed loop control of all the gates.

5.2.19 Low voltage AC switchboard shall be supplied, installed and commission to provide AC supply to all spillway gate and neighbouring systems as specified. DOL starters shall be provided for each HPU pump on the switchboard, existing common pump starter cabinet shall be removed. LV AC distribution board shall be provided for lighting and small power distribution.

5.2.20 All control wiring within the spillway gate area shall be replaced with new wiring except for wiring to the control building which shall be re used. All power cabling within the spillway gate area that is too short to be reused shall be replaced.

5.2.21 All systems and components shall be clearly labelled using anodized aluminium plates or oil resistant PVC castings, labels marking shall be as per IE81346-10 (RDS PP) codes. The name plates shall be clearly visible.

5.3 SPILLWAY GATES HYDRAULIC SYSTEM REQUIREMENTS

5.3.1 HPU Components.

5.3.1.1 The existing tank, the four motor-pumps and the three hand pumps shall be reused while all the other devices shall be replaced. These components can be found in drawing number 251-13585.

5.3.1.2 Contractor shall supply all hydraulic control components necessary for gate lifting function. The components shall have a design life exceeding **25 years** and suitable for use in harsh environments.

5.3.1.3 Contractor shall supply and install a minimum of the following devices on the reservoir shall be supplied and installed:

(a) Breather with an oil moisture vapour filter and dehumidifier.

(b) Dual changeover filter on the tank return line with clogging indicator flag and electrical contacts for clogged status

(c) Three (3) Pressure line filters one on each pump each with clogging indicator flag and electrical contacts for clogged status

(d) PT100 temperature detector to monitor the oil temperature.

(e) Electronic float Level switches with at least three switching points & relays for too low level (stop pumps), low level (alarm) and high oil level (alarm).

(f) Electronic Oil Level transmitter with digital display and 4-20mA analogue output

(g) Oil temperature transmitter with digital display, two contacts and 4-20mA analogue output

5.3.1.4 Contractor shall supply and install four (4) manifold valve blocks one for each pump to replace the existing ones. Each valve block shall contain the following:

(a) Pressure relief valve of same rating as existing.

(b) Spring loaded check valve.

(c) Mechanical pressure gauge

(d) Electronic pressure switch and transmitter meeting requirements in clause 3.5.1.3 and with 4-20mA output, two contacts and digital display

5.3.1.5 Contractor shall supply and install a minimum of the following isolation valves for the pumps.

(a) Twelve (12) 2-way isolating ball valves for the pressure pumps

(b) Two (2) Return line 2-way isolating ball valves.

5.3.1.6 Contractor shall supply and install a Return line pressure relief valve rated for continuous duty, to control filling and emptying of the upper side of the cylinder.

5.3.1.7 Contractor shall supply new hydraulic oil to fill all the six cylinders while fully closed plus a spare capacity equivalent to half the six cylinders volume. The oil shall of the same type of as existing and meet all other employer requirements.

5.3.1.8 Contractor shall also supply any other hydraulic component necessary for spillway gate control operation.

5.3.2 Cylinder Control Components.

5.3.2.1 The contractor shall replace all the hydraulic components on the spillway gate pier and at the spillway gate lifting cylinders. These components can be found in drawing number 251-13585.

5.3.2.2 Contractor shall supply all hydraulic control components necessary for gate lifting function. The supplied components shall be rated for outdoor use at the climatic conditions at site. The components shall have a design life exceeding **25 years** and suitable for use in harsh environments.

5.3.2.3 Contractor shall restore the existing open loop control using equivalent Rexroth valves for cylinder operations, this shall include.

5.3.2.3.1 Supply and installation of a minimum of the following devices at the pier for **each** gate:

(a) Two (2) Two-way ball valve for maintenance isolations
(b) One (1) Flow control valve for the pressure line
(c) One (1) Flow control valves for the return line
(d) One (1) Fine flow control valves for the synchronous control system
(e) One (1) Four by three-way directional control valve
(f) Two (2) Three by two directional poppet valves
(g) One (1) Constant flow divider valves.
(h) Two (2) Mechanical pressure gauge
(i) Two (2) Electronic pressure swich and transmitter meeting requirements in clause 3.5.1.3 and with 4-20mA output, two contacts and digital display

5.3.2.3.2 Supply and installation of a minimum of the following devices at the cylinder base for **each** gate:

(a) Two (2) Three by two poppet valves with solenoid and manual override (one for each cylinder)
(b) Two (2) Pilot operated check valves (one for each cylinder.)
(c) Two (2) Two-way ball valve (one for each cylinder).
(d) Two (2) Normally open ball valve (one for each cylinder)

5.3.2.3.3 Each control valve line (each valve port line) shall have a port for pressure monitoring and bleeding with an appropriate check valve.

5.3.2.3.4 All solenoid valves shall have manual override with extended handle.

5.3.2.3.5 The existing open loop control function shall be maintained and shall utilise hardwired electrical control circuits for each gate.

5.3.2.4 The contractor shall also supply and install a modern **closed loop control** system for synchronising the two gate cylinders movement by utilising the cylinder piston position transducers. This shall include but not limited to the following for **each** gate:

5.3.2.4.1 At least two (2), one for each cylinder, robust Rexroth, or equivalent, proportional directional control valve suitable for outdoor harsh environments with the following characteristics

(a) Utilise 4-20mA control signal.
(b) 4-20mA valve position output.
(c) Control module shall be separate and installed inside the gate control room.
(d) Shall be suitable for oil with high risk of contamination. The spools shall be resilient to contamination.
(e) Valve shall remain totally isolated from the pressure line and return line while no operation is required or while open loop control is selected.

5.3.2.4.2 At least two (2), one for each cylinder, Suitable solenoid directional control poppet valves with manual override and auxiliary contact for open status

indication shall be used to isolate the proportional valve while not in use or when open loop control is selected.

5.3.2.4.3 Suitable manifold valve block shall be supplied for mounting the valves.

5.3.2.4.4 At least two isolation valves for maintenance isolation

5.3.2.4.5 All other hydraulic devices necessary for closed loop control of the cylinders shall be supplied and installed.

5.3.2.4.6 Each control valve line (each valve port line) shall have a port for pressure monitoring and bleeding with an appropriate check valve.

5.3.2.4.7 Closed loop control valves shall be installed at the pier unless there is a major technical limitation.

5.3.2.4.8 Closed loop control logic shall be implemented on the PLC/PAC at the SCADA interface panel for the three gates.

5.3.2.4.9 Existing open control loop function **MUST** be retained.

5.3.2.5 Contractor shall supply and install **Three (3)** outdoor cabinets for **each** gate, one at the gate pier and the other at the cylinder base for housing the gate control valves. The valves shall have however be rugged and sealed for outdoor application irrespective of being housed at the cabinets. The cabinets shall provide physical security for the valves and hence it shall be sturdy and have robust locks.

5.3.2.6 Contractor shall supply and install a linear displacement transducer for accurate measurement of the cylinder piston position with 4-20mA output and at least four (4) programmable contacts wired to the control panels. The transducer shall be factory installed for the new cylinders and retrofitted into the existing cylinders during refurbishment. The transducer shall be appropriate for large cylinder application and shall not have any adverse effect on the cylinder. The transducer **shall not** utilise **external** cables or wires and **shall not** utilise rods. The transducer port shall be totally sealed with appropriate rugged seals to ensure no oil leakage during gate operations.

5.3.3 Servicing of Existing Hydraulic Cylinders

5.3.3.1 The contractor shall service and test all the spillway gates hydraulic cylinders. This shall include supply and installation of new rod and piston seals and testing shall be done to guarantee no leakage in any of the seals. The contractor shall submit the test results which the employer will conduct due diligence to verify.

5.3.3.2 The servicing of the servo motors (cylinders) shall include the following:

5.3.3.2.1 Complete stripping of each unit in a clean environment.

5.3.3.2.2 Inspection of all the components after cleaning to measure up in accordance with standard cylinder tolerances to determine if they are required to be re-used, re-worked or replaced.

5.3.3.2.3 The Rod and its Chrome surface shall be inspected for damage, deep scoring, and signs of underlying corrosion below the chrome surface as well as the thickness of the chrome which should not exceed.

5.3.3.2.4 The barrel bore shall be inspected for deep scoring and measured up for tolerance regarding the bore as well as any ovality in the barrel bore. The barrel can then be determined if it needs a polishing hone (on a proper honing machine) or if it needs to be replaced if damage cannot be repaired to standard repair tolerances.

5.3.3.2.5 Gland (Head) and rod piston shall also be measured against international standards to determine if re-use, repair or replace.

5.3.3.2.6 Valves mounted directly onto the servo motors shall be replaced and the mounting surface ground and polished.

5.3.3.2.7 Transfer tubes shall be replaced. Pipe support Clamps must be replaced by aluminium stauff clamps.

5.3.3.2.8 All seals shall be replaced. The replacement seals must be of equivalent or better quality.

5.3.3.2.9 All fasteners shall be replaced to the correct specification.

5.3.3.2.10 Spherical Bearings shall be replaced to the correct specification with the correct material, lubrication and sealing against the environment. This shall be from a well-known International Bearing manufacturer like SKF, NTN, Timken or NSK.

5.3.3.2.11 Hydraulic Hoses shall be replaced together with all port adapters and fittings.

5.3.3.2.12 Assembly shall be done in a clean environment and all fasteners torqued to the required rating in the correct sequence as per standard practices.

5.3.3.2.13 Testing procedure shall be advised and witnessed by a KenGen person. The test shall include the following:

(a) Pre-testing procedure
(b) Low pressure end-of-stroke testing in both directions without leaks. (Minimum pressure required to stroke the cylinder)
(c) Full test pressure end-of-stroke testing in both directions (at least 20% above the working pressure).
(d) Open and closed centre measurements as well as stroke length to a 1mm tolerance.
(e) Mid-stroke bypass tests conducted a 1m intervals.

5.3.3.2.14 A detailed tamper proof test report must be produced and shall include the following:

(a) Open and closed Centres
(b) Stroke length
(c) Low pressure end-of-stroke tests with minimum pressure recorded.

(d) Full test pressure for end-of-strokes recorded.
(e) Test Oil temperature and specifications recorded.
(f) ISO Cleanliness level of test oil recorded.
(g) Water content of test oil recorded as a percentage of saturation.
(h) Details of the person who carried out the test.
(i) Photos of the unit on test for record purposes.

5.3.3.2.15 Preparation for painting shall include shot blasting of the barrel and gland external surfaces.

5.3.3.2.16 The cylinder shall be hard stamped with a job reference number for traceability and future repairs. This job number shall be clearly marked by a different colour paint on top of the final coat for ease of finding the number.

5.3.3.2.17 Painting of the cylinder to marine specification and as detailed in clause 3.3.10

5.3.4 Supply of New Hydraulic Cylinder

5.3.4.1 The contractor shall be required to supply two new hydraulic cylinders with the same specifications, features, sizes, performance, and ratings as the existing cylinders and with all attachment components (spherical bearing, transfer tubes, support clamps, valves).

5.3.4.2 The body and rod material and their finishing of the new cylinders shall be the same as existing.

5.3.4.3 The Cylinder shall be large cylinder type designed for civil engineering applications in hydro power applications with a design life of over 25 years.

5.3.4.4 Shall meet all the specifications of the existing cylinders as provided for in the manuals and drawings.

5.3.4.5 Bidder shall study the existing cylinder specifications and drawings before making their offer. Drawing of existing cylinders is attached in the appendix.

5.3.5 Gas-Driven Emergency Backup System

5.3.5.1 The contractor shall install a gas-driven emergency backup system composed of a piston accumulator and nitrogen gas bottles and interface it into the HPU using appropriate control and isolation valves. This system shall be fully manually actuated in case of emergency.

5.3.5.2 Accumulator shall meet all requirements in clause 3.13.

5.3.5.3 Accumulator shall be sized for **six (6) meters** travel of one gate equivalent to two (2) meters travel of all the three gates without running the pumps. Accumulator size, backup nitrogen bottles size and Nitrogen pressure shall be sized to ensure this desired

travel is achieved, this shall be tested during site acceptance testing. Sizing calculations shall be provided during design.

5.3.5.4 The accumulator hydraulic circuit shall be designed such that:

5.3.5.4.1 It can be charged by any of the three pumping units.

5.3.5.4.2 It is connected to the main pressure line of any of the three gates and thus can open any of the three gates.

5.3.5.4.3 It shall not be used during the normal operation of the gates.

5.3.5.5 The gas loaded pressure accumulator shall be connected to each pump pressure line using solenoid directional control poppet valves, flow control valves and isolation ball valves. The solenoid valves shall have a manual override with extended handle to enable manual operation during loss of control supplies. Flow control valves shall limit flow to each gate to the rated flow rate for safe operations.

5.3.5.6 Accumulator shall remain isolated by directional control poppet valves with zero leakage to ensure minimal loss of pressure. Pressure re charging shall be done on scheduled intervals to minimise pump operations. Provisions for remote scheduled manual recharging through the SCADA PLC shall be provided.

5.3.5.7 Release of accumulator pressure for gate operation shall only be done manually during emergencies, pumps shall be used for all normal operations.

5.3.5.8 The accumulator shall meet the following minimum requirements.

(a) **Type**: Piston accumulator
(b) **Design Working pressure**: 350 Bar.
(c) **Test pressure (p x 1.5):** 525 Bar
(d) **Seals**: "Viton" seal suitable for fluids HAS to HSD among others, Working temperature: -10˚C to 80˚C.
(e) **Bores** hard chromium surfaced.
(f) Use only nitrogen on the gas-side.

5.3.5.9 Accumulator shall be equipped with a safety and shutoff block at the top of the accumulator with a minimum of the following devices.

(a) pneumatic pressure relief valve for accumulator safety pressure release
(b) test port,
(c) Nitrogen Charging port,
(d) Pressure transducer ports -for connecting mechanical pressure gauge and electronic pressure transmitter.
(e) Pneumatic isolation valve
(f) Nitrogen bottle connection points

5.3.5.10 Valves manifold block shall be provided for backup system fluid power supply and charging control. The manifold valve block shall be mounted on the accumulator

system structure. The manifold block shall be provided with a minimum of the following Rexroth or equivalent valves and Hydac or equivalent instruments.

(a) At least three (3) solenoid directional control poppet valves or equivalent each with manual override with an extended handle and with an auxiliary contact for open position status

(b) At least three (3) flow control valves for gate pressure supply

(c) Pressure relief valve with auxiliary contact for operated status

(d) Manual flow control valve for maintenance pressure discharge

(e) Oil Pressure transmitter type Hydac EDS 1700 or equivalent meeting specification in clause 3.5.1.3; with four (4) switching point relays,4-20 mA signal output, digital display, and full-scale pressure range of 0 to 250 bars shall be provided and mounted on the HPU. Pressure transducer shall be connected to the main pressure line using an appropriate minimess hose.

(f) Each control valve line (each valve port line) shall have a port for pressure monitoring and bleeding with an appropriate check valve.

(g) Any other valve required for interfacing the accumulator system to the existing system shall be provided and installed on the manifold block.

5.3.5.11 At least Four (4) Isolation ball valves with lockable handles shall be provided for all oil piping connections to allow accumulator maintenance isolations.

5.3.5.12 Accumulator shall be equipped with a minimum of the following instruments.

(a) mechanical pressure gauge displaying its operating pressure for maintenance. The maximum permissible excess operating pressure must be clearly marked on the gauge.

(b) Electronic pneumatic pressure switch and transmitter meeting specification in clause 3.5.1.3 with at least two programmable contacts ,4-20mA output and display for nitrogen pressure indication which shall be wired to the control panels.

(c) Oil level switches for oil level (piston position) measurement in the accumulator shall be provided for oil level low and high alarms and connected to the control panel.

(d) Pneumatic pressure relief valve shall be provided equipped with auxiliary contacts for connection to the control system to annunciate when the relief valve is operated.

5.3.5.13 The nitrogen bottles shall each be equipped with a lockable shut off pneumatic isolation valve.

5.3.5.14 A HPU control cabinet (as per clause 5.4.4) shall be provided for termination of all the accumulator system wiring and manual operations of pumps and accumulator system.

5.3.5.15 The compete gas driven backup system composed of accumulator, nitrogen bottles, valve manifold block and HPU control cabinet shall be structurally jointed as one compact system for easy, testing, delivery and mounting at site.

5.3.5.16 All the works necessary for mounting the complete gas driven back up system shall be carried out by the contractor. Bidder shall study the current HPU and the tender requirements to ensure they include all materials and works required.

5.3.5.17 The contractor shall also provide nitrogen charging devices, filling and testing equipment for use when re-filling the nitrogen bottles.

5.3.5.18 The pressure accumulator shall be firmly mounted with mountings that must be able to withstand shocks in case of pipe break.

5.3.6 Piping Requirements

5.3.6.1 The contractor shall replace all hydraulic pipes at the spillway with steel plated pipes painted to marine specifications suited for outdoor application (adverse conditions.)

5.3.6.2 Piping shall meet all requirements in clause 3.11.

5.3.6.3 A pressure line and return line shall be supplied for each gate from the HPU's to the cylinder. Return line piping shall not be jointed outside the gate control room.

5.3.6.4 The pipe clamps shall all be of Aluminium Stauff type. The clamps shall be installed with a spacing of 1m between adjacent clamps, clamps shall be installed directly behind threaded pipe connectors and couplings. Pipe bends shall be supported by clamps as near to the bending curve as possible. In places with valves, the clamp support shall be provided both in front and behind the valves.

5.3.6.5 The contractor shall pressure test the piping system at **400 bars** as per recommendations in the Hydraulic Piping Standard Handbook and applicable ISO standards. All equipment necessary for pressure testing shall be provided by the contractor. Piping shall be observed to withstand **400bar** test pressure for at least **30 minutes** without leakages and mechanical strength of the system shall be observed to be sufficient for the test to be successful.

5.3.6.6 The contractor shall flush the piping system to remove any contaminants according to the recommendations of the 'Hydraulic Piping Standard Handbook revision 1' or newer. An equivalent or better standard shall be accepted.

5.4 SPILLWAY GATES ELECTRICAL CONTROL REQUIREMENTS

5.4.1 General Requirements

5.4.1.1 The Bidder shall study the existing gate control scheme and make a proposal based on that and the scope and specifications provided in this document.

5.4.1.2 The bidder shall ensure that all the existing functions of the gate control scheme are maintained in the offer. All the existing operation modes of the spillway gates shall be maintained.

5.4.1.3 Electrical control circuit/logic for the pumps and open loop gate operation shall hardwired using contactor relays meeting specifications in clause 3.5.3. All interlocks and commands for pump and open loop gate control shall be hardwired, local operation using pushbuttons, indicator lamps and panel instruments shall implement. PLC or any other IED's shall only be used for remote interfaces to SCADA and for protective functions if any.

5.4.1.4 Closed loop control and remote operation of gates and pumps through PLC shall be provided with a remote selection interlock.

5.4.1.5 The hardwired control scheme shall include all necessary controls, interlocks, protection functions and indications to ensure safe and reliable operation of the gates.

5.4.1.6 All control wiring within the spillway gate area shall be replaced with new wiring except for wiring to the main control building which shall be re used. All power cabling within the spillway gate area that is too short to be reused shall be replaced

5.4.1.7 All the components of the gate control scheme shall be housed in panels that meets the specifications in clause 3.6.

5.4.1.8 Contractor shall supply the following control panels.

(a) Three (3) spillway gate control panels for each of the three gates operation
(b) Three (3) Outdoor cabinets for each of the three gates operation
(c) HPU electrical control cabinet mounted on the new accumulator system.
(d) SCADA panel housing SCADA interfaces and closed loop control functions as described in clause 5.4.7.
(e) DC supply cabinet

5.4.1.9 The spillway gate control panel with all the necessary switches, wiring and electrical items as specified shall be housed in the existing spillway control room. The existing electrical equipment shall be dismantled and removed by the Contractor.

5.4.1.10 The gate control supplies, and the motor-pump supplies shall be supplied from the spillway gate low voltage switchboard as described in the switchboard specifications. Existing pump starters in the existing gate control pumps shall not be restored.

5.4.1.11 Each gate shall have the following levels of control:

(a) Operation through pushbuttons in the gate control panel at the spillway gate control building.

(b) Local operation through pushbuttons located at the pier.
(c) Operation from SCADA panel

5.4.1.12 The following operations of the spillway gates shall be provided for:

(a) Raising or opening the gate
(b) Lowering or closing the gate
(c) Stopping in any position of travel

5.4.1.13 The spillway gate control panel shall have control circuits for each of the operations mentioned above for each of the gates.

5.4.2 Gate Operation Description (Open loop Control)

5.4.2.1 Introduction

5.4.2.1.1 The following clauses describe the implementation of open loop gate control to be implemented using hardwired logic.

5.4.2.1.2 The gate control scheme shall be designed to accomplish the following operating functions:

(a) Normal hoisting
(b) Normal Lowering
(c) Stopping the gate when hoisting
(d) Stopping the gate when Lowering
(e) Emergency operation
(f) Synchronous control of the gates during lowering and hoisting.

5.4.2.1.3 The open loop gate control scheme shall enable operation of the gates with the following levels of control:

(a) Manual operation from the spillway control room
(b) Manual operation from the spillway pier.

5.4.2.1.4 A selector switch shall be used to select between the two levels of control.

5.4.2.1.5 There shall be selector switch for selecting between open loop and closed loop control.

5.4.2.2 Normal Hoisting:

5.4.2.2.1 The gate control scheme shall have a selector switch for each gate control selecting the pumping unit to supply the pressurised oil for the operation of that gate. This selector switch shall match the selection made using the manual isolating valves on the hydraulic circuit that direct the outlet of a pump to the pressure line of one of the three gates.

5.4.2.2.2 A command for hoisting the gate shall send a command to start the respective pump motor selected on the pump selector switch. This command shall enable the pressure monitoring circuit of the respective pump in the pump control scheme.

5.4.2.2.3 The command for hoisting the gate shall latch itself once the raise pushbutton is pressed, energizing the necessary hydraulic valves and starting the selected pumping unit. The gate control scheme shall have a timer that is energized once the raise pushbutton is pressed. The timer shall limit the opening time for the gate. Once the time has elapsed or the gate has reached the fully open position, the hoisting circuit shall be reset, the pumping unit shall be stopped and the hydraulic valves that were energized to raise the gate shall be de-energized. The gate shall remain in its current position.

5.4.2.2.4 If the gate has not reached its fully open position and the normal hoisting has been stopped by either timer elapsing or the stop pushbutton being pressed, further raising of the gate shall be possible by pressing the raise pushbutton.

5.4.2.3 **Normal Lowering:**

5.4.2.3.1 When the lowering pushbutton is pressed, it shall latch itself. The lowering command shall energize the necessary hydraulic valves and start the piston rod differential volume compensation pump.

5.4.2.3.2 The lowering command shall be interrupted when the gate reaches the closed position or when the stop command is issued. A subsequent lower command after the gate has been stopped shall necessitate pressing of the lower pushbutton thus issuing the command again.

5.4.2.3.3 The command shall energize one timer for the compensation pump pressure monitoring circuit and one timer for monitoring the pressure of both cylinders.

5.4.2.3.4 The gate control scheme shall be implemented such that if pressure is not detected at one or both hydraulic cylinders of the gate being operated on after the elapsed time (approximately 4-5 Seconds), the gate shall come to a stop and the respective hydraulic valves that were energized for lowering shall be de-energized.

5.4.2.4 **Piston rod differential volume compensation pump**

5.4.2.4.1 The spillway gate hydraulic circuit has a pump that is used to compensate for the volume difference in the hydraulic cylinder due to the piston rod.

5.4.2.4.2 When the gate is being lowered, oil flows from the lower part of the cylinder to the upper part of the cylinder to prevent corrosion in the event of extended shutdown periods.

5.4.2.4.3 The lower part of the hydraulic cylinder has less volume of oil as compared to the upper part due to the piston rod thus oil flowing from the lower compartment is not enough to fill the upper compartment.

5.4.2.4.4 A pump is included in the hydraulic circuit to pump oil from the sump tank to completely fill the upper compartment of the hydraulic cylinder. The oil is pumped to the main return line through non-return valve and pressure monitoring circuit with pressure indicator and switch.

5.4.2.4.5 A pressure relief valve in the main return line shall be set similar to the pressure switch in the pressure monitoring circuit and shall control the pressure of the compensation pump.

5.4.2.4.6 The pump shall be energized when the lowering command is issued and shall remain energized until the pressure monitoring circuit of the pump detects the maximum pressure (set at 6 Bars) indicating the complete filling of the upper compartment of the hydraulic cylinder.

5.4.2.5 **Stopping the gate when raising or lowering:**

5.4.2.5.1 Pressing the stop pushbutton when the gate is being raised shall stop the running pumping unit, de-energize the opening time limiter and de-energize the hydraulic valves that were energized to raise the gate. The gate shall come to a stop and remain in its current position.

5.4.2.5.2 Pressing the stop pushbutton when the gate is being lowered de-energizes the necessary solenoid hydraulic valves that were energized for lowering the gate. The pressure monitoring circuit for checking the pressure at the hydraulic cylinders shall also be de-activated. The gate shall come to a stop and remain in the current position.

5.4.2.5.3 Pressing emergency stop at the pier shall stop gate operations irrespective of the control level selection.

5.4.2.6 **Synchronous control:**

5.4.2.6.1 The gate control scheme shall have a selector switch that shall be used to select either Automatic or Manual mode of control for the Synchronous Control of the gate. When the Automatic mode is selected, the gate control scheme shall automatically compensate for the gate inclinations. Manual mode shall involve using pushbuttons mounted on the outdoor control panel to compensate for the gate inclinations.

5.4.2.6.2 The gate control scheme shall have proximity sensors or any other position transducers that shall indicate the position of the gate relative to the gate guides or railing. The position transducers shall have the relative IP rating protecting against ingress of water when subjected to water jets or when immersed in

water. The transducers shall be ruggedized to withstand the environmental factors related to their mounting positions.

5.4.2.6.3 The position transducers shall be mounted on each of the three gates and shall be used to detect and signal inclination of the gates during gate movement. The position indicators shall be used to detect the following inclinations as viewed in the direction of flow:

(a) Inclination of the gate to the left
(b) Inclination of the gate to the right
(c) Lateral movement of the gate on the left
(d) Lateral movement of the gate on the right

5.4.2.6.4 Each of the tilting of the gate listed above shall light its own indication lamp on the gate control panel once the inclination is detected by the position transducers.

5.4.2.6.5 The gate control scheme shall be implemented such that when an inclination of the gate to the left is detected, the scheme energizes the solenoid hydraulic valve that reduces the amount of pressurized oil flowing towards the right-side hydraulic cylinder of the gate. Normal amount of pressurized oil shall flow towards the left-side hydraulic cylinder until the gate reaches its straight position again. Once the gate reaches the straight position, the solenoid valve shall be de-energized and normal amount of pressurized oil will flow to the right-side hydraulic cylinder resuming normal operation.

5.4.2.6.6 The gate control scheme shall be implemented such that when an inclination of the gate to the right is detected, the scheme energizes the solenoid hydraulic valve that reduces the amount of pressurized oil flowing towards the left-side hydraulic cylinder of the gate. Normal amount of pressurized oil shall flow towards the right-side hydraulic cylinder until the gate reaches its straight position again. Once the gate reaches the straight position, the solenoid valve shall be de-energized and normal amount of pressurized oil will flow to the right-side hydraulic cylinder resuming normal operation.

5.4.2.6.7 Control scheme shall monitor the lateral movement of the gate either on the left or on the right. If the gate moves laterally from the centre position by 2mm on the left, the control scheme shall detect and annunciate by lighting the respective LED lamp on the gate control panel. The gate control scheme shall further interrupt the synchronous control circuit such that no further compensation during the gate movement in the direction of the left-hand gate guide takes place.

5.4.2.6.8 Similarly, once the lateral movement of the gate on right is detected when the gate moves by 2mm laterally from its centre position, the gate control scheme

shall interrupt the synchronous control circuit such that no further compensation during the gate movement in the direction of the right-hand gate guide takes place. The gate control scheme shall annunciate by lighting the respective LED lamp on the gate control panel.

5.4.2.6.9 The synchronous control shall have a manual operation control mode. The compensation of the gates when inclined shall be achieved using pushbuttons that shall be mounted on the outdoor control panel when this control mode is selected. The pushbuttons shall be used to energize and de-energize the solenoid hydraulic valves that control the amount of pressurised oil flowing to each of the hydraulic cylinders.

5.4.2.6.10 The outdoor control panel shall have indication lamps that shall annunciate each of the four inclinations listed above.

5.4.2.6.11 The gate control scheme shall have position transducers to indicate the position of the gates. The transducers shall be IP 67 rated with ruggedized housing for outdoor mounting. The main gate positions to be monitored and used by the control scheme for each gate are as follows:

(a) Gate fully closed
(b) Gate fully opened

5.4.2.7 **Emergency Operation:**

5.4.2.7.1 The gate control scheme shall be implemented in such a way that the gates can be operated by manually operating the hydraulic valves that release the pressurised oil from the gas-driven emergency back-up (accumulator) and direct it to the hydraulic cylinders of the gate in case of a power failure.

5.4.2.8 **Pump control**

5.4.2.8.1 Pump control function shall be implemented on the gate control panels

5.4.2.8.2 Each of Motors for the pumping units shall be supplied with **415 VAC directly** from the gates Low Voltage supply board in the gate control room. Switchboard shall have a DOL starter for each pump.

5.4.2.8.3 The three existing pump motors are equipped with heating elements that are turned on when the motor is switched off. The control scheme shall include the necessary hardwired logic using contactor relays for switching on and off the motor heating element.

5.4.2.8.4 The gate control scheme has a return pump that shall be switched on when the lowering gate command is issued.

5.4.2.8.5 The oil is supplied from a common high-pressure unit. The high-pressure unit (HPU) for the spillway gate control has a common sump tank and three motor-pumps. Each pump shall supply pressurized oil to the two hydraulic cylinders of a specific gate. However, using manually operated isolating valves, the pumps can be re-directed to supply pressurised oil to the hydraulic cylinders of the other gates.

5.4.2.8.6 The pump control scheme shall have a pressure monitoring circuit that is activated once the command for starting a pump is received. The control scheme shall have pressure transducers mounted on pump outlet and in the two pressure lines of the hydraulic cylinders. If pressure build up is not detected at the three pressure transducers after a command to hoist the gates is issued and a time delay has elapsed, the pump-motor is switched off and the hydraulic valves for hoisting the gates are de-energized. The gate shall come to a stop.

5.4.2.8.7 For the compensation pump that supplies oil to the upper part of the hydraulic cylinder during closing to ensure that its filled to avoid corrosion, its pressure monitoring circuit shall be activated when the gate lower command for any of the three gates is issued. The pressure on the return line shall be monitored until it reaches the set pressure of around **6 Bars** indicating that the upper compartment of the cylinder is filled and thus stopping the compensation pump.

5.4.2.8.8 Each pump control shall have three levels of control. There shall be a selector switch mounted on the switchboard for selecting between the three control levels for each of the pump. The control levels shall be as follows:

(a) Manual
(b) Auto
(c) SCADA

5.4.2.8.9 When the Auto level of control is selected, the pump shall receive its start/stop commands from the gate control panel according to the gate control scheme.

5.4.2.8.10 When the manual level of control is selected at the pump control, the pumps shall be controlled via the push buttons mounted on the HPU. The start/stop push buttons for each pump shall have integrated status LED indications.

5.4.3 Gate Control Panels

5.4.3.1 **Three (3)** gate control panels shall be provided for gate control. Each gate shall have a separate control panel.

5.4.3.2 The gate control panel shall implement a hardwired open loop control scheme, using contactor relays meeting requirements of clause 3.5.3, for all the gate & pump operations described in clause 5.4.2. All gate operations described in clause 5.4.2 and any other existing function necessary for gate operation shall be implemented. The panels shall also provide robust contactor relays for operating the valves from both open loop control and closed loop control on the PLC in the SCADA panel.

5.4.3.3 Robust contactor type or equivalent timer relays shall be provided as per operating description and existing system requirements. Timers shall not be plug in type of relays.

5.4.3.4 A minimum of the following instruments and signals shall be wired to **each** gate control panel.

(a) The gate proximity switches as detailed in clause 5.4.5.3
   (i) shall be wired for each of the six switches:
   (ii) All the six contacts shall be multiplied for use in gate control panel and wired to SCADA panel.

(b) Two (2) Hydraulic cylinder linear displacement transducer as detailed in clause 5.3.2.6 for each
   (i) 4-20mA output shall be wired to digital panel indication meter and to SCADA panel through signal multiplication and isolator. Series wiring of the analogue signal to meter and SCADA without isolation shall not be accepted.
   (ii) Contact outputs shall be used to back up the limit switches contact i.e., wired in parallel.

(c) Two (2) Hydraulic cylinder pressure switch & transmitter as detailed in clause 5.3.2.3.1 for each.
   (i) 4-20mA output shall be wired to digital panel indication meter to SCADA panel through signal multiplication and isolator or using a meter with 4-20mA output. Series wiring of the analogue signal to meter and SCADA without isolation shall NOT be accepted.
   (ii) Contact outputs shall be multiplied for control circuits and wiring to SCADA panel.

(d) Pump pressure switch & transmitter as detailed in clause 5.3.1.4
   (i) 4-20mA output shall be wired to digital panel indication meter to SCADA panel through signal multiplication and isolator or using a meter with 4-20mA output. Series wiring of the analogue signal to meter and SCADA without isolation shall NOT be accepted.
   (ii) Contact outputs shall be multiplied for control circuits and wiring to SCADA panel and HPU cabinet.

(e) Gate position switch & transmitter as detailed in clause 5.4.5.2

(i) 4-20mA output shall be wired to digital panel indication meter, to SCADA panel and to employers' common PLC through signal multiplication and isolator. Series wiring of the analogue signal to meter, common PLC and SCADA without isolation shall NOT be accepted.

(ii) Contact outputs shall be multiplied for control circuits and wiring to common PLC and SCADA panel.

(f) HPU reservoir oil level low from HPU cabinet

(g) Grouped Pump starter fault from LV switchboard.

(h) Clogging indicator contact on the pump Pressure line filter.

(i) Closed loop/open loop changeover solenoid directional control poppet valve status auxiliary contact with contact multiplied for wiring to SCADA panel

(j) All other transducers and signals necessary for gate control as described in clause 5.4.2 and as per existing scheme shall be provided and wired to the control panel.

5.4.3.5 A minimum of the following LED lamps shall be mounted on **each** gate control panel door for gate operations.

(a) Gate open status

(b) Gate closed status.

(c) Gate inclined left

(d) Gate inclined right.

(e) Lateral movement left.

(f) Lateral movement right

(g) Low pump pressure

(h) High pump pressure

(i) Low pressure left cylinder.

(j) Low pressure right cylinder

(k) Reservoir oil level low

(l) Pump filter clogged.

(m) Pump failure – If pump fails to build pressure 10-15 secs after starting (to latch until reset). Robust contactor type timer relay to be used. Or if emergency stop is pressed at the HPU.

5.4.3.6 A minimum of the following pushbuttons with at least two NO contacts, one contact wired to SCADA panel, panel shall be mounted on **each** gate control panel door for gate operations.

(a) Gate raise command.

(b) Gate lower command
(c) Stop command.
(d) Emergency stop (button as per clause 3.5.2.7)
(e) Alarm reset.
(f) Lamp check-lamp check circuit to be provided.

5.4.3.7 A minimum of the following three pole selector switches shall be mounted on **each** gate control panel door for gate operations.

(a) Three position key switches for PIER/CONTROL ROOM/SCADA location of gate operation interlock
(b) Two position Key switch for OPEN LOOP/CLOSED LOOP control selection
(c) Two position Key switch for MANUAL/AUTO open loop synchronous control selection
(d) Three position selector switches for duty pump selection

5.4.3.8 A minimum of the following digital panel indication meters meeting requirements of clause 3.5.8.3 shall be mounted on **each** gate control panel door for gate operations.

(a) Right Hydraulic cylinder pressure with 4-20mA output
(b) Right Hydraulic cylinder position with 4-20mA output
(c) Left Hydraulic cylinder pressure with 4-20mA output.
(d) Left Hydraulic cylinder position with 4-20mA output.
(e) Pump pressure with 4-20mA output.

5.4.3.9 A minimum of the following solenoid valves shall be actuated from **each** gate control panel to carry out gate operations described in clause 5.4.2. All the solenoid valves shall be actuated using a **contactor control relay** meeting requirement in clause 3.5.3. The relay contacts shall be wired to SCADA panel for monitoring.

(a) Raise solenoid.
(b) Lower solenoid (pier), Right cylinder solenoid & Left cylinder solenoid
(c) Right Cylinder fine control solenoid
(d) Left Cylinder fine control solenoid.
(e) Closed loop/open loop changeover solenoid directional control poppet valve.

5.4.3.10 A minimum of two contactor control relay meeting requirement in clause 3.5.3. Shall be provided for **each** gate for pressure pump and return pump start and stop. Pump operation of pump shall be interlocked to switchboard auto selection. The relay contacts shall be wired to SCADA panel for monitoring.

5.4.3.11 A minimum of the following electrical supplies devices shall be installed on **each** gate control panel or compartment.

(a) At least two (2) double pole DC MCB's for 24 V DC and 110V DC supply

(b) At least two (2) AC MCB's shall be provided for AC supplies.
(c) At least one (1) British type socket
(d) At least one (1) LED panel lighting with door switches
(e) Panel heater and hygrostat

5.4.3.12 All existing signals and functions from the employers' common PLC at the control building shall be restored for **each** gate this shall include but not limited to

(a) Gate fully open status
(b) Gate closed status.
(c) Gate position 4-20mA signal

5.4.3.13 **Outdoor control panel:**

5.4.3.13.1 For operation at the spillway pier, an outdoor control panel shall be mounted housing:

(a) Illuminated pushbuttons with integrated feedback lamps and at least two NO contacts, one contact wired to SCADA panel, for gate operations. This shall include.
(i) Raise
(ii) Lower
(iii) Stop
(iv) Emergency stop (button as per clause 3.5.2.7)
(v) Left cylinder fine control (used when manual selection is active)
(vi) Right cylinder fine control (used when manual selection is active)
(b) LED indication lamps for the following indications
(i) Gate inclined left
(ii) Gate inclined right.
(iii) Lateral movement left.
(iv) Lateral movement right

5.4.3.13.2 The outdoor control panel shall have a minimum IP rating of IP55. The panel shall also have double doors with the pushbuttons mounted in the inner door ensuring that the pushbuttons are not exposed to the environment.

5.4.3.13.3 **Each** gate shall have its own outdoor control panel that shall be mounted on the spillway pier in the same locations as the existing local control pushbuttons for convenient operation.

5.4.4 HPU Control Cabinet

5.4.4.1 An electrical panel shall be supplied for HPU local operations and indications. The HPU electrical control panels shall be mounted on the new accumulator system and shall be supplied as a compact unit together with the accumulator system.

5.4.4.2 The HPU panel shall implement a hardwired accumulator control scheme, using contactor relays meeting requirements of clause 3.5.3, for accumulator operations described in clause 5.3.5. It shall also provide local interface for pump control and reservoir alarms and any other existing function necessary shall be implemented.

5.4.4.3 A minimum of the following the Reservoir instruments described in clause 5.3.1 shall be wired to HPU electrical panel for interfacing to the SCADA panel and gate control.

(a) Two (2) Clogging indicator contacts for the dual changeover filter on the tank return line
(b) PT100 temperature detector to monitor the oil temperature.
(c) Electronic float Level switches with at least three switching points & relays for too low level (stop pumps), low level (alarm) and high oil level (alarm).
(d) Electronic Oil Level transmitter with digital display and 4-20mA analogue output
(e) Oil temperature transmitter with digital display, two contacts and 4-20mA analogue output

5.4.4.4 The following reservoir instruments contacts shall be multiplied for wiring to gate control panels and SCADA.

(a) Oil level too low level (stop pumps) electronic level switch.
(b) Oil level low level (alarm) from the reservoir electronic level switch.
(c) Oil temperature too high alarm from temperature transmitter
(d) Three (3) Pump filters clogged.
(e) Two (2) Return line filters clogged.

5.4.4.5 A minimum of the following the accumulator instruments described in clause 5.3.5 shall be wired to HPU electrical panel for accumulator control and interfacing to the SCADA panel.

(a) Oil Pressure transmitter type Hydac EDS 1700 or equivalent meeting specification in clause 3.5.1.3; with four (4) switching point relays and 4-20 mA signal output.
(b) Accumulator oil pressure relief valve auxiliary contact for accumulator pressure relief valve operated status.
(c) Electronic pneumatic pressure switch and transmitter meeting specification in clause 3.5.1.3 with at least two programmable contacts ,4-20mA output and display for nitrogen pressure indication.
(d) Oil level switches for oil level (piston position) measurement in the accumulator for oil level low and high alarms
(e) Pneumatic pressure relief valve auxiliary contact for accumulator pressure relief valve operated status.

(f) Gate1/Pump1 Accumulator Valve on status with contact multiplication to SCADA

(g) Gate2/Pump2 Accumulator Valve on status with contact multiplication to SCADA

(h) Gate3/Pump3 Accumulator Valve on status with contact multiplication to SCADA

5.4.4.6 A minimum of the following shall be interfaced to DOL starter on the switchboard for **each** pump.

(a) Pump start and stop on the switchboard and on the HPU control panel shall be interlocked by manual selection at the switchboard. In manual selection starting or stopping of pump shall be possible at the switchboard and at the HPU

(b) Pump starter on the switchboard shall be wired in failsafe (series connection) to the following devices on the HPU control panel for Pump to start. Emergency push button reset, Oil level too low trip off, pressure high off and DC MCB on.

(c) Main contactor ON and OFF status and starter fault status shall be wired to the HPU electrical control cabinet for indications.

5.4.4.7 A minimum of the following two pole selector switches shall be mounted on the cabinet door for accumulator operations.

(a) Two position key switches for LOCAL/SCADA location of accumulator valves operation interlock

5.4.4.8 A minimum of the following LED lamps shall be mounted on the HPU cabinet.

(a) Pressure Pump 1 starter/motor fault

(b) Pressure Pump 2 starter/motor fault

(c) Pressure Pump 3 starter/motor fault

(d) Return Pump starter/motor fault.

5.4.4.9 A minimum of the following illuminated pushbuttons with integrated feedback LED shall be mounted on **the** HPU cabinet.

(a) Pressure Pump 1 start

(b) Pressure Pump 1 stop

(c) Pressure Pump 1 Emergency stop (button as per clause 3.5.2.7)

(d) Gate1/Pump1 Accumulator Valve ON

(e) Gate1/Pump1 Accumulator valve OFF.

(f) Pressure Pump 2 start

(g) Pressure Pump 2 stop

(h) Pressure Pump 2 Emergency stop (button as per clause 3.5.2.7)

(i) Gate2/Pump2 Accumulator Valve ON
(j) Gate2/Pump2 Accumulator valve OFF.
(k) Pressure Pump 3 start
(l) Pressure Pump 3 stop
(m) Pressure Pump 3 Emergency stop (button as per clause 3.5.2.7)
(n) Gate3/Pump3 Accumulator Valve ON
(o) Gate3/Pump3 Accumulator valve OFF.
(p) Return Pump start
(q) Return Pump stop
(r) Return Pump Emergency stop (button as per clause 3.5.2.7)

5.4.4.10 A minimum of the following pushbuttons shall be mounted on each HPU.

(a) Lamp check-lamp check circuit to be provided.

5.4.4.11 A minimum of the following solenoid valves shall be actuated from HPU cabinet to carry out accumulator operations described in clause 5.3.5. All the solenoid valves shall be actuated using a **contactor control relay** meeting requirement in clause 3.5.3. The relay contacts shall be wired to SCADA panel for monitoring.

(a) Gate1/Pump1 solenoid directional control poppet valve or equivalent
(b) Gate2/Pump2 solenoid directional control poppet valve or equivalent
(c) Gate3/Pump3 solenoid directional control poppet valve or equivalent
(d) Any other solenoid valve applicable to accumulator control

5.4.4.12 A minimum of the following electrical supplies devices shall be installed on the cabinet.

(a) At least two (2) double pole DC MCB's for 24 V DC and 110V DC supply
(b) At least two (2) AC MCB's shall be provided for AC supplies.
(c) At least one (1) British type socket
(d) At least one (1) LED panel lighting with door switches
(e) Panel heater and hygrostat

5.4.5 Gate Instrumentation

5.4.5.1 The Bidder shall study the existing instruments mounted on the bulkhead gate and its structures and make a proposal based on that and the scope and specifications provided in this document. Contractor shall replace all the instruments including but not limited to the following: proximity switches b31, b32, b33, b34, b35, b36, b60; gear limit switch u1, existing SCADA position transducer.

5.4.5.2 Contractor shall replace the existing SCADA gate position transducers for **each** gate. The new transducer shall be robust with IP68 ingress protection and designed for harsh environments and ambient temperature of 40˚C. It shall have a 4-20mA output and at

least two (2) contacts. It shall be wired to the gate control panel where the signal shall be multiplied into three for wiring to SCADA interface panel and employers' common PLC.

5.4.5.3 Contractor shall replace the existing six (6) proximity switches for **each** gate with new switches meeting the following requirements.

5.4.5.3.1 Electrical ratings:

(a) 24 VDC +15%/-20%
(b) Harmonic Content: ≤10%
(c) Output: Voltage measured across loads.
    (i) Metal absent: ≤1 VDC
    (ii) Metal present: Unom. -1VDC
    (iii) Rated current(max): ≤200 mA
(d) Quiescent current: ≤15 mA
(e) Switching rate:100 Hz
(f) DC supply, 3 wire type with built in transistor amplifier, pnp output, normally off.
(g) Sensing range: 15mm ±10%

5.4.5.3.2 Mechanical Specifications:

(a) Protective class: IP68
(b) Vacuum potted to make it waterproof.
(c) Potting material provides shock and vibration resistance.
(d) Temperature range: -25˚C to +70˚C
(e) Maximum change is sensing range over full temperature range: ≤±10%
(f) Metal housing: cadmium plated brass
(g) Max shock and Vibration loading: to IEC 60068-2-6 and 60068-2-7, b≤30 Hz, t≤11ms, fv≤55Hz, a≤1mm.

5.4.5.3.3 Construction:

(a) Connection cable is mounted into the potting material so that the cable entry doesn't affect the sealing of the unit.
(b) A gland is provided to protect the cable from the metal housing.

5.4.5.3.4 New control wiring to be supplied and installed from spillway control room to each switch.

5.4.6 DC supply

5.4.6.1 Contractor shall supply and install a DC distribution cabinet for supply of all spillway gate systems.

5.4.6.2 Panel shall distribute both 110V DC and 24V DC.

5.4.6.3 The panel shall have two 110V DC incoming circuits and one 240V AC UPS supply

5.4.6.4 A diode block shall be provided for paralleling the two 110V DC incoming circuits.

5.4.6.5 Two (2) redundant power supply units one for 240V AC supply input and another for 110V DC supply input for providing the SCADA cabinet with 24V DC supply shall be installed.

5.4.6.6 24V DC supply from the two power supply units shall paralleled using a diode block.

5.4.6.7 A minimum of the following 110V DC circuits shall be provided.

(a) LV switchboard
(b) SCADA panel
(c) Gate control panel 1
(d) Gate control panel 2
(e) Gate control panel 3
(f) HPU cabinet
(g) Other
(h) Spare 1
(i) Spare 2

5.4.6.8 A minimum of the following 24V DC circuits shall be provided.

(a) LV switchboard
(b) Gate control panel 1
(c) Gate control panel 2
(d) Gate control panel 3
(e) HPU cabinet
(f) General instruments supply
(g) Spare 1
(h) Spare 2

5.4.6.8.2 A DC supply supervision relay shall be wired on the 110V DC bus. Its auxiliary contact shall be wired to the employer's common PLC at the main control building.

5.4.7 SCADA Interface & Closed Loop Control

5.4.7.1 Contractor shall supply, install, and commission a SCADA panel at the spillway control room meeting requirements in **clause 4.6** and implementing the gate control functions in the subsequent clauses.

5.4.7.2 Contractor shall Implement all the control schemes as described in clause 5.4.2 on the SCADA panel automation system. The SCADA selection at the gate control panels, HPU cabinet and at the switchboard shall allow operation of equipment from the operator panel on the SCADA panel at the spillway gate. At the SCADA panel, local/ remote selection shall interlock remote SCADA operations and operator panel operations.

5.4.7.3 Contractor shall also implement a closed loop control of the spillway gate cylinders to achieve synchronised travel of the two cylinders. Automatic adjustment of gate position to maintain a certain dam level or overflow shall also be provided for in the SCADA panel.

5.4.7.4 Requirements for SCADA panel and all associated equipment are described in clause 4.6.

5.4.7.5 All the signals required for gate operations shall be provided and wired from the spillway gate systems to the SCADA panel. At minimum however, the following shall be provided:

5.4.7.5.1 A minimum following signal shall be wired from **each** gate control panel (at the gate control room) to the SCADA panel.

1. Gate open status
2. Gate closed status.
3. Gate inclined left
4. Gate inclined right.
5. Lateral movement left.
6. Lateral movement right
7. Pump filter clogged.
8. Pump failure
9. Closed loop/open loop changeover solenoid directional poppet valve status auxiliary contact.
10. Right Hydraulic cylinder linear displacement transducer 4-20mA output
11. Right Hydraulic cylinder pressure switch & transmitter 4-20mA output
12. Two (2) contacts of Right Hydraulic cylinder pressure switch & transmitter
13. Left hydraulic cylinder linear displacement transducer 4-20mA output.
14. Left hydraulic cylinder pressure switch & transmitter 4-20mA output.
15. Two (2) contacts of left hydraulic cylinder pressure switch & transmitter.
16. Pump pressure switch & transmitter 4-20mA output
17. Two (2) contacts of Pump pressure switch & transmitter
18. Gate position switch & transmitter 4-20mA output
19. Two (2) contacts of gate position switch & transmitter
20. Gate raise command.

21. Gate lower command
22. Stop command.
23. Emergency stop command.
24. Alarm reset command.
25. Gate raise in progress.
26. Gate lower in progress
27. Gate stopped.
28. Gate raise fault.
29. Gate lower fault
30. Gate operation location selection- GATE
31. Gate operation location selection- CONTROL ROOM
32. Gate operation location selection- SCADA
33. OPEN LOOP control selection
34. CLOSED LOOP control selection.
35. MANUAL open loop synchronous control selection
36. AUTO open loop synchronous control selection
37. Pump 1 duty
38. Pump 2 duty
39. Pump 3 duty
40. Pressure pump start
41. Return Pump start
42. 110V DC MCB trip
43. 24V DC MCB trip
44. Grouped fault (to reset)

5.4.7.5.2 A minimum following command shall be wired to **each** gate control panel from SCADA panel.

(a) Raise solenoid.
(b) Lower solenoid (pier), Right cylinder solenoid & Left cylinder solenoid
(c) Right Cylinder fine control solenoid
(d) Left Cylinder fine control solenoid.
(e) Closed loop/open loop changeover solenoid directional poppet valve.
(f) Duty pump start
(g) Return pump start.
(h) Fault reset.

5.4.7.5.3 A minimum following signal shall be wired from **each** outdoor gate control panel at the pier to the SCADA panel.

(a) Gate raise command.

(b) Gate lower command
(c) Stop command.
(d) Emergency stop command.

5.4.7.5.4 A minimum following signal shall be wired from the HPU cabinet to the SCADA panel.

(a) Two (2) Clogging status contacts, one on each tank return line filter
(b) PT100 temperature detector to monitor the oil temperature.
(c) Three (3) Electronic oil Level switches contacts
(d) Electronic Oil Level transmitter 4-20mA analogue output
(e) Two (2) Oil temperature transmitter contacts
(f) Oil temperature transmitter 4-20mA analogue output
(g) Four (4) Accumulator Oil Pressure transmitter contacts
(h) Accumulator Oil Pressure transmitter 4-20 mA signal output.
(i) Two (2) Accumulator pneumatic pressure contacts
(j) Accumulator pneumatic pressure,4-20mA output.
(k) Two (2) accumulator Oil level switches contacts
(l) Accumulator Pneumatic pressure relief valve operated auxiliary contact.
(m) Accumulator oil pressure relief valve operated auxiliary contact.
(n) Gate1/Pump1 Accumulator Valve on status
(o) Gate2/Pump2 Accumulator Valve on status
(p) Gate3/Pump3 Accumulator Valve on status
(q) Pressure Pump 1 emergency stop
(r) Pressure Pump 2 emergency stop
(s) Pressure Pump 3 emergency stop
(t) Return Pump emergency stop.
(u) Accumulator valves operation selection- LOCAL
(v) Accumulator valves operation selection- SCADA
(w) 110V DC MCB trip
(x) 24V DC MCB trip

5.4.7.5.5 A minimum following command shall be wired to HPU cabinet from SCADA panel.

(a) Accumulator Gate1/Pump1 control solenoid
(b) Accumulator Gate2/Pump2 control solenoid
(c) Accumulator Gate3/Pump3 control solenoid

5.4.7.6 Contractor shall implement closed loop control of cylinder movement to ensure synchronised travel of the gates. All the components and works required to achieve this functionality shall be carried including but limited to

5.4.7.6.1 Proportional directional control valves shall be supplied installed and wired to the SCADA panel for the three gates.

(a) Control 4-20mA for each proportional valve shall be wired.

(b) Valve position 4-20 mA for each proportional valve shall be wired.

(c) Electronic valve positioning and control module shall be provided for each proportional valve and installed at the SCADA panel.

(d) Valve shall be designed for optimal control of the gates as per gate design requirements.

(e) Valves shall be robust for long term outdoor application and highly resilient to oil contamination.

5.4.7.6.2 Contractor shall implement control PID logic in the automation system suitable for closed loop control of large cylinders. In as much as possible the contractor shall utilise function blocks tested for similar applications of spillway gate control of other power plants

5.4.7.6.3 Closed loop control shall be configured not to have any adverse effect on the gate cylinders. All protective functions shall be implemented in the logic to ensure safety of the cylinders, gates and personnel.

5.4.7.6.4 In case of failure of any of the required signals to carry out the closed loop control of the cylinder the automation system shall switch control back to open loop and annunciate an alarm

5.4.7.6.5 Tuning parameters shall be available on the operator panel and on employers' SCADA.

5.4.7.7 Contractor shall implement automatic adjustment of gate position to maintain a certain dam level or overflow. All the components and works required to achieve this functionality shall be carried including but limited to

5.4.7.7.1 Suitable PID logic for closed loop gate position control shall be implemented to enable.

(a) Setting a desired gate position to be maintained automatically for each gate or all gates (opening control).

(b) Automatically adjusting gate position based on overflow rate required (flow control).

(c) Automatically adjusting gate position based on dam level required (level control).

5.4.7.7.2 A program shall be implemented to compute the overflow rate (water released by the spillway gate) based on the gate geometry and position. Program shall allow manual setting of the gate position in case of loss of gate position signal.

5.4.7.7.3 Tuning parameters for all the controllers shall be available on the operator panel and at the employers' SCADA.

5.4.7.7.4 Dam level signal shall be obtained from the employers' common PLC via Modbus TCP

5.4.7.7.5 Turbine discharge rates for each of the running units shall be obtained from the employer SCADA system. In absence of these values spillway gate system shall compute turbine discharge based on the distributer (guide vane) position of each unit

5.4.7.7.6 The following devices shall be supplied and installed on the SCADA panel for the closed loop control functions.

(a) Double pole, three position, selector switches for gate priority selection

(b) Three (3) Digital panel indication meters meeting requirements of clause 3.5.8.3 for:

(i) Overflow rate in cumecs

(ii) Dam level position in masl

(iii) Gates' position (synchronised gate position)

5.4.7.8 All the signals/functions shall be made available to employer SCADA as detailed in clause. 4.6.1.3

5.4.7.9 Program development shall be carried as described in clause. 4.6.1.3

5.4.7.10 All SCADA panel and its interface wiring shall be supplied and installed by the contractor.

5.5 LOW VOLTAGE SPILLWAY SWITCHBOARD

5.5.1 General LV Switchboards Requirements

Shall meet all the requirements and specifications given under intake gate particular specifications clause 4.5.1

5.5.2 Switch Board Particular Requirements

5.5.2.1 The switchboard shall have two incomer supplies from the main station switchboard duty bus section and reserve bus section.

5.5.2.2 The following incomers and feeder circuits with the indicated switchgear ratings shall be provided in the new switch board:

	incomers

	Incomer cubicle compartments	Module rating	Type	MCCB	Contactor
1	Duty incoming supply	300A	Incomer	400A	200KW
2	Reserve incoming supply	300A	Incomer	400A	200KW
3	Control & metering	N/A	Control & metering	N/A	N/A
	Feeder Withdrawable plug-in modules				
	Feeder cubicle compartments	Module rating	Type	MCCB /MPCB	Contactor
1	Crane	125A	Cable feeder	160A	N/A
2	Power outlet	125A	Cable feeder	160A	N/A
3	Lighting and small power 4 Way TPN distribution board	125A	Cable feeder	160A	N/A
4	Gitaru central office supply	125A	Cable feeder	160A	N/A
5	Spare	125A	Cable feeder	160A	N/A
6	Spare	125A	Cable feeder	160A	N/A
7	Gatehouse	32A	Cable feeder	32A	N/A
8	Spare	32A	Cable feeder	32A	N/A
9	Pressure pump 1	32A	11KW motor DOL starter	32A	18.5KW
10	Pressure pump 2	32A	11KW motor DOL starter	32A	18.5KW
11	Pressure pump 3	32A	11KW motor DOL starter	32A	18.5KW
12	Return pump	32A	11KW motor DOL starter	32A	18.5KW
13	Motor supply (spare)	32A	11KW motor DOL starter	32A	18.5KW
14	Street lighting	32A	11KW motor DOL starter	32A	18.5KW
15	Spare	32A	11KW motor DOL starter	32A	18.5KW
16	Spare	32A	11KW motor DOL starter	32A	18.5KW
	Lighting and small power 4 Way TPN distribution board				
	feeder circuit		Type	MPCB rating	MCB rating
1	1		Three phase circuit	32A	N/A
2	2		Three phase circuit	32A	N/A
3	3		Single phase circuit	N/A	32A
4	4		Single phase circuit	N/A	32A
5	5		Single phase circuit	N/A	32A
6	6		Single phase circuit	N/A	16A
7	7		Single phase circuit	N/A	16A
8	8		Single phase circuit	N/A	16A

	Switchboard Basic rating	
	Main bus bar rating In	400A
	Distribution bus bar rating In	300A
	Switchboard short-time withstand current (Icw)	50KA/1s
	Rated operating voltage	433V AC

5.5.2.3 Switchboard and switchgear shall be compliant with specifications in clause 3.6, 8.4 & 8.5.

5.5.2.4 Spillway gates control centre switchboard shall meet basic ratings and features as per clause 3.9.10plus the following:

(a) Rated continuous current of the main bus bars: 400A.

(b) Rated continuous current of the distribution bus bars: ≥300A.

5.5.2.5 Switch board shall contain four bus bars for each phase and neutral. Both main and distribution bus bars shall consist of four bus bars

5.5.2.6 The switchboard shall have at least two cubicles with compartments for bus bar; cable connection; incomer and feeder modules and Protection, metering & control.

5.5.2.7 The switchboard shall conform to the IEC 61439-2 Form 4b form of separation and external ingress protection IP54 according to IEC 60529. Switchgear and metering compartments shall be separated from each other by finger-proof partitions (IP2X). Bus bar and cable compartments shall be separated from the switchgear and metering compartments by finger-proof partitions (IP2X).

5.5.3 Incomers

Shall meet all the requirements and specifications given under intake gate particular specifications clause 4.5.3

5.5.4 Control Metering and Protection

Shall meet all the requirements and specifications given under intake gate particular specifications clause 4.5.4

5.5.5 Feeder Modules

5.5.5.1 Eight (8) 11 KW standard sized withdrawable motor DOL starter modules meeting requirements of clause 3.9.20 shall be provided.

5.5.5.2 Six (6)125A standard sized withdrawable cable feeder modules meeting requirements of clause 3.9.19 shall be installed,

5.5.5.3 Two (2) 32A standard sized withdrawable cable feeder modules meeting requirements of clause 3.9.19 shall be installed.

5.5.6 Lighting and Small Power 4 Way TPN Distribution Board

5.5.6.1 A 4-way TP&N distribution board shall be mounted on one switch board compartment.

5.5.6.2 The board shall meet requirements of clause 3.9.9

5.5.6.3 A minimum of the following circuit breakers shall be mounted on the board

(a) 2(two) 32A MPCB meeting requirements in clause 3.9.13

(b) 3(two) 32A AC SP Miniature circuit breakers with Icu ≥10KA @ 400VAC and at least one SPDT auxiliary contacts

(c) 3(three) 16A AC SP Miniature circuit breakers with Icu ≥10KA @ 400VAC and at least one SPDT auxiliary contacts

5.5.6.4 The board's bus bar shall have continuous current rating of at least125A at 400C ambient temperature.

5.6 INTERFACING TO SCADA SYSTEM

Shall meet **all** the requirements and specifications given under intake gate particular specifications clause 4.6.