

II – Design – Build Requirements

Part 4 – Material and Equipment

General and Specific Requirements for Electrical and Automation Works

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2.6. DESIGN-BUILD REQUIREMENTS

2.6.1. General Specifications for Electrical Works

This technical specification includes the procedures and principles to be followed for the installation of Electrical, Environmental Lighting, Automation, SCADA, Communication, Lightning Protection, and Fire Alarm systems.

The Hurma WTE Facility shall receive its electrical power supply from the existing Medium Voltage (MV) Switchgear Room of the Hurma Wastewater Treatment Plant (WWTP). One additional outgoing feeder cell shall be installed in this Switchgear Room. The nominal operating voltage level of the Hurma WWTP electrical network is 36 kV; however, the current operating voltage is 31.5 kV.

The Contractor shall install a dedicated MV switchgear system for the Incineration Plant. This switchgear line-up shall be arranged from left to right as follows:

For outlet of the existing Hurma WWTP;

- 1 Incoming Feeder Cell (Note: Due to power generation, the Distribution Company may require an auto producer cell),
- 1 Measurement Cell,

For Hurma WTE Facility;

- 1 Hurma WTE new inlet cell
- 1 Outgoing Feeder Cell with Circuit Breaker (for internal consumption of the Hurma WTE Facility OTOP),
- 1 Outgoing Feeder Cell with Circuit Breaker (for electricity production connection OTOP),
- 1 Outgoing Feeder Cell with Circuit Breaker (spare).

All cells shall be equipped with disconnectors. The switchgear shall be of metal-clad modular type, metal-enclosed, air-insulated, with SF6 gas-insulated circuit breakers and disconnectors. Short-circuit current calculations shall be made for a duration of not less than 1 second, and the short-circuit rating shall not be less than 25 kA.

The Contractor shall be responsible for the preparation and approval of all relevant electrical design projects required by the Employer's Representative and the local Distribution Company, as well as for the inspection, testing, and acceptance procedures following manufacturing and installation.

A diesel generator set with a rated power capacity equal to that of the transformer installed for the internal consumption of the Hurma WTE Facility shall be provided and installed.

Construction Site Monitoring System

Immediately after the commencement of design-build works, a monitoring system shall be installed for security purposes in the Construction Site. This system shall include the installation of four outdoor, true day/night, full HD PTZ (pan-tilt-zoom) cameras on 10-meter galvanized poles (including mounting brackets) at four locations to be designated by the Employer's Representative. The system shall also include fiber optic cabling, FO to Ethernet converters, and necessary consumables. An 8-channel NVR (network video recorder) with a 16 GB capacity compatible with the cameras shall be installed in the site office of the Employer's Representative. The system shall also include a 32-inch LCD monitor.

2.6.1.1. Scope of Work

The installed electrical units shall cover the electrical power distribution system and ensure the efficient and harmonious operation of the facility and its components. Materials and installations to be used in the facility shall comply with the applicable regulations and energy efficiency standards.

The technical specification covers the main groups listed below. These scopes are not independent but shall be considered as a complete whole along with other documents of the contract and the other articles of this specification.

The scope of work includes, but is not limited to, the following responsibilities of the Contractor:

- Supply, procurement, and provision of all types of goods, materials, consumables, equipment, instruments, systems, units, devices, tools, etc., required for the contract execution (design-build) period, as indicated in the bidding documents, Employer's Requirements or as necessary by the nature of the work.
- Horizontal and vertical transportation of these items, testing, type testing, delivery to the site, disassembly, assembly, and covering all related costs.
- Providing all engineering and labour services related to the above.
- Ensuring the safety and security of the system until its delivery to the Employer.
- Compliance with workplace and worker health and safety standards, including the implementation of requirements under Law No. 6331.
- Obtaining all necessary legal permissions, approvals, consents, and authorizations required during the contract execution (design-build) period.
- Covering all types of insurance and related costs.
- Ensuring compliance with waste and environmental management systems and the legal and current regulations of the Ministry of Environment, Urbanization, and Climate Change, and covering all associated costs.

The Contractor shall be fully responsible for ensuring compliance with these requirements and implementing them effectively.

The Scope of Work is presented below in main headings, without being limited to the items listed. In addition, all other requirements specified in the subsequent sections of this Employer's Requirements – General and Specific Requirements for Electrical and Automation Works shall also be considered as part of the Scope of Work.

➤ **Construction of Distribution Centers**

➤ **36 kV Electrical Distribution Network Systems**

- Construction of distribution/substation centers
- 36 kV cabling, excavation, manhole construction, piping, and connection of associated equipment
- Installation of metal-enclosed modular cells in distribution centers
- Installation of transformers and low-voltage (LV) systems in distribution centers
- Complete supply, installation, testing, commissioning, and delivery of all electrical and control systems in operational condition

- High-voltage switchgear systems, step-down transformers, and measurement/protection systems
- Projects, revisions, construction, and excavation works required for energy supply
- Power supply cables for high and low voltage systems
- Complete electrical installations, including transformers, UPS systems, distribution panels, control panels, cable ducts, cable trays, piping, and building installations
- Installation of outlets, power, control, and signal cables, along with their associated trays
- Emergency lighting system in all rooms
- **Building Lighting:** Power supply for all building and site installations shall be sourced from distribution panels. The panels shall be manufactured according to the specifications and shall include automatic circuit breakers on their outputs.
- Automatic power compensation system for the main low-voltage distribution panelPanel systems shall be durable, motorized, highly resistant to external conditions (rain, snow, wind), and equipped with the following:
 - Industrial-type remote and side-controlled automatic opening and closing features
 - Glass doors with photocells and card readers
 - Battery systems capable of operating for at least 1 hour during power outages
 - Easy opening and closing functionality when the battery is depleted or power is cut
 - Fully closed and fully open user modes
 - Automatic vertically sliding shutters, including supply, installation, and commissioning.

➤ **SCADA Systems**

➤ **Automation Systems**

➤ **Communication Systems**

➤ **Lightning Protection**

- Supply, installation, and commissioning of lightning rods, roof, wall, and ground materials, including all associated consumables, conductors, and rods
- Welding Works

➤ **Grounding Systems**

- Supply, installation, and commissioning of grounding rods, Cu conductors, test pits, piping works, and connections for buildings, walls, cable trays, cell and panel surfaces, doors, and windows, including operational and protective grounding, along with all associated consumables, conductors, and rods
- Welding Works for Grounding Systems

➤ **Environmental Lighting Systems**

- **Firefighting Alarm Systems**
- **Installation of lightning protection systems, including operational and protective grounding systems and equipotential bonding, as well as the associated internal lightning protection systems**
- **Firefighting Systems**
 - Installation of dry/gas-type automatic fire extinguishing systems to mitigate fire risks in high-voltage metal-enclosed modular cell rooms, generator rooms, generator fuel tanks, transformer rooms, panel rooms, and SCADA rooms
- **Internal and External Electrical Installations**
- **Supply of Electrical Spare Parts**
 - Supply and delivery to the Employer of insulated mats, helmets, gloves, fireproof clothing, fire extinguishers, single-line diagrams, insulated benches, neon lamp testers, and similar equipment for all panels and cells, along with operational guidelines, first aid instructions, and danger warning signs.

The Contractor is responsible for thoroughly examining the contents of the bidding documents and the site conditions in detail prior to the bidding process. During the contract execution period, it shall be assumed that the Contractor visited, inspected, researched, analyzed the site, understood the requirements expected of them, prepared their proposal accordingly, and evaluated costs, risks, probabilities, and technical, administrative, financial, and legal processes accordingly before the bid submission deadline.

The bidding documents shall be evaluated as a whole.

In cases where necessary information related to the works is not included in any part of the bidding documents, the Contractor is obligated to perform the design and built works for electrical items.

The Contractor shall supply, install, assemble, commission, and test the envisaged Electrical, Electronic, Automation, SCADA Systems, Communication Systems, Lightning Protection, Grounding Systems, Environmental Lighting Systems, Fire Alarm Systems, and all related auxiliary systems in compliance with the specifications, the applicable laws and regulations of the country, and technical requirements.

Batteries, UPS systems, transformers, MV/HV cells, LV panels, LV/MV cables, and generators shall be manufactured after the contract date. For other materials to be supplied, if their production date is before the contract date, only those manufactured within the last year can be submitted to the Employer's Representative. If approved by the Employer's Representative, the Contractor may initiate the procurement process. Otherwise, it shall be required that they are manufactured after the contract date.

The models presented in the material approval form shall include their technical specifications, catalogues, and current certifications, as well as compliance documents with the standards specified in the specification and project requirements. Materials with outdated certifications shall be rejected. All materials proposed by the Contractor shall be listed on the official websites of the respective product brands.

Electric power shall be supplied from the existing 31.5 kV network serving, in accordance with the process determined by the Employer/Employer's Representative or the authorized Energy Distribution Authority/Company.

The Contractor shall be responsible for all project approvals and infrastructure works required for energy supply and capacity increase.

Throughout the entire process, all types of protection and measurement systems shall be implemented in compliance with IEC Standards.

The cells shall consist of MV/HV cells with rear-top explosion ducts to ensure compatibility with the construction structure and, where possible, to prevent personnel positioned in front of the cells from being affected.

The network's LV system shall be installed as a Main Distribution Panel with compensation.

A generator shall be supplied and installed.

In the entire system, Cu (copper) shall be used for busbars, bars, LV-MV cables, and grounding lines, if applicable.

Transformers shall have copper windings.

2.6.1.2. Degree of Protection

All terminal boxes, panels, lighting fixtures, etc. (unless otherwise specified in the relevant sections of the Technical Specification) shall have the following degrees of protection:

Protection (min.)	Indoor	Outdoor
	IP54	IP65
Panels:	IP54	IP65
Terminal Box:	IP65*	IP67
Lighting Fixture:	IP40	IP65
Indoor Socket (Outlet):	IP65	IP65
Cable Gland:	IP54	IP65
Combined Box:	IP54	IP65
Other Materials:	IP65	IP65
Local Control Box:	IP54	IP65

*The lighting equipment to be used in offices and operator rooms shall have a minimum protection class of IP40, and IP20 shall be applied for recessed socket outlets, switches, and similar applications.

Other requirements are as specified in the relevant sections of the Technical Specification.

2.6.1.3. Condensation and Temperature

All enclosures shall be designed to prevent condensation by ensuring proper ventilation and drainage. The openings used for ventilation and drainage shall be designed to prevent the entry of insects, rodents, and similar pests.

All surface-mounted panels shall have IP65-rated cable glands, and no brush or sponge-based entries shall be allowed.

The internal temperature of all panels shall not exceed 20°C, and the temperature of all panel rooms shall not exceed 30°C. These rooms shall be air-conditioned accordingly, and the air conditioning calculation shall be submitted for approval.

Transformer rooms, high-voltage cell rooms, Main Distribution Panel (MDP) rooms, and PLC panel rooms shall be air-conditioned.

2.6.1.4. Voltages

In the system, the electrical supply shall be:

- Single-phase AC: 230 V $\pm$ 5%, 50 Hz
- Three-phase: 230 V/400 V $\pm$ 5%, 50 Hz $\pm$ 2 Hz
- The power factor shall be 0.99.

Voltage drop limits are as follows:

- Voltage drop between the transformer and the main distribution panel: <1%
- Voltage drop between the main distribution panel and the MCC panel: <1%
- Voltage drop between panels and motors/equipment: <1%
- Voltage drop for lighting panels: <1%
- The simultaneity factor shall be taken as a minimum of 1.

2.6.1.5. Labelling

Each piece of equipment shall be provided with a nameplate showing its type, serial number, and service conditions. Labels and nameplates necessary to clearly define the equipment's function and circuit identification shall be provided. The supply voltage and nominal ratings shall be written on the nameplate. All panels, switches, boxes, internal and external panel cables, etc., shall be labelled.

All marking plates, nameplates, labels, and cable tags shall be made of durable materials (plastic or metal alloy). Paper or similar materials shall not be used. All writings and warning signs shall be legible from a working distance and written in Turkish. The details and placement of all such plates, labels, etc., shall be subject to the Employer's Representative's approval.

Cable Tags (Outer Sheath):

- Material: PP (Polypropylene) insulation base
- Flammability Class: HB as per UL94
- Operating Temperature Range: -40°C to +80°C
- Dimensions: Minimum length 30 mm, width 10 mm

All cables that are not underground or in conduits shall be labelled and coded every 2 meters.

Cable Tags (Inside Sheath):

- Resistance: Resistant to light solvents

- Temperature Range: -10°C to +60°C
- UV Resistance: Resistant to UV rays, does not fade under sunlight
- Material: Plastic alloy, thermal printed, water-resistant

All safety warning signs required for occupational safety shall be installed by the Contractor. Adhesive warning signs shall not be applied to metal surfaces. Instead, flexible materials with flex printing shall be mounted on these points.

2.6.1.6. Abbreviations

TEİAŞ	Turkish Electricity Transmission Corporation
TEDAŞ	Turkish Electricity Distribution Corporation
EDAŞ	Electricity Distribution Company
CK	Antalya Electricity Distribution Co.
TMMOB	Union of Chambers of Turkish Engineers and Architects
EMO	Chamber of Electrical Engineers
TSE	Turkish Standards Institute
TSEK	Turkish Standards Institute Organization
ISO	International Organization for Standardization
CE	European Conformity
IEC	International Electrotechnical Commission
EN	European Norm
VDE	Association for Electrical, Electronic & Information Technologies
DIN	German Institute for Standardization
ANSI	American National Standards Institute
BS	British Standards
SI	International System of Units
DWG	Drawing (AutoCAD)
ÇED	Environmental Impact Assessment
AC	Alternating Current
DC	Direct Current
AG	Low Voltage
YG	High Voltage
DOL	Direct On-Line Starter
SS	Soft Starter

F/C	Frequency Converter (Inverter)
BAR	Maintenance-Free Battery Rectifier
SCADA	Supervisory Control and Data Acquisition System
ADP	Main Distribution Panel
MCC	Motor Control Center
CCTV	Closed-Circuit Television
PLC	Programmable Logic Controller
CPU	Central Processing Unit
DI	Digital Input
DO	Digital Output
AI	Analog Input
AO	Analog Output
HMI	Human-Machine Interface (Touchscreen Graphic Display)
UPS	Uninterruptible Power Supply
LCD	Liquid Crystal Display
LED	Light Emitting Diode
UV	Ultraviolet
TMS	Thermal Magnetic Switch
MCCB	Molded Case Circuit Breaker
RMU	Ring Main Unit
THD	Total Harmonic Distortion
RCCB	Residual Current Circuit Breaker
MCB	Miniature Circuit Breaker
PVC	Polyvinyl Chloride
ATS	Automatic Transfer System
HSD	High-Speed Diesel
SCR	Silicon Controlled Rectifier
HOA	Hand-Off-Auto Selector
LAN	Local Area Network
WAN	Wide Area Network
VPIS	Voltage Presence Indicating System for MV/HV Cell Breaker Sections

2.6.1.7. Units

All measurement units, except for temperatures expressed in degrees Celsius, shall comply with the International System of Units (SI). The Contractor shall account for the temperature increase caused by installed equipment and solar radiation in this design, ensuring the nominal performance and stability of the facility under prevailing climatic conditions.

2.6.1.8. Hazardous Area Classification and Ex-proof Equipment

The Contractor's process and electrical engineers shall jointly identify all explosion and fire hazards and define hazardous areas in accordance with international standards. Facilities and equipment specified for such areas shall be restricted in type and structure according to the area classification. Test certificates shall be provided for all facilities and equipment posing a hazard, and these certificates shall comply with the relevant standards.

All terminals and terminal blocks shall have individual termination numbers. Connectors in all panels shall be numbered. Power supply terminals shall be identified with colors and/or numbers corresponding to phase indications. Depending on the terminal type, cable lugs shall be connected to wires or cores; however, "C" or "Jaw"-type clamps shall not be used.

2.6.1.9. Approvals and Acceptances

The Contractor shall submit an approval form to the Employer's Representative, this form shall include all materials, cables, panels, switchgear materials, and protective devices (thermal-magnetic switches, coils, fuses, residual current relays, etc.), as well as all other equipment proposed for use in the facility. The materials shall strictly comply with the project requirements and specifications, specifying their brand, model, type test reports, certificates, and technical catalogues. Material approvals shall be finalized upon the Employer's/Representative's consent and approval.

The Contractor shall bear all costs related to applications, energy permits, project approvals from EMO and other authorized institutions, testing, commissioning, and facility acceptance processes for bringing energy to the facility. These costs include fees, dues, expenses, taxes, and all financial liabilities.

For TEDAŞ temporary acceptance applications, the Contractor is responsible for obtaining all necessary documents such as the Fire Safety Approval from relevant institutions like the Governor's Office, District Governor's Office, Municipality, Ministry of Public Works, Universities, TEDAŞ, and EDAŞ, as well as other required documents like the EIA certificate and zoning permit.

Document procurement shall be carried out under the supervision of the Employer's Representative/Employer. The Contractor is directly responsible for ensuring the provision of the necessary production, documents, and information for obtaining compliance certificates.

The Contractor is responsible for all temporary and final acceptance processes for the MV system, LV system, transformers, and other electrical systems as required by regulations. This includes any unforeseen changes, scope increases/decreases, cancellations, additions, or changes in the system/regulations during the contract period. All responsibilities and requirements shall be fulfilled by the Contractor.

The preparation of projects, project revisions, revised connection agreements, acceptance reports, and application files, including approval cover letters for submission to local distribution companies, TEİAŞ, and TEDAŞ, is the responsibility of the Contractor. The Contractor is also responsible for completing any deficiencies identified following the submission of project revisions and acceptance applications.

The Contractor shall handle all necessary coordination, staff allocation, project design, drawings, calculations, engineering work, fees, taxes, payments, and administrative and technical matters for application tracking and results.

If any issues arise during facility operation after temporary acceptance that were not detected earlier, the Contractor is responsible for addressing them. During final acceptance, the Contractor is obligated to rectify any deficiencies identified after temporary acceptance or during its process.

The Contractor shall obtain approval for all materials to be used before commencing production. Materials used in production shall comply with the specifications outlined in the relevant institutions' technical documents and meet the standards and quality assurance requirements (TSE and CE certified).

During construction, the Contractor shall record all information necessary for the preparation of as-built drawings. These drawings and related documents, showing the completed permanent works, shall be carefully prepared and kept available for the Employer's Representative's inspection throughout the construction period.

Marked drawings shall be kept up to date and submitted to the Employer's Representative for approval monthly as the work progresses. Submissions shall be made in paper format.

As-built documentation shall include all disciplines. The final version of the as-built drawings, incorporating changes and revisions made during construction, shall be submitted at the time of temporary acceptance.

The Contractor shall prepare and deliver final as-built drawings, including all material specifications and information used during the work, to the Employer/Employer's Representative in both original and digital formats (on CD).

All documents except drawings shall be in A4 format. Drawings shall be in international A-size sheets and marked as "As-Built Drawings."

The Contractor shall deliver all completed and implemented production projects, as-built projects, DWG files, open-source software for systems containing automation (e.g., LADDER diagrams, SCADA and HMI codes), IP address lists, access passwords, and software licenses issued in the Employer's name.

For MV systems, each commissioning shall include remote control and simulation tests for all options, and results shall be recorded.

Selective coordination settings and differential functions between relays in MV rings shall be checked and reported.

Insulation and related tests shall be performed and recorded for newly installed MV and fiber optic cable lines.

The Contractor shall conduct thermal fault detection and reporting for the supplied and installed cables, cable terminals, splice points, and accessories.

Test reports shall be submitted to the acceptance committee during temporary acceptance and repeated during final acceptance.

Temporary acceptance by the local Distribution Company, TEİAŞ, and TEDAŞ, if required, shall be arranged by the Contractor before temporary acceptance and submitted to the acceptance committee.

Planned power outages during work shall be in advance, and power cuts shall be scheduled as per the Employer's Representative/Employer's program, ensuring continuous coordination. In cases requiring long-term outages (e.g., MV busbar installations, transformer center setups, or relocations of existing systems), the Contractor shall arrange for a mobile generator of adequate capacity to prevent disruption to operations.

The Contractor shall not request time extensions or cost increases for rental or similar reasons. Temporary cables and other materials used for backup power supply shall be removed from the site and shall not be used within the scope of the work.

2.6.1.10. Tests

For factory/routine tests, the Contractor shall formally inquire with the Employer's Representative in writing whether the Employer shall attend the tests conducted at the production facility or an equivalent laboratory. Even if the Employer does not participate, the test reports shall still be provided to the Employer by the manufacturer.

Factory tests shall be conducted prior to the shipment of materials, and only materials that are to be used in the relevant project shall be tested.

The general requirements for the competence of testing and calibration laboratories shall comply with ISO/IEC 17025.

At least three (3) technical personnel designated by the Employer's Representative/Employer shall supervise the factory tests. The Contractor shall bear all travel expenses, including domestic and international transportation, as well as accommodation and subsistence costs for these personnel. It is assumed that the Contractor has anticipated these costs prior to submitting the proposal and included them in the price quotations.

The Contractor shall coordinate with the manufacturer to create a schedule for the tests and shall follow this schedule during participation. The test program shall be submitted to the Employer's Representative/Employer by the Contractor at least one (1) month prior to the start of the tests and agreed upon with the Employer's Representative/Employer.

If deemed necessary by the Employer's Representative/Employer, the Contractor shall provide an interpreter to accompany the Employer's/Employer's Representative's personnel attending the tests.

The Contractor shall ensure that the following devices/equipment/systems are tested at the manufacturer's facilities (domestic or international) in the presence of the Employer's Representative and the Employer's personnel, in accordance with the specifications:

- Transformers
- Generators
- MV Cells
- Panels
- MV-LV Cables

2.6.1.11. Distribution Transformers

Routine tests shall be conducted at the manufacturer's facilities in accordance with BS EN 60076-11.

- Measurement of winding resistance
- Verification of ratio, polarity, and phase relationship
- Impedance voltage
- Load losses
- Measurement of no-load losses and current
- Insulation resistance
- Induced overvoltage withstand
- Separate source voltage withstand
- Measurement of short-circuit voltage and load losses
- Measurement of no-load losses and current
- Applied voltage test
- Induced voltage test
- Measurement of insulation resistance: In oil-filled transformers, insulation resistance between windings and between each winding and the tank shall be measured using a 2500 V or 5000 V insulation tester at 0, 15, 30, 45, and 60 seconds. Results shall be corrected to 20°C, and the measurement result at 60 seconds shall be indicated on the transformer nameplate.
- Transformer tank leak test
- Measurement of paint thickness

Additional Tests for Dry-Type Transformers to be conducted at the manufacturer's test laboratory are as follows:

- Measurement of winding resistance (IEC 60076-11 Clause 14.2.1)
- Measurement of voltage ratio and verification of phase displacement (IEC 60076-11 Clause 14.2.2)
- Measurement of short-circuit impedance and load loss (IEC 60076-11 Clause 14.2.3)
- Measurement of no-load loss and current (IEC 60076-11 Clause 14.2.4)
- Applied voltage test (IEC 60076-11 Clause 14.2.5)
- Induced overvoltage withstand test (IEC 60076-11 Clause 14.2.6)
- Partial discharge measurement (IEC 60076-11:2006 Clause 14.2.7)
- Full wave lightning impulse test (IEC 60076-11 Clause 14.3.1)
- Temperature rise test (IEC 60076-11 Clause 14.3.2)
- Noise level measurement test (IEC 60076-11 Clause 14.4.2)
- Additional monitoring tests shall also be conducted as follows:

- Impulse voltage with stand: Type test certificates shall be accepted if the manufacturer provides documents covering impulse voltage withstand tests for transformers of similar type and design.
- Temperature rise: Type test certificates shall be accepted if the manufacturer provides documents covering temperature rise tests for transformers of similar type and design.

2.6.1.12. Panels / Medium and High Voltage (MV-HV) Switchgear

To ensure the accuracy of the production and workmanship of panels and switchgear, the following routine tests shall be conducted at the manufacturer's factory:

- Mains frequency voltage test on the main circuit,
- Testing of auxiliary and control circuits,
- Resistance measurement of the main circuit,
- Cabling inspection,
- Compliance check with design and drawings,
- Mechanical operation test,
- Visual inspection for compliance,
- Switchgear shall successfully pass the type tests specified in IEC 62271-200 standards, and circuit breakers shall comply with the type tests outlined in IEC 62271-100 standards.
- Type tests (all tests defined in IEC 62271-200) shall be conducted by internationally accredited independent organizations.
- Dielectric insulation tests, including lightning impulse withstand test and mains frequency voltage withstand test,
- Temperature rise and resistance measurement test,
- Verification of the rated short-time withstand current and peak withstand current capacities of the main circuit and grounding circuit,
- Verification of the short-circuit making and breaking capacities of switching devices while housed in the panel,
- Verification of the mechanical operation of switching devices and moving parts used within the panel,
- IP tests to confirm the specified protection class,
- Internal arc withstand tests to determine the resistance to the effects caused by internal arc faults.

2.6.1.13. Power System

The following tests and inspections shall be conducted for power systems:

- Inspection of all power circuits,
- Insulation testing,

- Verification of torque settings,
- Inspection of component dimensions,
- Verification of conductor dimensions,
- Verification of conductor colors,
- Inspection of cable numbering,
- Inspection for loose connections,
- High voltage testing,
- Phase sequence verification,
- Inspection of measuring transformers,
- Verification of fuses, motor protection, isolators, etc.,
- Testing of fault current relays using testing equipment,
- Verification of thermal relay settings,
- Inspection of fuse functionality,
- Verification of settings for controlled starters, etc.,
- Inspection of busbar connections,
- Inspection of conductors leading to all components (transformers and DC units),
- Inspection of conductors leading to sockets,
- Verification of cable numbering,
- Inspection for loose connections,
- Verification of lamp tests,
- Inspection of lamps,
- Verification of documentation,
- Inspection of digital inputs,
- Inspection of digital outputs,
- Verification of analog inputs,
- Verification of analog outputs,
- Inspection of analog loops,
- Verification of wire fastening and protection,
- Inspection of component codes on sockets,
- Verification of component labeling,
- Inspection of terminal dimensions,

- Verification of terminal numbering,
- Inspection of internal cable labeling,
- Verification of electronic component settings,
- Inspection of section covers,
- Verification of labeling,
- Inspection of panel markings and certifications,
- Inspection of grounding system,
- Verification of adequate spare capacity and space,
- Inspection for cleanliness,
- Verification of drawings in the panel,
- Inspection of handles and locks,
- Verification of front layout,
- Inspection of component layout according to documentation.

2.6.1.14. Diesel Electrogene Group (Generator)

a. General

The scope of this work includes the supply of materials for the generator and its installation, transportation to the workplace, storage, assembly and necessary tests, and delivery of the generator and its installation in fully operational condition on a turnkey basis to the Employer's Representative after obtaining the necessary official permits, in accordance with the technical specifications specified in the project and specifications.

All precautions will be taken by the contractor company to prevent damage to the generator during transportation, storage and assembly processes. In such a case, the contractor company is responsible for all material losses and is obliged to cover all losses and damages that may occur. The contractor will not charge any additional fees for transportation, unloading and assembly processes.

If the factory tests conducted by the manufacturer of the generator set and the idle and partial load operation tests conducted on site before acceptance are positive, the Contractor will apply to the institution assigned by the Ministry of Energy and Natural Resources by providing all necessary electrical projects and documents and will carry out the acceptance procedures and obtain the operating permit.

The contractor will provide training on operation and maintenance to the technical personnel who will use the generator.

b. Standards and Regulations

The diesel generator set and the equipment to be used within the scope of this specification shall be designed in accordance with the latest editions of the following TS standards or valid international standards. The diesel generator set shall comply with the laws and regulations in force in terms of operational safety.

Standard Number	Standard Name
TS ISO 8528	Reciprocating internal combustion engine driven alternating current generator sets
TS EN 12601	Reciprocating Internal Combustion Engine Driven Generator Sets - Safety
ISO 3046	Internal Combustion Engines Reciprocating Motion-Performance
TS 3205 EN 60034-1	Rotating electrical machines – Part 1: Rated values and performance
TS 18001	Occupational health and safety management systems – Terms
2000/14/EC	European noise directive 2000/14/EC for groups with soundproof enclosures

c. Documents

The following documents will be submitted to the Employer's Representative along with the Equipment Procurement Form:

- Detailed catalogue and technical brochure containing explanatory information for diesel engine, alternator, battery type, fuel tank and auxiliary devices,
- Pictures showing the overall dimensions of the diesel generator set with all its equipment,
- Certificate of conformity of the manufacturing to the relevant standards,
- TSE Manufacturing Competence Certificate,
- Ministry of Industry After Sales Service Competence Certificate,
- Ministry of Industry Authorized service certificate,
- ISO 9001 Quality System Certificate and ISO 14001 Environmental Management Systems Certificate of the manufacturing company,
- TS 18001 Occupational Health and Safety Management Certificate,
- Reference list,
- It must be documented that the generator carries the CE mark.

The maintenance manual to be used in the maintenance, repair and operation of the diesel generator group and transfer panel will be presented separately after commissioning.

d. Technical Specifications

The generator set and necessary equipment that will meet the emergency power need will be completely new, unused, reliable, easy to operate, and easy to maintain. The generator set and equipment will consist of a diesel engine and cooling radiator, a synchronous alternator and flexible connection discs, a steel chassis and fuel tank, an automatic control panel, an automatic transfer panel, a start battery, and connection cables.

The generator set will have a soundproof cabin suitable for use outdoors.

The diesel engine and alternator will be directly connected to each other with elastic discs, and a flexible assembly will be made on a common steel chassis with the help of isolators to prevent vibration effects.

There will be a level indicator, filler cap, air vent and drain plug on the daily fuel tank. The fuel tank will be capable of operating the engine for 10 (ten) hours under full load and will be in the cabin. The fuel tank and the engine fuel system will be connected to each other with flexible fuel hoses.

The generator group will operate automatically via the control panel. The panel will be mounted on the generator group chassis.

The group's common chassis will be designed in a strong structure made of shaped steel sheet and connected to each other by welding. The chassis will carry the wet weight of the generator and its equipment and will not cause any bending or twisting. There will be lifting points on the chassis to lift the entire weight of the generator group. They will be positioned at appropriate points on the chassis to prevent damage to the elements on the generator during lifting.

The group label will be in a suitable and visible place in the cabin and will contain information such as manufacturing year, serial number, type, etc.

Working conditions

The diesel generator set will be capable of operating continuously in open air conditions and the environmental conditions listed below.

Maximum altitude: 1000 meters above sea level

Maximum ambient temperature: + 50°C

Minimum ambient temperature: - 15°C

Average temperature of the hottest month: 40°C

Generator Operating Voltage

The output voltage will be 400/230 volts (3 phase and neutral output, star connected) and the frequency will be 50 Hz, 1500 rpm.

Diesel engine

The diesel engine to be used as a drive source in the generator set will be 4-stroke, 1500 rpm, water-cooled, naturally aspirated, diesel fuel-powered, direct injection fuel system. The diesel engine, which will be suitable for 24 (twenty-four) hours of continuous operation (Prime) under variable loads, will be able to be loaded with 10% overload on prime power for one hour every 12 hours.

Fuel, oil, water pumps and radiator fan will be mounted on the diesel engine and driven by the engine.

The governor hardware that keeps the speed of the diesel engine constant will be of the electronic type.

In case of diesel engine constant load, speed/frequency regulation will be at least 5%.

The diesel engine will have 6 cylinders and an in-line type cylinder arrangement.

In the diesel engine fuel system; there will be a replaceable cartridge type fuel filter on the fuel line, fuel transfer pump, sequential type fuel injection pump, solenoid to stop the engine, fuel pipes, pencil

type injectors for each cylinder. Flexible hoses resistant to diesel fuel will be connected on the feed and return lines for external connection to the fuel system.

Diesel engine lubrication system; It will be a lubrication system with a changeable cartridge type oil filter and a crankshaft driven gear type oil pump with pressurized circulation. The system will have an oil pressure sensor to stop the engine at low oil pressure and measure the pressure value. There will be an oil drain valve at the oil pan outlet to drain the engine lubrication oil during periodic maintenance. The crankcase ventilation line will be of a closed type and will be given to the air intake system of the engine.

Diesel engine cooling system; the cooling water circulating in the engine jacket will be cooled by the radiator and fan. The radiator fan will be rotated from the engine crankshaft by means of a belt and pulley. The cooler will be mounted on the radiator group chassis in front of the diesel engine.

The cooling system will consist of the cooling water pump, thermostat to adjust the temperature of the water, cooling radiator, etc. There will be protection against touching the rotating radiator fan.

The cooling system shall be capable of ensuring continuous operation of the engine at an ambient temperature of + 50 °C.

The system will have a water temperature sensor to stop the engine in case of high cooling water temperature and measure the temperature value.

There will be a jacket water heater that works with mains energy so that the diesel engine can easily start and take the load in cold weather. There will be a thermostat in the system that will keep the water temperature above 40°C.

The engine air intake system will have a dry type, replaceable cartridge element air filter. The air filter element will be in a metal casing.

The diesel engine exhaust system will be dry type, exhaust gas will be directed upwards. There will be flexible expansion compensator, flanges, fireproof gaskets and silencer in the system to throw exhaust gas to external environment. Exhaust pipes in the cabin will be insulated against touching.

The diesel engine will be started by the electrical system and for this purpose, a 12 (twelve) volt maintenance-free lead acid battery will be used. There will be a charge alternator driven by the diesel engine to keep the battery fully charged. Battery connection cables will be connected to the starter motor. The batteries will be mounted on the battery stand on the group chassis.

Alternator

The synchronous alternator shall comply with the standards BS EN 60034, VDE 0530, BS 5000, IEC 34, NEMA MG1-32 and shall provide the following features. The alternator shall be waterproof, grid protected, rotating field, brushless, with an exciter generator, and directly connected to the engine. It shall have a single bearing, 4 poles, self-excited and self-regulating, and an electronic type automatic voltage regulator.

Output voltage: Single phase 230 (two hundred and thirty) / Three phase 400 (four hundred) Vac

Output frequency: 50 Hz

Power factor: 0.8 (zero point eight)

Number of revolutions: 1500 (one thousand five hundred) revolutions/minute

Number of phases: 3 (three) phases

Power : Suitable for the installed power, sufficient for all equipment (including spares)

Waveform : Sinusoidal

Connection type: Star

Insulation class: H

Protection degree: IP 22 (twenty-two)

The alternator winding insulation system will be Class H.

Alternator brushless and electronic type automatic voltage regulator.

Alternator efficiency will be at least 87% at prime load.

The alternator shall be designed to withstand a load of 110% (one hundred and ten percent) of the nominal power for 1 (one) hour at the end of every 12 (twelve) hours of operation.

There will be no power loss in the alternator up to 1000 meters above sea level.

There will be no power loss in the alternator up to 40 degrees ambient temperature.

Power output module for connecting power cables to the generator

There will be a power output terminal panel mounted on the generator chassis for easy connection of power cables to be connected to the generator. The generator power output module will be manufactured from sheet steel and painted with electrostatic powder paint and baked. There will be a busbar or terminal with a suitable cross-section inside the module for the connection of power cables coming from the alternator and power cables going to the load.

Control Panel

Within the scope of this specification, to prevent damage to the engine, alternator, mechanical and electrical devices for safe and reliable operation, control of the diesel generator group and all auxiliary equipment, alarm system, monitoring devices and measuring circuits will be provided.

The diesel generator set control module will be microprocessor based, and the operating program parameters can be changed via the module. The control panel will be made of sheet steel, powder-coated and baked. The panel will be hinged, locked and mounted on the generator set chassis.

Equipment;

Electronic generator control module

Electronic battery charger

Emergency stop button

Circuit protection fuses

Interior panel lighting lamp

Control circuit cables will be numbered in the channel for circuit tracking.

The generator control panel will provide the operating modes specified in the following items. All control and protection of the generator will be done by means of an electronic microprocessor control module. The control panel will be mounted on the generator group.

The operating status can be selected with the following push buttons on the generator control module.

Off/Reset – Manual – Test – Automatic – Start – Horn Silence / Lamp test

In the Off/Reset position, the module will not function, if the mains supply is available, it will activate the mains and when a fault/alarm situation occurs, the relevant alarm situation will be reset. The generator operating in the manual position will stop when it is turned off.

In manual position: The generator will be put into manual position by means of the manual button on the front face of the module and will be operated with the start button.

In Test Mode: Test mode will be selected by pressing the Test Mode button and the test run will be started by pressing the Start button. In the Test Run, the fuel line will be opened by giving energy to the coil on the fuel line and 3 engine cranking attempts will be made. If the engine does not start, no more cranking attempts will be made and the start failure symbol will be displayed on the module screen. When the engine is ignited and a frequency of 20 Hz is measured from the alternator output voltage, the module will cut off the energy of the starter motor. In order to prevent damage to the generator, the load will not be given to the generator until the generator is operating normally. After the generator is operating normally, the load will be fed by the generator and the generator will operate under load until the automatic or stop position is selected.

In automatic position: Automatic operation will be performed with the automatic button on the front panel of the module. If the mains voltage goes out of the set limits, the generator will be activated within 20 (twenty) seconds at most.

The generator control module is in automatic mode, when the mains power is cut off or when the set low and high voltage limits are exceeded; it will give the generator a start command and will make three cranking attempts consisting of 10 seconds of cranking and 10 seconds of waiting. If the generator cannot start as a result of the start attempts, it will not try again and the control module will give a start failure signal. When the set voltage and frequency are reached at the end of the successful start process, the generator contactor will be activated and will feed the customer loads.

When the mains power returns or the voltage returns to appropriate limits, the generator will automatically transfer the load to the mains and at the end of the cooling period, which can be adjusted between 0 seconds and 30 minutes, it will automatically stop and remain active.

The control module will have the following warnings and protections.

Warning alarms:

The engine will continue to run when the warning alarm occurs.

- Charge alternator failure; If the charge alternator does not produce enough voltage to charge the battery while the generator is running, the fault status will be shown by lighting up the relevant fault symbol LED on the screen.
- Low – High battery voltage alarm; the module will monitor the DC supply voltage, and when the voltage goes outside the adjustable limits after an adjustable period of time, the fault symbol LED will light up and the fault status will be displayed on the screen.
- It will also appear in the alarms listed below.
- Stop failure.
- Low/High generator voltage.

- Low/High generator frequency.
- Low/High engine speed.
- Low oil pressure.
- High water temperature.

Stop alarms:

When shutdown alarms occur, the generator will stop and the module will be reset to remove the fault alarm. In order to prevent faults that may occur during the first start of the engine from being detected by the module and the system from stopping, there will be a safety time that can be set to the desired value between 8 seconds and 1 minute.

Start failure; if the system does not start after three cranking attempts, the relevant failure symbol will illuminate.

Low oil pressure; when the oil pressure in the engine falls below the limit set by the manufacturer, the relevant fault symbol will be displayed on the screen and the engine will stop without delay.

High engine temperature; when the engine coolant temperature exceeds the limit set by the manufacturer, the relevant fault symbol will be displayed on the screen and the engine will stop without delay.

Overspeed / High frequency; when the engine speed exceeds a value that can be set between 50-72Hz, the relevant fault symbol will be displayed on the screen and the engine will stop without delay.

Low speed / Low frequency; when the engine speed drops below a value that can be adjusted between 0-59.5Hz, the relevant fault symbol will be displayed on the screen and the engine will stop without delay.

Low generator voltage; if the generator voltage does not reach the adjustable loading voltage level after the system starts, the relevant fault symbol will be displayed on the screen and the engine will stop.

There will also be the following stop alarms.

- Emergency stop.
- High generator voltage.
- There is no oil pressure switch connection.
- There is no temperature sensor connection.

There will be a LED mimic diagram on the control module front panel, indicating the status of the mains, generator and related contactors.

All settings such as time settings, network low and high voltage level settings, digital input and output configurations for the generator operating program will be made via the control module front panel or by connecting to the control module via a PC.

The control module will have a minimum of 2 programmable digital inputs and 2 digital outputs. The digital inputs will have an activation delay that can be adjusted between 0 and 10 seconds.

In addition, the control module should be able to be operated remotely via a programmable digital input and feed the load or, in automatic operation mode, always assume the network and prevent the generator from operating.

The control module will have a password protection mechanism to prevent unauthorized persons from accessing the module settings via PC.

The control module shall have adjustable overcurrent protection.

Along with system fault status warnings via the LCD panel on the control module,

ENGINE

- Engine speed.
- Oil pressure.
- Water temperature.
- Working hours.
- Battery voltage.
- Adjustable timing.

GENERATOR

- Voltage (LL, LN).
- Currents (L1-L2-L3).
- Frequency.

NETWORK

- Voltage (LL, LN).
- Frequency.

values can be monitored.

There will be a charger on the control panel to charge the group battery when the generator is not working.

All elements and cables in the generator control panel will be numbered to facilitate circuit tracking in the event of a fault, and these numbers will be indicated on the relevant control diagrams. The relevant control diagrams will be designed to be easily understood.

Automatic Grid/Generator Power Transfer Panel

The transfer panel will provide the features specified in the LV Panels section of the specification. The transfer panel will be installed in the LV panel room. The panel will be in IP65 protection class.

There will be an electrical interlock circuit between the Network and Generator contactors.

Contactors will be 4 poles and contactor current values will be selected according to the starting currents of the pumps. The load will not be considered resistive, contactor current values will be selected according to the appropriate AC curve.

All energized power circuits shall be protected against careless touching.

All metal parts that are not under voltage will be grounded.

All control circuits will be protected by line head fuses of appropriate value.

Safety guards/measures

All parts of the device shall be covered with protective equipment to prevent personnel from touching and exposing them to danger. Protective covers shall be designed in a way that they do not affect the operation of the device. The following equipment shall be covered with protective casing;

Rotating parts; flywheel, vibration damper, V-belts, V-belt pulleys

Radiator fan

Heat-radiating parts and pipes

Terminals where electrical connections are made

Generator Sound and Dust Proofed Cabin

The generator will have a container type sound insulation cabin. It will be manufactured from 1.5 mm DKP steel sheet. The sound insulation cabin will have a volume that will allow technical personnel to easily maintain the generator. The cabin interior will be covered with flame-retardant sponge in accordance with the "Class 0" criteria according to TS EN 13501-1 standard B S2 d0 class, BS 476 Section 6 and BS 476 Section 7 standards. There will be covers on at least two sides of the cabin. There will be absolutely no windows on the doors. The doors will be designed ergonomically. The interior and exterior surfaces of the cabin will be electrostatically painted with a phosphate-free surface pretreatment. The paint to be used will be environmentally friendly non-technological Tgic Free feature, qualicoat and reach approved polyester powder paint application. The cabin doors will have locking covers and a mushroom-head emergency stop button that does not protrude outside the cabin and on the control panel will be placed. The noise level of the group with the cabin will be an average of maximum 75 dbA in a 1 m diameter circle. Cabin air inlets and outlets will be designed to prevent power loss and overheating. A cooling system calculation report will be submitted. There will be a heat and fire protective metal piece at the exit of the exhaust pipe from the cabin. The exhaust will be specially sound-blocked. The cabin will be designed to be suitable for maintenance and repair. There will be carrying hooks or forklift lifting channels in appropriate places to carry the cabin group. It will have an appropriate ergonomic structure that will allow for easy supply of oil, water and fuel.

e. Tests

The material will be subjected to the tests required by the standards before shipment. The factory acceptance test will be carried out in accordance with the ISO 8528 standard.

Load tests will be carried out with load banks with a power factor pf: 1 value.

The Employer's Representative reserves the right to participate in inspections and tests, and reports showing the test results will be submitted to the Employer's Representative before shipment

2.6.1.15. Maintenance and Repair Equipment

The Contractor shall supply the following materials as spare stock under this heading and deliver them to the Employer's Representative/Employer. It shall be assumed that the Contractor was aware of this obligation before submitting their bid and included the related costs in their offer. Therefore, the costs of the materials shall be borne by the Contractor, and no additional payment shall be made.

The Contractor shall provide all special hand tools required for the proper maintenance of all delivered equipment.

Special electrical tools refer to tools or equipment specifically used for testing electrical circuits.

Maintenance tools necessary for the electrical and control systems should include items such as insulated mats, two complete sets of electrical tools in carrying cases, etc.

The Contractor shall submit a spare parts program with the bid, which includes the description and prices of spare parts recommended for general maintenance during the operation period (excluding free spare parts to be used during installation, testing, and commissioning).

The final spare parts list prepared by the Contractor shall include at least the following spare parts. The spare parts listed in this document shall be delivered to the Employer's Representative/Employer before the Provisional Acceptance of the Works.

- 2 protection relays for MV switchgear,
- 5 energy analyzers for LV panels,
- 5 galvanic isolators for analog signals,
- 100 signal LED lamps for each color,
- 10 outdoor/environmental lighting fixtures,
- 5 addressable combined fire detectors,
- 5 fire alarm push buttons,
- 1 fire warning siren with flasher,
- 3 CPUs for the PLC unit,
- 2 power supplies for the PLC unit,
- 10 DI (Digital Input) modules for the PLC unit for each capacity type,
- 10 DO (Digital Output) modules for the PLC unit for each capacity type,
- 5 AI (Analog Input) modules for the PLC unit for each capacity type,
- 5 AO (Analog Output) modules for the PLC unit for each capacity type.

2.6.1.16. HV/MV Switchgear Centers

High-voltage switchgear and transformer centers shall be designed and manufactured to ensure safe, reliable, and maintenance-free operation under the environmental conditions at the sites.

An emergency stop button shall be installed at transformer centers.

Transformer rooms, high-voltage switchgear rooms, and all panel rooms shall have steel doors (aluminium shall not be accepted) and shall comply with TEDAŞ and local electricity provider standards.

Emergency lighting kits shall be provided in transformer, switchgear, and panel rooms.

The selection of transformers and high-voltage switchgear shall consider the Employer's facility's main incoming supply voltage, current/voltage transformer conversion ratios, and power ratings.

The requirements specified in this specification are the minimum protection requirements for the power system and electrical installation.

The Contractor shall design the power and installation protection system in accordance with the specified design parameters and measurement transformer conversion ratios and classes, ensuring compliance with the Employer's standards for protective relays, adjustment limits, and operational characteristics. High-voltage switchgear relay features, current transformer, and voltage transformer specifications shall be confirmed by the Employer's Representative/Employer.

Distribution transformers shall be constructed on concrete foundations and with a pathway for wheels.

The layout of the switchgear and panels shall allow easy access to equipment inside the structure. Additionally, the design shall permit easy replacement, particularly for transformers.

All connectors in the panels shall be numbered.

All cables inside the panels shall be labelled with codes.

High-voltage equipment shall be rated for continuous operation under the maximum load of the distribution transformers and the fault levels calculated by the Contractor.

All materials shall be prepared for easy on-site assembly, minimizing fieldwork and delivered as "ready-to-install."

a. Switchgear

Factory-assembled, metal-enclosed, air-insulated, indoor modular switchgear shall be used for medium voltage (MV) distribution systems up to 36 kV and MV/LV distribution transformer centers. The technical specifications and requirements for these switchgear are defined as follows:

The MV switchgear to be manufactured and supplied according to this technical specification shall be designed and produced to meet the conditions and characteristics outlined in the following sections of the specification.

The MV modular switchgear covered by this specification shall be compliant with the features specified in the specification and its appendices, and it shall include:

- Three-phase busbars and supporting insulators,
- Bushing insulators,
- MV cable connection arrangements suitable for double ring systems,
- SF6 gas-insulated circuit breakers,
- Earthing switches,
- Current and voltage transformers,
- Protective control and measurement devices,
- Internal connections between these components,
- Earthing systems,
- Locking mechanisms,

- Other auxiliary materials.

These switchgear shall be factory-manufactured and assembled with all necessary installations and connections completed and shall have undergone complete type testing in internationally independent test laboratories in accordance with IEC 62271-200 standards.

The switchgear shall be designed, planned, and equipped with materials and equipment as specified in the single-line diagram, circuit diagrams, and related projects approved by the Employer and in compliance with this specification. The electrical connections shall be manufactured to ensure accurate and complete operational functionality.

All switchgear shall be factory-produced, internal, modular, and under the system guarantee of the manufacturer.

The design and manufacturing of the switchgear, including digital protective relays, disconnectors, load disconnectors, and breakers to be used in the switchgear, shall be from the same manufacturer.

The switchgear may be subject to inspection by the user at any stage of factory production, provided prior notice is given.

The design of the switchgear shall prioritize:

- Safety during intervention and maintenance by personnel,
- Reliability of service,
- Ease of maintenance,
- Mechanical protection of the equipment,
- Equipment relocation capability,
- Accommodation of future load additions.

Metal-enclosed, air-insulated, modular switchgear shall meet the following criteria:

- Capability to add additional cells from the left, right, or in between,
- Indoor type,
- Open-ended design,
- Easy installation,
- Safe and simple operation,
- Easy front access to the cable compartment,
- Minimal maintenance requirements,
- Compact and standard dimensions,
- Personnel safety.

If requested by the Employer's Representative/Employer, the manufacturer shall demonstrate experience in MV switchgear facilities, prove that the same type and design of products have been previously manufactured, and show that these products have been in operation for at least 5 years.

All switchgear shall have durable capacity for the above-mentioned conditions and shall comply with paragraphs 4.5, 4.6, and 4.7 of IEC 60694 and paragraph 4.5 of IEC 62271-200.

RESISTANCE		
Switchgear	Mechanical Resistance	Electrical Resistance
Load Disconnecter	IEC 60265-1 1000 operations (open-close cycles)	IEC 60265-1 100 operations (open-close cycles), at In, Cos Phi = 0.7
Circuit Breaker	IEC 62271-100 10,000 operations (open-close cycles)	IEC 62271-100 40 operations at 20 kA 10,000 operations, at In, Cos Phi = 0.7

Panels shall be metal-enclosed, suitable for indoor use, and classified as LSC2A loss of service continuity class and PI partitioned class, as defined in paragraphs 3.131.1, 3.109.2, and 5.102 of IEC 62271-200 (2003-11). The main busbar and the switching element shall be located in separate compartments, and the partition between them shall be made of insulated material.

Medium voltage switchgear shall fully ensure the safety of life and property while providing a high level of operational and service continuity.

The switchgear shall be designed as a three-compartment structure within a single metal enclosure:

- Switching element and cable connection compartment,
- Main busbar compartment,
- Low-voltage (LV) compartment.

b. Operating Environment

The switchgear shall be able to operate under the following environmental conditions without any adverse effects or changes in its nominal values, operational characteristics, or service life:

- Ambient temperature: Maximum 40°C, minimum -5°C. (With heating measures in the switchgear rooms, -10°C or -25°C)
- Relative humidity: 85% at 40°C
- Altitude: Up to 1000 meters above sea level

c. Switchgear

Metal-enclosed modular switchgear shall be manufactured as indoor, air-insulated units in compliance with IEC 62271-200 standards. All external surfaces and the bottom of the switchgear shall be made of metal, and the external metal enclosures shall be grounded.

The panel system shall consist of factory-assembled, individual enclosures with a compartmentalized design, including switching equipment (a horizontally mounted load disconnect and a vertically mounted removable circuit breaker). All switchgear with the same characteristics and design shall be interchangeable. The switchgear shall be designed to allow for the addition of switchgear units in both directions when necessary.

The switchgear shall be manufactured to safely handle normal operations, inspections, and maintenance tasks, including checking whether the main circuit is energized, phase sequence monitoring, grounding of cables, voltage testing of cables and other equipment, and preventing hazardous electrostatic charges.

The switchgear shall have a robust structure capable of withstanding excessive pressure increases that may occur inside and external mechanical impacts without damage. In case of gas pressure increase due to an internal fault arc, the gas shall be safely vented from the bottom of the switchgear to ensure operator safety. Protection against internal arc faults shall ensure operator safety on three sides of the panel (front and sides).

The switchgear shall be made of galvanized sheet steel with a thickness of at least 2 mm and meet the requirements of IP3X protection class. Galvanized and electro-galvanized metal sheets and metal fasteners shall be painted to provide corrosion protection. The epoxy-based paint shall have a thickness of at least 50 microns and be applied to both sides of the metal sheets. The color should comply with the RAL color scale and be RAL 9002.

The switchgear shall be manufactured considering cable ducts and cable connections.

Each switchgear shall have a label, as defined in section 5.1 of IEC 62271-200, indicating its structural characteristics (dimensions) as well as its functional and electrical properties.

The position of the switching element shall be designed to be visible to the operator from the front of the switchgear through a safe transmission mechanism. Additionally, the switching element shall be operable from the front of the switchgear.

A construction manual detailing the construction-related aspects shall be provided for each switchgear. Construction details provided for circuit breaker switchgear should serve as a reference for other switchgear.

In accordance with relevant standards, the panels shall be designed to prevent access to live parts during any operation or maintenance activities.

d. Grounding of Metal Parts

The grounding bars in each switchgear shall be interconnected and extend throughout the switchgear facility, allowing connections to be made from outside the panel.

The cross-sections of the grounding bars shall be determined according to the project requirements and have the capacity to carry the short-time withstand current in compliance with IEC 62271-200.

The grounding bar shall be designed to connect to the main grounding bar of the switchgear center without disassembling any of the bars.

e. Grounding of the Power Circuit

The grounding of cables shall be performed with a grounding switch that has short-circuit making capacity and complies with IEC 62271-102.

To ensure safety and ease of operation, additional interlocking arrangements shall be provided between the equipment in the switchgear. The grounding switch shall be operable only when the circuit breaker, disconnecter, or load disconnecter is in the "open" position.

To prevent erroneous operations (e.g., attempting to close the grounding switch while the switching element is in the closed position or attempting to close the switching element while the grounding switch is in the closed position), mechanical interlocking systems shall be implemented.

A padlock system shall be available to lock the grounding switch in the "open" or "closed" positions. The position of the grounding switch shall be visible from the front of the switchgear through a reliable transmission mechanism.

Key-operated or electric interlocks that activate the above-mentioned locks shall not be accepted.

f. Load Disconnectors

Load disconnectors shall use low-pressure SF6 gas for current interruption and shall be maintenance-free. The disconnector enclosure shall be made of cast epoxy resin and horizontally mounted within the switchgear.

The positions of the main and grounding contacts shall be directly connected to the transmission mechanism, and the position indicator shall be placed directly on the contact-operating shaft.

The disconnectors shall be of a high operating frequency type, compliant with paragraph 3.104 of IEC 60265-1, and have three positions: closed, open, grounded. They shall be fully factory-assembled and factory-tested.

The relative SF6 pressure ratio shall be a maximum of 1.5 bar (1500 hPa) for 36 kV.

The poles shall comply with section 3.118.2 of IEC 62271-200 as a "sealed pressure system," and their service life shall be at least 30 years without requiring gas refilling. Disconnectors requiring maintenance or gas refilling shall not be accepted.

The mechanical durability of the load disconnector operating mechanisms shall support at least 1000 operations (open-close cycles).

g. Circuit Breakers

The short-circuit current values for circuit breakers shall be at least 25 kA for the incoming, coupling, and incoming/outgoing cells, as well as for the measurement and transformer cells in the ring network.

Circuit breakers shall be vertically mounted, side-mechanized, and of the type that can be removed after disconnecting their electrical connections. Once the circuit breaker is removed, entry into the switchgear compartment shall only be allowed after the compartment's mechanical interlocks are engaged. Isolation using external intervention, such as slides or similar mechanisms, for entry into the switchgear compartment shall not be accepted.

The poles shall be made of epoxy resin and fully factory-assembled and tested. The MV switchgear and the circuit breaker shall be manufactured by the same producer. Circuit breakers with the same nominal ratings and accessories shall be interchangeable.

Circuit breakers shall have minimal maintenance requirements and high electrical endurance. Their mechanical and electrical endurance shall support at least 10,000 operations (open-close cycles).

The position of the circuit breaker shall be clearly and visibly displayed. Circuit breakers shall be mechanically interlocked with the power circuit disconnectors.

Circuit breakers shall include a fast-opening mechanism that operates through energy stored in springs. The mechanism shall include the following components:

- Open-close button,
- Mechanical "open-closed" position indicator,
- Operating mechanism spring status indicator (charged or discharged),
- Spring charging-discharging accessories,
- Auxiliary contacts.

The spring charging lever shall be an integral part of the mechanical operating mechanism and shall not be detachable.

A motor mechanism and necessary accessories to perform the spring charging process with an electric motor shall be available for future procurement.

Circuit breakers shall have type test reports demonstrating compliance with the relevant IEC 62271-100 standard issued by an international certification body.

Circuit breaker-equipped cells shall optionally be capable of being equipped with a voltage transformer upon request.

h. Main Busbars

The main busbar section shall be located at the top of the switchgear. The main busbars shall consist of three parallel bars. There shall be no phase separators between the busbars.

The main busbars, connection bars, and connection components shall be made of copper (Cu), and their cross-sections shall be dimensioned to withstand the thermal and dynamic effects caused by the nominal normal currents, short-time withstand current, and peak withstand current without exceeding the specified temperature rise limits.

The main busbars shall be mounted on insulating supports made of epoxy resin. Busbar connections shall be made at the upper parts of the disconnector or load disconnector enclosure. The main busbars shall not require any maintenance. To ensure the necessary insulation level, it shall be acceptable to cover the main busbars with an insulating sheath.

There shall be no partitions between the busbar sections of adjacent switchgear. Access to the busbar section of each switchgear shall be possible by removing a bolted cover marked with a warning sign. Access to the busbar by any other means shall not be allowed.

Connections between the main busbars of adjacent switchgear shall be made without the need to remove, relocate, or disconnect any component in the circuit.

i. Cable Connections

The MV cable connection section shall be designed to accommodate the type, number, double-line configuration (if applicable), and cross-section of the cables to be connected. It shall be suitable for connecting internal cable terminations in a vertical plane at a height that ensures the required insulation level.

Medium-voltage cables shall be connected to the connection terminal of the disconnecter, the lower fuse holder connection terminal, or the grounding switch connection terminal, depending on the type of switchgear.

The cable connection section shall include, depending on the switchgear type, the grounding switch, fuses, circuit breaker, current and voltage transformers, and cable connections.

Access to the cable connection section shall only be allowed after the grounding switch is closed. Access by any other means shall not be accepted.

j. Control Mechanism

Control mechanisms and related auxiliary equipment shall be placed in a compartment separated from other parts of the switchgear by grounded metal partitions and shall meet the specified protection level. A separate operating mechanism compartment shall be provided for the circuit breaker.

Access to the control mechanisms shall be possible while the system is energized.

The front panel of the control mechanisms, designed in accordance with the single-line diagram, shall include the following equipment:

- Mimic diagram,
- Position indicators for disconnectors, load disconnectors, and grounding disconnectors,
- Slots for inserting the control lever for each disconnector and grounding disconnector (the "open" position shall be marked with "O," and the "closed" position shall be marked with "I"),
- Slots for inserting the spring charging lever for load disconnectors (spring charged and discharged states shall be indicated with text or appropriate symbols),
- Locking mechanism installation for securing operating mechanisms,
- Illuminated voltage indicators.

The control mechanism compartment shall include a position indicator showing the position of the load disconnector and grounding disconnector contacts. This indicator shall be directly connected to the shaft of the moving contact spindle without any intermediate linkages.

The contact and control mechanism movement transfer structure of the load disconnectors shall be designed without any joints, levers, or additional parts, ensuring the complete reliability of the device.

This compartment shall include illuminated voltage indicators and a "fuse blown" indicator for units that combine fuses and load disconnectors. Padlocks, key locks, auxiliary contacts, and LV accessories shall be easily installable.

It shall be possible to add a motor mechanism to the control mechanism without replacing it. Systems requiring a new control mechanism for motorization shall not be accepted.

The opening and closing operations of the control mechanisms shall be independent of the operator's speed. Operations of disconnectors and load disconnectors shall be carried out with an anti-reflex system.

The front panel of the control mechanisms, designed in accordance with the single-line diagram, shall include:

- A mechanical "open/closed" position indicator,
- A "spring charged/discharged" indicator for the operating mechanism spring (text or symbol),
- A control lever as part of the operating mechanism for each disconnecter (circuit breakers without this feature shall not be accepted),
- A control lever for opening and closing the circuit breaker,
- A control lever for manually discharging the spring.

Accessories that may be required later, as well as the electrical installation of the operating mechanism for motorization, shall be field-installable.

k. Low Voltage (LV) Section

At the upper front of the medium voltage (MV) switchgear, there shall be an enclosed low voltage (LV) compartment that can be accessed without isolating the entire panel system, even when the cable and busbar sections are energized. This compartment shall include the auxiliary circuits and motor mechanism controls based on the requirements of the project.

Depending on the type of switchgear, the LV section shall include:

- Protection relays,
- Auxiliary relays,
- Measuring instruments,
- Active and reactive energy meters,
- Test switches,
- Miniature circuit breakers,
- Fuses,
- Terminal blocks, and
- Other necessary equipment.

For specific needs, the LV section shall be expandable by adding an additional compartment on top of the switchgear. The total height of the switchgear shall not exceed 2225 mm.

LV compartments that do not meet these criteria shall not be accepted.

l. Interlocking Systems

Disconnecter, load disconnector, and circuit breaker mechanisms shall be equipped with interlocking systems to ensure safe operation and prevent operator errors.

For switchgear with load disconnectors:

- The load disconnector can be closed if the grounding disconnector is open and the compartment door is closed.

- The grounding disconnecter can be closed if the load disconnecter is open.
- The compartment door can be opened if the grounding disconnecter is closed.
- When the compartment door is open, the load disconnecters shall be locked in the open position. In this case, the grounding disconnecter can be operated for testing purposes.

For switchgear with circuit breakers:

- The disconnecters can be closed if the circuit breaker is open and the compartment door is closed.
- The grounding disconnecter can be closed if the disconnecters are open.
- The compartment door can be opened under the following conditions:
 - If the circuit breaker is locked in the open position,
 - If the disconnecters are open,
 - If the grounding disconnecter is closed.

A. Access to cable connection (supply) sections:

- Shall be possible only after the switching element is opened,
- And the grounding disconnecter in the cable compartment is closed.

B. Access to the fuse section of the transformer protection switchgear:

- Shall be possible only when the load disconnecter is open,
- And the grounding disconnecter is closed.

C. Access to the circuit breaker section in the outgoing switchgear:

- Shall be possible only when the circuit breaker and disconnecter are open,
- And the grounding switch is closed.

D. Access to the circuit breaker section in the coupling switchgear:

- Shall be possible only when the circuit breaker and both right and left disconnecters are open,
- And the grounding disconnecter is closed.

For all switchgear types, disconnector mechanisms shall be lockable in the desired position (open, closed, or grounded) using a padlock. Furthermore:

- Compartment covers cannot be opened unless the grounding disconnecters are closed,
- And covers cannot be placed back unless they are in the open position.

m. Grounding Disconnecter

The grounding blade shall be of the fast-closing type, independent of manual speed. It shall have the capability to close onto a short circuit with a value equal to the short-circuit withstand current of the switchgear, and this capability shall be proven by type test reports. The position indicator of the

grounding blade shall be visible on the front panel, directly connected to the main shaft of the grounding blade.

The grounding disconnector shall have a total of 6 position indicator contacts: 3 for the open position and 3 for the closed position.

The grounding disconnectors shall be manufactured in compliance with the IEC 62271-102 (class: MO, E1) standard. They shall be of the fast-closing type and capable of closing onto a short circuit equal to the peak short-circuit withstand current of the switchgear.

The grounding disconnector shall be operated from the front of the panel using a portable lever.

Switchgear shall be grounded through an appropriate grounding bar made of copper, specifically designated for grounding. The copper grounding bar shall extend throughout the entire switchgear installation, connecting at both ends to the transformer station grounding system.

The metal parts of moving components shall be connected to the grounding circuit of the panel (or switchboard).

n. Indicators

There shall be 3 neon indicator lights with a capacitive voltage indicator to check whether the cables are energized.

The capacitive voltage dividers shall allow the neon lamps, compliant with VDE standards, to indicate from the front of the switchgear whether the cable is energized.

The indicators and controls on the switchgear shall be as follows:

Signal Lamps

- Automatic breaker closed: Red
- Automatic breaker open: Green
- Automatic breaker tripped due to fault: Amber
- Fault relay activated notification: White

All available signals shall be provided for SCADA and connected to the PLC for remote control and monitoring.

o. Protection Relays

The protection relays shall be digital, multifunctional, and compatible with SCADA systems and PC communication.

Relays shall comply with IEC 60255, EN 50082-2, and IEC 61000 standards and bear the CE mark.

Excluding communication interfaces, they shall pass isolation tests of 3.5 kV-DC for auxiliary voltage and binary inputs, and 2.5 kV-rms / 50Hz for other units. Additionally, they shall meet the 5 kV peak pulse voltage isolation test.

Relays shall be front-removable, and the current transformer connections shall automatically short-circuit when the relay is removed.

The protection relay display shall include a mimic diagram showing the single-line diagram and equipment of the MV switchgear, and the circuit breaker and grounding switch positions shall be monitored online.

In addition to predefined fixed-function LEDs, relays shall have at least 10 programmable dual-color LEDs.

Relays shall feature directional and non-directional overcurrent protections with inrush blocking capability to protect against the second harmonic during transformer energization.

The circuit breaker trip circuit monitoring shall be performed via single or dual inputs. The breaker coil and trip circuit shall be continuously monitored. The breaker closing operation shall depend on the trip circuit monitoring being active, ensured by internal relay interlocking.

Relay settings shall be easily adjustable through the relay's buttons and display. To facilitate parameterization:

- A numeric keypad for simple input,
- An "Enter" button for confirming settings,
- An "Esc" button for exiting menus,
- Directional buttons for faster navigation between screens, and
- Buttons for breaker operation (open/close) shall be included.

The relay shall have a cold-load pick-up function, allowing reduced sensitivity during the inrush period due to high initial currents during energization. Fixed and inverse time phase and ground overcurrent protection settings, as well as directional phase and ground overcurrent protection settings and delays, shall be programmable separately. After the defined energization period expires, the relay shall revert to its normal protection settings.

The complete blocking of protection functions shall not be allowed. The starting condition can be selected based on current tracking or breaker position contact status.

The digital protection relay shall include an internal test and monitoring system (watchdog) to test relay power supply, current and voltage signal gains, processing units (memory and processors), software/hardware monitoring systems, and logic inputs/outputs.

In case of an internal failure rendering the relay inoperative, it shall switch to a fail-safe mode, and this condition shall be transmitted to the PLC via a contact.

The relay shall detect fuse failures in voltage transformers and cable disconnections or short circuits in the secondary circuits of voltage transformers. This shall be achieved through continuous voltage fuse monitoring by tracking zero-sequence voltage and residual current. If a voltage fuse fault occurs, directional phase and ground protections, undervoltage protection, and sensitive ground protections shall be blocked.

To enable quick adjustments to protection plans, threshold values, and time delays: Overcurrent settings shall be selectable through logic conditions defined by logic inputs or SCADA.

To adapt to changes in energy demands and system load requirements, the relay shall support at least 6 different setting groups, which can be changed via the relay, its parameterization software, SCADA, or input contacts.

Relays shall maintain statistics on breaker operations and trip voltage, enabling monitoring of breaker maintenance needs and operational lifespan.

Relays shall comply with time curves defined by ANSI and IEC, with the addition of one user-programmable curve.

Relay settings menus shall be in Turkish.

The relays shall have four different security levels protected by passwords. Operators with different authorizations shall be able to perform operations within their authority.

The front panel shall include 8 LEDs, of which at least 4 shall be assignable. The relay shall have at least 7 binary inputs and 8 assignable/programmable binary outputs.

The relay shall support 4 current inputs (3 phases + 1 ground) and 3 voltage inputs.

The protection classes specified for each switchgear cell shall be provided either within a single multifunctional relay or using multiple relays, as long as all required functions are fulfilled.

Digital relays shall include the following protection and measurement features:

Protection:

- Three-phase overcurrent protection (measured separately for each phase), 50/51 (3 independent set values),
- Phase-to-ground overcurrent protection, 50N/51N (3 independent set values),
- Undervoltage protection, 27,
- Overvoltage protection, 59,
- Basic overload protection, 49,
- Phase imbalance / Negative sequence protection, 46,
- Ability to select inverse or fixed time curves for phase and ground protections,
- International standard protection curves selectable:
 - IEC (short time inverse, standard inverse, very inverse, extremely inverse, long time inverse),
 - IEEE/ANSI (short time inverse, moderately inverse, inverse, very inverse, extremely inverse),
- Trip relay lockout, 86,
- Trip circuit supervision, 74TC.

Measurement:

- True RMS measurement,
- 3-phase and ground current,
- Active / reactive / apparent power,
- Phase angles,

- Active / reactive energy (4-quadrant measurement for positive and negative),
- Power factor,
- Frequency,
- Operating hour counter,
- Minimum and maximum measurements of Current, Voltage, Active Power, Reactive Power, Apparent Power, Power Factor, Frequency, Current Demands, and Power Demands,
- Peak value measurement,
- Event records: last 200 events with 1 ms time accuracy.

Additional Features:

- Compatible with 1A and 5A current inputs.
- 7 inputs and 8 output contacts.
- Assignable input and output contacts.
- At least one changeover contact output for the circuit breaker trip coil.
- RS232 connection on the front panel and RS485 serial link connection on the rear panel.
- Communication protocol infrastructure compliant with RS485 and IEC 60870-5-103.
- Software for PC to adjust settings, retrieve events, fault, and failure records.
- The relay's settings shall be adjustable remotely via SCADA. Additionally, all event and fault records shall be transferable to SCADA.

p. Current Transformers

The current transformers used in the panels shall comply with the IEC 61869-2 standards, be suitable for their intended purpose, and have appropriate ratios and dry-type.

The rated burden of the current transformers shall not be less than the total burden of all connected relays, measuring devices, and related loads.

Current transformers shall be of the cast resin, pole block type.

In general, the accuracy limit factor and accuracy class of the current transformers shall be determined based on the characteristics of the measurement or protection devices used.

In 34.5 kV panels, current transformers shall be located at the cable entry points or in the main busbar section.

q. Voltage Transformers

Voltage transformers shall comply with IEC 61869-3 and relevant TSE standards, and shall be of cast resin, block type.

Voltage transformers shall be located in the incoming cell or on the main busbar in 36 kV panels.

The secondary windings of voltage transformers shall be protected by fuses. Protection, control, measurement, and auxiliary circuits shall be selectively coordinated.

The rated burden of the voltage transformers shall not be less than the total burden of all connected relays, measuring devices, and related loads.

In general, the accuracy class of voltage transformers shall be determined based on the characteristics of the measurement or protection devices used.

r. Measuring Instruments and Indicators

All measuring and indicator equipment shall comply with TSE, TSEK standards, and the norms and recommendations of IEC and TSE-EN-ISO 9000.

For matters not specified in this specification, the articles stated in the "Applicable Standards" section shall apply in the order of their listing.

Measurement equipment shall always be properly calibrated, and any calibration errors that may arise due to transportation, installation, etc., shall be rectified by the contractor at no additional cost.

The nominal values, conversion ratios, and other necessary information shall be indelibly marked on the measurement equipment. All connection terminals shall be clearly labeled to avoid any misinterpretation.

Ammeters:

- Ammeters shall have dimensions of 95x95 mm or 144x144 mm, considering the compatible appearance on the panel.
- Ammeters shall be used together with current transformers with a 5A secondary current.
- They shall be manufactured to prevent the ingress of dust, moisture, or gas. Their glass shall be colorless and smooth.
- The measurement scale shall be marked in accordance with the applied conversion ratio. Scale lines and numbers shall be legibly marked in black on a white background.
- They shall withstand an impulse current equal to twice their nominal current.

Voltmeters:

- Voltmeters shall have dimensions of 95x95 mm or 144x144 mm, considering the compatible appearance on the panel.
- Voltmeters shall operate within a range of 0-500V and be suitable for high-voltage cells.
- They shall be used together with a 5-position voltmeter selector switch, designed to measure voltage between different phases or between a phase and neutral. Fuses may be added to the circuit for safety purposes.
- They shall be manufactured to prevent the ingress of dust, moisture, or gas. Their glass shall be colorless and smooth.
- The measurement scale shall be marked according to its nominal value. Scale lines and numbers shall be legibly marked in black on a white background.

s. Electricity Meters

Meters shall operate at a nominal voltage of 220V for single-phase types and 220/380V for three-phase types. The nominal current shall be as specified in the project requirements and shall be of the electronic type.

Meters connected through current transformers shall have a nominal current of 5A.

Meters shall be bidirectional and suitable for use in electricity generation/consumption systems.

Three-phase meters shall have 4-wire connections.

Meters shall be installed in special meter panels, in separate compartments within regular panels, or in specially designated sections within MV switchgear (subject to the approval of the Employer's Representative/Employer and the Local Distribution Company). The meters and the panels/sections in which they are installed shall be equipped with the necessary features for sealing.

The glass on the meters shall be colorless and smooth. The scaling factors used on the meters shall be permanently marked.

All meters shall be capable of operating at 200% of their nominal load.

Meters shall be manufactured to be unaffected by incorrect phase connections and shall have a locking mechanism to prevent reverse operation.

Meters shall be capable of accurate measurement for both balanced and unbalanced loads.

All meters shall be connected to SCADA via Ethernet, monitored from SCADA, and the data they measure shall be recorded in a database at intervals determined by the Employer's Representative/Employer.

t. Indicator Lamps

Indicator lamps shall operate at a nominal voltage of 250V. The lamps shall be mountable on the panel.

Green lamps shall indicate when the circuit is not operating, and red lamps shall indicate when the circuit is operational or there is a fault. The colors of other lamps shall be based on the requirements of the Employer/Employer's Representative.

All indicator lamps shall be connected through a fused circuit. A test circuit shall be provided to check the functionality of all lamps.

u. Power Quality Analyzers

This section defines the specifications for the Power Quality Analyzers to be used in medium-voltage panels. The Power Quality Analyzer shall be designed and manufactured to meet the conditions and characteristics described below:

- Shall support multi-level security with customized access for up to 8 users.
- When locked, the following data shall be protected from modifications:
 - kWh and kVARh (import, export, net, and total),
 - kVAh (total),
 - kW, kVAR, kVA demand (thermal and rolling window),

- kWh, kVARh, kVAh pulse outputs.

Sampling:

- Sampling rates of 1024 or 512 samples/cycle.
- Shall detect high-speed voltage dips and swells on a per-cycle basis, presenting minimum, maximum, and average voltage values for each phase during interruptions.

Logging:

- Shall include a programmable internal data logging capacity of at least 5MB.
- Shall store critical company and revenue data during power interruptions.
- Shall feature non-volatile memory.
- Shall provide time-stamped event logging with the following capabilities:
 - Support at least 500 events.
 - Programmable logging capacity.
 - Log event dates, times, causes, results, and priorities.
 - Log setpoint activations, relay operations, and diagnostic events.
 - Timestamp resolution of 1 millisecond.
 - Synchronization of timestamps within 100ms on the same serial communication network.
 - Minimum event recording duration: ½ cycle (8.3ms at 60Hz, 10ms at 50Hz) for high-speed events, and 1 second for other events.

Power Quality:

- Shall statistically evaluate power quality per IEC61000-4-30 Class A without requiring separate software.
- Shall determine power quality indicators (voltage dips, swells, harmonics, interharmonics) according to EN50160 requirements for public distribution systems.
- Shall display statistical power quality indicators on the front panel or via communication protocols (e.g., ION, Profibus, Modbus TCP, DNP 3.0, IEC870-5).

Transient Capture:

- Shall provide sub-cycle transient detection at 1024 or 512 samples/cycle.
- Shall capture transients as short as 20 microseconds at 50Hz.

Waveform Capture:

- Shall record waveforms at 1024 or 512 samples/cycle.
- Shall include a programmable oscillographic waveform recorder with the ability to trigger manually, periodically, or based on internal conditions such as setpoint activation.

- Continuous recording capability for extended waveforms, limited only by memory capacity.

v. 24-110VDC Battery Charger (Rectifier)

- Input Fuse (AC): Shall be double-pole with auxiliary contacts.
- Output Fuse (DC): Shall be double-pole with auxiliary contacts.
- The rectifiers, powered by a 230 VAC (compatible with 220-240VAC) 50Hz mains supply, shall have a 110VDC output and be designed and manufactured to provide an output stabilized at 110VDC $\pm 1\%$.
- The graphic LCD screen on the rectifiers shall display adjustable current and voltage values, input and output current, input and output voltage, battery charge current, temperature, and (+) and (-) DC leakage.
- The rectifiers shall include standard alarms with dry contact relay outputs for at least the following conditions: "Battery charge completed," "Battery charge failure," "High/low DC voltage," "Ground fault," "Input voltage failure," "Fan failure," and "Overtemperature."
- The "Battery Charge Completed" alarm shall activate when 75% of the battery capacity is depleted. This threshold shall be adjustable between approximately 50% and 90%.
- Rectifiers shall be microprocessor-controlled, utilizing DSP (Digital Signal Processor) technology, and shall support adjustable current and voltage settings.
- The charging unit shall be thyristor-controlled.
- Rectifiers shall be designed and certified to operate flawlessly under voltage fluctuations of $\pm 20\%$ on the supply voltage.
- An isolation transformer shall be used at the input of the rectifiers.
- Rectifiers shall feature a soft start (ramp) charging capability.
- The output voltage ripple of the rectifiers, when operating without batteries, shall be less than 1%.
- The rectifier unit shall be capable of meeting the required current and voltage demands indefinitely without battery support. The battery charge current shall not be drawn from the required load current. The independent battery capacity shall be manually entered, and the charge current shall be adjustable. During manufacturing, it shall be limited to 10% of the standard battery capacity.
- The device shall include a harmonic filter and high-voltage protection at the input, and suitably sized filter inductance and capacitance at the output.
- Rectifiers shall be designed and certified to withstand transient voltage surges up to 2 kV.
- They shall have an IP 51 protection class.
- The metal enclosure of the DC system unit for the rectifiers shall be painted with RAL 7035 electrostatic powder coating. It shall be suitable for operation in humid environments and comply with IEC 60335-1 standards.

- The display shall provide real-time readings of input-output current, voltage, and operating parameters.
- Deep discharge protection shall be included as a standard feature in the rectifier.
- The enclosure of the DC system unit shall be suitable for both wall-mounted and floor-mounted installations. Upon request, the rectifier unit shall be removable from the wall-mount bracket without the need for any tools and placed on the floor. The wall-mount apparatus shall be a hanger-type carrier.
- The DC system unit and the battery unit shall be integrated into a single device but shall be separable into independent units if required.
- Output terminals shall be suitable for a cross-section of at least 35 mm². There shall be three separate terminals for protection and control. The (+) terminals shall be red, and the (-) terminals shall be gray. Each output shall be individually protected with appropriately rated double-pole "w-automatic" output fuses. A grounding terminal shall be provided on the enclosure.
- While the rectifier is operating from the battery, to protect the batteries from deep discharge, a "DC low" signal shall be sent to the SCADA contact when the battery output voltage drops to 100V. When the battery voltage reaches 95V, the output load shall be disconnected via a contactor.
- While charging the connected batteries, the device shall not allow the charging current to exceed the set value. It shall enter current limitation mode when necessary, thereby protecting the batteries and its power components.
- When the AC supply to the rectifier is interrupted, the display panel shall remain operational, and the values shall be readable without any issues.
- The rectifier shall be of the cabinet type and shall support SCADA communication and connection.

2.6.1.17. Transformers

- The primary input voltage of the transformers shall be confirmed with the Local Electricity Distribution Company and the Employer's Representative/Employer.
- Transformers shall be of the hermetic type.
- Transformers shall have high-voltage (HV) and low-voltage (LV) copper windings.
- All materials used in the manufacture of transformers shall be selected according to their purpose, high-quality, durable, and possess excellent physical and electrical properties.
- The design and manufacture of the transformers shall incorporate the latest technical applications, superior craftsmanship, and safety factors, and these shall be considered throughout the entire process.
- Transformer connection cables shall be securely fastened with special fixtures, ensuring no cable load is exerted on the transformer connection points.

- Distribution transformers shall be suitable for continuous system loads under the worst climatic conditions and shall be three-phase transformers with a voltage level of 31.5/0.4 kV (approved by the Mediterranean electricity authorities).
- Transformer losses (no-load and load losses) shall be minimized. Under standard conditions, the transformer rating shall comply with IEC-60076.
- Transformers shall feature plug-in type HV bushings, and the LV bushings shall be covered with LV enclosures.
- Three-phase transformer windings shall have a group 4 phase shift, vector group reference Dyn11, connected in a delta-star configuration. The star point of the LV winding shall be brought out and properly terminated for grounding.
- Winding insulation shall be of 'A plus' Class. Temperature rise shall be limited to the maximum operating temperature specified for 'A plus' Class materials under the climatic conditions defined in IEC 60076.
- HV windings shall provide fixed flux voltage variation, adjustable in steps of $\pm 2.5\%$ from +5% to -5%, as defined in IEC 60076.
- The tap changer shall have 6 positions.
- The winding design and structure shall provide properly placed cooling flow channels to eliminate potential hot spots. The windings shall be supported to withstand dynamic stresses caused by short-circuit conditions. Details of provisions for addressing coil shrinkage during operation shall be provided.
- The transformer core and windings shall be designed for minimal losses, with a ratio of copper loss to iron loss suitable for economic design, which the manufacturer shall specify.
- The complete transformer assembly shall withstand impulse voltage on the primary windings as per IEC 60076-3.
- Transformers shall meet the standards and regulations described in Employer's Requirements - I General Information, Clause 1.4 Technical Standards and Applicable Regulations.

Temperature control of the LV winding shall be conducted with a PTC, which shall activate forced cooling fans at the set value and shut down the transformer if the temperature persists.

Temperature control shall be performed on the low-voltage winding using PTC, which shall activate the forced cooling fan at the set value and shut down the transformer if the temperature persists.

The transformer shall operate at its rated current at a voltage equal to 105% of its rated voltage.

It shall be suitable for continuous operation at no-load conditions at a voltage equal to 110% of its rated voltage.

Transformers shall be equipped with a "Temperature Protection System" to prevent overheating and thermal stress caused by high ambient temperatures and overloading.

The Temperature Protection System shall consist of temperature sensors (at least one per phase) with resistance varying with temperature and a tripping unit. The temperature sensors shall be placed at the hottest point of the low-voltage winding.

When the warning temperature is reached, the relay contacts on the tripping unit shall change position, providing a control signal (alarm or tripping). The relay contacts on the tripping unit shall return to their normal position when the winding temperature drops approximately 6K below the warning temperature.

The temperature protection relay system shall provide automatic protection against faults such as voltage loss or open circuit occurring in its own circuit.

The tripping unit shall be powered by 220 V AC voltage. Alternative power supply methods and any required additional equipment shall be specified during approval.

The warning temperatures for alarm and tripping, the characteristics of the protection system, and connection diagrams shall be provided along with the approval.

Nameplate Information:

The nameplate shall include the following information in addition to the details specified in TS 267 / IEC 60076-1:

- The Employer's order number
- Year and month of manufacture
- No-load losses and load losses
- Tap changer position number and voltages (in V and/or kV)
- The Employer's material code number
- Environmental class, climatic class, fire class

For the final coat of paint, one of the following types of paint shall be used: polyurethane paints, alkyd and silicone paints, or various mixed vinyl paints.

Each layer of paint shall have a minimum thickness of 35 microns (total 105 microns).

Warnings and Safety Notices:

Painting works shall be completed before routine tests. The total paint thickness shall be measured at five randomly selected points using a paint thickness gauge. The average of the measured values shall not be less than 105 microns.

The adhesion of the paint layers shall be tested at five randomly selected points using the tape adhesion test method in accordance with TS 4313/ASTM D 3359. The test results shall not be worse than Class-4 as defined in these standards.

Warning and caution signs, including visual and written warnings such as "Danger," "Risk," "Caution," "Death Risk," and operating instructions, maneuver rules, and first aid instructions, shall be placed on the sections of the transformer cabinet deemed suitable in terms of physical and regulatory compliance.

2.6.1.18. Panels

This section includes the design, manufacture, and testing of low-voltage electrical panels used for the generation (if applicable), transmission, distribution, conversion of electrical energy, and the supply and control of equipment consuming electrical energy. These panels are for cells with a protection class of IP = 55, at an ambient temperature of 35°C, and with the following conditions:

- Nominal DC voltage not exceeding 500 V,
- Nominal frequency up to 60 Hz,
- Nominal AC voltage up to 500 V for three-phase systems,
- Nominal current of the main supply busbars up to 4000 A.

The systems where the following conditions apply are referred to and accepted as voltage switching and control arrangements, Main Distribution Panels, MCC Panels, Compensation Panels, Distribution Panels, Lighting Panels, Control and Command Panels, Local Panels, control arrangements, etc.

Panels shall generally be classified as follows:

- Main Distribution Panel (MDP)
- Motor Control Panel (MCC)
- Compensation Panel (CP)
- Distribution Panels (DP)
- Lighting Panel (LP)
- Local Panel (LP)
- PLC and Automation Panel (PP)

Main Distribution Panel (ADP):

The structure of the Main Distribution Panel shall be of Form 3b type and have an IP54 Protection Class as detailed in EN 60439-1. The Main Distribution Panel shall be manufactured from 2 mm thick DKP sheet metal and painted with electrostatic coating.

The Main Distribution Panel (Power Distribution Panel) shall be designed with its own independent air conditioning system.

The Main Distribution Panel shall have a cable trunk on the energy input side.

The Main Distribution Panel shall include an emergency stop button and a micro fire suppression system. No work shall be conducted on the micro fire suppression system without obtaining approval from the Fire Department. In parallel, a protected "emergency stop button" shall be installed at a location outside the building, as determined jointly with the Employer, to cut off power in case of an emergency.

The maximum short-circuit current that may occur in the Main Distribution Panels shall be calculated, and the applications shall be carried out accordingly. To meet the required short-circuit currents for MDP panels, the type-tested panel manufacturer's declared isolator type and isolator spacing, as specified in their technical catalogs, shall be implemented according to the test method.

The Transfer Panel shall also comply with the same conditions as the Main Distribution Panel and shall be located in a separate section within the Distribution Panel. The transfer shall be carried out using a 4-pole ATS (Automatic Transfer Switch) in the Transfer Panel.

Motor Control Panel (MCC)

MCC panels shall be of Form 3b type, made of stainless steel 304 L with a minimum thickness of 1.8 mm, and shall have an IP54 protection class.

Compensation Panel (CP)

The compensation panel shall be of Form 3b type, made of stainless steel 304 L with a minimum thickness of 1.8 mm, and shall have an IP54 protection class.

Distribution Panels (DP)

Flush-mounted and surface-mounted electrical distribution panels to be used in the electrical installation shall refer to panels made of stainless steel 304 L and insulating material.

Lighting Panel (LP)

Panels that are not related to the facility process and are not remote shall have their doors, covers, bodies, and all internal assembly construction elements made of stainless steel 304 L.

Local Panel (LP)

- Local control panels shall be made of stainless steel 316 L and shall have an IP65 protection class.

PLC and Automation Panel (PP)

Automation panels shall be made of stainless steel 304 L with a minimum thickness of 1.8 mm. Their doors, covers, bodies, and all internal assembly construction elements shall also be made of stainless steel 304 L and shall have an IP54 protection class.

General Features Required for Panels

The installation of panels shall comply with the following:

- EN 61439, Low-voltage switchgear and controlgear assemblies.
- EN 60204-1, Electrical equipment of machines.

The assemblies shall provide at least 20% free space for future use after the installation is completed and delivered.

Panels shall be mounted on a flat surface. They shall not be installed in locations where there is a risk of falling.

There shall be no level difference between the walking surface and the base of the panel at the installation location.

Panels in the energy distribution room shall be designed with transparent external covers to prevent accidental contact with control buttons. Necessary precautions shall also be taken inside the panel to prevent accidental contact.

The inner and outer covers of the panels shall be hinged.

All panels shall include a fire protection relay. All branch circuits shall be supplied individually through residual current relays.

All panels shall have a grounding bar. All grounding connections shall be made separately to the grounding bar.

The busbars inside all panels shall be selected with 20% higher current-carrying capacity than required, considering factors such as short circuit, mechanical strength, and dielectric strength.

Heat-shrink tubing shall be applied and fixed with a flame torch over all busbars inside the panels. All busbars shall be coded.

Lighting, sockets, electric heaters, etc., in the building installation shall be powered only from equipment intended solely for building services.

Single-line diagrams shall be placed inside all panels. Panels shall include a pocket for storing single-line diagrams.

If necessary, a steel construction base shall be provided under low-voltage panels.

All freestanding panels shall be secured to the wall at their upper two corners using seismic brackets.

There shall be a minimum clearance of 1 meter between the back of the panel and the wall.

There shall be a minimum clearance of 2 meters between the front of the panel and the wall.

The base profiles or legs of the panels shall be suitable for the weight of the panels.

The Contractor shall provide a drainage pit and a drainage pump beneath each panel room.

The equipment in the panels shall be designed for normal maintenance to be performed from the front.

All compartments shall be equipped with doors on the front side to allow access to control cables and equipment.

The front doors and covers shall be hinged and lockable with a common key for each compartment.

The enclosures shall provide protection against moisture, water, dust, and pests.

Solid barriers shall be provided to separate each load compartment from other compartments and the busbar chamber, to prevent objects from falling into live compartments below, and to restrict fault propagation to other compartments.

The equipment shall be rectangular and properly shaped and, whenever possible, designed and constructed for floor mounting over cable trenches.

Small equipment shall be designed and constructed for wall mounting.

All cables shall enter or exit the equipment via a gland plate provided with appropriately sized and typed cable glands (bushings) at the bottom of the assembly.

The internal covers of the panels shall be hinged rather than clip-on for opening and closing.

The walls of the panel rooms shall allow at least 1.2 meters of clearance between the end of the open panel covers and the wall when the covers are opened, ensuring comfortable working space for personnel.

An insulated mat with a width of 1 meter shall be placed on the floor in front of each panel. The insulated mats shall be fixed to the floor.

The circuit breakers, relays, and other switchgear components inside the panels shall all be of the same brand.

A single-line diagram of the facility shall be printed in A1 size, PVC-laminated for readability, and hung on the wall of the electrical room.

All panel inputs and outputs shall be made via terminals, and the panels shall include grounding and neutral bars.

Panel inputs and outputs shall be made from the bottom side. Additionally, a cable compartment shall be provided at the panel inputs for extra protection.

All cables inside the panel shall run through cable ducts or be placed in spirals according to the cable structure.

All cable connections inside the panel shall be made using insulated ring terminals, and original connection parts shall be used for bridging and parallel connections.

Signal and power cables to be used inside the panel shall pass through separate routes.

Every terminal, cable, switch, fuse, signal lamp, etc., inside the panel shall be labelled with special labels resistant to wear and fading.

Measuring instruments shall be placed on the panel door.

Labels related to occupational safety shall be affixed to the panel door in a way that they cannot be removed. There shall be no screws on the panel door; however, if labels or equipment need to be screwed, nuts and bolts shall be used.

All products used inside the panel shall comply with CE and/or TSE standards, and high-quality products shall be preferred.

All cables entering and exiting the panel shall be marked with colored heat-shrink tubing as R-S-T-N-Pe.

Fuse output names shall be written on a computer, laminated with PVC, and mounted on the panel.

Flags and sufficiently long separators shall be used to facilitate the entry of AC cables into the circuit breakers. The connections of the main circuit breakers and other circuit breakers to the main busbar shall also be made using copper busbars of appropriate cross-sections.

All cables entering the main circuit breakers in the panels shall pass through toroids.

All circuit breakers shall have adjustable settings.

Panels shall be installed in compliance with TEDAŞ Low Voltage Panel specifications.

Exposed parts of the connection points shall be covered with transparent plexiglass to prevent contact.

Panels shall be equipped with residual current and overcurrent protection relays.

All secondary output groups (including lighting, outdoor lighting, and socket circuits) shall be protected by residual current relays.

All panels shall have a fire protection relay.

All panels shall be equipped with phase lamps and an energy analyzer.

All components mounted on the assemblies shall be CE-labelled and capable of withstanding dynamic and thermal stresses without damage caused by potential fault currents.

The trip device system for circuit breakers shall be designed and adjusted to ensure full selectivity. For example, any short circuit in a circuit shall be interrupted by the circuit breaker/switch/fuse closest to the short circuit.

Relays shall have LEDs, at least 5-ampere rated two changeover contacts, and DIN rail sockets. Signal lamps (LED) shall include an indication of status (on/off). PLC output relays shall be slim type, 24VDC, and equipped with LEDs.

Pilot and signal indicator lamps shall be of the LED type.

Unless otherwise specified in the annexes to the specification, low-voltage electrical panels shall conform to the features specified below and/or those selected:

- Nominal Frequency: 50/60 Hz
- Operating Voltage (Ue): 415/690 VAC
- Nominal Insulation Voltage (Ui): 1000 VAC and 1000 VDC
- Nominal Impulse Withstand Voltage (Uimp): 12 kV peak value
- Insulation Test Voltage: 2500 VAC
- Insulation Class: 2

Circuit breakers with a short-circuit withstand current equal to or greater than the value of the short-circuit current that may occur in the panel shall be selected. The "short-time withstand current," "peak impulse withstand current," and Cos Ø values of the panel for which the short-circuit current is determined shall be taken into consideration.

The (PE) grounding bar shall be made using an uninsulated copper flat bar. This value, related to the energy limited by the protection device used, shall be calculated and manufactured accordingly. The cross-section of the selected grounding bar is as follows:

$$\sqrt{I^2 t}$$

It should be verified with the formula $SPE = \frac{\sqrt{I^2 t}}{176}$

$$176$$

2.6.1.19. Uninterruptible Power Supply (UPS)

A double-conversion online UPS system shall be provided for all data, control, and monitoring systems within the system. The UPS shall include an automatic transfer switch and a manual maintenance bypass switch. Its design shall be based on microprocessor/DSP-controlled pulse width modulation (PWM) technology.

The UPS system shall ensure the operation of the control and monitoring systems and protect the system against data loss during power outages. The UPS shall feature an online test procedure to test the battery condition and management system, ensuring a 10-year battery life.

CONTROL CENTER	PLC Panels	SCADA	Fire System	Telephone/Data System (Ethernet/Fiber Converter)
10 kVA, 3-phase AC UPS	3 kVA AC UPS	Powered from the Control Center UPS system		
1 hour	1 hour		1 hour	1 hour
The UPS shall supply power to the entire administrative building. If systems like SCADA, CCTV, fire alarm, telephone, or data systems exist in the administrative building, they shall be powered by this UPS.	Shall be powered by the new UPS to be installed in the Distribution Center.	Powered from the new UPS system to be installed in the Distribution Center.	Powered from the new UPS system to be installed in the Distribution Center.	Powered from the new UPS system to be installed in the Distribution Center/Administrative Building.

The above table's power values are provided as examples, and the Contractor shall revise these power values and obtain the Employer's Representative's approval if any changes occur during the execution of the work.

All equipment necessary for the operation of the control and monitoring system, including but not limited to the following, shall be powered by the UPS system:

- Operator station, including all connected equipment
- Maintenance station, including all connected equipment
- PLCs
- SCADA
- Server system
- Communication network
- Fire detection system
- Explosion risk and emergency systems
- UPS sockets (only for computers)

The UPS system shall meet the following requirements:

- Efficiency (AC/AC): Minimum 90%
- Overload, 1 min.: 110%
- Disturbance: <15%
- Power factor: >0.9

The system shall include indicators for:

- Power supply status (mains or battery)
- Charging
- Battery OK
- Inverter OK
- Charger OK
- Static Bypass

The UPS systems shall transmit the information requested by the Employer's Representative/Employer to SCADA via the communication network.

2.6.1.20. Socket Systems

Distribution centers shall be equipped with socket outlets to supply power for electrical tools and maintenance equipment.

Socket outlets shall be provided in interior and basement areas as follows:

- Sockets shall be installed in a socket station made of polyester. The enclosure shall comply with IP65 protection class.
- Each station shall consist of the following sockets, each fed by its own circuit breaker and RCCB:
 - One 230V, CEE type, 3-pin socket
 - One 400V, CEE type, 5-pin socket

In all rooms of the distribution centers (e.g., Cell Room, Basement Cable Room, Transformer Room, and Panel Room), 230V single-phase and 400V three-phase sockets shall be installed to supply power for hand tools and similar equipment.

- Specific Requirements:
- 400V sockets should be installed at locations deemed necessary for cell placement, maintenance, etc.
- 230V AC sockets:
 - Shall include an active grounding contact.
 - When the plug is not inserted, the plug holes shall be covered with a protective cap.
- 400V AC sockets:
 - Shall have 5 pins and include an active grounding contact.

- When the plug is not inserted, the plug hole shall be covered with a protective cap.
- If the plug is pulled while under load, any arc formation shall be extinguished within the unit and confined within the enclosure.

Each socket combination shall include:

- A main incoming fuse combined with an RCCB (Residual Current Circuit Breaker).
- Separate fuses for each socket outlet.

400V socket outlets shall comply with CEE standards and be rated for 32A.

2.6.1.21. Lighting System

Lighting in all rooms of the Distribution Centers shall be arranged as follows:

- Lighting shall be installed along pathways, within buildings, in passageways, and for outdoor street/road lighting. Outdoor lighting shall provide sufficient illumination for safe navigation.
- LED-type lamps and fixtures shall be preferred for both indoor and outdoor applications. High-bay fixtures or LED fixtures with gooseneck wall mounts may be used in areas with high ceilings or wide rooms.
- Indoor LED fixtures shall feature factory-pressed LEDs with polycarbonate bodies or polycarbonate lenses. Drivers shall have PFC constant current, short-circuit and overload protection, operating voltage of 220-240 VAC, 50-60 Hz, operating temperature range of -5 to +60 degrees Celsius, efficiency of at least 90%, and a lifespan of 100,000 hours. Emergency lighting kits shall also be included.

Lighting Levels

The following average illumination levels shall be achieved with variations not exceeding 25%:

- The power factor of lighting fixtures shall be at least 0.9.

In control rooms and offices, lighting fixtures shall be decorative and designed for use alongside computer monitors. These fixtures shall have an IP40 protection class.

Installation Details

- Every fixture shall be connected through a junction box.
- Lighting in each room shall be controlled by manual switches located at every door of the respective room.
- All fixtures and related equipment shall be grounded.
- Flexible cables shall not be used for connecting multiple fixtures.
- All cables used in the building's lighting system shall be copper cables with a minimum cross-sectional area of 5x2.5 mm².
- Outside buildings where recessed installations are not possible, the installation shall be done using surface-mounted plastic conduits. All switches, sockets, etc., shall be surface-mounted and protected with weatherproof enclosures.

Emergency Lighting

- Emergency lighting fixtures shall be installed in all areas to illuminate exit and escape routes, ensuring personnel can safely evacuate the buildings during power outages.
- Emergency lighting fixtures shall operate for at least 3 hours in the event of a power failure.
- Regarding to sudden power outage occurs for execution of WTE facility, stand-by generator with the capacity of the 2250 kVA shall be supply to WTE emergency power requirement.

Considering the future capacity increase of Hurma WWTP, 2250 kVa capacity was selected to ensure synchronous operation with existing generators in the switchgear change.

- Emergency exit fixtures shall be maintenance-free and include an integrated charger/battery/inverter module.
- Emergency lighting fixtures shall be connected to the main lighting circuits of their respective zones, ensuring operation during full or partial power outages.
- Test switches to simulate power failures shall be included in emergency lighting fixtures. These switches shall be installed in appropriate locations within the area covered by the lighting system and labeled with their function.

Test Switches

- Test switches installed in accessible areas shall be tamper-proof and operable with a key.
- All such test switches shall be operable with a common key, and the contractor shall provide two keys for each installed switch.

a. Lighting and Outdoor Lighting Equipment

- The outdoor lighting system shall include all necessary equipment such as poles, fixtures, cables, foundations, etc.
- Fixtures used in the lighting installation shall be manufactured in accordance with the project requirements and technical specifications.
- Before procurement, detailed catalogues and any samples required and requested by the Employer's Representative/Employer shall be submitted for approval. The Contractor shall place orders only after receiving approval from the Employer's Representative.
- All lighting fixtures shall comply with the relevant current standards, including their published updates, and shall be certified accordingly.
- Declarations of conformity for all lighting fixtures, drivers, and components in line with 2014/35/EU, 2014/30/EU, 2011/65/EU RoHS, 2009/125/EC Eco-Design, and 2010/30/EU directives shall be submitted to the Employer's Representative/Employer inspection authority during the proposal/material approval stage.
- Accredited independent test reports for all drivers shall be submitted to the Employer's inspection authority during the proposal/approval stage. Drivers shall have high power

factor and efficiency values with low THD. Drivers for LEDs shall comply with TS EN 62384 standards.

- Fixtures for outdoor lighting shall include surge protection of at least 4kV, either externally or integrated within the driver.
- LED fixtures for environmental lighting shall have aluminium injection bodies, tempered glass, short-circuit and overload protection, and meet the following specifications:
 - Operating voltage: 220-240 VAC, 50-60 Hz
 - Operating temperature: -10°C to +45°C
 - Efficiency: Above 85% even at low power usage
 - Lifespan: Minimum 100,000 hours
 - Luminous flux: Minimum 8000 lumens
 - Color temperature: Minimum 4000K
- Outdoor/street/environmental LED lighting fixtures shall provide wide and symmetrical light distribution between 0°-180°, and a 90° distribution angle.
- Each lighting pole shall have porcelain terminals and a junction box with 30 mA RCCB and automatic circuit breakers installed inside the pole.
- Fixtures shall be made of weather-resistant materials and have a protection class of at least IP65.
- Grounding for outdoor lighting poles shall be ensured by connecting them to grounding rods driven into the ground. Every second pole shall be connected to a Q20 mm/2-meter copper grounding rod, and the grounding lines of all poles shall be interconnected and linked to the facility's general grounding system.
- Poles shall include base plates mounted on concrete foundations, and cable entries to the foundations shall be housed in PVC conduits.
- Road lighting shall be fed by radial circuits installed with cables encased in buried conduits, as specified in the design.
- Outdoor poles shall be coated with polyurethane (color-coded to match the pole) up to a height of at least 2 meters and a thickness of at least 3 mm above ground level.

b. Emergency Lighting

- Emergency lighting shall be provided for the facility.
- Lighting levels and exit signs with directional evacuation indicators shall be provided for all buildings.
- The emergency lighting system shall automatically turn on when the main power supply fails. Emergency units shall be powered by battery units that provide light for at least 3 hours.

- Units shall include complete components such as enclosures (minimum IP54 for structures outside administrative buildings), LED fixtures (minimum 18W), batteries, and charge indicators.
- For emergency lighting with a kit, a separate circuit protected by a fuse shall be drawn from the main switch.
- Directional emergency exit (EXIT/ÇIKIŞ) signs shall be powered by batteries with at least 3 hours of operation and have a protection class of at least IP20.
- Battery charging shall be automatic.

2.6.1.22. Lightning and Surge Protection System

a. External Lightning Protection

An external lightning protection system shall be installed on the buildings to prevent damage to Distribution Centers due to fire or mechanical destruction caused by lightning strikes. The internal lightning arresters shall be installed for each phase, neutral, and ground line belonging to the automation and weak current systems. A lightning rod shall be used in the system.

The system shall comply with the requirements of IEC 62305-1 Protection of Structures Against Lightning, Class I.

The grounding system for external lightning protection shall be connected to the building reinforcement.

b. Internal Lightning Protection

The core of the internal lightning protection system shall be the equipotential bonding system to be installed. All lines, including incoming and outgoing field signal and control lines, shall be indirectly included in the lightning and surge protection equipotential bonding system via lightning and surge arresters.

At the Main Distribution Board Entry	At the PLC Panel Entries
Type 1, Class B	Type 3, Class D

Each surge arrester shall be equipped with an alarm contact that shall activate in case of a fault. The alarm contact shall be wired to the PLC, and information shall be communicated to the SCADA system.

2.6.1.23. Power Factor Correction

Power factor correction shall be performed automatically via the Main Distribution Panel (MDP) according to the project requirements. The contractor is responsible for supplying, installing, testing, and commissioning an adjustable, remotely monitored relay system that does not introduce harmonics into the grid.

The facility's power factor shall be set to 0.99/1 (unity) with all necessary compensation systems provided and installed. Fixed capacitors of appropriate value for transformer no-load losses shall be placed in the MDP.

Key Requirements:

- Necessary measures shall be taken to suppress harmonics when required.
- An automatic power factor relay (reactive power control relay) with a minimum of 8 steps shall be included.
- All equipment for power factor correction shall be provided as a fully enclosed unit up to IP20 protection degree. The unit shall comply with EN 61439 and maintain $\cos \phi = 1 \pm 3\%$ under all load conditions.
- The system shall automatically deactivate when the generator is operational. Proper cooling fans should be used in the panel.

The front panel of the unit shall include:

- Power Factor Indicator [0-1-0].
- Step indicator (showing the active step).
- Indicator lights:
 - **Alarm**
 - **Normal Operation**

Alarm signals shall be hardwired to the PLC and transmitted to the SCADA system.

Capacitors:

- Shall have <0.2 W/kVAr losses, be rated for a minimum of 520 volts, and be PCB-free.
- Shall comply with:
 - **EN 60891**
 - **IEC 60831**, self-healing type shunt power capacitors
- Should be compatible with shunt power reactors.
- The last three steps shall use thyristor-controlled shunt reactors.
- Contractors shall have early closing blocks and limiting resistors to reduce current during closing to a maximum of 60 In. They shall meet IEC 60831-1 / 60871-1 and EU standards.

Additional Features:

- Power factor correction units shall include properly rated internal overcurrent protection for capacitors and common phase sensing for simultaneous correction across all three phases. Delay between corrections shall be adjustable between 30-120 seconds to comply with local power utility requirements. The default setting shall be 40 seconds if no specific requirement exists.
- A capacitor bank with a minimum of 15 steps (including 3 shunt circuits) shall be provided, with appropriately sized steps based on inductive loads.

Reactive Power Control Relay Features:

- Microprocessor-controlled and multifunctional.

- Equipped with a color LCD display with a screen saver feature to extend screen life.
- Equipped with an alert LED on the front panel to notify end-users when the system approaches penalty limits.
- Supports connection of single-phase, two-phase, or three-phase capacitors or reactors without restrictions.
- Displays detailed information about active/inactive steps, their phases, and whether they are capacitors or reactors.
- Automatically detects the power values of connected capacitors and reactors. Users can also input step values manually.
- Allows remote parameter read/write permissions via Modbus-Ethernet.

Minimum Measurement and Monitoring Features:

- Active Power [kW]
- Apparent Power [kVA]
- Reactive Power [kVAr]
- Required reactive power to reach the target power factor
- Alarm functionality for exceeding set voltage limits
- Current
- Temperature (via specialized probes)
- Highest voltage harmonic
- Highest current harmonic
- Frequency
- Power Factor
- Voltage harmonics (1st to 19th as percentages)
- Current harmonics (1st to 19th as percentages)
- Number of steps required to reach the target power factor
- Activation count for each step
- Active steps
- Automatic phase shifting for connection errors
- Automatic C/k calculation
- Automatic step number determination
- Automatic sequencing calculation
- Communication capability
- Day/night power factor adjustment contact

- Operation under high ambient temperatures: up to 50°C
- Grid Voltage: 400 V

2.6.1.24. Cable and Wiring System

All cables shall be fixed to the trays with clips in such a way that they do not touch each other. Only a single row of cables shall be laid in the tray. Cables shall not be stacked on top of each other. A grounding conductor shall be passed through all trays and connected at least at two points on each tray. Strong current and weak current cables should not be routed through the same tray, if possible.

In areas with high temperatures, power and signal cables shall be selected as heat-resistant.

a. Cable Entries

Cable transitions between rooms or from outside to inside shall be made with waterproof and fire-resistant multi-cable transit seals to provide an effective barrier against fire, smoke, flooding, and pests.

b. Cable Glands

All cable glands shall be of the compression type, acting on the cable sheath, and equipped with cable grip socks if necessary. Cable glands shall not reduce the enclosure's ingress protection rating and shall be sized appropriately for the cable being sealed.

c. Power Cables

Power cables are defined as cables with a working range of $U \geq 50$ V. Signal cables are those with a working range of $U < 50$ V. Cable sizes, types, and structures shall be selected considering the requirements of connected equipment, environmental conditions, installation methods, and fault and overload currents. Generally, the published data of the cable manufacturer shall be used to determine cable adequacy.

Power cables shall be selected so that the voltage drop at any point in the installation does not exceed the maximum value defined in IEC 60364. All cables shall be copper (Cu).

Power cables shall generally be of two types:

- HF-PVC, NHXMH, and N2XH for interior and exterior lighting systems. Generally, HF-PVC cables shall have a cross-section not less than 2.5 mm². HF-PVC-sheathed cables shall consist of stranded copper conductors with HF-PVC insulation placed inside an extruded HF-PVC bedding and jacket. Where mechanical protection is required, cables shall be placed in metal conduits or armored, depending on the installation.

d. High Voltage (HV) Cables

High-voltage connections between transformer substations shall be 34.5 kV. 20.3/35 kV cross-linked polyethylene (XLPE) cables shall be manufactured in compliance with TSE standards, with stranded copper conductors, XLPE-insulated cores, screened insulation, and a galvanized steel wire sheath (and/or chemically protected against rodents). A PVC assembly part shall be placed on top.

Compliance with TS 11178 IEC 60502 and its amendments shall be ensured, and red-colored PVC, considering its physical and chemical properties, shall be selected for insulation. Appropriate cable termination accessories and materials shall be used for HV cable connections.

HV cables shall be laid as single-core cables. The PVC bedding shall retain adhesion to sheath wires and bedding under prolonged storage or exposure to direct sunlight without softening or deformation.

The Energy Transmission Line shall be pulled by the Contractor along the designated route as shown by the Employer's Representative/Employer, using XLPE cables.

e. Low Voltage (LV) Cables

Low-voltage power cables shall generally be of 600/1000 V quality. All cables shall be terminated using original crimping tools and cable lugs with heat-shrinkable tubing. Cable sizes, types, and structures shall be selected considering equipment requirements, environmental conditions, installation methods, and fault and overload currents.

The installation of power cables shall ensure that the voltage drop at any point does not exceed the maximum value defined in IEC 60364.

Power cables shall generally consist of:

- **For Indoor Use:** Halogen-free polyvinyl chloride (HF-PVC) or cross-linked polyethylene insulated cables such as NHXMH, N2XH.
- **For Outdoor Use:** Cables shall not be directly buried in the ground. They shall be routed through conduits or ducts.

All power cables, both indoor and outdoor, shall be single-core for each phase, neutral, and grounding.

f. Signal Cables

Signal cables shall be of finely stranded electrolytic copper conductor type with PVC insulation, suitable for both indoor and outdoor use (LIYCY/YSLCY cables). At device terminals, signal cable cores shall be numbered, and panel outputs shall be labeled.

g. Lighting Cables

Indoor lighting cables shall be halogen-free and concealed under plaster. Outdoor lighting cables shall be N2XH type, routed within conduits.

h. Grounding and Bonding Cables

Bare grounding cables shall comply with IEC 60228, and where suitable for the equipment's grounding terminal, they shall be insulated, multi-stranded, single-core copper conductors sized according to IEC 60364 requirements. If not suitable, the equipment manufacturer's catalog data shall be used.

PVC-insulated grounding cables shall comply with IEC 60227 and IEC 60228, featuring spiral green/yellow extruded PVC insulation, with a minimum cross-section of 2.5 mm².

i. Cable Separation

Cables operating at different voltages and for different purposes shall be adequately separated. All power and signal cables shall be routed through separate cable trays.

Four continuous separate routes shall be established throughout the facility for:

- Power cables for technical power.
- Power cables for building services.

- Power cables energized by frequency converters.
- Signal cables.
- The minimum distance between the above-mentioned cables shall be no less than 100 mm.

j. Cable Trays, Ladders, and Conduits

Cable trays, ladders, and conduits shall generally comply with IEC 60364, constructed of perforated, hot-dip galvanized mild steel, and designed to be rigid in structure. The selection of the manufacturer shall ensure that the product range includes standard elbows, tees, intersections, reducers, risers, and drop sections.

Cable trays shall be heavy-duty, with a hot-dip galvanized thickness of at least 2 mm.

Cable trays, ladders, and conduits shall be sized according to the clearance and separation requirements specified above and equipped with insulation barriers.

Exits from cable trays shall be made using glands suitable for the connection.

Any cuts, drilling, or damage to the galvanization of cable trays, ladders, or conduits shall be restored to the original galvanization standard with appropriate processing.

Cable trays, ladders, and reserves shall be grounded. A grounding jumper shall be made at each tray joint. A continuous, seamless 1x35 mm² braided copper conductor shall run through the cable trays and be grounded. This conductor shall be connected to the equipotential bar. The grounding conductor shall be bonded at least at two ends of each tray length using jumper conductors of the same cross-section. For tray-jumper connections, copper lugs shall be used, and for jumper-conductor connections, copper terminals shall be used.

Cable trays shall be separately mounted for weak current and low-voltage (LV) cables. Weak current cables and LV cables shall not be placed in the same tray. Separators shall not be used between cables.

All cables shall be fixed along their routing using clamps (brackets), hooks, or plastic bands.

Cables shall be mounted side by side with adequate spacing between them, ensuring no contact, and installed in a manner that maintains proper bending radii.

Cables inside trays shall be secured every meter with special brackets.

Supports shall be provided at intervals to ensure that the maximum deflection allowed by the manufacturer for the specified loading is not exceeded. The weight and quantity of cables placed on the cable tray or ladder shall not exceed the manufacturer's recommendations.

Adequate space shall be left in the selected cable trays, ladders, and conduits for future expansion, ensuring that the number of cables installed does not exceed 80% of the available area factor.

All vertical cable trays, ladders, and conduits shall be fitted with perforated covers secured with bolts up to a height of 2 meters above ground level.

Site cables shall be routed within reinforced concrete channels and marked accordingly. Drain connections shall be provided within the channels to prevent water accumulation.

k. Pipe Systems

Pipes used within buildings and structures shall be heavy-duty PVC / HDPE pipes. Pipes laid outside buildings shall be HDPE.

Fittings and accessories associated with channel systems shall either be made of wear-resistant materials or coated appropriately to make them wear-resistant.

l. Underground Cables

In distribution centers, cable channel areas shall be created in the form of basements.

Outside distribution centers, underground cabling shall be done using HDPE pipes and manholes.

A concrete section opening shall be left, allowing for cable entries according to the cell layout plan. Installations shall provide at least one cable tray per cable type (signal cables, power cables) to ensure proper separation.

m. Cable Installation

Cables laid on trays, ladders, and conduits shall not overlap or cross over one another. Trays, ladders, and conduits shall be sized based on cable bending radius and weight. Cables shall be secured to trays and ladders with ultraviolet-stabilized ties at intervals appropriate to the cable size and weight.

All cable tray, ladder, and conduit routes shall be completed before cable installation begins.

Individually routed cables mounted directly on walls or ceilings shall only be installed after construction workers and painters have finished their work. Cables shall be laid strictly in vertical and horizontal planes using the least obtrusive routes for aesthetic acceptability. Only single-hole plastic mounting clips shall be used.

All cables terminated at equipment shall use cable glands only – epoxy putty shall not be used.

Cable pathways in structures shall be continuous from start to finish, and no splicing or joints shall be made in channels or pull points under any circumstances.

Cables shall not be exposed to direct sunlight.

Cables with different voltage levels shall be laid on separate trays. If a specific route is designed to have both types of cables on the same tray due to a small number of cables (using separators), Employer's Representative's approval shall be obtained.

In internal cable installations, sufficient distance shall be left between cables to prevent a reduction in current-carrying capacity due to proximity. A minimum distance of 200 mm shall be left between cables carrying different voltages, or separators shall be placed in the channels.

Cable supports shall be of heavy-duty, corrosion-resistant, covered types.

High-voltage (HV) cables shall be installed within the pipe and manhole system.

Appropriate cable termination accessories and materials shall be used where necessary.

n. Cable Identification

Cables and cable cores shall be identified at both ends using sleeve bands that carry the cable/core reference number as indicated on the drawings.

For routes where multiple cables are laid in grooves, pairs, long runs passing through multiple rooms in buildings, clipped onto trays, or laid on the ground in close proximity, interim markings shall be applied to identify specific cables.

When cables are laid in pairs, each cable in the pulling section shall be identified with the cable reference number.

2.6.1.25. Warning Signs and Plates to be Used

➤ OUTSIDE THE DOOR OF THE ELECTRICAL ROOM



➤ ON THE ADP AND MCC PANELS



2.6.2. AUTOMATION SYSTEMS

➤ SCADA System

The systems that shall be connected to the SCADA system, exchange data with it, and be monitored and controlled via the SCADA system are outlined below. (The Automation and SCADA works also cover specific issues explicitly mentioned in the relevant sections of the Technical Specification.)

- Positions of systems located in MV (Medium Voltage) Cells
- Measurement data from systems located in MV Cells
- Control Relays located in MV Cells
- Energy Quality Analyzers located in MV Cells
- Meters located in MV Cells
- BAR 24/110 Vdc Systems
- LV (Low Voltage) Panel Energy Analyzers
- Compensation Relays
- Fire Alarm Systems
- UPS Units
- Outdoor Lighting System

➤ Licensing, Software, and SCADA System Specifications

• Licensing of Software

All software to be used in the system and subject to licensing shall be delivered to the Employer's Representative/Employer in the form of DVDs together with their original certificates. All software shall be handed over to the Employer's Representative/Employer with a formal protocol.

• Delivery of Software and Programs

All licenses of programs used in any PLC/SCADA equipment, Operator Interface/SCADA, and HMI (Operator Panel) supplied by the Contractor, together with the software and programs, shall be delivered to the Employer's Representative/Employer at the end of the work. Documents for each piece of equipment, programming software required for the operation of the automation system, and spare parts shall be delivered together with the system.

• Energy Quality Analysers and Measurement Integration

Energy Quality Analysers, electricity meters, control, and protection relay systems shall be used separately in each MV Cell. All values from these devices shall be transferred to the SCADA system.

• SCADA System Functionality

The SCADA system shall be designed to monitor and control the MV Cells and Circuit Breakers with full automation. However, if the Employer's Representative/Employer requests to deactivate the "remote control and operation" feature due to occupational safety conditions after the testing and commissioning phase, the Contractor shall be responsible for implementing this functionality.

- **System Design**

The computer-based control and monitoring system shall not be a Distributed Control System (DCS).

- **Required Features of the SCADA System**

The SCADA system shall include the following features:

- Monitoring, supervision, and management of Medium Voltage systems and the Incineration Facility's equipment and systems (as outlined in the P&I diagram)
- Monitoring and control of alarms and the status of all systems
- Modification of timers and parameters
- Execution of calculations
- Real-time data and alarm collection and storage
- Processing of data and alarms
- Emergency stopping and starting of components from the operator station
- Automatic control of the Outdoor Lighting Automation section
- Monitoring tools, monitoring software, and printers

The fundamental architecture and hardware components of the SCADA system shall include the following:

- One rack-type server and mini PC-type operator stations
- Operator monitors and screens
- Report and graphic printers
- Industrial network
- PLCs
- Distributed I/O modules, cables, modems, interfaces, and all other hardware and software necessary for proper operation

All software (SCADA and PLC) shall be installed as open-source, operating systems shall be set up, and the licenses/dongles for SCADA and PLC programs shall be loaded. Dongles used with virtual servers shall be "physical dongles" connected to the server. Software dongles shall not be used.

The Monitoring and Control Room shall be installed within the facility in a room approved by the Employer's Representative. A custom architectural design shall be prepared by the Contractor. The special design for the SCADA Room shall be submitted for the Employer's Representative's approval.

2.6.2.1. Product Requirements and Specifications

- All proposed products shall be within their respective product families and shall not have been issued an E.O.L. (End of Life) announcement by the manufacturer, nor have a disclosed E.O.L. announcement. Products that have been discontinued shall not be offered under any circumstances.

- All products and components offered under this technical specification shall be brand-new and unused. Refurbished, reconditioned, reset, or otherwise overhauled products ("Refurbished," "Reconditioned," "Refactored," etc.) shall not be offered.
- Proposed products shall be explicitly marked in the approved design documentation. The Contractor shall submit a list of the brand and model of the proposed products.
- All active devices proposed shall support IPv6 technology.
- All components required for the operation of the supplied hardware (e.g., cables, sockets, etc.) shall be included in the proposal.
- All proposed products shall comply with electrical standards valid in Türkiye.
- Each product shall be delivered in its original packaging, with all necessary precautions taken to protect it from damage or impact.

2.6.2.2. Delivery, Installation and Responsibilities

- The delivery, installation, and assembly of the required products shall be performed by the Contractor. No additional fees shall be requested for these processes. The Contractor is responsible for performing the assembly, installation, and adjustments at the locations designated by the Employer's Representative/Employer and delivering the products in operational condition.
- The Contractor shall be liable for compensating any damages or malfunctions caused by negligence or faults during the installation work.

During installation and assembly works, occupational safety shall be provided by the Contractor. The Contractor shall be responsible for any damages suffered by employees or third parties. The Contractor shall not cause any damage to the existing infrastructure at the facility during the execution of the works covered under this specification.

The licenses and information for all hardware, software, and support packages procured under this technical specification shall be delivered to the Employer's Representative/Employer in a file signed and stamped by the Contractor. These licenses shall be registered in the manufacturer's system and transferred to an electronic account belonging to the Employer's Representative/Employer. If these transfers have been completed, signed and stamped screenshots of these registrations by the Contractor shall also be provided.

All software licenses required under this technical specification shall be procured and delivered by the Contractor, and the licensing shall be performed in the name of the Employer.

The installation of all proposed products into cabinets to be provided by the Employer shall be carried out by the Contractor. The Contractor shall ensure that installation and configuration services are performed by expert personnel with the necessary qualifications. After completing all installations and configurations, the usernames and passwords for the devices shall be delivered to the Employer's Representative in a sealed envelope.

➤ Warranty Provisions

The warranty period for all software and hardware products covered under this specification is three (3) years unless otherwise specified in the Employer's Requirements or Contract Draft. The warranty period for the purchased products shall commence on the date of Commissioning Certificate.

The Contractor shall rectify all defects and damages caused during interventions under the warranty. The Contractor shall also be responsible for any damage or defects occurring during the repair, transportation, or handling of the hardware covered by the warranty.

The Contractor shall ensure that the system (hardware/software) purchased under this specification operates as an integrated whole and remains continuously operational throughout the warranty period.

Any spare parts provided by the Contractor shall be original and compatible with the technical and functional characteristics of the replaced parts.

During the warranty period, the Contractor shall not object to the Employer's Representative/Employer's personnel participating in any maintenance, repair, or renewal activities and shall provide all necessary information either verbally or in writing.

In the event of the contract's termination or the Contractor ceasing its legal existence, the warranty for the products shall continue under the manufacturer's warranty.

The warranty provided for installed hardware under this specification shall be a 24/7 (day x hour) warranty.

The maintenance, repair, and update services for the products covered under this specification shall be performed by the Contractor. All costs associated with repairs, maintenance, part replacements, and any services necessary to ensure uninterrupted operation of the systems shall be borne by the Contractor without additional charges.

In the event of hardware failure, the Employer's Representative/Employer shall notify the Contractor via the website, telephone, fax, or similar communication methods.

Due to data security policies, defective disks shall not be returned to the Contractor and shall instead be retained by Employer's Representative/Employer shall have the right to version updates and upgrades, and the manufacturer shall provide 24/7 support services.

For virtualization software offered under this specification, the Contractor or manufacturer shall respond to reported failures/issues according to the following priority levels from the time of notification:

- **Critical Failures:** Within 2 hours
- **Major Failures:** Within 4 hours
- **Minor Failures:** Within 8 hours

The Contractor/manufacturer shall replace hardware that cannot be repaired with new hardware without requesting additional charges. If the same brand and model of hardware cannot be supplied, the proposed replacements shall meet the requirements of the relevant provisions of the technical specification, and their configuration and features shall be submitted to the Employer's Representative in writing along with original catalogues for approval.

For hardware failures/issues under this specification, the Contractor/manufacturer shall intervene and resolve the issue as follows, based on notification from the Employer's Representative/Employer:

- Within 6 (six) hours on weekends and public holidays
- Within 4 (four) hours during business hours

The problem or issue shall be fully resolved within a maximum of 24 (twenty-four) hours.

The Employer may use the purchased products in all workplaces belonging to the Employer, including locations other than those mentioned in this specification.

Relocating the hardware shall not invalidate its warranty coverage. The Contractor/manufacturer is obliged to provide support for relocated hardware throughout the warranty period.

The Contractor shall not transfer any part or all of the responsibility for warranty repair services to another party without the Employer's Representative's approval.

If there is a failure in the obligations specified in the contract (e.g., inability to reach the Contractor via the website, provided telephone, mobile phone, or fax numbers), reports, records, and logs prepared by the Employer's Representative/Employer shall be considered valid.

➤ **Architecture (System Architecture)**

The SCADA software shall operate in a Windows operating system environment and be deployed within a Virtual Machine (VM) installed on a server. The software shall utilize all graphical and functional features of the current Windows technology. Access to the software shall be through the internet using the TCP/IP protocol. A configurable web server or firewall shall ensure that only authorized personnel have access to operational data. Process images prepared as Java applets on the web server shall be monitored in administrative units via standard web browsers. The web server shall log all connections.

A separate VM shall be created within a rack-mounted server, where the SCADA software shall be installed. Data related to SCADA software tags shall be written to an SQL server by the SCADA software itself or through an additional software application (e.g., noteRED or other software with similar features). Additionally, SCADA data written to SQL at periodic intervals determined by the Employer's Representative/Employer shall be automatically transferred to external PCs and/or servers via the SCADA software or a desktop transfer application (e.g., aktarım.exe).

The facility shall implement an architectural topology compliant with industrial and cybersecurity standards, including **PUREDUE**, **NIST**, and **IEC61850**. For all works performed at the facility, transmittals (documents) shall be shared with the management of the Employer's Representative/Employer. Operating systems used in the project shall be reviewed and approved by the Employer's Representative/Employer.

The operator interface for centralized operations shall consist of the following Operator Interface Subsystems and various server subsystems:

- I/O Devices Subsystem
- Monitoring, reporting, distributing, and acknowledging alarms
- Collecting, storing, and distributing historical trends
- Processing, storing, and distributing reports
- Internet services for browser-based clients

Subsystems shall be designed as independent series so that a failure in one subsystem does not adversely affect the operation of other subsystems. Faulty subsystems shall be reset and corrected without shutting down the computer or application. This design shall prevent redundancy, minimize

network bandwidth usage, optimize field device operations, and reduce maintenance and repair operations while ensuring all historical records are stored in a centralized repository.

The operator interface proposed for managing different stations that support testing, development, operation, local monitoring, remote monitoring, and maintenance processes shall support the following Microsoft® operating systems:

- Windows 11 Pro (current technological versions)
- Windows Server® 2022
- 32-bit and 64-bit

The operator interface shall be deployable on platforms running Windows Server 2022, Windows 11 Pro, or later, capable of supporting all development and operational applications simultaneously.

Additionally, the system shall support ordinary internet browser-based clients to provide secure access for personnel located on the WAN. Internet browser clients shall support view and control features regulated by login security and license types. The browser client should provide graphic displays, trend pages, alarm pages, and system security for standard client software, among other features. The internet browser client shall not require additional design or customized software for configuration export.

All server-based software tasks shall reside on primary and backup computers for each task. Furthermore, the software shall support intelligent full redundancy. This capability ensures seamless and uninterrupted operation in case of hardware or software failures in subsystems, including replication and uninterrupted backup functionality, allowing operator operations to transfer from one server to another without requiring additional configuration or code.

In cases where multiple servers are running on a single computer, a subsystem failure shall not delay operations in other subsystems. While resetting the faulty subsystem, the remaining part of the Operator Interface system shall continue functioning properly.

The minimum tasks that shall run without interruption include:

- I/O device subsystems
- Monitoring, reporting, distributing, and acknowledging alarms
- Collecting, storing, and distributing historical data
- Processing, storing, and distributing reports
- Storing and distributing configurations for remote client stations
- Network communication between operator interface stations
- Field device communication (where supported by field devices)

The software shall be provided as a complete package. Additional software shall not be required to run or configure any features of the system.

Operator interface clients associated with the Operator Interface server shall be transferable to other server clusters with minimal engineering effort. Operator interface clients shall request and display live data, historical data, and alarm data from the server on the network without requiring restarts or operator intervention.

2.6.2.3. Servers

➤ General Features of the Servers

All servers shall be fully installed, operational, and ready to use at the locations specified by the Employer. The server chassis shall be rack-mounted. Servers shall be offered with sliding kits for ease of access (to pull forward). If provided by the manufacturer, the server shall be offered with a security frame equipped with a mechanical lock, attachable to the front.

The server shall include a Hot-Pluggable/Hot-Swappable power supply unit sufficient to meet the server's power requirements. Additionally, at least one backup Hot-Pluggable/Hot-Swappable power supply unit shall be included. Backup power supplies on the server shall automatically take over when the active power supply fails.

The server brand and model shall be listed on the compatibility list of the proposed "Virtualization Software." Ethernet cards on the server shall be supported by the proposed "Virtualization Software."

On-site support shall be provided for all physical servers throughout the warranty period.

The processor and chipset on the server shall be from the same manufacturer.

The server shall support hot-pluggable, high-availability RAID M.2 boot options.

Processors shall have original coolers provided or approved by the server manufacturer.

The server shall include an integrated or PCI slot-based remote management card and software.

UEFI support shall be available on the server.

The remote management software provided with the server shall include features for remote management, performance monitoring, and RAID management. If a license is required for these features, it shall be included in the proposal.

Even if the operating system has crashed or the server is powered off, it shall be possible to access the server's management interface and remotely power on the server.

The server shall support virtual media features, enabling the use of USB drives, CDs, DVDs, and similar media connected to a remote computer.

The manufacturer shall provide a proactive alert system for disk, processor, and memory components. The proactive alert system shall notify the system administrator of any potential failures in these components.

The proposed server shall be fully compatible with Microsoft Windows Server 2016/2019/2022, VMware operating systems, and their clustering software.

The central processing unit (CPU) shall support hyper-threading and be among the processors with the proposed number of cores, operating at the highest frequency supported by the chassis. For the selected high-speed processor, the bus speed shall also be the highest available. The processor cache size shall be the largest available among processors meeting the above criteria for speed and bus capacity. These criteria shall be evaluated based on products available on the date of the proposal.

The server's memory shall operate at the highest speed supported by the proposed processor and feature Chipkill, ECC, or similar technology. These criteria shall also be evaluated based on products available on the date of the proposal.

➤ **Server Technical Specifications**

- Number of Servers: 1.
- The proposed server shall be equipped with two (2) Xeon architecture processors, each with a minimum of 20 cores and a clock speed of at least 2.0 GHz.
- Each processor shall feature a minimum of 35.50 MB L3 cache memory.
- The server shall include DDR5 memory, with a minimum speed of 3200 MT/s and a total capacity of at least 512 GB. The memory shall be expandable to at least 2 TB. The proposed server shall support Advanced ECC and Online Spare features.
- The server shall include a minimum of eight (8) 2.5” hot-plug disk bays.
- The server shall be delivered with a minimum of three (3) SSD disks, each with a capacity of at least 480 GB.
- The server shall also be delivered with a minimum of five (5) 2.5” NVMe SSD disks, each with a capacity of at least 3.8 TB.
- The server shall feature at least one (1) flash- or battery-protected hardware RAID controller belonging to or approved by the server manufacturer, with a minimum of 2 GB cache and a speed of at least 12 Gbps. The RAID controller shall support at least four RAID levels among 0, 1, 10, 5, 6, 50, and 60.
- The server shall include a minimum of six (6) PCIe Gen3 expansion slots.
- The server shall feature at least two (2) BaseT Ethernet ports with a speed of 1 Gbps.
- For backbone switch connections, the server shall include at least four (4) 10 Gbps Fiber Ethernet ports, integrated into the motherboard or provided via a module. All ports shall be equipped with original 10 Gbps multi-mode SFP+ modules from the manufacturer.
- The server shall feature at least one (1) external serial connection port, two (2) USB 2.0 ports, and two (2) USB 3.0 ports.
- The server shall include one (1) internal or external DVD/RW drive.
- The server’s height shall not exceed 2U.
- The server shall include two (2) hot-swap/hot-plug redundant power supplies, each with a capacity of at least 1000W. The power supplies shall have a minimum efficiency of 90%.
- The server shall feature hot-plug n+1 redundant cooling fan units, with all cooling fan units installed and delivered.
- The server shall include one (1) remote access and management interface with a speed of at least 1 Gbps, complying with the BaseT standard.

➤ **Virtualization Software**

The proposed virtualization software package shall license one server equipped with two (2) physical CPUs.

The proposed virtualization software shall allow over-commitment of resources, enabling virtual machines (VMs) created on the same physical server to be assigned resources exceeding the available physical resources.

The virtualization software shall support SMP (Symmetric Multi-Processing). Each virtual machine shall be capable of being assigned up to 64 virtual CPUs as required.

The virtualization software shall allow up to 1TB of virtual memory to be allocated to each virtual machine.

The virtualization software shall support Thin Provisioning, enabling the disk space allocated to each virtual machine to grow dynamically as required, instead of being fully occupied from the disk pool at the time of allocation.

The virtualization software shall support the following guest operating systems: Windows 10, Windows 11, Windows Server 2016, Windows Server 2019, Windows Server 2022, CentOS, RedHat, Ubuntu, Solaris, MacOSX, FreeBSD, and others.

The virtualization software shall allow the disk sizes and file system used by virtual machines to be expanded while the system is operational.

The virtualization software shall support the assignment of virtual disks up to 62TB in size to virtual machines.

The virtualization software shall be capable of managing storage volumes of up to 64TB.

The virtualization software shall support storage technologies such as FC, iSCSI, and NFS, as well as storage units operating with these technologies.

The virtualization software shall provide system authorization features, allowing certain operational personnel to access and manage either the entire virtual system or specific portions of it.

The virtualization software shall allow real-time and historical performance monitoring and reporting for parameters such as CPU, memory, disk, and network.

The virtualization software shall include centralized management software that provides management of all physical and virtual servers from a single location. Licenses for the centralized management software shall be included in the proposal.

The centralized management software included with the virtualization software shall allow management through a web interface.

The virtualization software shall support VLAN assignment to virtual servers.

The virtualization software shall allow virtual servers to be copied while running.

The virtualization software shall support the migration of live virtual machines to other servers within the virtualization system without requiring shared disk storage. This migration shall support the simultaneous transfer of multiple virtual machines.

The virtualization software shall provide clustering functionality, enabling virtual machines from a failed server to automatically start on other servers within the system. This functionality shall include prioritization among virtual machines.

The virtualization software shall include a module capable of backing up virtual machines running Windows/Linux to disk storage. This module shall store backups using deduplication.

The virtualization software shall allow replication of specific virtual machines to virtualization servers located either locally or remotely.

The virtualization software shall support load balancing across physical servers. It shall allow, if desired, the workloads from lightly used physical servers to be transferred to other servers, enabling idle servers to be powered down for energy savings. These servers shall also be capable of being automatically powered back on when needed.

The virtualization software shall allow network-based access to the serial port console of virtual servers.

➤ **Microsoft Windows Server Software and Licenses (2022 or Higher Versions)**

Microsoft Windows Server 2022 Standard licenses shall be delivered together with the virtualization system to license at least four (4) virtual servers with a total of at least 40 virtual CPUs.

To enable user connections to applications installed on the Windows Server operating system, Microsoft Windows Terminal Server licenses shall also be delivered, supporting a minimum of 50 user devices.

➤ **Network-Attached Storage System (NAS)**

All software licenses required for the proposed system shall be included in the proposal, covering the system's maximum supported capacity.

The licensing method for the features required by this specification shall be perpetual, ensuring no additional licenses shall be needed in the future.

The device shall be equipped with a 64-bit architecture processor, at least an Intel® Core™ i5.

The device shall include at least two (2) 2280 PCIe M.2 slots.

The device shall have at least two (2) 1G Ethernet ports.

The device shall support Wake on LAN technology.

The device shall include Jumbo Frame support.

The device shall feature at least one (1) USB Type-C port and at least two (2) USB 3.0 ports.

To prevent the hard drives from overheating, the device shall include at least two (2) fans.

The proposed device shall have at least 8GB of memory and support memory expansion up to 64GB.

The device shall support the following file formats: EXT3, EXT4, NTFS, FAT32, HFS+, and exFAT.

The device shall include at least six (6) 2.5"/3.5" SATA SSD/HDD-supported hard drive slots.

The device shall be delivered fully equipped with SATA 6Gb/s disks, each with a capacity of at least 6TB.

The device shall support RAID levels 0, 1, 5, 6, and 10.

The device shall support Telnet and SSH protocols for console access and SNMP protocol for remote monitoring.

The proposed systems shall support snapshot functionality, and the necessary licenses for using this feature shall be included in the proposal.

The proposed systems shall support SMB, CIFS, NFS, and iSCSI protocols. Licenses required for the supported protocols shall be included in the proposal, covering the maximum capacity supported by the proposed storage unit.

The proposed systems shall allow rules to be applied to NAS-created storage areas based on file extensions (e.g., .iso, .mp4) to prevent the storage of unwanted files. Licenses required for this feature shall be included in the proposal.

The proposed systems shall support quota functionality for users on NAS-created storage areas. Licenses required for this feature shall be included in the proposal.

The disk controllers shall prevent data loss in the event of a power failure or similar situations by preserving data in the write-cache memory.

The proposed storage system shall work seamlessly with Linux, Microsoft Windows Server systems, Windows clients, VMware, and Hyper-V virtualization solutions, enabling simultaneous access.

The storage system shall notify the service center of any errors via email.

The storage system shall be managed through a web-based interface. All functions shall be accessible via this web interface.

The storage system shall support remote management via HTTP, SSH, or Telnet protocols. Management via HTTP shall be performed using a graphical interface, and all management functions shall be accessible through this graphical interface.

The storage system shall include capacity and performance analysis software. It shall enable real-time and historical analyses, allowing the graphical monitoring of all performance metrics of the system.

All administrative actions performed on the storage system shall be logged, with reports indicating which user performed which actions, accessible for retrospective review.

➤ **Mini PCs**

For the Clients to be located in the Monitoring and Control Room, two (2) Mini PCs with the following specifications shall be installed:

- **Processor Type:** Intel Core i7
- **Processor Cache:** 25 MB Cache
- **Base Processor Speed:** At least 1.4 GHz
- **RAM (System Memory):** At least 32 GB
- **RAM Type:** DDR4
- **Graphics Card Type:** Integrated Graphics Card
- **Graphics Card Model:** At least UHD Graphics
- **SSD Capacity:** At least 512 GB
- **Operating System:** Free DOS
- **USB Ports:** At least 7 ports

- **Wireless Capability:** Shall be available

Adequately sized desks, workstations, monitors, operator monitors, rack cabinets, rack-mounted server systems, Ethernet switch systems, fiber optic/CAT converters, an independent UPS system for SCADA, and a backup system shall also be provided.

For the Clients to be located in the Monitoring and Control Room, displays with **Ultra High Definition (UHD)** resolution of **3840 x 2160 pixels or higher** shall be used alongside the control device.

Additionally, the system shall include the specified number of operator monitors for the Clients.

The monitors shall meet at least the following minimum specifications:

Monitor Requirements;

Screen Size: 43.0 inches	43.0 inches
Screen Type: 4K UHD	4K UHD
Resolution	3840 X 2160
Response Time	4 ms
Contrast Ratio	5000:1
Brightness	300cd/m ²
HDMI Support	Yes
Additional Connections	Type C, Wi-Fi, Bluetooth
Wall Mount Compatible	Yes

Workstation Hardware and Specifications

The workstation shall have the following minimum specifications:

Operating System	Windows 11 Pro (minimum)
Processor Type	7. Nesil Intel Core i7
Processor Model	i7-6500U
Processor Speed	2,50 GHz
Cache	4 MB
Memory	16 GB
Memory Type	DDR4
Storage	1 TB SSD
Graphics Processor	INTEL HD Graphics

Graphics Memory	Shared
Display	15.6 inç
Resolution	1920x1080
Web Camera	Included
Bluetooth	Included
Numeric Keypad	INTEL
Keyboard	Included
Operating System	Q keyboard

The battery capacity shall be at least 16 hours. The system shall be delivered with a carrying case and a wireless mouse.

➤ **Control Systems**

The control section shall consist of a distributed system with distributed local intelligent controllers (PLCs) to perform the control and monitoring of equipment connected to the PLCs. In the event of a communication network failure, the PLCs shall operate autonomously, ensuring the continuity of control.

The system shall be designed to operate 24 hours without requiring personnel intervention.

The control and monitoring system requirements are as follows:

When the control switch of a component located in the panels is in the "auto" position, automatic control of the component shall be possible.

When the control switch is in the "manual" position, bypassing PLC control shall be possible.

An automation system shall be designed (hardware and software) to enable control and command of the facility through the centralized Operator Interface Computer.

Power supply, installation, configuration, or control interfaces close to the field, local control room interfaces, local instrumentation interfaces, power supply works for these interfaces, and all associated cables and auxiliary hardware works shall be installed.

Control panels, local instrumentation panels, buttons, indicator lamps, and all other necessary equipment and components for processing control commands executed manually and monitoring processes (SCADA/PLC) are within the scope of the work.

Procurement, installation, and commissioning of Ethernet cables, optical cables, and all necessary data cables shall be carried out to maintain communication between the controllers/SCADA and the Operator Interface within the facility.

➤ **Automation Structure**

The communication infrastructure to be established shall have a Single Mode Fiber Optic ring topology. Communication between units shall be via Fiber Optic (FO), while communication within units shall be Ethernet-based. In the event of a line interruption, the system shall continue operating without communication loss, thanks to the ring structure.

The PLC/SCADA, I/O cards, Operator Interface, and HMI shall be of the same brand. Remote controls, reporting, Operator Panel, and Industrial Switches shall be selected in models ensuring system reliability, fast response time, spare part availability, and long-term fault-free operation.

A controller structure necessary for the control, command, and monitoring system shall be established. All data exchange with the CPU shall be performed with minimal impact during each data scanning cycle period. Communication between the HMI (Operator Panel) and the Operator Interface/SCADA system shall use TCP/IP at a minimum speed of 100 Mbit/s.

Data acquired from the field (Digital and Analog) or signals sent for control from the CPU shall be received or transferred via I/O (Input/Output) cards and transmitted to the CPU in this manner. CPUs and I/O structures shall be of the same brand.

I/O cards within the system shall be hot-swappable (can be plugged and unplugged under power) in all racks (backbone structure). Additionally, these operations shall be performed while the system remains in RUN mode. During the replacement process, the operation of modules other than the faulty module shall not be interrupted.

The CPU shall allow digital signals to be set to 1/0 through the program and support the provision of simulation values for analog signals.

All CPUs within the system shall be programmed using the same software. Communication infrastructure between all CPUs and I/O modules shall be Ethernet-based.

It shall be possible to access I/O modules for diagnostic and maintenance purposes via a web browser (Edge, Chrome, etc.) from a network-connected computer.

All program-related descriptions shall be stored in the controller CPUs. Once connected through computer software, all data, variables, and descriptions shall be retrievable from the CPUs. CPUs shall operate in Master/Slave mode. In the event of a SCADA connection loss, they shall continue operating as the master.

The controller shall have an Ethernet port to facilitate programming. The PLC software program shall include a simulation feature, enabling program testing and verification without requiring the controller.

The PLC CPU shall have the capacity to process and support a minimum of 2000 I/Os. The controller (PLC) shall have the capability to expand the required programming memory of the CPU and shall have a minimum of 2 MB memory.

The I/O (Input/Output) terminals shall have the capacity to support and process 1024 I/Os.

CPUs shall have a real-time clock.

CPUs shall also support Profinet and/or Modbus communication.

The cards to be used in the system shall comply with the following standards and certifications:

- IEC/EN 61131-2
- CSA 22.2 No. 142
- UL 508
- ABS, BV, DNV, GL, LR, RINA, RMRS

The controller (PLC) software shall strictly support the IEC 61131-3 standard, and all of the following programming languages shall be usable:

- LD (Ladder Diagram)
- FBD (Function Block Diagram)
- SFC (Sequential Function Chart)
- IL (Instruction List)
- ST (Structured Text)

There shall be no restrictions on the use of blocks in the software library.

Remote inputs and outputs shall communicate with the controller via an Ethernet structure using TCP/IP and Ethernet IP.

The Controller Input/Output cards to be used shall meet the following minimum requirements.

PLCs shall include an internal web page for error diagnostics, and this web page shall be accessible through a web browser in a simple manner with operators' passwords and authorizations, if required.

➤ **Object Model**

The system shall be based on objects inspired by the real world. The software shall store data that shall be automatically generated in control and operator interfaces when an object is created in the application. The software shall allow users to create new objects and make modifications to objects within the library.

➤ **System Design**

Users shall be able to design the process as a hierarchical tree. The system software shall provide an easy way to add objects in configuration mode rather than through programming. A user interface shall be provided to add objects (such as motors) without requiring deep programming knowledge.

➤ **Operator Interface/SCADA**

The operator interface software shall enable the operation and maintenance of the system to be carried out easily and quickly by operators, controllers, and maintenance personnel. It shall write data to and read data from field control devices (HMI), archive and monitor historical data, and present graphical screens and reports.

All operator interface functions, such as communication drivers, graphical features, reporting, historical data storage, trend and alarm indicators, and development environment, are expected to be delivered as an integrated software package or set of packages. If software shall be procured from multiple vendors to meet this requirement, the software components and vendors shall be listed separately.

For the visualization of the facility, state-of-the-art graphic techniques (motion graphics and animations) shall be supported. The software shall include an advanced alarm system. Alarms within the system shall be archived, classified according to priority, and provide both visual and auditory notifications to the operator. Events shall be recorded in the system as an event log. These events shall include the actions taken by operators, the times when interventions were made, and the software startup times.

➤ **Operation Interface**

The software shall use the I/O server to read and write variables and tags in the I/O (Input/Output) subsystems. The I/O servers shall manage reading data from and writing data to the I/O device subsystems and provide this data to any client upon request.

The I/O servers shall only accept read and write requests from client or server systems within the network to reduce network traffic and operational load on field devices.

I/O devices for appropriate protocols, such as telemetry, shall have the capability to collect time-stamped data from field equipment in addition to historical data in the alarm and data log files. This information shall be automatically replicated in the operator interface's historical records without requiring any user configuration or intervention.

The software shall be capable of redundant operation when required, without the need for any user interface, program generation, or the addition of a second computer or license.

All available drivers shall be provided with the software and included in the price. No additional licensing fees should be required for the use of a single driver or all drivers.

Real-time process data in the system shall be easily transferable to any OPC client application via the system's OPC DA 2.0 Server, while archived data belonging to the system shall be transferred via the OPC HDA 1.0 Server. Alarms and events shall be transferred via the OPC AE Server in the system.

The software shall offer the following minimum connection options for third-party programs or databases without any additional cost:

- OPC Client
- OPC Server 2.0 DA
- ODBC Client
- ODBC Server
- DDE Client
- DDE Server
- Open API (2 licenses)

The API shall allow third-party applications written in C, C++, or VBA to access tag, alarm, and trend data.

The system shall be able to define time-based or periodic programs to read variables from and write variables to field devices. A stable cache shall be available to provide the most recent known best values immediately after restart without requiring memory for re-reading.

Detailed diagnostics shall be internally maintained by the system and provide information about each communication bus and processor communication. Accessing diagnostic information shall not require any configuration or programming.

These diagnostics shall maintain statistics for minimum monitoring information, including:

- Number of retries

- Number of timeouts
- Read and write operations for control equipment
- Minimum, maximum, and average response times for control equipment

To facilitate commissioning, a debugging feature shall allow read and write operations without requiring any configuration in the graphical interface for tags. This feature shall have security protection to prevent unauthorized access to tag values or commands.

In the event of a communication line failure with remote field devices, which provide historical alarm records and tag value changes, all archived historical records in the remote terminal unit (PLC) shall be backed up to the Operator Interface Alarm and Trend History files for event and trend data once the remote connection is re-established. This data shall be viewable via the Operator Interface Alarm and Trend monitoring tools.

The operator interface software shall include a package to facilitate equipment drivers for users. The package shall provide examples with source codes for processing drivers for similar types according to user requirements (e.g., serial driver, TCP/IP driver, exception report, custom card, etc.).

➤ **Multi-User Engineering**

The SCADA software shall support a server-client architecture for engineering purposes. Multiple engineering users shall be able to connect to the same engineering server simultaneously and perform activities such as commissioning, maintenance, and fault tracking.

Any logic, visual, or system configuration changes made by engineering users shall be recorded for security and traceability. This ensures that all program changes are logged.

Engineering users connected to the same network shall be able to perform all operations without restrictions, as if they were working directly on the same engineering server.

➤ **Security**

The operator interface shall support a dual-signature feature, ensuring that critical operations cannot be executed without the approval of a second party.

Security shall be fully integrated into the operator interface software to allow access to any part of the system for users with the appropriate security level. Security controls shall be managed on the server, and passwords shall be encrypted.

The software shall be able to group users according to their roles. Roles shall be clearly defined and configured based on privilege levels and facility areas.

The operator interface shall work seamlessly with Windows Firewall and support operator interface users defined within the Windows domain. Operator interface users shall be able to add, remove, and access operator interface roles through the Windows domain server without the need to modify the operator interface configuration. Credentials of authenticated Windows users shall be securely cached on the Operator Interface node to allow login even if the controller is not part of the domain. The current Windows user shall be able to log in to the Operator Interface session automatically without re-entering credentials. The internal operator interface shall also support the use of Windows users in the same manner.

A user request to shut down the system shall not result in system shutdown; instead, the system shall transition to a read-only security state.

The software shall support the definition of a minimum of 8 privilege levels. For all functions, the software shall verify that the logged-in user has the correct privilege level. If a user does not have the correct privilege level for a function or object, a message notifying the operator of insufficient rights shall be displayed.

Each graphical object shall be assignable to facility areas. It shall also define whether the object is authorized for operator access, visible, or trusted by a user with a specific privilege level in certain facility areas. Unauthorized access to operating systems shall be blocked. Windows shortcut keys such as Ctrl, Esc, Ctrl+Alt+Del, and similar combinations shall be disabled to prevent unauthorized access by the operator.

The software shall include a mechanism to restrict access to different areas of the facility for individual users or user groups. Unauthorized personnel shall be prevented from accessing the operating system.

➤ **Operator Screens**

The number of graphical representations to be used shall not be limited by the software.

Graphic pages shall be resizable according to the screen resolution without requiring recompilation, regardless of the resolution at which the pages were created or configured, or whether vector or bitmap graphics are used, and without closing the operator interface. Additionally, the window containing the graphic page shall be resizable, with all components automatically adjusting to the window dimensions.

The graphic system shall support screen resolutions up to 2000x2000 pixels and the connection of multiple monitors to a single computer. This support shall include opening different windows on one monitor or the same window across multiple monitors, depending on the configuration.

The graphic system shall support 32-bit (65 million) colors and allow the use of images from third-party packages, including animated visuals and color lighting applications, for the Operator Interface display.

The I/O server shall perform caching of data acquisition during read and write operations within a configurable time interval for each field device separately. This prevents unnecessary data reads and avoids affecting the bandwidth of field device communication. In other words, caching shall only perform reads if the same tag is required by multiple processors and/or subsystems.

Other graphic screen targets shall be selectable and automatically displayed based on the status of a tag. For example, a specific graphic screen shall be called automatically during an alarm.

Keyboard macros shall be configurable either for specific graphics or for all screens globally.

If multiple objects are blinking on a page, all of these objects shall blink simultaneously.

The software shall have appropriate capabilities for pop-up windows for trends, loops, equipment status pages, and other graphical displays. To avoid operator confusion, pop-up windows shall be configured to prevent multiple copies of the same window from opening simultaneously.

The software shall support opening up to 50 windows simultaneously. It shall also allow configuration of the number of windows to be opened simultaneously, ranging from 1 to 50.

Full-screen pages shall display the page name, time, and date, as well as details of the last three alarms.

Operational graphics shall consist of the following minimum dynamic objects:

- Straight Line
- Polyline
- Rectangles (including user-defined rounded corners)
- Ellipses
- Pie Slices
- Text
- Button with the latest window style
- 3D Depth
- Bitmaps

Dynamic objects shall possess the following features to modify the object based on tag or expression values:

- Horizontal, vertical, and rotational motion
- Level mapping for up, right, left, or backward for local and retrieved objects (including 3D bitmaps)
- Slanted Level Mapping
- ON-OFF, Multi-state, Integer, Threshold, or Gradient Color Changes
- Vertical or Horizontal Scaling
- Visibility
- Keyboard Input
- Click (mouse up, down, hold)
- Horizontal, Vertical, or Rotational Scroll Bar
- Security Access
- Disable Functionality
- Tooltip for Pop-up Windows

The above-mentioned features shall be usable simultaneously.

All types of color changes shall be supported:

- **ON-OFF:** The ON color and OFF color shall change based on the result of a condition.
- **Multi-State:** Up to 5 conditions shall display all possible Boolean results in defined colors.
- **Integer:** Each different integer shall be displayed with a defined color, supporting up to 256 colors.

- **Threshold:** A color defined based on multiple threshold expressions shall be displayed. For example, a color fill shall turn red in case of a fault, white at or below 100 RPM, and gray for values in between.
- **Gradient:** The color shall change within a range based on the analog tag value. The starting and ending colors shall be configurable.

Dynamic object graphics shall be groupable, and dynamic properties shall be applicable to the entire group rather than individual objects. Objects within the group shall retain their independent properties regardless of the grouping. For example, a hinged group component may have its own separate ON/OFF state, but the group shall move as a single entity. The properties of objects within the group shall be editable without breaking the group.

Each screen object shall support keyboard inputs for tag changes within the system. When the operator wishes to enter a value, the object shall be selected, and the operator's input shall be displayed in a tooltip adjacent to the object. The system shall verify whether the value is within the approved range before sending it to the field device. The value displayed or promoted by the object shall be the value read from the field rather than an unapproved value entered by the user.

The software shall support full-screen, live camera video streaming, and video playback from disk (MPEG, AVI) simultaneously without interruption. Screen window refresh rates shall remain unaffected.

In the event of communication loss with a specific I/O tag, the software shall provide a visual warning at the location where the data is displayed, indicating that the value is not valid.

The software shall be designed to allow modifications to graphics while the system is running. There shall be no need to shut down the system to make changes.

The operator interface software shall include ActiveX and allow for the implementation of ActiveX objects. The Operator Interface Software shall interact with ActiveX objects in the following ways:

- Dynamically modifying the properties of ActiveX objects based on field device tags.
- Dynamically changing properties through the high-level language of the Operator Interface Software.
- Triggering events in the Operator Interface Software based on the events of an ActiveX object.
- Reading ActiveX ratio values with the Operator Interface Software.

The user shall be able to navigate within the graphic system using various navigation methods. Switch keys shall be available to provide quick access to specific graphic pages.

On the Windows keyboard, shortcut keys shall be provided to allow quick access to specific graphic pages.

Windows-style navigation menus shall be included to provide access to all configured pages from other pages within the system.

The system shall be configured with problematic areas that shall transition to a detailed view of the facility and system (if applicable).

Windows-style navigation menus shall allow access to all configured pages from other pages within the system. These menus shall be configurable during operation and shall be saved and reloadable via the project backup/restore utility.

Trend and alarm group assignments shall remain configurable during operation and shall be stored as part of the project configuration, enabling their inclusion in the backup and restore functionality.

➤ **Alarms**

The number of supported alarms shall not be limited by the software. The local alarm archive shall be able to store at least 1 billion alarm summaries and retain them in memory for a minimum of 10 days, allowing retrieval through standard alarm monitoring screens.

Alarm events shall be written to log files and stored separately in periodic files for archiving purposes.

The software shall be integrated to ensure that an alarm acknowledged on the operator station is recognized on the primary and backup servers/PCs and appears as acknowledged on all client/operator stations.

The Operator Interface software shall support the use of event time stamps provided by the field control device for alarm events, rather than relying on its own time stamps, to ensure greater accuracy. The Operator Interface shall support millisecond-level accuracy for these time stamps.

➤ **Analog Alarms**

An alarm shall be configured for each analog tag, defining the relevant limits for the following requirements:

- Low-Low, Low, High, High-High, Deviation Low, Deviation High, Rate of Change

All analog alarm limits shall be adjustable without shutting down the system. Changes shall be automatically saved to ensure the correct alarm settings when the system restarts.

The use of deadband values in analog alarms shall be supported.

➤ **Digital Alarms**

An alarm shall be assigned for each state of every digital tag, including:

- Tag ON
- Tag OFF

Alarms shall be configurable for multiple digital tag combinations, and each state combination shall be configurable as an alarm output. Additionally, if multiple digital alarms are activated in a single alarm version and another state changes, a new alarm shall be generated.

Two-State Alarm		Three-State Alarm		
Tag 1 State	Tag 2 State	Tag 1 State	Tag 2 State	Tag 3 State
OFF	OFF	OFF	OFF	OFF
OFF	ON	OFF	OFF	ON
ON	OFF	OFF	ON	OFF

ON	ON	OFF	ON	ON
		ON	OFF	OFF
		ON	OFF	ON
		ON	ON	OFF
		ON	ON	ON

➤ Alarm Display

All alarms and/or the most recent alarms shall be displayed or acknowledged on any page with appropriate priorities.

The software shall support multiple alarm priority levels or categories. The priority of an alarm shall be indicated by the text type in the alarm message on the screen. Color codes for prioritized alarm messages shall be configurable by engineers. The system shall support up to 10,000 alarm categories and 255 alarm priorities.

Each alarm category shall have a configurable audible alert feature. This configuration shall be applicable across all stations. Alarm sound alerts shall be delivered via internal or external speakers.

The software shall include a standard alarm display page configured for the project. Transitions on the alarm page shall allow for alarm receipt and deactivation.

The alarm display page shall show the following information for each alarm:

- Alarm Tag Name
- Alarm Description
- Tag Value
- Trip Limit
- Alarm Status (Disabled, Acknowledged, Unacknowledged)
- Alarm Category
- Alarm Priority
- Date and Time in International Format
- Priority
- Category
- Operator Comments
- Tag Value or Calculated Result

The alarms shall be displayed with different text types and colors according to the alarm status (including blinking colors).

The alarm screen shall support proportional and fixed text types, and all displayed alarm fields shall be properly aligned.

Alarms shall be disabled individually or in bulk based on the page or alarm category. When an alarm is disabled, it shall appear on separate disabled alarm pages, enabling system users to easily identify which alarms have been disabled.

Alarms present in all stations within the system shall be acknowledged individually or by category and page.

Operator comments shall be added to alarms either upon acknowledgment or later using the software. These comments shall be displayed alongside the alarms when clicked.

All graphic screens shall be viewable during an alarm condition, or the appearance of graphic objects shall dynamically change based on the alarm state, such as ON, OFF, acknowledged, communication failure, or disabled.

The alarm screen shall include a mechanism for dynamically filtering alarms by status, type, area, category, and priority, including sub-status for analog inputs, as well as alarm tag, alarm name, alarm description, and date/time range for operators. Additionally, custom filters defined during development for each alarm shall provide quick access for operators during operations.

➤ **Alarm Sorting**

The alarm screens shall support sorting based on one or more alarm lists without any grouping limitations (ascending or descending order). Sorting shall be possible by clicking on the headers in the alarm list, such as:

- Tag
- Name
- Category
- Area
- Priority
- Status
- ON Time
- OFF Time
- Acknowledgment Time
- Alarm Delay

The duration for which an alarm remains active before notifying the operator shall be configurable. The timestamp available on the alarm shall represent the time the alarm was activated, not the completion time of the delay.

➤ **Alarm Logging**

Different alarm logging methods shall be configurable for each alarm category. It shall be possible to specify whether an alarm is logged when its state changes to ON, OFF, or Acknowledged.

Alarms shall be logged to a printer, disk file, or database, along with text, time, and date. Alarms shall be printed or filed in a user-configurable format.

The operator interface software shall provide logging capabilities to all users on the network. The software shall also be able to redirect printing tasks to another printer when the system is online.

➤ **Trends**

The number of trends to be collected shall not be limited by the software.

Trend data shall be recordable with sampling periods configurable between 1 millisecond and 24 hours using the software. Trend data shall be configurable with file count, file size, sampling period, file location, priority, and trend tag, and it shall be stored in a circular file system along with area information. File names and paths shall support up to 255 characters in length.

Historical data for up to one year shall be stored in each file with a 3-second sampling interval. Files shall be combined to generate configurable historical data. A minimum of 3 years of data shall be stored in the historical data archive with a 10-second sampling interval.

Trend data shall be transparently retrieved from the historical data archive regardless of the archive file in which the data resides or the date the data was acquired. Trends shall be accessible online through operator queries without requiring backup or reloading of historical data files.

Trend data recording shall be executed periodically (e.g., once per sampling period) or based on events such as a callback when specific conditions are met. The storage of trend data shall be initiated or stopped based on various conditions such as state and time or manually by the operator.

Trend values shall be stored with floating-point resolution and shall not require rescaling for retrieval or display. This ensures accuracy without deviation and shall be configurable for new scaling ranges without compromising the integrity of the tag storage pool.

Trend graphs shall display time on a linear, continuous vertical, or horizontal axis, with the monitored trend values on the corresponding perpendicular axis. When multiple tags are plotted, the resolution of each graph shall be within 0.1% of the full scale. Each tag's graph and associated information shall be displayed in a distinct color.

The trend view shall support both analog and digital pens on the same graph. Trend pen assignments shall be definable and accessible while the software is running, allowing the easy creation and management of frequently used trend groups.

Each trend graph shall display up to 32 pens, configured to sample data at a 1-second interval and report up to 10,000 points for user-defined time intervals.

The graph shall be able to display the entire trend history for a specific pen group on a single screen.

Multiple pens shall be creatable over several time periods. Each pen shall display separate ranges and engineering units. Each pen shall be independent of other pens displayed on the page and shall be scalable for display purposes.

Using the software, the user shall be able to navigate forward or backward in a specific time range and read the exact value of a tag by selecting a point on the table. The system shall allow monitoring of historical data by moving backward within the desired time frame and display it, along with all necessary information, with an average rendering speed of 1 second.

A sliding bar shall be available on the trend screen to display the trend date, time, and tag value when intersecting with trend tags.

The trend screen shall be dynamic, scrollable over time, and capable of redisplaying. In addition to current data, historical data shall also be scrollable. To facilitate detailed analysis of specific historical data, the auto-scroll feature shall be pausable. Pens within the same window shall be separable on time and range axes.

The user shall be able to switch between local time and UTC time on the trend screen. When in local time, the transition to daylight saving time shall be clearly represented on the trend screen.

The software shall include zoom and pan functionality for the trend tag range and time axis. Zooming shall allow the operator to compress and expand the axis range, and panning shall allow the operator to move to the beginning of the axis. The software shall permit the user to define a zoom area by dragging the mouse within the axis.

The software shall provide minimum, maximum, and average summaries for all displayed analog pens.

The trends stored based on events rather than periodically shall be viewable along the time axis or based on the number of events.

The software shall be capable of monitoring up to 32 tags on a single trend screen.

Tags shall be distinguishable by different colors. Raw data and time/date values shall be retrievable from the screen, a single trend or trend group, or through detailed analysis.

It shall be possible to transfer trends and historical data to disk files or external databases. The section of the trend to be transferred shall be definable by clicking with the mouse or dragging the cursor within the trend. Data shall be exportable in .csv, .dbf, .xml, or .txt file formats. Any part of the historical data shall be transferable via ODBC, DDE, DBF, .xml, .csv, and .txt formats.

The software shall allow printing trends based on historical data shown in trend plotters. The software shall have the capability to output trends. The trend printing function shall utilize objects during printing instead of bitmaps. Trend outputs shall include engineering units and ranges for each trend, trend grid, and trend period. For monochrome printers (e.g., dot, line, solid, etc.), specific line styles shall be defined, and for color printers, different colors shall be assigned.

Each logged-in operator or user shall have access to fully customized trend pages. These pages shall be customizable online by each user using drag-and-drop methods or standard configuration methods. All configurations in a specific configuration environment shall be usable by the user to modify trend graphics while the system is running. These shall include minimum pen color, pen scaling, grid, and trend tag assignments for each trend page.

➤ **Historical Analyses**

The alarm tag shall provide detailed information about any point selected by the operator and also indicate the active/passive/acknowledged status of the alarm tag. For example, conditions such as high-level and deviation states shall be displayed based on user preferences.

Alarm tags shall be scrollable, and alarm statuses shall be viewable in real time. The operator shall be able to select which alarm tags to monitor in order to retrieve data for a specific process unit or historical data.

Alarm tags shall display historical states on the screen, aligned with the trend tag history, while maintaining access to historical data. For historical data viewing, the operator shall make a single

request for a specific date and time, and all tags, including alarm and trend tags, shall be configured to retrieve data for the specified time range.

It shall be possible to configure and save trend graphs in a file to adjust/configure them within the graphical screen interface and reload these configurations. The graphical interface shall allow trend data to be exported to a .csv file.

Real-time graphs shall be viewable for various tag and alarm tag data. For real-time tag data (instantaneous trends), it shall be possible to display temporary graphs without needing to adjust previously retrieved historical data.

➤ **Reporting Software (Dashboard)**

During commissioning and operation, the reporting software, used for measuring and analysing values, shall be a separate software package.

SCADA data shall be compatible with SQL databases or exportable in CSV and XML formats, allowing the reporting software to process and analyse this data. SCADA is responsible for providing its data to the reporting software either directly or indirectly by recording it into the SQL database. The reporting software can either be a standalone application or an additional tab within the SCADA software. (Reporting software prepared using Excel or Microsoft Office programs shall not be accepted.)

The expected reporting content from this software includes:

Fault Maintenance Management, Service Management, Spare Parts Management, Document Management, and Energy Consumption. Additionally, for the tags monitored/managed by the SCADA, Energy Automation, and Lighting Automation systems, as specified by the Employer's Representative/Employer, it shall allow listing and graphing at adjustable intervals. It shall also enable exporting outputs in xls, xml, doc, and pdf formats. Furthermore, the software shall create a Visual Managerial Summary on the main dashboard screen.

➤ **Reports**

The operator interface shall independently perform report creation, scheduling, and management activities without requiring third-party software packages. Apart from high-speed collectors, long-term data storage or collectors shall not be required to send data to the operator interface for reporting purposes. It shall not be necessary to program in the controller subsystems. The operator interface shall include the necessary functions for these purposes, and triggering shall not be required for activation.

Reports shall be scheduled using the software, either periodically, as per the operator's request, or when an event occurs, at specific times of the day, or on a periodic basis (e.g., alarm-conditioned or collectively at the end of a task).

The software shall allow all reports to be displayed with user-defined text types and colours.

The software shall support defining reports based on archived data. Reporting by a single point over time (online and historical data) and interval-based reporting shall permit an unlimited number of tags to be reported within a single report.

➤ **Documentation**

Comprehensive documentation related to configuration and system development for the software shall be maintained online.

The technical manuals shall include commissioning and installation guides, user manuals, and advanced-level guides. A detailed field device manual covering all protocols and routers shall be available in the online documentation.

➤ **Online Modifications**

It shall be possible to add, modify, and refresh alarms, trends, and reports online without restarting the server.

The system shall allow for changes to alarm, trend, and report servers without requiring a server restart. New configurations shall be added, recompiled, and modified by reloading only the relevant server.

Only the changes shall be reloaded. Alarms, trends, or unchanged configurations shall continue to operate without interruption.

➤ **Operator Panel (HMI)**

Operator panels shall have a minimum screen size of 15 inches and display all analogue and digital data, including the colour scheme for the group of monitoring stations to which they are connected. They shall be mounted on control panels.

Operator panels shall comply with certifications such as **UL 508**, **CSA C22.2 (#142)**, **UL1604**, **ANSI/ISA 12.12.01**, and **CSA C22.2 (#213)**.

TCP/IP communication shall be maintained as standard.

The operator panel software shall support a minimum of **Microsoft Windows 7 64-bit**. Alarms generated within the system shall be stored in memory and printable when required. The HMI software shall allow for coding to create custom functions. The screen shall have **QVGA resolution** and support a minimum of **65,000 colours**. The operator panel shall support continuous and long-term operation, with a minimum display lifespan of **50,000 hours**, and the backlighting shall be of the LED type. The operator screen view shall be accessible remotely via a web browser and controllable using an IP address (protected by IP filtering) if required.

The system shall support sending emails and attaching files for information regarding faults or maintenance.

The operator panel shall have at least one **RS 485/232 RJ45 serial port**, one **10/100 BaseT RJ45 Ethernet port**, and a **mini-USB Device port**, in addition to one **USB Host V2.0 port**.

The recipe application shall be standardised within the software. Functions shall be adjustable and configurable to meet specific requirements.

The software shall include simulation capabilities, allowing the application to be tested without the HMI. Furthermore, it shall support simulation without requiring a controller via online simulation.

Historical data regarding requested changes shall be stored in the software memory. Additionally, memory capacity shall be expandable using a compact flash card or USB memory stick.

If required, a mouse, keyboard, or barcode reader shall be connectable via the USB port. Panels shall share data with each other seamlessly without requiring additional processes. Operator panels shall be viewable and controllable using a smartphone or tablet PC via a wireless network or 3G communication.

The illuminated columns used in the system shall be connected to the HMI via USB and programmable through the HMI as needed.

➤ **SCADA Training**

The Contractor shall provide comprehensive training services to inform the Employer's Administrative Managers, engineering team, and field personnel (referred to as the Final Recipients). Prior to commencing training activities, the Contractor shall prepare a document containing details such as the programme content, training activities, the number of participants, prerequisite knowledge required of participants, the start date, and the duration of the training. This document shall be submitted to the Employer for approval.

Unless otherwise stated, training activities shall commence after the provisional acceptance and shall be completed within the first year following the provisional acceptance. The Contractor shall also explicitly state the start date and duration of the training activities in the training programme submitted for the Employer's Representative's approval.

The Contractor shall be responsible for providing and bearing the costs of resources such as documents, audio and visual equipment, and other similar materials required for the training activities. Furthermore, with the Employer's Representative's approval, the Contractor shall use materials, hardware, or software to be supplied by the Contractor according to the definitions specified in this specification or as agreed upon with the Final Recipients.

The Contractor shall prepare a training programme covering all hardware and software components of the SCADA system. The training services shall include different levels of course groups, considering who will be responsible for or use these hardware and software components. In addition to the aforementioned training service, the Contractor shall also conduct a course for Final Recipient personnel who will not attend the formal training sessions to ensure they acquire adequate knowledge about the SCADA system.

The course content for non-technical personnel shall be carefully designed to include general information about the SCADA system, excluding technical details. The Contractor shall prepare the content of this course in advance and submit it to the Employer's Representative for approval before the training service is provided.

To assist the Contractor in developing the training programme, sample definitions of course groups shall be provided. While the Contractor shall utilise these definitions, they shall not be limited to them and shall design the training programme they deem most suitable for the SCADA system to be installed. Although the Contractor shall prepare the training programme they find most appropriate for the system, the content shall at least provide customised preparation for the different roles of personnel who will use the system.

➤ **System Engineer Training**

Subject	:	The structure of computer systems, peripheral hardware components, interface hardware components (computers, workstations, printers, etc.), and their interconnections. General information on data communications, including LAN, wide area networks (Wide Area Network - WAN), data communication protocols, communication network structures, and the data communication protocols in use. General information on SCADA software, an introduction to the fundamental functions of SCADA software (e.g., collecting and interpreting data from PLCs, alarm testing and notification, archiving collected data, etc.), usage of the software, SCADA software configuration, and modifications or additions to the configuration. General information on field PLC devices, PLC hardware, PLC software, and the communication medium between PLCs and the control centre. Information on instrumentation hardware components, sensors, transmitters, and transducers, including their operating principles, calibration processes, and connections to PLCs. Detailed technical information for system engineers responsible for the technical operation of the Management System. This includes hardware components within the system and the software components operating on them. The system engineers shall be equipped with the knowledge required to handle changes to the system's operational logic or to address technical issues effectively.
Objective	:	Providing detailed technical information to system engineers responsible for the technical operation of the Management System regarding the hardware components within the system and the software components operating on these devices. The training shall ensure that system engineers are equipped with the knowledge and expertise necessary to address changes in the operational logic of the system or to resolve any technical issues that may arise.
Duration	:	Approximately 2 weeks.
Participants (Staff)	:	Unit technicians and supervisors.
Notes	:	This training is specifically designed for system engineers who will be technically responsible for the SCADA system. Participants shall possess basic prerequisite knowledge of computer hardware and software.

➤ **Technician Training**

Subject	:	General information on PLCs and an introduction to the hardware components that constitute a PLC. The functional structure of PLCs, their operating principles, connections with instrumentation, and the data communication logic with the central system. Information on PLC software components to be used for testing and maintenance, including instructions on their usage, understanding fault conditions, and troubleshooting. Details on data communication networks, communication protocols, and troubleshooting procedures in case of faults. The general characteristics and operating principles of instrumentation hardware components. Information on periodic maintenance settings and calibration procedures. Practical applications for identifying faulty hardware and resolving issues.
Objective	:	Providing the necessary information for performing maintenance activities on these hardware components; equipping technicians with the knowledge required to intervene in and resolve faults that may occur; and enabling these technicians to carry out periodic adjustments or calibration procedures for specific hardware components. This information shall be directed towards technicians responsible for the maintenance of hardware components within the SCADA system, including communication hardware facilitating the connection between PLCs and the control centre, measurement and control sensors, transmitters, transducers, and similar devices.
Duration	:	Approximately 2 weeks.
Participants (Staff)	:	Up to 10 technicians.
Notes	:	This training is intended for technicians who will be responsible for the maintenance of hardware components within the SCADA system. Participants shall possess sufficient prior knowledge in areas such as electronics, communication, and instrumentation and should be familiar with basic electronic workshop practices.

➤ **Operator Training**

Subject	:	Introduction to the hardware components present in the facility (e.g., computers, printers, etc.). An introduction to and usage of hardware components that shall be utilised for interaction with SCADA software. An overview of SCADA software, including its functionalities and usage. Monitoring system operations on computer screens. Detection of alarms occurring within the system and performing the necessary actions in case of an alarm.
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		Controlling the system and monitoring the results.
Objective	:	Providing information about all measurements and controls provided by the SCADA system to the operators who will be responsible for the operation and control of the facility; thus, operators can easily monitor the system and intervene in the system when necessary.
Duration	:	Approximately 2 weeks.
Participants (Staff)	:	Up to 10 technicians.
Notes	:	This training is for operators who will be responsible for operating the facility using the SCADA System as a tool. The personnel participating in the training do not need to have prior knowledge of computer use, but they shall have sufficient prior knowledge of the water network and its operation.

➤ **Executive Training**

Subject	:	Introduction of hardware (computer, printer etc.) items in the facility. Introduction to hardware items that shall be used to interact with SCADA software and their use. Introduction to SCADA software, software functions and uses. Monitoring the system operating logic on computer screens. Obtaining statistical reports or images from the collected data that shall assist management activities. Controlling the system and monitoring its results in some important situations that cannot be left to the operators' decision.
Objective	:	Providing information about all measurements and controls provided by the SCADA System to the managers who will supervise the operation of the facility when necessary; to ensure that the managers can easily monitor the system and intervene in the system when necessary.
Duration	:	Approximately 1 week.
Participants (Staff)	:	Up to 10 Supervisors.
Notes	:	This training is for managers who will supervise the operation of the facility through the SCADA System when necessary. The personnel participating in the training do not need to have prior knowledge of computer use, but they shall have sufficient prior knowledge of the water network and its operation.

2.6.2.4. Communication System

A Monitoring-Control Room and Client system shall be installed in the system to be built within the scope of this contract. At this point, the mini PCs that shall serve the Clients shall connect to the Ethernet Switches located at the nearest cable collection point via Ethernet. The Ethernet Switches shall also be connected to the Central Cabinet with a fiber optic cable.

The Fiber Cable shall be installed as 2 separate lines and each line shall be installed as a Central Single Tube 24 fiber 1x24 9/125 SM Armored F/O Cable. The fiber line should be combined at both ends to form a closed ring system. At this point, the Ethernet Switch system should be converted to Fiber Optic/CAT Converter again. The Contractor should install rack cabinets, industrial type switches and necessary systems in each Unit and Administrative Building together with these.

The Employer's Intranet network shall be used throughout the system and a network that shall not allow security breaches should be established by BTK during the contract period and/or later. The infrastructure should be planned as a completely fiber optic system, considering additional data processing systems that shall/may enter the system in the future. GSM, RF or Point to Point (free band) systems should not be planned.

➤ **Fiber Optic Cabling**

Fiber Optic Cable infrastructure shall be established with 2 separate lines and each line shall be installed with F/O Cable. The fiber line should merge at both ends to form a closed ring system. In order to make the FO connection of the existing Treatment Plant in the future, the connection connector shall be left with the 2-point Fiber cables terminated.

In addition to these, the Contractor shall install rack cabinets, industrial type switches and necessary systems in each Unit and Administrative Building.

Fiber optic cables shall comply with ANSI/TIA/EIA-568B.3, ISO/IEC 11801 and CENELEC EN50173 standards.

Fiber optic cables, patch panels, pigtails and adapters to be used shall be of the same brand. At the end of the installation, a system performance certificate of at least 25 years shall be issued by the manufacturer.

After the cable termination process, all ends shall be tested and the test results shall be delivered to the Employer/Employer's Representative in digital environment.

All cables shall be pulled in one piece from end to end. There shall be no additions in between.

Cables; Suitable spiral pipes shall be used at the transition points in the passages of walls, concrete, etc., and no bare wall passage shall be made.

Any breakage, cutting, etc. that occurs during cable pulling. The processes shall be repaired and restored at the end of the cable pulling.

The optical cable characteristics of the fibers should be as follows:

- Fiber Optic cable shall be steel armored against rodents.
- The operating temperature range of Fiber Optic cables shall be –20 to +80 Celsius.
- Fiber optic cables shall have water-resistant tube filler gel
- Maximum optical attenuation: at 1310nm: 0.38 db/km, at 1550 nm: 0.25 db/km.
- The color of each core fiber should be different from the other cores.
- The cable outer sheath shall be protected against friction and strain.

The central tube where the fibers shall be placed is thixotropic gel filled, and the tube is covered with water-blocking glass fiber material with a thickness of 1.5 mm nom. It should be enclosed in the LSZH sheath with thickness.

The short-term tensile strength of the cable shall be 1000 N max and the long-term tensile strength shall be 500 N max.

The impact resistance of the cable shall be min. 3000N.

Fiber patch panels should provide the following features.

24 port SC patch panels to be used for fiber cable termination should be 19" wide

- The front of the patch panels should be modular. 1U panels shall be manufactured in such a way that 3 independent front modules can be installed. The front module shall be capable of attaching a 4-port SC duplex adapter. Different connectors, including UTP jacks, should be able to be installed on the front panels if needed
- Rack type Patch panels should be black in color, metal in structure, and should be sliding type in a way that can provide ease of workmanship and termination within the panel.
- Along with the patch panel, the splice protector tubes and splice cassettes required for fusion termination shall also be supplied by the same manufacturer.
- Fusion attachments should be placed in 24-port splice cassettes that can be placed on top of each other in the patch panel.
- Records that make it easy to fix the cable at the rear entrance of the panel should be supplied with the panel. A special metal nail structure should be on the panel base, which allows it to be fixed with the help of a cable tie inside the panel.

Fiber optic adapters and pigtails shall meet the following features:

- Each fiber cable core shall be terminated with 1 meter long SM pigtails of SC type.
- The connectors at the end of the pigtails shall have ceramic ferrule.
- Fiber optic connectors shall support 500 plug-ins and shall be able to operate in the temperature range of -20/+80 degrees.
- Adapters to be used in patch panels shall be of SC Duplex structure.
- The sleeve materials of SC Duplex adapters shall be phosphor bronze.
- SC duplex adapters shall be able to operate in the temperature range of -20/+80 degrees.
- Pigtails and adapters shall be products of the same manufacturer as the cable and patch panel.
- Fiber optic adapters and pig tails shall meet the following features:
 - Each fiber cable core shall be terminated with 1 meter long SM pigtails of SC type.
 - The connectors at the end of the pigtails shall have ceramic ferrule.
 - Fiber optic connectors shall support 500 plug-ins and shall be able to operate in the temperature range of -20/+80 degrees.

- The adapters to be used in patch panels shall be of SC Duplex structure.
- The sleeve materials of SC Duplex adapters shall be phosphor bronze.
- SC duplex adapters shall be able to operate in the temperature range of -20/+80 degrees.
- Pigtails and adapters shall be products of the same manufacturer as the cable and patch panel.

Fiber optic patch cables shall meet the following features:

- The fiber optic patch cords to be offered shall be single mode, dual (duplex), SC-LC structure.
- Fiber optic patch cords shall be factory-made.
- Fiber patch cords shall be the same brand as all other fiber materials.
- Patch cord connectors shall be ceramic.
- SC and LC connectors shall be attached together with original clips in duplex.
- Operating temperature: -20/+80 C.
- Fiber optic patch cables shall support 500 plug-and-unplugging
- Patch cables shall have an outer diameter of 2.0 mm ± 0.2 mm.
- 3 meters of single mode fiber patch cables shall be delivered to the Employer/Employer's Representative by the contractor as many as the number of fiber ports in the active devices to be used during the design-build phase.

➤ **Copper Wiring**

Copper cables shall meet the following features;

- Cat7A SFTP type cable shall be used. The cable shall comply with the performance specifications specified in Category 7A IEC 61156-5 (ISO/IEC-11801 2nd Edition) standard. This situation shall be certified by independent test organization ETL.
- In order to minimize signal interference between the spiral pairs in the cable to be used, each pair shall be foiled.
- The cable conductor shall be bare and solid copper.
- The cable outer sheath material shall comply with FR LS0H and IEC 60332-1 standards.
- The cable conductor shall be at least 24 AWG.
- There shall be 4 spiral pairs in the cable.
- The cable shall support communication at 500MHz frequency in 100 meters and the ACR value shall be positive at this frequency.
- The cable shall allow communication up to 10 Gbps.
- The characteristic impedance of the cable shall be 100 ± 6 Ohm.

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- The cable shall allow communication up to 10 Gbps.
- The characteristic impedance of the cable shall be 100 +/- 6 Ohm.

Copper cables shall never be pulled out in the open as bare. Cable channels of appropriate dimensions shall be used. In places where cable channels are not possible, appropriate solutions shall be provided with the approval of the Employer/Employer's Representative.

Keystone jacks that meet the cable standards used by the cable manufacturer shall be used in cable terminations.

Connections between patch panels and active devices shall be provided by the contractor with patch cables.

Patch panels shall meet the following features:

- Patch panels shall be empty, modular and completely metal, with a smart structure that shall complete grounding.
- Jacks used in patch panels shall have at least one independent laboratory (ETL, UL, 3P) test certificate regarding their compliance with ANSI/TIA/EIA-568.C-2 standard. This status shall be visible online on the relevant laboratory's website.
- Patch panels shall be 1U/2U high with 24/48 ports.
- Metal bodies of keystone jacks used in patch panels shall be connected to the panel with stainless metal tabs to ensure grounding continuity.
- The back of the panel shall have a suitable structure to ensure cables can be connected to the patch panel.

Patch cables shall meet the following features:

- The patch cords shall comply with the ANSI/EIA/TIA 568-C.2 Cat6A specifications.
- The patch cords shall have an S/FTP structure.
- The patch cords shall possess a certification from an independent testing organization confirming their compliance with the ANSI/TIA/EIA-568-C.2 Cat6A standard.

- The patch cords shall be factory terminated.
- The patch cords shall be available in lengths of 1/3/5 meters.

The cables shall be terminated at the user side either on channel outlets or wall outlets.

The data outlets shall be of keystone size and RJ-45 type, supporting both T568A and T568B wiring configurations.

After the cables are terminated in the keystone jacks, the IDC blocks shall be covered with dust caps to protect against external factors such as dust, moisture, etc.

The data outlets shall have a spring-loaded dust cap and be of 22.5x45 or 45x45 size.

There shall be transparent label holders on the outlets for labeling purposes.

The patch cables shall be labeled in such a way that, when viewed from one end, it is clearly evident which device and port the other end is connected to.

After the cable termination process, all ends shall be tested, and the test results shall be submitted to the Authority in digital format.

➤ **Edge Switch – TYPE 1**

The switch should be capable of operating independently, but it shall also support stacking up to at least 4 units. If a license is required for this, it shall be included in the offer.

For stacking the switches, 0.5-meter long stacking cables required for two switches shall be delivered together with the products.

The switch shall be mountable in a 19" standard rack. The necessary mounting parts shall be provided free of charge. The switch height shall be 1U.

The switch should operate in a temperature range of at least 0-50°C and a humidity range of at least 10%-90%, and it shall be able to be stored in a temperature range of at least -40 ~+70°C.

The switch shall have an internal redundant power supply, and the power supplies should be hot-swappable, meaning they can be removed and replaced while the device is operational.

The switch shall have at least 48 10/100/1000 BaseT ports and at least 4 1GE/10GE SFP+ uplink ports, all of which shall be actively usable simultaneously. All SFP+ ports shall be delivered filled with the manufacturer's original 10G LR SFP+ modules.

The switch should have at least 176 Gbps switching capacity and at least 130 Mpps packet forwarding performance. The switching shall be hardware-based, and the switch should be capable of providing the specified port speeds at wire speed (non-blocking).

The switch shall have a MAC address table capacity of at least 16,000 entries.

The switch shall support at least 4094 active 802.1q VLANs.

The switch shall support Jumbo frames of at least 9198 bytes in length.

The switch shall support the IEEE 802.1ab LLDP (Link Layer Discovery Protocol) protocol.

The switch shall support CDP or an equivalent protocol.

The switch shall support static IP routing.

The switch shall support hardware-based IPv6 routing.

The switch shall have the ability to define PBR (Policy-Based Routing).

The switch shall support the protocols RIP, EIGRP, HSRP, IP SLA, and OSPF. If a license is required for this, it shall be added to the offer.

Native VLAN and management VLAN shall be configurable on a per-port basis. The switch shall support Guest VLAN. The switch shall support Voice VLAN. IP phones and PCs should be able to connect to the switch through a single port, where the IP phone shall be assigned to an IEEE 802.1q VLAN, and the PC shall exchange traffic over the native VLAN.

The switch shall support MUX VLAN or an equivalent feature. The switch shall support the GVRP protocol. The switch shall support 1:1, 2:2, or N:1 VLAN mapping. The switch shall support the creation or deletion of one or more VLANs with a single command.

The switch shall be capable of understanding the priority values of packets classified with QoS 802.1p and, when necessary, changing these priority values. The switch shall be able to perform remarking on internal/external VLAN tags, 802.1p priority, DSCP priority, local precedence, IP precedence, and source/target MAC addresses.

Each port on the switch shall have at least 8 priority queues. The queue structures shall support "Priority Queueing" and "Weighted Round Robin" algorithms.

The switch shall support QoS.

The switch shall be capable of filtering packets based on the following criteria: specified target/source IP address, TCP source/target port, UDP source/target port, protocol type, DSCP, ToS, IP Precedence, Fragmentation flag, ICMP type, ICMP code, time range, logging field values, and VLAN-based ACLs.

The switch shall support CAR algorithms bidirectionally on interfaces. This shall allow traffic of the desired type to be limited up to 64Kbps.

The switch shall be able to mirror traffic from one port to another on the same or different module on the switch. (Port mirroring). The switch shall be able to mirror traffic from one port to a port on another switch. The switch shall be able to mirror traffic from multiple ports to another port simultaneously. (N to 1 port mirroring)

The switch shall support at least 1,000 multicast groups. The switch shall support IGMP Proxy, IGMP Snooping v1/v2/v3. The switch shall support MLD Snooping v1/v2.

The switch shall support BPDU Tunnel and BPDU Guard features.

The switch shall support port isolation for Layer 2 and Layer 3 services.

The switch shall support DHCP Server, Client, and Relay. The switch shall support DHCP Snooping. The switch shall support DHCP option82 and be able to modify the option82 string.

The switch shall support IEEE 802.3ad LACP protocol. At least 20 different LAGs can be defined, each having at least 8 ports.

The switch shall support IEEE Spanning Tree Protocol (STP) 802.1d, IEEE Rapid Spanning Tree Protocol (RSTP) 802.1w, and IEEE Multiple Spanning Tree Protocol (MSTP) 802.1s protocols. The switch shall support 48 simultaneous MSTP instances.

The switch shall be able to apply rate-limiting on broadcast and multicast traffic and suppress broadcast/multicast/unknown unicast traffic.

The switch shall allow setting a limit for the number of learnable MAC addresses. MAC learning capability shall be able to be disabled. The switch shall be able to drop packets with an "invalid MAC address."

The switch shall have security features such as IP Source Guard, Unicast Reverse Path Forwarding, Dynamic ARP Inspection, Static ARP Inspection, and Egress ARP Inspection.

The switch shall support MAC address authentication. A port's access shall be stopped if the authentication attempt fails three times. The switch shall support authentication based on a combination of 802.1x and MAC addresses.

The switch shall support simultaneous authentication for multiple devices connecting through a NAC-compliant port. Only devices with authenticated MAC addresses should be granted access, and devices that fail authentication shall have their access stopped. The switch shall ensure that VLAN and ACL rules are assigned to ports of devices that pass 802.1x and MAC address authentication, using RADIUS.

The switch shall support RADIUS.

The switch shall support TDR (Time Domain Reflectometry) or an equivalent technology to check cable statuses.

The switch shall support the RMON (RFC 2819) standard and at least 5 RMON groups (statistics, log, alarms, events, performance).

The switch's console port shall be manageable via Telnet/SSHv2, SNMP v1/v2/v3, HTTP, and HTTPS. The switch shall allow different access permission levels to be defined for different operators.

➤ **Edge Switch – TYPE 2**

The switch shall be capable of operating independently, but it shall also support stacking up to at least 4 units. If a license is required for this, it shall be included in the offer.

For stacking the switches, 0.5-meter long stacking cables required for two switches shall be delivered together with the products.

The switch shall be mountable in a 19" standard rack. The necessary mounting parts shall be provided free of charge. The switch height shall be 1U.

The switch should operate in a temperature range of at least 0-50°C and a humidity range of at least 10%-90%, and it shall be able to be stored in a temperature range of at least -40 ~+70°C.

The switch shall have an internal redundant power supply, and the power supplies should be hot-swappable, meaning they can be removed and replaced while the device is operational.

The switch shall have at least 24 10/100/1000 BaseT ports and at least 4 1GE/10GE SFP+ uplink ports, all of which shall be actively usable simultaneously. All SFP+ ports shall be delivered filled with the manufacturer's original 10G LR SFP+ modules.

The switch should have at least 128 Gbps switching capacity and at least 95 Mpps packet forwarding performance. The switching shall be hardware-based, and the switch should be capable of providing the specified port speeds at wire speed (non-blocking).

The switch shall have a MAC address table capacity of at least 16,000 entries.

The switch shall support at least 4094 active 802.1q VLANs.

The switch shall support Jumbo frames of at least 9198 bytes in length.

The switch shall support the IEEE 802.1ab LLDP (Link Layer Discovery Protocol) protocol.

The switch shall support CDP or an equivalent protocol.

The switch shall support static IP routing.

The switch shall support hardware-based IPv6 routing.

The switch shall have the ability to define PBR (Policy-Based Routing).

The switch shall support the protocols RIP, EIGRP, HSRP, IP SLA, and OSPF. If a license is required for this, it shall be added to the offer.

Native VLAN and management VLAN shall be configurable on a per-port basis. The switch shall support Guest VLAN. The switch shall support Voice VLAN. IP phones and PCs should be able to connect to the switch through a single port, where the IP phone shall be assigned to an IEEE 802.1q VLAN, and the PC shall exchange traffic over the native VLAN.

The switch shall support MUX VLAN or an equivalent feature. The switch shall support the GVRP protocol. The switch shall support 1:1, 2:2, or N:1 VLAN mapping. The switch shall support the creation or deletion of one or more VLANs with a single command.

The switch shall be capable of understanding the priority values of packets classified with QoS 802.1p and, when necessary, changing these priority values. The switch shall be able to perform remarking on internal/external VLAN tags, 802.1p priority, DSCP priority, local precedence, IP precedence, and source/target MAC addresses.

Each port on the switch shall have at least 8 priority queues. The queue structures shall support "Priority Queueing" and "Weighted Round Robin" algorithms.

The switch shall support QoS.

The switch shall be capable of filtering packets based on the following criteria: specified target/source IP address, TCP source/target port, UDP source/target port, protocol type, DSCP, ToS, IP Precedence, Fragmentation flag, ICMP type, ICMP code, time range, logging field values, and VLAN-based ACLs.

The switch shall support CAR algorithms bidirectionally on interfaces. This shall allow traffic of the desired type to be limited up to 64Kbps.

The switch shall be able to mirror traffic from one port to another on the same or different module on the switch. (Port mirroring). The switch shall be able to mirror traffic from one port to a port on another switch. The switch shall be able to mirror traffic from multiple ports to another port simultaneously. (N to 1 port mirroring)

The switch shall support at least 1,000 multicast groups. The switch shall support IGMP Proxy, IGMP Snooping v1/v2/v3. The switch shall support MLD Snooping v1/v2.

The switch shall support BPDU Tunnel and BPDU Guard features.

The switch shall support port isolation for Layer 2 and Layer 3 services.

The switch shall support DHCP Server, Client, and Relay. The switch shall support DHCP Snooping. The switch shall support DHCP option82 and be able to modify the option82 string.

The switch shall support IEEE 802.3ad LACP protocol. At least 20 different LAGs can be defined, each having at least 8 ports.

The switch shall support IEEE Spanning Tree Protocol (STP) 802.1d, IEEE Rapid Spanning Tree Protocol (RSTP) 802.1w, and IEEE Multiple Spanning Tree Protocol (MSTP) 802.1s protocols. The switch shall support 48 simultaneous MSTP instances.

The switch shall be able to apply rate-limiting on broadcast and multicast traffic and suppress broadcast/multicast/unknown unicast traffic.

The switch shall allow setting a limit for the number of learnable MAC addresses. MAC learning capability shall be able to be disabled. The switch shall be able to drop packets with an "invalid MAC address."

The switch shall have security features such as IP Source Guard, Unicast Reverse Path Forwarding, Dynamic ARP Inspection, Static ARP Inspection, and Egress ARP Inspection.

The switch shall support MAC address authentication. A port's access shall be stopped if the authentication attempt fails three times. The switch shall support authentication based on a combination of 802.1x and MAC addresses.

The switch shall support simultaneous authentication for multiple devices connecting through a NAC-compliant port. Only devices with authenticated MAC addresses should be granted access, and devices that fail authentication shall have their access stopped. The switch shall ensure that VLAN and ACL rules are assigned to ports of devices that pass 802.1x and MAC address authentication, using RADIUS.

The switch shall support RADIUS.

The switch shall support TDR (Time Domain Reflectometry) or an equivalent technology to check cable statuses.

The switch shall support the RMON (RFC 2819) standard and at least 5 RMON groups (statistics, log, alarms, events, performance).

The switch's console port shall be manageable via Telnet/SSHv2, SNMP v1/v2/v3, HTTP, and HTTPS. The switch shall allow different access permission levels to be defined for different operators.

➤ **Industrial Ethernet Switch – TYPE 1**

The switch shall be capable of operating independently, but it shall also support stacking up to at least 4 units. If a license is required for this, it shall be included in the offer.

For stacking the switches, 0.5-meter long stacking cables required for two switches shall be delivered together with the products.

The device shall have at least 24 100/1000 RJ45 downlink ports.

The device shall have at least 4 1G/10G SFP+ uplink ports. SM and MM modules shall be able to be installed on the ports, and all ports shall be actively usable simultaneously. All SFP+ ports on the device shall be delivered filled with the manufacturer's original 10G Gbic modules.

The switch shall have at least 128 Gbps switching capacity and at least 64 Gpps packet forwarding performance. The switching shall be hardware-based, and the switch should be capable of providing the specified port speeds at wire speed (non-blocking).

The device shall support at least 16,000 MAC addresses.

The switch shall be mountable in a 19" standard rack. The necessary mounting parts shall be provided free of charge.

The device shall be resistant to vibration, shock, electrical surges, and impact.

The device shall have a fanless cooling technology.

The device shall have a redundant DC power input.

The power inputs shall have overcurrent protection and reverse polarity protection.

The device shall have at least 1 alarm relay output.

The device shall be capable of operating in a temperature range of -40 / +75°C and a humidity range of 5% - 95%.

The switch shall have certifications for EN 61000-4-2 (ESD) Level 4, EN 61000-4-3 (RS) Level 3, EN 61000-4-4 (EFT) Level 4, EN 61000-4-5 (Surge) Level 4, EN 61000-4-6 (CS) Level 3, EN 61000-4-8, and IEEE 1613.

The switch shall have FCC Part 15 Subpart B Class A and EN 61000-6-4 certifications.

All field network switches shall be manageable.

The switch shall have IEC 60068-2-27 (Shock), IEC 60068-2-6 (Vibration), IEC 60068-2-32 (Drop) certifications.

The switch shall have UL/CUL 62368-1 and ATEX Zone 2 certifications.

The device's outer casing shall be a metal enclosure protected against foreign object impacts with at least IP30 standard.

The switch shall be manageable via RS232 serial console, HTTP WebGUI, HTTPS WebGUI, Telnet CLI, SNMP, and similar systems.

The device shall have an RS232 or RS485 serial console port. The device's configuration backup shall be able to be automatically stored to a remote location using a USB flash drive or TFTP.

The switch shall allow IP address restrictions for administrative access.

The switch shall support IPv6.

The switch shall be able to serve as an NTP/SNTP Server.

The switch shall support the 802.3ad LACP Trunk protocol.

The switch shall support SNMP v1, v2c, v3, and SNMP trap. At least two trap servers shall be definable.

The switch shall support at least 4 different RMON groups.

The switch shall support 802.1d Layer 2 and DiffServ Layer 3 traffic prioritization. Prioritization shall be definable individually for each port.

The switch shall support 802.1Q VLAN. At least 1024 VLAN IDs shall be definable.

The switch shall have a VLAN ID ignore feature. When required, it shall have the ability to forward frames without reading the VLAN ID information in the frame.

The switch shall support EIGRP, HSRP, BGP, OSPF, RIP, and PBR protocols. If a license is required for this, it shall be added to the offer.

The switch shall support IGMP v1, v2, v3, and IGMP snooping. It shall be capable of functioning as an IGMP querier when required. The switch shall support at least 1000 IGMP groups.

The switch shall allow defining traffic bandwidth values for both ingress and egress directions on a per-port basis for broadcast, multicast, and unicast traffic.

The switch shall support storm control functionality.

The switch shall support RADIUS and TACACS+ for user authentication when accessing the switch.

Port security shall be able to be provided based on MAC address restrictions or 802.1x.

The switch shall support Resilient Ethernet Protocol (REP) or an equivalent. If a license is required for this, it shall be added to the offer.

The switch shall support MRP protocol.

When the switch is powered on or off, when a change occurs in the ring, or when digital inputs are triggered, the switch shall be capable of sending external information.

In ring topologies, in case of a failure or device shutdown, the system shall be able to recover in less than 30ms using specialized Ring protocols.

The switch shall support DHCP Relay agent, DHCP Server, and DHCP Option 82.

Multiple ports shall be able to be monitored simultaneously via another port.

The device shall support LLDP.

The device shall support Dynamic ARP Inspection (DAI), DHCP Snooping, AAA, Secure Copy Protocol (SCP), and IP Source Guard. If a license is required for these features, it shall be added to the offer.

Port statistics shall be viewable through the device's WEBGUI.

Event logs shall be able to be sent to syslog servers using the syslog protocol.

The device shall support RSTP-2004 (Rapid Spanning Tree 802.1D-2004) and MSTP (Multiple Spanning Tree) protocols.

The device shall be definable in automation software and shall support ModbusTCP, PROFINET, and Ethernet/IP for monitoring.

➤ **Industrial Ethernet Switch – TYPE 2**

The device shall have at least 24 100/1000 RJ45 downlink ports.

The device shall have at least 4 1G/10G SFP+ uplink ports. SM and MM modules shall be able to be installed on the ports, and all ports shall be actively usable simultaneously. All SFP+ ports on the device shall be delivered filled with the manufacturer's original 10G Gbic LR (Single Mode) modules.

The switch shall have at least 128 Gbps switching capacity and at least 64 Gpps packet forwarding performance. The switching shall be hardware-based, and the switch should be capable of providing the specified port speeds at wire speed (non-blocking).

The device shall support at least 16,000 MAC addresses.

The switch shall be mountable in a 19" standard rack. The necessary mounting parts shall be provided free of charge.

The device shall be resistant to vibration, shock, electrical surges, and impact.

The device shall have a fanless cooling technology.

The device shall have a redundant DC power input.

The power inputs shall have overcurrent protection and reverse polarity protection.

The device shall have at least 1 alarm relay output.

The device shall be capable of operating in a temperature range of -40 / +75°C and a humidity range of 5% - 95%.

The device shall have certifications for EN 61000-4-2 (ESD) Level 4, EN 61000-4-3 (RS) Level 3, EN 61000-4-4 (EFT) Level 4, EN 61000-4-5 (Surge) Level 4, EN 61000-4-6 (CS) Level 3, EN 61000-4-8, and IEEE 1613.

The device shall have FCC Part 15 Subpart B Class A and EN 61000-6-4 certifications.

All field network switches shall be manageable.

The device shall have IEC 60068-2-27 (Shock), IEC 60068-2-6 (Vibration), and IEC-60068-2-32 (Drop) certifications.

The device shall have UL/CUL 62368-1 and ATEX Zone 2 certifications.

The device's outer casing shall be a metal enclosure protected against foreign object impacts with at least IP30 standard.

The switch shall be manageable via RS232 serial console, HTTP WebGUI, HTTPS WebGUI, Telnet CLI, SNMP, and similar systems.

The device shall have an RS232 or RS485 serial console port. The device's configuration backup shall be able to be automatically stored to a remote location using a USB flash drive or TFTP.

The switch shall allow IP address restrictions for administrative access.

The switch shall support IPv6.

The switch shall be able to serve as an NTP/SNTP Server.

The switch shall support the 802.3ad LACP Trunk protocol.

The switch shall support SNMP v1, v2c, v3, and SNMP trap. At least two trap servers shall be definable.

The switch shall support at least 4 different RMON groups.

The switch shall support 802.1d Layer 2 and DiffServ Layer 3 traffic prioritization. Prioritization shall be definable individually for each port.

The switch shall support 802.1Q VLAN. At least 1024 VLAN IDs shall be definable.

The switch shall have a VLAN ID ignore feature. When required, it shall have the ability to forward frames without reading the VLAN ID information in the frame.

The switch shall support EIGRP, HSRP, BGP, OSPF, RIP, and PBR protocols. If a license is required for this, it shall be added to the offer.

The switch shall support IGMP v1, v2, v3, and IGMP snooping. It shall be capable of functioning as an IGMP querier when required. The switch shall support at least 1000 IGMP groups.

The switch shall allow defining traffic bandwidth values for both ingress and egress directions on a per-port basis for broadcast, multicast, and unicast traffic.

The switch shall support storm control functionality.

The switch shall support RADIUS and TACACS+ for user authentication when accessing the switch.

Port security shall be able to be provided based on MAC address restrictions or 802.1x.

The switch shall support Resilient Ethernet Protocol (REP) or an equivalent. If a license is required for this, it shall be added to the offer.

The switch shall support the MRP protocol.

When the switch is powered on or off, when a change occurs in the ring, or when digital inputs are triggered, the switch shall be capable of sending external information.

In ring topologies, in case of a failure or device shutdown, the system shall be able to recover in less than 30ms using specialized Ring protocols.

The switch shall support DHCP Relay agent, DHCP Server, and DHCP Option 82.

Multiple ports shall be able to be monitored simultaneously via another port.

The device shall support LLDP.

The device shall support Dynamic ARP Inspection (DAI), DHCP Snooping, AAA, Secure Copy Protocol (SCP), and IP Source Guard. If a license is required for these features, it shall be added to the offer.

Port statistics shall be viewable through the device's WEBGUI.

Event logs shall be able to be sent to syslog servers using the syslog protocol.

The device shall support RSTP-2004 (Rapid Spanning Tree 802.1D-2004), MSTP (Multiple Spanning Tree) protocols.

The device shall be definable in automation software and shall support ModbusTCP, PROFINET, and Ethernet/IP for monitoring.

➤ **Industrial Ethernet Switch – TYPE 3**

The device shall have at least 8 100/1000 RJ45 downlink ports. The device shall be capable of expanding to 16 ports with an expansion module that can be added later. If a license is required for this, it shall be added to the offer.

The device shall have at least 2 1G/10G SFP+ uplink ports. SM and MM modules shall be able to be installed on the ports, and all ports shall be actively usable simultaneously. All SFP+ ports on the device shall be delivered filled with the manufacturer's original 10G Gbic LR (Single Mode) modules.

The device shall support at least 16,000 MAC addresses.

The switch shall be mountable in a 19" standard rack. The necessary mounting parts shall be provided free of charge.

The device shall be resistant to vibration, shock, electrical surges, and impact.

The device shall have a fanless cooling technology.

The device shall have a redundant DC power input.

The power inputs shall have overcurrent protection and reverse polarity protection.

The device shall have at least 1 alarm relay output.

The device shall be capable of operating in a temperature range of -40 / +75°C and a humidity range of 5% - 95%.

The device shall have certifications for EN 61000-4-2 (ESD) Level 4, EN 61000-4-3 (RS) Level 3, EN 61000-4-4 (EFT) Level 4, EN 61000-4-5 (Surge) Level 4, EN 61000-4-6 (CS) Level 3, EN 61000-4-8, and IEEE 1613.

The device shall have FCC Part 15 Subpart B Class A and EN 61000-6-4 certifications.

All field network switches shall be manageable.

The device shall have IEC 60068-2-27 (Shock), IEC 60068-2-6 (Vibration), and IEC-60068-2-32 (Drop) certifications.

The device shall have UL/CSA 62368-1 and UL/CSA 60079-0, -15 (Class I, Zone 2, Gc/IIC) certifications.

The device's outer casing shall be a metal enclosure protected against foreign object impacts with at least IP30 standard.

The switch shall be manageable via RS232 serial console, HTTP WebGUI, HTTPS WebGUI, Telnet CLI, SNMP, and similar systems.

The device shall have an RS232/RS485 serial console port. The device's configuration backup shall be able to be automatically stored to a remote location using a USB flash drive or TFTP.

The switch shall allow IP address restrictions for administrative access.

The switch shall support IPv6.

The switch shall support the NTP protocol. It shall be able to function as a server.

The switch shall support the 802.3ad LACP Trunk protocol.

The switch shall support SNMP v1, v2c, v3, and SNMP trap.

The device shall support the RMON protocol.

The device shall support 802.1d and DiffServ traffic prioritization. Prioritization shall be definable individually for each port.

The switch shall support 802.1Q VLAN. At least 256 VLAN IDs shall be definable.

The switch shall support the EIGRP, HSRP, BGP, OSPF, RIP, and PBR protocols. If a license is required for this, it shall be added to the offer.

The switch shall support IGMP v1, v2, v3, and IGMP snooping. It shall be capable of functioning as an IGMP querier when required. The switch shall support at least 1000 IGMP groups.

The switch shall allow defining traffic bandwidth values for both ingress and egress directions on a per-port basis for broadcast, multicast, and unicast traffic.

The switch shall support storm control functionality.

The switch shall support RADIUS and TACACS+ for user authentication when accessing the switch.

Port security shall be able to be provided based on MAC address restrictions or 802.1x.

The switch shall support Resilient Ethernet Protocol (REP) or an equivalent. If a license is required for this, it shall be added to the offer.

The switch shall support the MRP protocol.

When the switch is powered on or off, when a change occurs in the ring, or when digital inputs are triggered, the switch shall be capable of sending external information.

In ring topologies, in case of a failure or device shutdown, the system shall be able to recover in less than 30ms using specialized Ring protocols.

The switch shall support DHCP Relay agent, DHCP Server, and DHCP Option 82.

Multiple ports shall be able to be monitored simultaneously via another port.

The device shall support LLDP.

The device shall support Dynamic ARP Inspection (DAI), DHCP Snooping, Secure Copy Protocol (SCP), and IP Source Guard. If a license is required for these features, it shall be added to the offer.

Port statistics shall be viewable through the device's WEBGUI.

Event logs shall be able to be sent to syslog servers using the syslog protocol.

The device shall support RSTP (Rapid Spanning Tree 802.1D) and MSTP (Multiple Spanning Tree) protocols.

The device shall be definable in automation software and shall support ModbusTCP, PROFINET, and Ethernet/IP for monitoring.

➤ **Network Firewall System**

The proposed system shall have, as a minimum, the following next-generation firewall features:

- Firewall
- IPSec VPN Termination System
- SSL VPN Termination System

- Intrusion Prevention and Detection System (IPS)
- Application Recognition and Control System
- Virus/Malicious Content Control
- URL Category Filtering
- Bandwidth Management

These features shall be provided as a hardware solution from the manufacturer in a single device.

The proposed security system shall have at least 20 / 18 / 10 Gbps firewall performance for 1518/512/64 Byte IP packet sizes in the proposed configuration. These values shall be specified in the product documentation of the proposed product, and the manufacturer shall publicly publish these values on their website.

The system shall support at least 1.5 million concurrent sessions and have the performance to open at least 50,000 new sessions per second. These values shall be specified in the product documentation of the proposed product, and the manufacturer shall publicly publish these values on their website.

The firewall system shall have at least 10 Gbps IPSec VPN throughput. These values shall be specified in the product documentation of the proposed product, and the manufacturer shall publicly publish these values on their website.

The firewall system shall have at least 1 Gbps SSL VPN throughput. These values shall be specified in the product documentation of the proposed product, and the manufacturer shall publicly publish these values on their website.

The system shall support at least 500 Site-to-Site IPSec VPN tunnels and 16,000 Client-to-Site IPSec VPN tunnels. The device shall be compatible with VPN Gateway devices that support the mentioned VPN protocols and standards.

The system shall have at least 2.5 Gbps IPS throughput performance. These values shall be specified in the product documentation of the proposed product, and the manufacturer shall publicly publish these values on their website.

The system's Threat Protection value shall be at least 1 Gbps.

The system's NGFW throughput value shall be at least 1.5 Gbps.

The system shall have:

- At least 8 Gigabit Ethernet interface ports.
- At least 2 SFP+ 10Gb/s interfaces. These ports shall be delivered with 10G SR Gbics that are either manufactured by the vendor or officially supported by the vendor.
- At least 480 GB SSD storage.

The system shall not have any user limit for the Firewall, VPN, or IPS functions, and it shall be offered with an unlimited user license.

The system shall have a redundant DC power supply.

The system shall have SPI (Stateful Packet Inspection) Firewall functionality.

The system shall detect and block spoofed packets.

Each network interface in the system shall be definable as LAN, WAN, DMZ, or user-defined segments. The system shall support IEEE 802.1Q VLANs, and the defined VLANs shall be usable as interfaces.

The system shall be able to operate in both Layer 3 (routing mode) and Layer 2 (transparent mode). Virtual firewall systems can operate in Layer 3 mode, while the same virtual firewalls can simultaneously operate transparently in Layer 2 mode.

In Transparent mode, the system shall provide the following features:

- SPI (Stateful Packet Inspection)
- Intrusion Prevention and Detection System (IPS)
- Application Recognition and Control System
- Virus/Malicious Content Control at the Gateway
- URL Category Filtering

In Routing mode, the system shall provide the following features:

- SPI (Stateful Packet Inspection)
- IPSec VPN Termination
- SSL VPN Termination
- Intrusion Prevention and Detection System (IPS)
- Application Recognition and Control System
- Virus/Malicious Content Control
- URL Category Filtering
- Bandwidth Control
- Static Routing
- Support for RIP, OSPF, and BGP routing protocols. If a license or additional software is required to support these routing protocols, it shall be provided.

The Network Security System shall support multiple Wide Area Network (WAN) connections, allowing for redundant and/or simultaneous use of multiple Internet connections.

The Network Security System shall support Policy-Based Routing (PBR).

The system shall have DHCP Server and DHCP Relay features.

Firewall policies shall be configurable based on user groups. There shall be Active Directory (AD) integration for user information.

The system shall be capable of rule-based traffic shaping and traffic prioritization for Bandwidth Control purposes. The system shall support QoS and Differentiated Services.

- In rules written based on source, destination, and protocol (such as SMTP, FTP, DNS, H323, etc.), traffic shaping definitions shall also be configurable.

- The maximum and/or guaranteed bandwidth values shall be definable with priority levels (low, medium, high, etc.).
- For each source permitted under the same rule, the defined bandwidth shall be able to be shared in a common way.
- The system shall be able to perform bandwidth control on an application basis.

The Security System shall support authentication and authorization via its own defined user database, RADIUS, and LDAP.

The system shall have application control functionality. The system shall be capable of recognizing, controlling, and blocking traffic from at least 3,000 (three thousand) predefined applications, including Messaging (MSN, ICQ, Yahoo, AOL, etc.), P2P (Kazaa, Skype, bitTorrent, eDonkey, Gnutella, etc.), and Web Applications, independently of the used ports. The applications recognized under application control shall be updated via an internet-based update service.

For every firewall rule written based on source (IP and/or user), destination, and service, an application control policy shall be set.

The system shall support IPSec VPN as a VPN Gateway. It shall support DES, 3DES, AES encryption with MD5, SHA-1, and SHA-256. IKE and PKI support shall be provided.

The IPS system shall be able to detect and block both traffic and protocol anomalies as well as signature-based attacks. IPS signatures shall be automatically updated via an internet-based update service, and manual updates shall also be possible.

For every firewall rule written based on source (IP and/or user), destination, and service, an IPS policy shall be set.

The proposed Network Security System shall be capable of detecting and blocking Botnet activity.

The Network Security System shall have an SSL VPN Gateway feature to ensure secure access for mobile users to corporate resources. The SSL VPN client shall support at least Windows, Mac OS, Linux operating systems, and mobile devices based on iOS and Android.

TCP and UDP-based traffic shall be tunnelable through the SSL VPN Gateway.

The SSL VPN feature shall be offered with a minimum of 50 concurrent user licenses.

Users accessing via SSL VPN shall be able to authenticate their identity through the system's defined user database, RADIUS, or LDAP, be authorized, and the internal and external resources that can be accessed through this authorization shall be definable.

For users or systems accessing via SSL VPN, the following features shall be applicable: SPI (stateful packet inspection), Intrusion Prevention and Detection System (IPS), Application Recognition and Control System, Virus/Malicious Content Control, URL Category Filtering, and Bandwidth Management (QoS).

The Network Firewall System shall have malware detection and blocking features. The system shall be able to scan HTTP, SMTP, FTP, and POP3 traffic and block malware. The system shall be able to detect and stop threats such as Worms, Trojans, Keyloggers, Spies, and Dialers within these protocols. Virus Control shall be performed across all network segments on the Network Firewall System. The AntiVirus system shall be capable of automatically updating virus signatures via an internet-based update service.

For every firewall rule written based on source (IP and/or user), destination, and service, an AV control policy shall be definable.

The Network Security System shall have a URL Filtering feature. It shall support category-based URL filtering. Different categories of URL filtering shall be applied to different users and user groups.

For every firewall rule written based on source (IP and/or user), destination, and service, different URL filtering policies shall be definable.

The system shall have at least 60 URL categories.

There shall be no user limit for the URL filtering function, and it shall be offered with an unlimited user license.

Apart from URL categories, addresses can be defined under different profiles using wildcard, regex, or exact URL (e.g.gov.tr). Access to these defined addresses shall be either blocked or allowed.

When desired, the system shall be able to block access based on full URL information (e.g., www.abc.com/test/page1.php), independent of categories.

The system shall be able to inspect SSL traffic using a self-generated certificate or a certificate with adequate properties obtained from a different CA. This allows blocking at the URL level (e.g., www.abc.com/test.php), not just at the domain level.

For SSL inspection, domains that should not undergo inspection based on URL categories shall be definable.

URL filtering warning screens shall be customizable.

All proposed systems shall support IPv6, and they shall support the dual-stack feature, which allows the simultaneous use of both IPv4 and IPv6 protocols. At a minimum, the following features shall be supported under IPv6: IPv6 addressing, IPv6 static routing, IPv6 DNS, IPv6 security rules, IPv6 logging and reporting, and Ping6.

The system configuration shall be possible using at least the following methods:

- Via serial connection through the console port,
- Via HTTP and HTTPS connections through the web interface or the manufacturer's own Linux or Windows-based management application,
- Via SSH connection through the command-line interface (CLI).

The Network Firewall System shall support SNMP and shall support SNMPv3.

The Network Firewall System shall be capable of performing operating system and software updates through the Web interface, TFTP, or FTP.

System updates shall be possible through at least the web GUI.

The Firewall System shall have a geographic database. Rules shall be written based on countries, allowing the system to block traffic coming from specific countries.

The system shall have the necessary structure and associated licenses to store internet access logs in compliance with Law No. 5651. These licenses shall be included in the offer.

➤ **Server Type 19" Cabinets**

The cabinets shall be at least 19 inches in accordance with ETSI and/or EIA 310-D standards.

The cabinets shall be factory-made, and quality certificates shall be provided.

The main chassis and profile structures shall be designed to provide axial strength and resistance to external impacts.

The main profile structure shall have a depth of at least 12 cm, which shall enhance mechanical strength.

The bottom chassis shall be designed to increase strength and durability, featuring a monoblock twisted and welded structure with a profile insertion design. The profiles shall be inserted and screwed to the bottom chassis and shall have a dustproof, sliding cable entry section. Nuts shall be welded to the bottom chassis to provide pinion foot connections. Additionally, to reinforce the connection of the cabinet to the floor, movable 30x30 square profiles shall be mounted, with nuts welded to the front of the chassis for the pinion foot connection.

The bottom chassis shall have passage points that allow for cable/air transitions. If necessary, these points should be able to be fitted with brushes.

The cabinets shall allow for the connection of pinion feet along with wheels.

The rear cover shall be removable, openable, and lockable with 3 points.

The rear covers shall have a perforated structure with a width of no more than 5 mm and 64% ventilation capacity. It shall be made of two parts, which open to the left and right.

The side panels shall be removable, and they should feature a snap-lock mechanism and a key-lockable structure. To enhance passive ventilation, the panels shall be equipped with special shutter form molds applied on CNC punch machines.

The front doors shall be made of metal, curved, with a width of no more than 5 mm and 64% ventilation capacity. The front doors shall be lockable at 3 points.

The cabinet's painting process shall be highly durable against impacts, with an electrostatic textured RAL9005 MAT powder coating. Before painting, all metal components shall undergo chemical processes such as oil removal, iron phosphating, passivation, and shall be painted with electrostatic powder coating. The metal surfaces shall have a coating thickness of 85 +/- 5 microns.

The top cover shall extend 10mm above the cabinet's top chassis. This shall prevent dust from entering the cabinet and allow ventilation through the 10mm gap.

The top cover shall have cable entry points with pop-out and brush types for cable entry.

The top chassis shall be designed to enhance strength and durability, featuring a monoblock twisted and welded structure with a profile insertion design. The profiles shall be inserted and screwed to the top chassis and shall be prepared for easy connection of a 6-fan group.

The top chassis shall have cable entry points with pop-out and brush types for cable entry.

The 19-inch mounting rails shall consist of 2 at the front and 2 at the back, made with a precise measurement of 1U = 44.45 mm, with 9.5x9.5mm square holes, manufactured with a precision of +/- 0.01 in CNC punch machines.

The 19-inch mounting rails shall be designed and installed so that they can move along the cabinet's depth. Additional support parts shall be placed in the gap between the mounting rails to enhance durability.

The 19-inch mounting rails shall be numbered along the height, and the numbering shall be designed in such a way that it cannot be removed later.

All cabinets shall have the feature to be connected side by side when required.

All cabinets shall be produced in accordance with ISO 9001:2008 quality management system standards. The cabinets shall meet the EN 61587-1:2007 (Mechanical structures for electronic equipment) and EN 62208:2003 (Empty enclosures for low-voltage switchgear and controlgear) standards.

➤ **Wall-Mounted 19" Cabinets**

The cabinets shall be 19 inches according to ETSI and/or EIA 310-D standards.

The cabinets shall be factory-made, and quality certificates shall be provided.

The main chassis and profile structures shall be manufactured to provide axial strength and resistance to external impacts.

Cabinet Painting Process: The cabinets shall be painted with high-strength, electrostatic RAL7035 powder coating to resist impacts. Before painting, all metal components shall undergo chemical processes such as oil removal, iron phosphating, and passivation, and shall then be painted with electrostatic powder coating. The metal surfaces shall have a coating thickness of 85 +/- 5 microns.

The bottom and top chassis shall be designed to enhance the cabinet's strength and durability, featuring a monoblock twisted and welded structure with profile insertion. The profiles shall be inserted and fastened with high-strength steel rivets to the bottom and top chassis.

The cabinet side panels shall be lockable, removable, and openable.

On the top chassis, there shall be ventilation slots for fan group connections and airflow.

The rear cabinet cover shall be easy to mount onto the main body and shall be designed to be robust. The cabinet shall have an appropriate number of mounting holes for wall attachment. Additionally, for security purposes, the rear cover shall be capable of being screwed into the main body from the inside.

The front cover shall be tempered, antistatic, secure, smoked, and polished 4mm glass. The front glass cover shall have a metal frame that holds the glass on both the left and right sides with screws, enhancing its strength. The front glass cover shall be able to open at least 180 degrees, be lockable, and removable.

To allow for free-standing use of the wall-mounted cabinets, there shall be holes designed for attaching feet or wheels.

The 19-inch mounting rails shall be configured with 2 at the front for cabinets with a depth of 450mm and 2 at the front and 2 at the back for cabinets with a depth of 560mm. The mounting rails shall have a precise measurement of 1U = 44.45 mm, with 9.5x9.5mm square holes, manufactured with a precision of +/- 0.01 using CNC punch machines.

The 19-inch mounting rails shall be designed and installed in such a way that they can move along the cabinet's depth.

All cabinets shall be produced in accordance with ISO 9001:2008 quality management system standards. The cabinets shall meet EN 61587-1 (Mechanical structures for electronic equipment) and EN 62208 (Empty enclosures for low voltage switchgear and controlgear) standards.

2.6.3. INSTRUMENTS AND CONTROLLING

The Contractor shall provide all necessary instrumentation and control systems to enable the facility to be commissioned, operated, controlled and shut down fully automatically and efficiently.

The facility includes, but is not limited to, material transfer equipment for fuels and consumables, electricity generation, water and steam systems, flue gas and waste treatment and transfer systems and their subsystems. It also includes all systems and subsystems of the facility, including safety, communication, security and fire systems. All necessary protective and auxiliary systems will be provided to ensure the safety of personnel, the facility and the environment.

This section is not comprehensive in describing the facility and there may be some missing information. The Contractor is responsible for including all services, equipment, apparatus and various items required for the facility to be fully operational. In addition, it will be the Contractor's responsibility to ensure that all necessary protective and auxiliary systems are included for the safety of personnel, facility and the environment. Equipment suitable for the intended use will be selected in accordance with the agreement reached with the Employer's representative.

In case of any conflict between other tender documents and the general requirements of this section, the Contractor shall bring this to the attention of the Employer's Representative and request clarification.

The supply, calibration, installation, minimum and maximum set settings and other settings of all flow meters and field measurement devices and their adaptation to the automation system (including cabling and other workmanship for this purpose) are within the scope of this work.

Within the scope of this Contract, instruments will be supplied and installed where necessary, depending on the Contractor's design, including but not limited to the following, and will be connected to the automation system.

2.6.3.1. General Features of Instruments

All analog measurements to be made at the stations will be carried out via sensors and transmitters. All sensor and transmitter outputs will be able to make serial communication with standard 0-10 V, 4 – 20 mA or one of today's digital field bus technologies (Modbus, Profinet, HART, Profibus PA, Profibus DP, Foundation Fieldbus etc.) and will be selected according to the communication infrastructure project. Conversion to engineering units (lt/sec, ampere, volt etc.) will be made by transmitter or controller devices and all measurement results will be reflected to the user as engineering units. All sensors and transmitters to be used in the facilities will be compatible models of the same brand.

All sensors and instruments will be selected from types designed in accordance with 2000/76/EC and easy to maintain, operate and calibrate. In addition, all instruments, sensors, transmitters and connection equipment to be supplied must be ATEX certified, and the connection equipment must be halogen-free.

By evaluating the IP protection level specified in standards such as IEC/EN 60079-0 and the relevant product standard (e.g. 60079-1, 60079-7, 60079-31 etc.), instruments with a minimum IP68 protection class for sensors and a minimum IP 66/67 protection class for transmitters should be selected.

When connecting the cables of the instruments, equipment such as records etc. suitable for the IP protection class of the equipment will be used and this will be taken into consideration during installation.

It is a very important parameter that the sensors and transmitters that play a role in the decision-making of the entire system can make accurate measurements. Since any error made by the sensors and transducers can cause the decision mechanisms of the system to work incorrectly, care will be taken to ensure that the sensors and transmitters to be recommended are sensitive and reliable devices.

Special buffer solutions will be provided free of charge for instruments that can be calibrated on site. Buffer solutions to be provided will be calibrated (traceable), and values such as expiration date and shelf life will be taken into consideration.

Calibration certificates for instrument measuring devices (flow, level, pH, pressure, temperature, oxygen meter, etc.) will be submitted to the Employer Representative together with the equipment supply. For products calibrated in the manufacturer's factory laboratory, the Accreditation Certificate of the manufacturer's laboratory will be provided together with the "Equipment Supply Form" and the Calibration Certificate together with the product supply. If there is equipment to be calibrated in the facility, these will be done under the participation and supervision of the Employer Representative and recorded in a report.

During the supply of instruments, the same group and type of instruments will be selected from the same brand and suitable models. Maximum standardization will be achieved among all flow meters and field measurement instruments and their auxiliary equipment, and the same manufacturer's products will be preferred as much as possible in terms of operation and maintenance.

Field elements such as sensors, transmitters, power supplies, etc. must be protected so that they are not affected by transient events (shocks, voltage spikes, etc.) occurring in energy circuits during stop-start operations or load changes.

The input and output circuits of all types of sensors, transmitters and their related power supplies will be optically or galvanically isolated from each other.

The necessary training for the calibration and maintenance of the instruments will be given by the expert staff of the supplier company.

Transmitters with digital displays and RS 232 or RS 485 serial communication ports compatible with SCADA will be preferred.

All sensors that come into contact with water will be manufactured from water-resistant, non-corrosive, and non-harmful material.

The chemical design of separate and/or integrated instruments such as pressure gauges and temperature gauges should be stainless steel enclosures and the enclosure diameter should be >100 mm.

Binary type signals (especially NAMUR) must be used as proximity sensors. Mercury switches are not allowed if they are not possible as a fast closing mechanical contact. The power supply must be at least 24 V DC. If this is not possible, at least 230 V AC must be used.

If possible, 0-10 V or 4...20 mA, HART type, 2-wire type analog signals should be used. Power supply should be min. 24 V DC. If this is not possible, min. 230 V AC should be used.

A handheld terminal for operating bus protocol instruments must be provided.

Parts that come into contact with the environment must be designed to withstand environmental conditions (chemical corrosion, wear, pressure, temperature, etc.).

- **Flow Measuring Instruments**

- **For Water, Wastewater and Sludge Lines:**

- **Electromagnetic Flowmeter**
 - For dense, conductive and particle-containing sludge
 - **Ultrasonic Flowmeter**
 - In contactless, portable applications
 - **Positive Displacement Flowmeter**
 - For precise measurement in dosing pumps

- **For Gas Lines:**

- **Thermal Mass Flowmeter**
 - Biogas or natural gas flow measurement
 - **Vortex Flowmeter**
 - For compressed air, steam and flammable gases
 - **Orifice Plate and Differential Pressure Transmitter**
 - For high temperature gases

- **Temperature Measuring Instruments**

- **Thermocouple**
 - For internal oven temperature (800–1000°C+)
 - **RTD (Pt100)**
 - Temperature monitoring in tanks, pipes and close to the process
 - **IR (Infrared) Temperature Sensor**
 - Surface temperature (conveyors, ash line)

- **Level and Pressure Measurement Systems**

- **Level Measurement:**

- **Radar Level Sensor**
 - Silos, bunkers, ash tanks
 - **Ultrasonic Level Sensor**
 - Open tanks

- **Capacitive or Vibration Type Level Switch**
 - Dry ash level for overflow/empty alarm
- **Differential Pressure Type Level Meter**
 - Liquid/mud level in pressure tanks

Pressure Measurement:

- **Pressure Transmitter**
 - Combustion air, fuel, sludge pump outlet
- **Vacuum Transmitter**
 - Filter for purification units
- **Safety Pressure Switches**
 - For overpressure alarm and shut-down
- **Gas Analyzers and Emission Monitoring**
 - **Oxygen (O₂) Sensor**
 - Combustion efficiency control
 - **Carbon Monoxide (CO), Carbon Dioxide (CO₂), NO_x, SO₂ Analyzers**
 - Continuous emission monitoring at flue gas outlet
 - **Particle Measuring Device**
 - Dust emission monitoring at the filter outlet
 - **CEMS Unit (Continuous Emission Monitoring System)**
 - Integrated monitoring system for legal compliance
 - **Gas Leak Detectors (CH₄, H₂S, VOC)**
 - Biogas / Natural gas line, silo / bunker, odor control, for closed areas
- **Safety Instrumentation**
 - **Fire Detection and Extinguishing Systems (addressable detectors)**
 - **Gas Detectors (CH₄, O₂ deficiency)**
 - **Alarm Relays and Warning Lights**
 - **Emergency Stop Buttons (ESD Switch)**
 - **Explosion-proof instruments**
 - **Smoke Detectors**
 - **Flame Detectors**
 - **Indoor gas sensors (H₂S, CH₄, Lack of O₂ etc.)**
- **Process Specific Instruments**
 - **Sludge Cake Moisture Sensor**
 - Quality control before and after drying
 - **Ash Density Meter**
 - Combustion efficiency control

- **Vibration Sensor**
 - Fans, blowers, conveyor motors etc.
- **Belt Speed Sensor and Weight Meter**
 - To calculate the conveyor transport quantity
- **pH, conductivity, redox sensors**
 - For gas scrubbing system outlet

D - Density

- The measuring system should be of the Corioles type.

F – Flow

The flow measurement techniques specified below will be selected following the approval of the Employer's Representative, depending on the location and conditions used during the design phase.

- Corioles type flow meters
- Float flow meters (Rotameter),
- Flap flow meters or (for meters) positive displacement meters
- Vortex flowmeters or equivalent
- Electromagnetic flowmeters
- Ultrasonic flow meters
- Flow measurement with orifice plate and Venturi tube

L - Level Measurement

The level measurement techniques specified below will be selected following the approval of the Employer's Representative, depending on the location and conditions used during the design phase.

- Hydrostatic pressure based type
- Radar type
- Ultrasonic type,
- Float type (direct mounted or with bypass tank),
- Conductive, displacer type (for separation),
- Vibrating type,
- Capacitive type,
- Winged type

P - Pressure

The measuring range shall be in bar or mbar, or abs.

Integrated or separate type transmitters and sensors will be used where the Employer Representative deems appropriate.

Pressure sensors will be Bourdon and/or Diaphragm type depending on their area of use.

Q - Quality (Analyzer)

For oxygen in the flue gas, the zirconium type should be selected.

According to 2000/76/EC (Waste Disposal Directive), the BEIS system and the probe and extraction system/systems must be integrated with the analyzers and SCADA system.

T - Temperature

The measuring range should be in °C.

Each temperature sensor must be installed with a protective thermowell.

The length to be immersed should be designed according to accurate measurement.

Integrated or separate type transmitters and sensors will be used where the Employer Representative deems appropriate.

- type NiCr-Ni (type K) or PtRh-Pt (type S) for temperatures > 500 °C
- Type PT100 for temperature < 500 °C, minimum % DIN accuracy or better

2.6.3.2. General Measuring Instruments

All replaceable parts in the system (sensor, probe, etc.) will be kept in permanent reserve in 2 (two) sets.

An approved Continuous Emission Monitoring System (CEMS) shall be installed in the chimney. This system shall continuously measure, as a minimum, the flue gas temperature, pressure, flow rate/velocity, O₂ content, moisture content, NO_x, SO_x, dust, CO, CO₂, Total Organic Carbon (TOC), HCl, HF, NH₃ and Hg (Mercury) etc. to monitor compliance with the specified emission limits.

In addition to CEMS, since the Turkish Regulations and European Directive limit values will be provided at the bag filter outlets, devices that continuously measure SO₂ and particulate matter will be used as a minimum. These measurements will be monitored from CEMS and the sensors and probes of these devices will be kept in permanent reserve.

The devices required to continuously measure the NO_x level will be placed immediately after the combustion boilers. When necessary, urea/ammonia can be added to the boilers or water can be sprayed into the boilers to control NO_x. These measurements can also be monitored from CEMS. The sensors and probes of these devices will be kept in reserve at all times.

The Contractor shall provide a sufficient number of sampling points to validate CEMS data through manual testing.

A boiler combustion profile measuring and monitoring system will be established for each boiler.

H₂S, CO and CH₄ in the process, emission and energy turbine sections of the facility and in the sludge bunkers/silos. Level detectors and audible and visual alarms will be used for level measurements.

Biogas/Natural gas flow meter

Two turbine type natural gas / biogas flow meters with collector features will be provided for the incineration plant.

Sludge flow meter

By using mud flow meters with collection feature, the mud flow delivered to the mud injectors of the system from different lines will be visible.

Capacitance/resistance level switch

Point level measurement will be made in water, wastewater and sludge by placing a reverse frequency converted capacitance/resistance level switch.

Temperature element and indicating transmitter

A 100 ohm, 3-wire temperature probe shall be provided with a thermocouple type temperature transmitter built into a painted aluminum IEC/NEMA 4x or explosion proof wall mounted FM (if required) with LCD display in degrees C.

2.6.3.3. Instrument Control System

The entire facility will be monitored, controlled and supervised by the Facility Command and Control Center. In addition, each line will have its own control panel/panels as specified above. A system will be established that will allow the facility process to provide all automatic control, monitoring, supervision and operation as well as health, safety and environmental requirements. This microprocessor-based system will include all hardware, screens, manual controls, automatic controls, protection and fault tracking systems, backup and independent security systems, warning systems and control room equipment.

In addition, all SCADA data will be designed, manufactured/supplied in a way that it can be monitored in the SCADA Center in the Administrative Building/Unit.

The boiler and waste heat boiler will be operated under fully automatic control under normal conditions. The turbine will operate with the steam produced in the boiler. If the steam pressure exceeds the specified point, the amount of fuel fed to the facility will be reduced by the operator through the control system. In the event of increased pressure, the turbine bypass system will first be activated to protect the boiler, and then the boiler safety valves will open.

The noise will be reduced with the steam silencer to be used in the discharge line of the safety valves on the superheater, which can be opened manually and with the steam drum, and the discharge line will be taken to a safe height.