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Specification for PLC

Discipline: Instrument

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EuroChem

Chemical Complex for Phosphates Processing Project

CONTENT

1 General & Project Description

As part of the implementation of a strategic investment project, “EuroChem” decided to build a Chemical Complex for the processing of phosphates in the Republic of Kazakhstan. The Project Site is located approx. 25 km west of Zhanatas. This chemical complex will comprise process units and utilities as defined in the following paragraphs, and includes a set of interconnected productions:

Number	Production unit
7G16	Sulfuric Acid Plant (SAP)
7G21	Potassium Sulfate Plant (SOP)
7G25	Di Calcium Phosphate Production Plant (DCP)
7G17	Calcium Chloride ($CaCl_2$)
7G02	Offsite & Utilities (O&U)

2 Abbreviations

The list of abbreviations used in this document is provided in the below table:

List of Abbreviations

Abbreviation	Description
OWNER	EuroChem Karatau, Limited Liability Company
CNCEC	China National Chemical Engineering Group Corporation Ltd.
PRAYON	Process Design Package Licensor of DCP Plant
APCS	Automatic Process Control System
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
CCR	Central Control Room
DCS	Distributed control system
FAT	Factory Acceptance Test
GA	General Arrangement
GDS	Gas Detection & Alarm System
HMI	Human Machine Interface
I/O	Input/output
IS	Intrinsic Safety
ISBL	Inside Battery Limit
JB	Junction Box
LCR	Local Control Room
MMS	Machine Monitoring System
OSBL	Outside Battery Limit
P&ID	Piping & Instrumentation Diagram

Abbreviation	Description
PLC	Programmable logic Controller
SAT	Site Acceptance Test
SIL	Safety Integrity Level
SIS	Safety instrumented system
SS	Stainless Steel
UPS	Uninterruptible Power Supply

3 Introduction

This specification covers the minimum design, manufacturing, testing, installation, commissioning start-up support requirements for Programmable Logic Controller (PLC) to be provided for all process units and relevant system in Chemical Complex for Phosphates Processing Project. Additions or revisions to the specification may be proposed by licensor or sub-contractors by raising a technical query.

The scope of this specification is to provide the guidelines to make uniform along the whole project the design criteria.

The control philosophy for this project is for centralized DCS control. The specified PLC equipment shall provide means of package unit and equipment control only (e.g., turbine, compressors, bagging, loading, etc.).

English shall be governing language for engineering document, HMI interface, software operation and instruction manual shall be English/Russian.

4 Definitions

The words of varying rigor degrees are required in the provisions of this specification, and the limits of bid evaluation are described as follows:

1） Word that is very strict and understood as mandatory：

The positive word is "shall", and the negative word is "shall not".

2） Word that is strict and understood as strongly recommended or advised：

Positive word is "should", and the negative word is "should not".

3） Word that is understood as freedom choice and takes precedence when conditions are met：

Positive word is "maybe", and the negative word is "may not be".

5 Codes and Standards

1	IEC 61131	Programmable Controllers
2	IEC 60079	Explosive Atmospheres
3	IEC 60529	Degrees of Protection Provided by Enclosures (IP Code)

4	IEC(/EN) 61000	Electromagnetic compatibility (EMC)
5	IEC 61508	Functional Safety of Electrical / Electronic / Programmable Electronic Safety-Related Systems
6	IEC 61511	Functional Safety - Safety Instrumented Systems for The Process Industry Sector
7	IEC 61131	Programmable Controllers
8	IEC 60947-5-6	Low-voltage switchgear and controlgear - Part 5-6: Control circuit devices and switching elements - DC interface for proximity sensors and switching amplifiers (NAMUR)
9	NAMUR NE 043	Standardisation of the Signal Level for the Failure Information of Digital Transmitters
10	SN RK 4.02-03-2012 (CH PK 4.02-03-2012)	Automation Systems
11	GOST 14254-2015 (гост 14254-2015)	Degrees of protection provided by enclosures (IP Code)
12	ST RK 34.014-2002 (СТ РК 34.014-2002)	Information Technology Set of Standards for Automated Systems Automated Systems Terms and Their Definitions
13	ST RK 34.015-2002 (СТ РК 34.015-2002)	Information Technology Complex of Standards for Automated Systems Technical Specifications on Automated System Creation

Note: All undated standards and codes shall be the latest version as of the effective date of the contract. For the parts not included in the above standards and codes, the general national standards and manufacturer's standards no lower than the national standards shall be adopted.

6 Units of Measurement

Component	%v, ppm(v) , %mol/l
Liquid flow	m3/h, l/h, l/m
Gas flow	Nm3/h (0℃,1atm)
Vapor flow	kg/h, t/h
Flow rate	m/s
Level	%, m, mm
Pressure	MPa-g/-a, kPa-g/-a
Temperature	°C

Density	kg/m3, kg/Nm3
Conductivity	μ s/cm
Weigh	kg, t
Viscosity	mPa.s (cP)
Distance(Length)	m, mm
Power	W, kW
Force	N, kN
Current	A, mA
Dew point temperature	°C d.p.
Time	h, s, min, day
Potential of hydrogen (pH)	pH
Vibration	mm, mm/s, mm/s^2
Frequency	Hz

7 Environment Conditions

Maximum temperature	39.1 °C
Minimum temperature	-26.7 °C
Summer average relative humidity	32% for month
Winter average relative humidity	85% for month
Design minimum relative humidity	32% summer
Design maximum relative humidity	85% winter
Average site height	650 m above sea level
Average atmospheric pressure	94.6585 kPa
Average annual rainfall	420 mm
Peak rainfall	4.8mm in 20 minutes
Rainfall period	40 days/year
Prevailing wind direction	December-February-south
	April-October-north
Average wind speed	16.5 km/h
Earthquake seismic factor	Intensity 7 on the MSK-64 scale
Snow Load	180 kg/m2
Freezing depth	85 cm max
Maximum frozen soil depth	98 cm (Note 1)
Annual average thunderstorm days	19 days (Note 1)

Note 1: The data refer to meteorological parameter of Zhambyl region form СП РК 2.04-01-2017 BUILDING CLIMATOLOGY.

8 Design

8.1 Design Characteristics

PLC system is associated with process monitoring and control and shall have a high reliability greater than 99.9 percent with SIL 2 certification as a minimum if required based on IEC61508 and IEC 61511. In this respect, failure of one critical system component shall be considered as a total system failure. A critical component is defined as a component that is required for the system to operate correctly.

For Non-process application as water treatment, PLC without SIL degree shall be used if there's no SIL certification requirement.

Where high reliability is required, dual CPU's in a redundant configuration shall be provided. This shall utilize the vendor's standard arrangement for CPU changeover. PLC shall be provided with dual redundant power supply units arranged in a duty/backup configuration.

Reliability calculations shall be provided for the entire PLC system (processor, power supply, I/O, etc.).

PLC shall be of modular design for ease of maintenance. Components shall be arranged for ease of identification for testing and maintenance.

For PLC system, where the redundant I/O cards or processor cards are applied, the redundant I/O cards or processor cards shall be hot swappable. Input and output equipment shall have surge protection adequate for transient field conditions. Processors, data highways and networks shall also include electrical surge protection and isolation.

Most field mounted components will be located in Zone 1 or Zone 2 hazardous areas. Hazardous area protection shall be Intrinsically Safe Ex (i) in accordance with IEC60079 and GOST R 51330.9-99 Electrical apparatus for explosive gas atmospheres Part 10 Classification and Scope of Use of Electrical Plants in Fire and Explosion Hazard Zones. All equipment used in hazardous areas shall be approved by a recognized certifying authority.

8.2 Central Processing Unit (CPU)

The CPU shall preferably be located in an air conditioned, non-hazardous environment.

The CPU shall utilize a 16-bit microprocessor as a minimum. The processor shall have less than 100mS scan time, including I/O and program.

The processor shall perform the following typical functions:

- Logic.
- Boolean logic.
- Sequential logic.
- Floating point arithmetic.

- PID Control functions.
- Addition.
- Subtraction.
- Multiplication.
- Division.
- Comparison functions, (>, <, =).
- Totalization.
- Square root extraction.
- Timing functions.
- Counters.
- Self-diagnostics.
- Logic Functions: And, OR, exclusive OR, NOT.
- Shift Register Functions: Bit Shift Left, Bit Shift Right.
- Relay Contact Elements: N.O., N.C., Transition.
- Relay Coil Elements: Standard, Latch, Unlatch.
- Others.

8.3 Timers and Counters

Timer capability shall be provided with time bases of 0.01, 0.1 and 1.0 seconds. Timer types shall include ON delay, OFF delay, and retentive. Programming capability shall include timer reset and the ability to interrupt timing without resetting the timer.

Counter capability shall be provided with the ability to count to any present value in the range 1-999. Up and down counters shall be provided. Programming shall include a counter reset.

8.4 Control Functions

PLC shall be capable of executing analog control algorithms for control modes, Proportional (P), Proportional plus Integral (PI), and Proportional plus Integral plus Derivative (PID). The use of these algorithms shall generally be avoided in programs which feature time critical logic.

The range of settings for the control modes shall be:

- Proportional (Gain) - 10 to 1000 percent (0.1 to 10).
- Integral - 0.0 to 100 repeats per minute.

Ø Derivative - 0.0 to 100 minutes.

Relay functions shall also be provided. Coil types shall be normally energized, normally de-energized, and latching.

Normally open and normally closed contacts shall be configurable for each type of coil, timer, counter and discrete input. The number of times a relay, timer or counter contact can be addressed in the user program shall not be limited except by memory capacity.

Shift register, sequencer and bit modify functions shall also be provided.

8.5 Diagnostics

PLC shall be provided with comprehensive internal diagnostics. These shall include:

Ø Loss of field I/O communication.

Ø Battery low.

Ø Memory error.

Ø Forced I/O bit.

Ø Write-protect.

Ø Watchdog timer.

Light emitting diode (LED) indicator lights shall be provided to indicate the following information:

Ø Power on.

Ø Program executing.

Ø CPU failure.

Ø RAM battery backup available.

Ø Battery status.

Ø Operating on battery backup power.

Ø Output and input status.

A means shall be provided to generate an automatic diagnostic printout when faults occur. The CPU shall be capable of recording any fault which causes I/O errors, display the location of the fault to the operator, and generate a hard copy of the message via the Engineering Terminal. The CPU shall record any internal CPU error or communication error.

The essential diagnostics information should be presented to the operator on DCS screens via appropriate interfaces.

Where redundant CPU are provided, primary to secondary CPU changeover shall not cause any change in I/O or program execution which may cause a process fluctuation.

The system design shall provide for selecting (by means of a switch) whether the outputs retain the last state or are de-energized upon PLC malfunction.

CPU load utilization shall not exceed 60%.

8.6 Memory Requirements

PLC shall be provided with adequate Random Access Memory (RAM) and non volatile memory to handle the required logic and I/O operations, including at least 40% spare memory capacity. Volatile memory shall be provided with battery back-up for a minimum of 72 hours.

The following types of error checking shall monitor the functional status of memory and communication links between subsystems and peripherals:

- Parity (Vertical Redundancy Check) (VRC).
- Checksum using Block Check Character (BCC).
- Cyclic Redundancy Check (CRC).
- Longitudinal Redundancy Check (LRC).
- Error detection/correction using Hamming Codes.

Memory utilization shall not exceed 60%.

8.7 Input/Output Modules

PLC I/O modules shall normally be mounted in expansion racks within the processor cabinets. Remotely mounted I/O modules, if required, shall be capable of mounting up 1200m from the CPU.

Discrete I/O shall normally operate at 24VDC.

Analog I/O shall normally be 4-20 mA DC. Input modules shall also be available for direct thermocouple and RTD inputs if applicable. I/O modules shall be optically isolated channel per channel from the process signal input.

The isolated barrier is used for intrinsic safety applications and shall be installed in the PLC marshaling cabinets.

During normal operation, a malfunction in any I/O channel shall not affect the operation of the CPU or any other channel. It shall be possible to replace any I/O module without disturbing field wiring. Outputs shall be selected such that the output fails safe upon loss of power.

System shall have spare at the end of commissioning activities:

- 10% installed spares, wired and fully functional I/O of all types (minimum 1 card of each type).

Ø 20% of spare space inside I/O racks for slots.

Ø 20% spare terminal blocks in marshaling cabinets.

I/O modules shall come equipped with integral light emitting diode (LED) indicators indicating signal status. Each I/O termination assembly shall be individually fused. I/O modules shall come equipped with blown fuse indicators. Fuses shall be replaceable from the front or rear of the cabinet without removing the protected device from the cabinet.

Each output module shall be individually fused and shall be protected from voltage transients. Output modules should handle sufficient power to directly drive solenoid valves etc. without using interposing relays.

Capability shall be provided to force configured I/O through the Engineering Station.

I/O mounting rack assemblies shall be modular with individual, replaceable plug-in modules for each particular I/O type. It shall be possible to replace any I/O module as manufacturer's manual without removing power or disturbing wiring.

I/O modules shall incorporate protection against transient electrical disturbances and damage due to extended operation under cable fault conditions. All discrete I/O circuits shall be isolated from logic or processor circuitry. Transient voltage isolation for discrete I/O shall be a minimum of 1000 Volts RMS, common-mode.All I/O circuits shall be designed so that accidental normal-mode connection of 1000VAC/DC to discrete I/O field terminals for an unlimited time shall not destroy any devices in I/O circuits other than the circuit to which the voltage was applied.

Adequate filtering shall be provided to minimize effects of noise induced voltages on I/O signals.

8.8 Cabinets

PLC cabinets shall consist of processor cards, I/O cards, communication cards and termination accessories and redundant power supplies (detail shall be confirmed with vendor). All hardware cards shall be mounted in racks within the cabinet. I/O cards associated with any single plant item shall be mounted together in one rack wherever possible. Standby equipment shall not utilize the same I/O cards as duty equipment.

PLC cabinet layout design shall be based upon grouping of duties, with due consideration given to both operational segregation and limiting of floor space requirements. Consideration shall be given to ensure that a failure of one of the components shall affect only a limited number of common equipment. Also, a failure of a power supply unit shall not affect more than one equipment item for the same service, including standby equipment. All power supplies shall be redundant.

Temperature detectors shall be mounted inside any cabinet containing CPU, PSU or I/O cards. Each detector shall be wired into a suitable input module to initiate a temperature alarm. The set point for the alarm shall typically be set at 50 degree C or as required to protect the equipment. The alarm shall be annunciated locally to the PLC as well as being transmitted to the DCS.

Where required, louvers and suitable filters shall be provided for cabinet ventilation. Equipment shall preferably be cooled by natural convection. However, if under a serious working condition, cooling fans of PLC shall be used where possible.

The cabinets shall be with installed dimensions of 800 x 2000 x 800 mm (W x H x D) and shall be of modular design. All cabinets must be supplied complete with 100-mm-high plinths. Cabinet protection level shall be IP30 (as a minimum) and color RAL 7035.

Cabinets shall be suitable for bolted connection with a raised floor using of anchor bolts chassis.

Reinforcing pieces shall be welded to front corners of cabinet chassis, removable lifting brackets shall be provided.

Cabinets shall have door on both the front and the rear side. Identical lock/key pairs shall be provided for all doors. The doors shall be easy to remove, have neoprene sealing, and shall be rigid enough to avoid deformation or warping.

It is not allowed to mount heavy equipment on cabinet doors, but lamps, Pushbuttons are allowed.

8.9 Electrical Requirements

The PLC cabinets shall house redundant power supplies, each capable of supplying full rack load and to act as a backup with automatic switch-over in case of failure.

Each cabinet shall be provided with two main UPS incoming power supply with circuit breakers and a power distribution bus. All other internal branch power circuits shall be fed from this power bus and provided with individual circuit breakers. Individual DIN rail mounted circuit breakers shall be provided for each power supply. Tandem circuit breakers shall not be used.

Power supply units shall have their own current limiting devices on the primary side. Power supply units shall utilize diode isolation, current limiting circuitry and over-voltage protection. Each secondary circuit of power supply units shall have its own current limiting device.

All cable entries including power supply cables shall be through the bottom of the cabinets. All terminals and cables shall be easily accessible from the rear door.

Three terminal blocks shall be provided per signal pair for termination of 24 VDC analog wiring.

Circuits for alarm, shutdown and distribution of power, will have disconnect terminals.

8.10 Power Supply

Two primary electrical UPS feeds will be provided to the PLC equipment at 230VAC 50Hz 1Ph. The design shall minimize the number of feeds required. Distribution of power to field mounted equipment shall be derived from the PLC cabinets. Each device shall be provided with a separate means of isolation within the cabinets.

The PLC will be provided with power from two UPS system with 30 minutes battery backup. The UPS will have the following characteristics:

- Ø Voltage: 230 Volts AC ± 2%
- Ø Frequency: 50 Hz ± 1%
- Ø Harmonic Distortion: 5% RMS Maximum

Under fault conditions, when the UPS switches to bypass supply (raw mains), equipment shall continue normal operation without disruption under the following conditions:

- Ø Voltage: 230 Volts AC + 10% - 5%
- Ø Frequency: 50 Hz ± 1%
- Ø Switching Time: 40 milliseconds (short break duration)

Each cabinet shall contain any power supply units necessary for operation from the incoming supply. All power supply units shall include fault monitoring and running lamp.

Power consumption of PLC (system rack, including sensors and system) shall be provided by vendor.

8.11 Connection to DCS/SIS System

Each set PLC's rack shall be interfaced to the DCS and shall be capable of transmitting all available analog and digital information to the DCS. This shall include as a minimum:

- Ø I/O status I/O.
- Ø Logic status.
- Ø Power status.
- Ø Self-check status.
- Ø Alarms and miscellaneous signals.
- Ø PLC system status (if available).
- Ø CPU status (if available).

In addition, the PLC shall be capable of reading data transmitted from the DCS, including defeat signals, reset signals and set point data.

The interface to the DCS system shall be by bi-directional serial data link, where DCS operator intervention is essential. Modbus TCP/IP, Modbus RTU RS485 or Profibus DP shall be used for the communication between DCS and PLC.

PLC in this category shall not be used for emergency shutdown of facilities. Plant level shutdown signals shall be hardwired directly into the SIS System.

A master clock system based on GPS satellite clock technology with associated microprocessor- based components will be provided by Contractor for time synchronization of all control, monitoring and safety systems networks nodes across the plant. PLC shall be suitable to receive such synchronization signal and synchronized with DCS system.

8.12 Programming

PLC shall be programmed by means of a separate Engineering Station. This shall permit the users to enter, retrieve, and monitor internal PLC software and data at the primary or the backup processor. HMI shall be provided both in Russian and English.

The Engineering Station shall consist of a portable computer, and the necessary hardware and cables to interface with the PLC processors. Suitable software shall be provided to enable viewing and editing of the configured logic, I/O and communications data.

The use of ladder logic shall be avoided, if possible. A logic block, symbol orientated, self- documenting, graphical based programming language shall be used in accordance with IEC-61131-3.

PLC shall be capable of accepting program changes during program execution and shall be protected by keylock access for programming changes via the Engineering Station. The Engineering station shall be removable after configuration.

Software or hardware shall be provided to inhibit all outputs for system testing.

PLC shall allow the updating of programs under keylock protection without deleting and re-entering the entire program.

The PLC shall be capable of generating a hard copy printout of the application programs and cross reference listings of all storage registers.

All programs shall be fully documented by means of annotated listings dumped directly from the CPU. Programs shall clearly identify I/O points by tag number and shall be fully commented to assist with maintenance and debugging.

Logic for individual pumps, turbines, compressors, and process interlocks shall be segregated into separate networks. Identical logic structures and elements (except for tag names and addresses) should be used for identifying logic of equipment operating in parallel trains, or which are controlled in a similar manner.

The mixing of interlock and sequence logic with analog PID control loops should be avoided due to the large processing overhead required. Analog inputs may however be used for alarming, monitoring, sequencing, and interlock applications.

In the scope of PLC complete deliveries, the software must be open for the Customer to be able to carry out maintenance of the software and hardware complex. And also the customer should be able to make changes.

9 PLC Acceptance Tests

9.1 Factory Acceptance Testing (FAT)

A Factory Acceptance Test (FAT) is required for PLC. The factory test shall be an operating test and it shall be the vendor's responsibility to provide all facilities required to demonstrate the system in accordance with the purchase order and this specification.

PLC manufacturer internal test shall be implemented in control system manufacturer's factory. Each PLC shall be subject to a full functional test on full simulation basis of all inputs and outputs during FAT. Company's and/or Contractor's Inspector shall witness and approve all factory tests and reserves the right to approve the test procedure.

9.2 Integrated Factory Acceptance Test (IFAT)

Typically, the IFAT would test system communications between the PLC and the DCS. Key communication protocols that are tested by Modbus TCP/IP, Modbus RTU RS485 or Profibus DP. This network infrastructure configuration will be replicated during the IFAT.

9.3 Site Acceptance Test (SAT)

Even though the design system configuration and Factory Acceptance Test were performed to minimize site work, there are some final configuration and system integration checks that need to be done in the field. This procedure documents the tasks to be done in the field, as well as the testing procedures to verify that the MMS System is properly configured, interconnected, and integrated with all other interfacing plant systems, e.g., field transducers and DCS/SIS.

Site Acceptance Tests are not specification tests. They are not intended to verify hardware specifications nor software features. Manufacturing Quality Assurance documents certify that the products meet published specifications. The intent of the SAT is to verify that the PLC system is fully operational and properly integrated with DCS/SIS, and that it can be operated and maintained by end user.

The SAT Scope consists of:

- Cabinet Inspection and Testing.
- Loop Testing for all racks.

The SAT document is separated into the following phases:

- Cabinet Pre-Power Up Testing.
- Cabinet Initial Power Up Testing.
- SAT Test Procedure.
- Loop Checks.

- Close any SAT Punch list.

Applicable requirements of FAT, IFAT and SAT are detailed in the reference documents “DCS Acceptance Tests” of INS-7G02-00-85-002 “Specification for DCS System".

10 Documentation

The vendor shall give a particular attention to the documentation requirements:

All the contractual documentation shall be provided both in Russian and English languages, but the operating system and attached software could be in English language only (to be stated by Vendor). The Russian and/or Kazakh language shall be used in operation manual and human manual interface.

Documentation shall include vendor standard documents and special customized documents generated for the project. The documentation to be provided by vendor during the project development shall include as a minimum:

- Hardware documentation.
- Equipment list.
- Cabinet Wiring.
- Interconnection Diagram.
- Logic diagrams.
- Software documentation.
- DCS/PLC communication mapping list.
- Application documentation.
- Instruction manuals.
- Others if necessary.

11 Training, Spare Parts, Warranty and Guaranty

11.1 Training

Prior to contract award for the PLC, the scope of training will be defined for the individual groups as well as the number of trainees, specifically for:

- Design personnel.
- Maintenance personnel.
- Operations personnel.

If no special requirements, all PLC training shall be carried out on the site, Company shall be responsible for the organization of personnel according to the agreed time for training.

11.2 Spare Parts

During the installation, pre-commissioning, commissioning, start-up activities, the vendor shall provide consumables for the whole PLC as per its standards.

The vendor shall provide to Owner a spare parts list priced for the equipment delivered for the two years operation.

The list shall be grouped into the following categories:

- Consumables.
- Preventive maintenance.
- Failure /repair.

The list shall specify the following features, but not limited to:

- Maintenance name, address, telephone number.
- Manufacturer part number, part description.
- Current price.
- Maintenance requirements and service life of the part.

The vendor shall clearly state the procedure and prepare all documentation required for repair or replacement of the spare parts during the warranty period.

11.3 Warranty and Guaranty

Warranty and guaranty of PLC system will be provided in terms and conditions of purchase, detail refer to procurement management specifications.