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Specification for DCS System

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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
AI	Analog Input
AO	Analog Output
CCR	Central Control Room
CCS	Compressor Control System
CCTV	Closed-Circuit Television
CPU	Central Processing Unit
C/S	Client/Server
DCS	Distributed Control System
DI	Digital Input
DO	Digital Output
DPDT	Double Pole Double Throw
EMC	Electro-Magnetic Compatibility
EMI	Electro-Magnetic Interference
ES	Engineer Station
ESD	Emergency Shutdown System
FAT	Factory Acceptance Test
FBD	Functional Block Diagram

Abbreviation	Description
FDS	Functional Design Specification
FLD	Functional Logic Diagram
GDS	Gas Detection System
HAZOP	Hazard and Operability Study
HMI	Human Machine Interface
HSE	Health, Safety and Environment
HVAC	Heating Ventilation Air Conditioning
IFAT	Integration Factory Acceptance Test
IS	Intrinsic safety
I/O	Input/Output
KVM	Keyboard、Video、Mouse
LAN	Local Area Network
LCD	Liquid Crystal Display
LCR	Local Control Room
LED	Light Emitting Diode
MCC	Motor Control Center
MFR STD	Manufactory Standard
MMS	Machinery Monitoring System
MOS	Maintenance Override Switch
MTBF	Mean Time Between Failures
MTTF	Mean Time To Failures
MTTR	Mean Time To Repair
NA	Not Adopt
NTP	Network Time Protocol
OOS	Operational Override Switch
OPC	Object Linking and Embedding (OLE) for Process Control
OS	Operator Station
OSI	Open System Interconnect
PI	Pulse Input
P&ID	Piping & Instrument Diagram
PLC	Programmable Logic Controller
P/P	Peer to Peer
RTD	Resistance Temperature Detector
RTU	Remote Terminal Unit
SAT	Site Acceptance Test
SCADA	Supervisory Control and Data Acquisition
SER	Sequence Event Recorder
SIF	Safety Instrumented Function
SIS	Safety Instrumented System
SNTP	Simple Network Time Protocol
SOE	Sequence Of Event
SPD	Surge Protective Device
SPDT	Single Pole Double Throw
SQL	Structured Query Language

Abbreviation	Description
TC	Thermocouple
TCP/IP	Transmission Control Protocol / Internet Protocol
TMR	Triple Module Redundancy
UPS	Uninterruptible Power Supply
VLAN	Virtual Local Area Network
WS	Workstation

3 Introduction

This specification covers the minimum design, manufacturing, testing, installation, commissioning start-up support requirements for DCS system 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 design of all process units, utilities, and infrastructure facilities shall allow the operation of the process units for 5 years between turnarounds for inspection and maintenance. The facilities shall be designed for an operating life of 25 years.

In any case, the mandatory Kazakhstan regulations are to be considered by DCS vendor. In addition, vendor shall ensure the compliance of the basis of design and construction with the local mandatory regulations.

Unless otherwise agreed in writing with Company, prototypes are not allowed; only technical proven solutions are accepted.

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 60364-5-51	Electrical installations of buildings - Part 5-51: Selection and erection of electrical equipment - Common rules
2	IEC 60381-1	Analogue signals for process control systems -Part 1: Direct current signals
3	IEC 60381-2	Analogue signals for process control systems - Part 2: Direct voltage signals
4	IEC 60445	Basic and safety principles for man-machine interface, marking and identification - Identification of equipment terminals, conductor terminations and conductors
5	IEC 60529	Degrees of protection provided by enclosures (IP Code)
6	IEC 60751	Industrial platinum resistance thermometers and platinum temperature sensors
7	IEC 61000	Electromagnetic compatibility (EMC)
8	IEC 61131	Programmable controllers
9	IEC 61499-1	Function blocks - Part 1: Architecture
10	IEC 61499-2	Function blocks - Part 2: Software tool requirements
11	IEC 61499-4	Function blocks - Part 4: Rules for compliance profiles
12	IEC 61508	Functional safety of electrical/electronic/programmable electronic safety-related systems
13	IEC 61511	Functional safety - Safety instrumented systems for the process industry sector
14	IEC 61804	Function blocks (FB) for process control and electronic device description language (EDDL)
15	IEEE 802.3	IEEE Standard for Ethernet
16	ISA-5.2	Binary Logic Diagrams for Process Operations
17	ISA S71.04	Environmental Conditions for Process Measurement and Control Systems: Airborne Contaminants
18	OPC DA 3.00	OPC Data Access Custom Interface Specification Version 3.00
19	SN RK 4.02-03-2012 (CH PK 4.02-03-2012)	Automation Systems
20	GOST 14254-2015	Degrees of protection provided by enclosures (IP

	(ГОСТ 14254-2015)	Code)
21	ST RK 34.014-2002 (CT PK 34.014-2002)	Information Technology Set of Standards for Automated Systems Automated Systems Terms and Their Definitions
22	ST RK 34.015-2002 (CT PK 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	m ³ /h, l/h, l/m
Gas flow	Nm ³ /h (0°C, 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/m ³ , kg/Nm ³
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
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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/m ²
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 Vendor Supply and Work Scope

8.1 Vendor Supply Scope

- 1) The vendor shall provide the hardware according to the scope of supply in DCS data sheet and Control System Configuration Diagram. The bunched cables, communication cables and optical cables in Rack Room and CCR are provided by DCS vendor, and other cables are provided by EPC Contractor.
- 2) If the quantity of hardware, such as cabinets, is not specified, DCS vendor should provide the corresponding quantity of equipment's as the spare requirements.
- 3) For software, the vendor shall provide corresponding software in accordance with Chapter 17 of this technical specification, including configuration software, office software, anti-virus software and software firewall, etc.

8.2 Vendor Work Scope

The work scope of DCS vendor includes: DCS technical services (including project services and field services), system integration, packaging and transportation, unpacking inspection, installation guidance,

field testing and commissioning, system delivery and acceptance, including but not limited to the following:

- 1) Assign a project manager to be the main contact with EPC Contractor throughout the project implementation and provide the resume of the project manager in the vendor's technical documents. The project manager should be the same person during the execution of the project. After the selection of the project manager is confirmed, if the project manager needs to be replaced, it should be confirmed by EPC Contractor.
- 2) Organize the system kick-off meeting and various coordination meetings, etc.
- 3) Make the work schedule to meet the supply requirements and submit the biweekly work schedule reports.
- 4) Complete DCS engineering design documents including control system configuration drawing, I/O distribution table, cable list between cabinets, cabinet arrangement drawing, cabinet wiring diagram, internal communication connection table, etc. Improve control room layout drawing, provide hardware function specification and software function specification, and provide equipment thermal load, system power load and system grounding requirements.
- 5) Complete engineering design and integration of remote I/O, MMS console and auxiliary console, SIS auxiliary console, switch network monitoring, safety barrier, isolator, relay, DC power supply module, marshalling cabinet, auxiliary cabinet, etc., and other auxiliary equipment and system. The engineering design and integration of the system shall not be subcontracted to subcontractors without permission from EPC Contractor.
- 6) Complete the system configuration work, and this shall not be subcontracted to subcontractors without permission from EPC Contractor.
- 7) Complete inspection and testing of all hardwire and software at DCS manufacturer factory, complete coordination work with the third-party vendors and communication testing work between hardware, software, and system.
- 8) Complete FAT assist EPC Contractor and the Owner.
- 9) Pack all equipment's and deliver them to designated place.
- 10) Witness the on-site unpacking and acceptance, guide the equipment installation (cooperate with the construction organization), wire and power on, install system software, install application software and configuration software, modify the wiring in cabinets, system loop test, debug and verify the hardware and software.
- 11) Coordinate work of SAT on-site.
- 12) Provide technical support about on-site factory commissioning, system operation, etc.
- 13) Hand over the integrated system, including the hardware, software, and documents.
- 14) Provide technical training, including configuration, maintenance, and field operation training.

15) Provide other after-sales services.

16) Provide calibration devices and special tools, such as the range setting tools for rack mounted temperature transmitter.

9 Control System Overview

9.1 Configuration of Control System and Subsystem

In this project, the new APCS shall consist of Distributed Control System (DCS), Emergency Shutdown System (ESD), Gas Detection System (GDS), as well as the necessary interfaces to other systems and information management systems, including:

- Programmable Logic Controller (PLC)
- Continuous Emission Monitoring System (CEMS)
- Machinery Monitoring System (MMS) (if any)
- Advanced Process Control (APC) system (if any)
- Fire Detection System (by Telecom major)
- Automatic Fire Extinguishing System (by Fire Fighting major)
- Ventilation Control Systems (by HAVC major)
- Electric Heating Control System (by Electrical major) (if any)
- Automated Power Supply Management System (by Electrical major) (if any)
- Manufacturing Execution System (by IT major) (if any)

9.2 Description of The Rack Room/Control Room

9.2.1 Arrangement of Rack Room/Control Room

- 1) The layout of process units in this project is relatively centralized, and there is a Central Control Room (CCR) in this project. In CCR, the process units and utilities are centrally operated, controlled, and managed, with DCS display operator stations, a part of control stations and auxiliary equipment's. According to the general plan layout of the whole plant, there are five Rack Rooms. The DCS control stations of each process units and utilities are installed in each Rack Room according to the region.
- 2) Redundant armored fiber cables are used for control network between Rack Rooms and CCR, by star connection. Redundant fiber cables are laid on different paths. The DCS, SIS and GDS system could share a fiber cable, using different cores in the same fiber cable.

9.2.2 Operating Equipment and Control Station in CCR and Rack Room

- 1) Operator stations in Rack Room shall be able to monitor the process for field operators.

- 2) Engineer station in CCR shall be able to realize the configuration and maintenance functions of control stations in all Rack Room in the whole factory. Operator station in CCR shall be able to realize the monitoring function of all process units and utilities in the whole plant.
- 3) In each Rack Room, DCS process control station of each process unit shall be set up independently according to the partition and grouping, so as to ensure that each process device does not interfere with each other during normal production, running and shutdown, and reduce the correlation influence.

9.3 Network structure

DCS overall structure could be divided into process control layer, operation monitoring layer and data service layer.

- 1) Process control layer shall complete the direct process control, data acquisition, real-time storage and transmission of process variables. In general, the man-machine interface shall not be directly connected to the process control layer.
- 2) Operation monitoring layer shall be the main man-machine interface of DCS, which shall process and store the data from process control layer, to realize the function of centralized operation and management. In general, operation monitoring layer devices shall not have process interface units without permission. Also, process variables shall not be directly accessed to DCS via the operation monitoring layer device without permission.
- 3) Data service layer shall be the intermediate layer of data exchange between DCS internal network and external network, which is used to provide data services to users indirectly involved in the production process. The data service layer shall exchange data with the process control layer and operation monitoring layer through devices such as proxy servers or firewalls, instead of direct data communication. Data services directly related to production operation or system management shall not be implemented at the data service layer, such as alarms, histories, diagnostics, etc.
- 4) In this project, point-to-point or server/client data transfer mode are all acceptable. In case of server/client architecture, servers must be redundant. If it is in the form of ring network connection, only double ring network redundant structure is acceptable.

9.4 System Environment Conditions

- 1) The DCS modules installed indoors shall be able to work normally under the ambient temperature of 0°C~50°C and relative humidity of 10%~90%.
- 2) The temperature of the CCR and Rack Room is 20°C±2°C in winter and 26°C±2°C in summer, and the temperature change rate is less than 5°C/h. The relative humidity ranges from 40% to 60%, and the humidity change rate is less than 6%/h.
- 3) DCS hardware shall be able to prevent environmental corrosion and shall meet the G3 grade of ISA S71.04 standard.

9.5 System Power Supply Conditions

1) Dual UPS power supply is used for DCS, the UPS characteristics are as follows:

- ü Output voltage: 230VAC±10%, single phase.
- ü Output frequency: 50Hz±5Hz.
- ü Wave form deviation factor: less than 5%.
- ü Backup time: 30 minutes.

2) Fans and lighting in DCS cabinets are powered by 230VAC GPS.

9.6 System Grounding

- 1) The design of DCS grounding shall comply with the provisions of SH/T 3081.
- 2) DCS grounding system consists of protective grounding and signal/shield grounding, which are finally connected to the electrical equipotential grounding net.

10 System Performance Requirement

10.1 Reliability

- 1) The MTTF of elements or parts in process control layer shall be not less than 100 000h, the MTTF of controller shall be not less than 150 000h, the total time to failure rate (h) of control station shall be less than 1×10^{-6} .
- 2) The MTTF of device in operation and monitoring layer shall be not less than 80 000h.
- 3) For elements or parts that do not meet the requirements, redundant structures shall be adopted.
- 4) The requirements for the reliability and fault tolerance of equipment should be adjusted according to the conclusion of the SIL session and the final document.

10.2 Availability

- 1) The MTTR of elements or parts in process control layer shall be less than 4h.
- 2) The control unit, power supply unit and communication unit shall be hot bank up redundancy.
- 3) The modules of the process control layer shall adopt the plug-and-pull structure and can be replaced online under the normal operation of the system.

10.3 Dispersion

- 1) DCS shall be designed according to the principle of diversification of risk.
- 2) The Controller, I/O module, power supply and network device shall be independently arranged according to the different operation zones, process units, utilities and use functions.

- 3) The vendor shall provide the maximum allowable I/O points of the controller and the commonly recommended I/O points.
- 4) DCS control unit shall not be installed centrally.
- 5) DCS communication unit shall not be installed centrally.

10.4 Compatibility

- 1) DCS hardware and software shall be compatible with lower version.
- 2) The different versions, series of same brand of DCS shall be able to transmit data to each other.
- 3) The maintenance version and supplementary version of DCS software shall be compatible with hardware and operating system, and the compatibility time shall be consistent with the operation period of the equipment.
- 4) The maintenance and supply time of DCS hardware and software version shall not be less than 12 years.
- 5) DCS shall be compatible of data exchange of different versions and shall be able to connect and exchange data with the same brand products produced within 20 years through the network.

10.5 EMC

- 1) The immunity of DCS shall not be lower than the requirements in the following table and shall be able to recover the functions automatically after the interference source disappears.

Basic Standard	Interference type	Interference intensity	Level	Performance criterion
IEC 61000-4-2	Electrostatic discharge immunity test	Contact discharge: 6kV Air discharge: 3kV	3	B
IEC 61000-4-3	Radiated, radio-frequency, electromagnetic field immunity	10V/m@80~1000MHz & 1.4~2GHz	3	B
IEC 61000-4-4	Electrical fast transient burst immunity	Power port : 2kV Signal port : 1kV	2	B
IEC 61000-4-8	power frequency magnetic fields	30A/m	3	B

- 2) The electromagnetic radiation limits of all DCS system elements and auxiliary elements shall not be higher than the requirements in the following table.

Port	Frequency range MHz	Limit value	Basic Standard	Scope of application	Remarks
Enclosure	30~230	30dB(μV/m)	CISPR	If the CISPR 11:2016	

		quasi-peak value Measuring distance 30m	11:2016	is met, the measurement can be made at 10m distance, but the limit should be increased by 10dB	
	230~1000	37dB(μV/m) quasi-peak value Measuring distance 30m			
Alternating current power supply	0.15~1.50	79dBμV quasi-peak value 66dBμV average value	CISPR 11:2016		
	0.50~5	73dBμV quasi-peak value 60dBμV average value			
	5~30	73dBμV quasi-peak value 60dBμV average value			
Note: This table does not include field measurement.					

10.6 Integrity

For signals connected to DCS, in case of no change of input and output, the functions required in this technical specification shall be achieved without additional external function equipment's or modules. All relevant functions shall be realized in DCS.

11 System Functional Requirement

11.1 Essential Requirement

DCS control station shall be able to meet the function and speed requirements of conventional process control of chemical plant, and be able to meet the requirements of all process variable measurement, including, but not limited to, the following functions:

- Data acquisition and processing
- Regulatory control
- Sequential control
- Operator interface
- Interactive graphic displays
- Data base for data collection, archiving, reporting, and trending
- Process alarms and system diagnostic alarms

11.2 Data Acquisition

Data acquisition is applicable to all process data input to the system and shall be called according to requirements. The data may be from various sources which include, but no limited to, the following devices:

- a) I/O modules
- b) Controllers
- c) Operator input devices, keyboards, etc.
- d) Communication links with other devices

11.3 Alarm and Event Record

- 1) The control system shall inform the plant operator on events (trips and alarms) occurring in the process and in the control system.
- 2) DCS shall have the function of grading, partitioning and grouping of process variables.
- 3) DCS shall record all alarm events in order and time marking automatically.
- 4) There shall be clear difference between process variable alarm and system failure alarm. process variable alarm is the abnormal conditions of process variables (process parameters) issued by control unit. System failure alarm is the function diagnosis of the control unit, operation station and communication system, and it is issued in abnormal conditions.
- 5) DCS shall be able to record and output alarm information and be able to record the alarm sequence.
- 6) DCS shall have the function of classification, filtering, screening and retrieval of alarm and event records.
- 7) DCS shall have the function of preventing to delete and modify the alarm and event records.
- 8) Event or alarm message will be generated for example under the following circumstances:
 - a) Changes in the state of digital inputs
 - b) Control actions by either the operator or the system
 - c) Violations of set values
 - d) Alarm acknowledgements
 - e) Operator actions such as manual entries, entry locks etc.
 - f) Operator login/logout actions
 - g) System messages (overflow of archives and read-only memory, printer message, server failure (if any), interrupted process communication).

11.4 Failure Diagnostics

- 1) DCS shall have the functions of hardware and software failure diagnosis and shall be able to record the failures automatically and alarm.
- 2) The diagnostic functions in process control layer shall including as following at least:
 - a) I/O module failure
 - b) Communication failure
 - c) CPU failure
 - d) Power supply failure

11.5 System Management

- 1) System management shall include the management of resident data of the system, online diagnosis of each device in the system, maintenance of system software data, system configuration and modification, graphics management, network management, network address management, etc.
- 2) DCS shall support off-line configuration and debugging.

11.6 Data backup

- 1) DCS shall have the capability of back up the programming data and history data, at least 30 days, of hardware and software.
- 2) DCS shall have the function that it could be recovery when system fault.

11.7 Clock synchronization

- 1) In this project, clock synchronizer is required in CCR.
- 2) DCS shall make every node in network clock synchronization.
- 3) DCS shall transmit the clock synchronization signal to third part computer or network.
- 4) The timing accuracy of the clock synchronizer shall not be less than 1ms, and the punctuality accuracy shall not be less than 2μs/min.

12 System Security

12.1 Network Security

- 1) The DCS network linked with different buildings shall be connected by optical cable.
- 2) The hardware firewall shall be used between the factory management network and the DCS process control network.

- 3) Without permission, external management data interfaces, including the factory management network, shall not be directly connected to the DCS process control layer or operation monitoring layer. Data shall be exchanged through OPC server in the data service layer or similar workstations.
- 4) Without permission, application computers and networks of third part related to DCS functions shall not directly access the DCS process control layer or operation monitoring layer network. Data shall be exchanged through OPC server or similar workstations.
- 5) Without permission, computers, or control devices unrelated to the DCS function shall not directly access or use the DCS network.
- 6) Without permission, the network unrelated to the DCS function shall not access the DCS process control layer and operation monitoring layer.
- 7) Without permission, DCS shall not use wireless network, and control systems and instruments using wireless network shall not access DCS network.

12.2 Anti-virus

- 1) Anti-virus software or VirusScan software shall be installed in each PC and server internal DCS system.
- 2) All software installed in DCS devices shall be legally authorized official versions.
- 3) It is forbidden to install any third-party software in the equipment of operation monitoring layer, which is unrelated to DCS function, safety protection function or not licensed by DCS vendor.

12.3 Security Management Measure

- 1) DCS shall have identity authentication and access control functions and shall be able to grant different permissions according to different identities of users or devices, to prevent network information resources being used by unauthorized users. DCS shall be able to restrict user or device access to the system according to access permissions. DCS vendor shall specify the level of access and access settings in bidding technical documents.
- 2) DCS shall support data encryption technology.
- 3) DCS shall not be operated, managed, and maintained the by remote access service.
- 4) DCS shall not be upgraded software and updated virus definition files for the equipment of the process control layer and operation monitoring layer by external internet.
- 5) DCS vendor shall set operation access measures for external data interfaces of all man-machine interface, including laptop workstation. Unauthorized users shall not use mobile storage devices, CD burners, etc.
- 6) DCS vendor shall set all the external data interfaces of man-machine interface at the operation monitoring layer as forbidden status, which can be lifted by authorized users only when the equipment needs to be installed and maintained.

13 System Technical Requirement

13.1 Process Control Station

13.1.1 Control Function

- 1) The control station shall have at least the following functions:
 - a) PID Control
 - b) Switch Control
 - c) Set Point Limit
 - d) Output Limit
 - e) Output Change Rate Limit
 - f) Automatic/Manual Uninterrupted Switch
 - g) Automatic/Cascade Uninterrupted Switch
 - h) Manual Download
 - i) Ratio Control
 - j) Override Control
 - k) Feedforward Control
 - l) Batch Processing
 - m) Sequence Control
 - n) Division Control
 - o) Logical Control
 - p) Self-Correcting Control
 - q) Output Locking When Signal Failure
 - r) Numerical Calculation (Such as square root, addition, subtraction, multiplication, division, absolute value, etc.)
 - s) Temperature and Pressure Compensation (No need calculation formula from EPC Contractor)
- 2) DCS control station shall have the control period of 0.1s fast loop control function. The scanning cycles of common control loops are as follows:
 - a) Pressure regulating loop 0.5s
 - b) Temperature regulating loop 1s

- c) Flow regulating loop 0.25s
- d) Level regulating loop 0.25s

3) DCS control station shall have the function of PID parameter self-tuning.

4) DCS Vendor shall promise more than 60% automatic use rate of regulating loop after commissioning.

13.1.2 Redundancy Requirements and Setting Principle

- 1) The control station shall adopt synchronous redundancy configuration with fault tolerance function.
- 2) Redundant controllers shall process input data and perform control operations at the same time and controls the final executive element by the working controller.

13.1.3 Fault Tolerance Requirement

When the operation results of the working controller and the standby controller are inconsistent, there shall be self-diagnosis function and switching control module to judge the wrong position and select the controller.

13.1.4 Controller Load

The load of the controller shall not exceed 40%, and not exceed 50% after commissioning.

13.1.5 Spare Principle

- 1) The empty slots of I/O modules of each control station shall not be less than 20% spare.
- 2) There is spare controller.

13.2 Process Interface Unit

13.2.1 Basic Function

- 1) I/O modules shall have input signal filtering function.
- 2) According to different I/O module types, all input and output points shall have overload protection function.
- 3) I/O modules shall have signal isolation function.
- 4) The I/O modules shall have the isolation function between channels. Analog module shall be the type of electromagnetic isolation. And digital module shall be the type of optical isolation.

13.2.2 Analog Input Module

- 1) For analog input module (AI module for short), linearization shall be provided for standard and other non-linear input signal.
- 2) AI module shall be able to receive standard signals such as 4~20mADC, 1~5VDC and 0~10VDC, and shall support two-wire and four-wire signal type.

- 3) The wiring terminals of AI module should be three-terminal.
- 4) AI module shall support standard signal type of 4mA~20mADC.

13.2.3 Analog Output Module

- 1) Analog output module (AO module for short) shall be able to output standard signals such as 4~20mADC, 1~5VDC and 0~10VDC.
- 2) For 4~20mADC output, AO module shall be able to drive the load 750Ω minimum and support negative and positive output.
- 3) AO module shall support standard signal type of 4mA~20mADC.

13.2.4 Thermocouple Input Module

Thermocouple input module (TC module for short) shall be able to receive a variety of thermocouple signals of IEC standard graduation, and should have linearization and cold end compensation functions, and shall be able to set the upper and lower limits alarm of signal broke.

13.2.5 RTD Input Module

Resistance Temperature Detector input module (RTD module for short) shall be able to receive three-wire or four-wire RTD signals including platinum resistance and copper resistance and shall be able to set the upper and lower limits alarm of signal broke.

13.2.6 Digital Input Module

Digital input module (DI module for short) shall be able to receive switching signals. The input signal voltage is 24VDC and include active and passive signals.

13.2.7 Digital Output Module

Digital output module (DO module for short) shall be able to output switching signals. The output signal voltage is 24VDC and include power supply and non-power supply signals.

13.2.8 Pulse Input Module

- 1) Pulse input module (PI module for short) shall be able to receive pulse signal. The available frequency lower limit of pulse signal shall not be greater than 10Hz, and upper limit shall not be less than 5000Hz.
- 2) The voltage lower limit of high-level signal shall not be less than 4V; The upper voltage limit of a low-level signal shall not be greater than 3V DC.

13.2.9 Communication Module

- 1) Communication module (COM module for short) shall be able to receive and output communication signals related to other devices.
- 2) COM module shall be able to support protocols as following:

- a) Modbus RS485 RTU
 - b) Modbus TCP/IP
 - c) Profibus DP
 - d) Profinet
- 3) COM module shall be able to support hot bank up redundancy.

13.2.10 I/O Module Configuration Principle

- 1) If Signals are for the same purpose and from common and standby equipment's, the signals shall enter different I/O modules.
- 2) If the spare of I/O channel quantity is sufficient, it is as far as possible that there could be at least one channel for each I/O module.

13.2.11 Voltage Level of Signal Port

- 1) The AC voltage level of the I/O module interface shall not exceed 230VAC and the DC voltage level shall not exceed 24V DC.
- 2) The external active signal connected to the I/O module may be isolated by relay or isolator according to specific situation of the circuit, module voltage resistance characteristics and the signal type.

13.2.12 Redundancy Principle

- 1) The multi-channel AO module used for control function shall adopt synchronous redundancy, and the other multi-channel analog I/O modules used for control and interlock protection function shall adopt hot spare or synchronous redundancy.
- 2) It is not appropriate to connect additional signal conversion modules in series to realize the redundant configuration of I/O modules.
- 3) Redundant I/O modules shall be independent of each other. Redundant circuit in one module is unacceptable.

13.2.13 Spare Principle

- 1) The spare mode of I/O modules should be I/O channels spare.
- 2) The spare quantity of I/O modules of each type shall not be less than one.
- 3) The quantity of spare I/O channels of each type shall not be less than 20% of the quantity used.
- 4) The quantity of spare I/O module slots of each type shall not be less than 20%.
- 5) The quantity of spare I/O accessories of each type shall not be less than 20%.

13.3 Operator Station

13.3.1 Basic Function

- 1) As the man-machine interface of DCS, the operator station shall have the functions of processing process data, monitoring and controlling the production process, maintaining equipment and handling accidents.
- 2) The operator station shall realize data transmission with the control station through the communication network.
- 3) The mainframe of operator station shall have dual network cards.
- 4) The operator station shall have the functions of operation control, picture browsing, graphic display, alarm, data processing, data storage, information call, report call, etc.
- 5) The hardware and software of operator station shall have high reliability and fault tolerance, and the software shall be able to recover from errors.

13.3.2 Hardware Configuration

- 1) The mainframe of operator station should be a workstation.
- 2) The hardware configuration of operator station shall be able to fully meet the functional requirements of operator station. The mainframe of operator station shall be a workstation or high-performance industrial computer that in the market in the last two or three years, and its operating system shall be universal, suitable for industrial and reliable operating system.
- 3) The hardware specifications of the operator station shall be 32-bit bus, 64-bit CPU, and second-level cache. The operator station shall have a hard drive and can be configured to be redundant so that the mainframe could boot independently. The operator station shall be equipped with a CD drive.
- 4) The operator station shall be equipped with universal peripherals and interfaces, and the devices shall be commercially interchangeable, such as hard drive, display, universal keyboard, mouse, printer, etc.
- 5) The hardware configuration of operator station shall not be lower than the following requirements:

- Ø CPU: Intel i7 processor
- Ø Memory: 8GB
- Ø Hard disk: 1TB
- Ø Dual network cards
- Ø 24" LCD dual screen display
- Ø With keyboard and mouse
- Ø Operating system: WIN10

13.3.3 Operation Level

To prevent unauthorized personnel modifying the controller parameters, system display content, controller configuration data, etc., different access levels shall be set at least as follows:

- a) Level A - Operator
- b) Level B -- Supervisor
- c) Level C -- Engineer
- d) Level D -- DCS Technician
- e) Level E - Process control
- f) Level F - Dispatcher

13.3.4 Display Screen

The operator station shall be able to display the following standard images:

- a) General appearance.
- b) Grouping.
- c) Operation loop.
- d) Alarm list.
- e) Real-time trend.
- f) Historical trend (multiple loops could be displayed at the same time).
- g) Operation event record.
- h) System status and overview.
- i) Diagnostic information.
- j) Details of control points or detection points.
- k) Flow chart.

13.3.5 Alarm Function

- 1) Operator station shall have a perfect independent alarm function, and there shall be a clear difference between process variable alarm and system fault alarm.
- 2) Operator station shall be able to grade, partition and group the process variables alarm, and shall be able to automatically record and print alarm information. The resolution of recording alarm time shall be accurate to 0.1s.
- 3) Operator station shall have the function of alarm record classifying, filtering, screening, statistics and searching.
- 4) Operator station shall not have the function of alarm record deleting and modifying.
- 5) The alarm function of the operator station shall not depend on other alarm management equipment or software.

13.3.6 Auxiliary Operator Station

The function and hardware configuration of the auxiliary operator station shall be the same as that of the operator station, except the display device.

13.3.7 Software Configuration

In addition to DCS professional software, each operator station shall also be configured with antivirus software.

13.3.8 Others

- 1) The processor of the operator station does not require redundancy. If one operator station is broken down, the other operator stations shall have the same function, without configuration and overload.
- 2) Each operator station shall have independent power supply of 230VAC.

13.4 Engineer Station

13.4.1 Basic Function

As the man-machine interface for system management, configuration maintenance and modification, the engineer station shall have the following functions:

- a) System test and diagnosis.
- b) Hardware configuration and function definition.
- c) Configuration and download.
- d) Running operator station software and operating as operator station by modifying user permissions.

13.4.2 Hardware Configuration

The hardware configuration and performance of the engineer station shall not be lower than operator station.

13.4.3 Software Configuration

In addition to DCS professional software, each engineer station shall also be configured with antivirus software and Office software (version not less than Office 2016).

13.4.4 Configuration Management

The configuration application software shall have the following functions:

- a) System structure definition configuration.
- b) Database configuration.
- c) Control loop configuration.

- d) Programming.
- e) Picture drawing.
- f) Setting zeros, ranges, and alarm limits of process variables.
- g) Real-time and historical database configuration.
- h) Report configuration.
- i) Configuration download.
- j) Online configuration modification.

13.5 Power Supply Requirement

13.5.1 General Requirement

1) 230VAC Power Supply

- a) DCS shall provide independent AC power distribution cabinet for the process control system as far as possible. Only after approval of EPC Contractor, devices of non-process control systems could be installed in the power distribution cabinet, in different partitions and with different incoming breaker.
- b) Each 230VAC 4-wire instrument shall be equipped with an independent air circuit breaker.
- c) The switch capacity of the main intake circuit shall be not less than or equal the upstream power supply breaker.
- d) Integrated UPS fault signals shall be connected to DCS for monitoring and alarm.

2) 24VDC Power Supply

- a) 24VDC power conversion shall be inside the DCS cabinet. 24VDC power modules shall be hot backup redundancy.
- b) An independent unidirectional diode shall be provided for the output of each DC power module.
- c) The 24VDC power module for DCS internal system shall be separated with the 24VDC power module for field devices.
- d) Field devices of 24VDC power supply include 3- wire/4-wire field instruments, solenoid valves and other wet contact devices. Each 24VDC 4-wire instrument shall be equipped with an independent air circuit breaker.
- e) Fault signals of each 24VDC power module shall be connected to DCS for monitoring and alarm.
- f) The capacity of single 24VDC power module shall not be greater than 20A.

13.5.2 Load Requirement

The capacity of the DC power module shall consider the power load of spare I/O module slots and accessories, spare auxiliary equipment's. The load of the DC power supply unit shall be less than 50%.

13.5.3 Spare Principle

Air circuit breakers, power supply terminals, etc. shall not be less than 20% Spare quantity after commissioning.

13.6 Historical Data Storage

13.6.1 Basic Function

- 1) DCS shall be able to store and manage all process data, alarm records and event records, including process data from SIS, GDS, PLC and other control system by communication.
- 2) Historical trends shall be established for all analog process data involved in interlocking and regulating, including analog process data from SIS by communication.
- 3) All DCS operator stations shall be able to call the corresponding historical trend and data at any time.

13.6.2 Hardware Configuration

- 1) The model of the history recording workstation of this project shall be server type, and the hard disk shall adopt redundant configuration to fully meet the functional requirements of history recording.
- 2) The storage capacity of the data storage unit shall be as follows:
 - a) The quantity of stored variables shall not be less than 4 times of all I/O points.
 - b) The minimum interval period of analog data storage shall not be more than 1s.
 - c) Each variable store shall not be less than 200,000 bytes.
 - d) The storage time shall not be less than 180 days.
- 3) The history recording workstation shall be equipped with a Read-write optical disk drive or tape drive.
- 4) The percentage of storage capacity of hard disk in historical recording workstation shall be estimated, including the graphics, historical trends and other data saved on the hard disk, and the free space shall be greater than 40%.

13.6.3 Software Configuration

- 1) The software to realize historical data storage shall be database type and have the function of database management and operation.
- 2) Historical data storage software shall be able to record and store process variables, alarm records and event records.
- 3) The historical data storage software shall have the function of data processing and statistical operation, and shall be able to call data, display curves, display statistics, draw and tabulate, etc.

13.7 OPC Server

- 1) As the data interface for advanced application or management, OPC server shall be able to collect and transmit process data in DCS network.
- 2) OPC server shall be configured according to the operation partition or the third-party application server.
- 3) The network interface bandwidth of OPC server shall not be less than 1 Gbps, and its hardware shall be configured according to the amount of stored data to fully meet the requirements of real-time data exchange.

13.8 Spare part

- 1) The type and quantity of commissioning spare shall be recommended and provided by DCS vendor. The spare of I/O module, communication module and power module shall be one set of all type. The spare of consumables such as fuse wire shall not be less than 20%.
- 2) DCS vendor shall provide the recommended two-year spare list.
- 3) DCS vendor shall guarantee a supply period of 15 years for spare parts of the system.

13.9 Others

DCS vendor shall ensure that the system hardware is the latest model up to the date of shipment.

14 Network System

14.1 Network Structure

- 1) Ethernet is the backbone network to realize information exchange. The network interface adopts 100MB/1GB adaptive equipment, and the communication protocol adopts TCP/IP. The communication shall be fast speed, low load, safety and reliability, and the communication system shall be a fully redundant industrial digital communication system.
- 2) OPC server is used for data exchange communication between control system and data service layer, such as the factory management network.

14.2 Network Characteristic

- 1) The communication network of the operation monitoring layer and data service layer shall comply with ISO/IEEE802, OPC and other communication standards.
- 2) The network bandwidth of the process control layer shall not be less than 10Mbps, the operation monitoring layer shall not be less than 100Mbps, the data service layer shall not be less than 1Gbps, and the minimum permissible communication distance shall be greater than 1km.

- 3) The network device shall have the function of online network connection or disconnection. The network device could be connected or exited online without affecting the operation of other normal working devices.

14.3 Network Device

14.3.1 Switch

14.3.1.1 Basic Requirement of Switch

- 1) All switches shall be high quality industrial products through the overall system test by DCS manufacturer.
- 2) The switches used for the process control layer and operation monitoring layer shall be 1:1 redundancy, and the spare parts of switches shall not be less than 20% after the system configuration is complete.
- 3) The independent switch shall be used for communication between each Rack Room and CCR, to ensure the independence and security of the control layer of each unit. The Ethernet ports on all switches shall meet the network bandwidth requirements and shall be of the adaptive type of 10 MBPS/100 MBPS/1Gbps.

14.3.1.2 Basic Function of Switch

- 1) Switches used for process control layer, operation monitoring layer and data service layer shall have the functions of network interconnection, error checking and flow control. Products with modular structure or stacking function shall be used.
- 2) The Third layer network switch in this project shall also have functions of routing or VLAN.

14.3.1.3 Switch Configuration

- 1) The port rate of the switch shall meet the data communication requirements of the application location. The quantity of ports on a single switch shall not exceed 24.
- 2) The backplane bandwidth of switch shall not be less than two times of the maximum communication rate of all ports including the expandable ports.
- 3) The quantity of ports on the switch shall not be expanded in cascading mode.
- 4) Switches for different operation zones shall be independent.
- 5) The power supply of switch shall be redundant.

14.3.2 Firewall

14.3.2.1 Basic Requirement of Firewall

- 1) Firewall shall be used for communication between OPC server/interface and external network. The interface between DCS system and external system is firewall outlet ports.
- 2) Firewall shall be used for Ethernet communication between DCS and third-party devices in the LAN.

14.3.2.2 Basic Function of Firewall

- 1) The firewall shall have the functions of packet filtering, access control list setting, intrusion detection and traffic control.
- 2) The firewall filtering rules shall cover the processing methods of all packet's inlet and outlet the firewall, and there shall be default processing methods for packets that are not defined.
- 3) Filtering rules shall have a consistency detection mechanism to prevent conflicts between each rule.

14.3.2.3 Firewall Configuration

- 1) Firewall shall be hardware type and shall be independent. It shall not be shared with switches or routers. Hardware firewall shall not be replaced by software firewall.
- 2) The throughput capacity and concurrent connection of firewall shall meet the requirements of DCS network data exchange.
- 3) The throughput capacity of firewall in data service layer shall not be less than 100Mbps, and the maximum concurrent connection shall not be less than 100,000.

14.3.3 Photoelectric Converter and Optical Cable

- 1) Photoelectric converter shall support DCS network protocol, coordinate full/half duplex transmission mode and detect the port status automatically. The optical cable type shall match the optical cable interface of the photoelectric converter and meet the requirements of signal transmission distance.
- 2) For photoelectric converter, the Ethernet ports of shall be 10Mbps/100Mbps/1Gbps adaptive type and the optical cable ports shall be 100Mbps/1Gbps adaptive type, pure 100Mbps or 1Gbps products are unacceptable.
- 3) These optical fiber communication devices shall be supplied by DCS vendor, including optical cable between DCS and the third-party control system, photoelectric converter and installation accessories both at the DCS side and the third-party control system side. See technical Annex 1: DCS data sheet for the quantity of photoelectric converters.
- 4) For photoelectric converter in field, stainless steel junction box shall be provided in packaged. The power supply of the photoelectric converter in field shall be 24VDC, and DCS vendor shall specify the minimum working voltage in bidding technical documents.

14.4 Redundancy Principle

Network communication devices of all levels shall be synchronous redundancy or hot spare redundancy. The communication bus shall meet the following requirements:

- 1) I/O bus (including interface control devices and cables) shall be 1:1 redundancy.
- 2) LAN bus (including interface control devices and cables) shall be 1:1 redundancy.
- 3) Other network communicating with DCS could be configured as required, such as MODBUS,

PROFIBUS, OPC, TCP/IP, etc.

- 4) For Modbus RTU communication, the communication data of each bus shall not exceed 250 words to ensure the real-time performance of communication data.

14.5 Network Load

When industrial Ethernet is used in the LAN, the network load shall not exceed 20%. When token ring is used, the network load shall not exceed 30%. For networks using other protocols, the maximum allowable load shall not exceed 50%. In normal operation, the network load of the process control network shall be less than 50% of the maximum allowed load of the network protocol.

14.6 Communication with Other System

- 1) DCS shall be able to communicate with SIS, GDS and other control systems through Modbus, TCP/IP and other protocols.
- 2) Between DCS and SIS and between DCS and GDS, the communication link shall be redundant, and the control and interlocking signals shall be connected through hardware.
- 3) Between DCS and third-party devices including PLC, MMS and other systems, the communication protocol shall be Profibus DP, Modbus TCP/IP or Modbus RS485 RTU. And the control and interlocking signals shall be connected through hardware. When Profibus DP exceeds 400m or Modbus TCP/IP exceeds 100m, optical cables shall be used for communication.
- 4) DCS shall have OPC communication function, to connect with other packaged systems or the whole plant information management system.

14.7 Spare

The spare ports for network communication devices and parts of all levels shall be at least 20%.

15 Auxiliary System

15.1 Auxiliary Console

- 1) The auxiliary console includes emergency stop button, lock switch, manual reset switch, selection switch, indicator lamp, etc., which shall be determined during the kick-off meeting.
- 2) The shape, size and color of the auxiliary console shall be coordinated with the DCS operator station, and the DCS vendor shall provide the selection scheme to be determined by the Owner.
- 3) Configuration principle of switch, button, and indicator lamp:
 - a) Switches, buttons, and indicator lamps shall be arranged in different areas according to the unit.
 - b) The voltage level shall be 24VDC.

- c) Switches, buttons, and indicator lamps shall have labels indicating their position numbers and functions.
- d) Switches, buttons, and indicator lamps shall be connected to terminal block and connect to DCS cabinet through hardwire cables.
- e) Switches and buttons shall be equipped with safety cover to avoid accidental touch.
- f) Some indicator lamps can be installed in the switch buttons.
- g) Emergency stop button shall be red with operation protection.
- h) Commissioning bypass and "Allow" bypass switches shall be lock type, green.
- i) The signal alarm device shall be the type with the first signal memory, with confirmation, reset and light test buttons.

15.2 Cabinet

- 1) The DCS cabinet and auxiliary cabinet adopt the front and rear single-door and left axle mode. The dimensions of the cabinet are 800mm wide x 800mm deep x 2100mm high, with a 100mm base. The recommended color standard for the cabinet is RAL 7035. The material must be cold-rolled steel plate. Cabinet position plates must be configured on the front and rear of all cabinets. The numbering rules must comply with the EPC Contractor requirements and be determined during the kick-off meeting.
- 2) The protection level of indoor installed cabinets should not be lower than IP30. The protection level of the cabinet installed in the semi-open workshop shall not be lower than IP55. The protection level of outdoor cabinets should not be lower than IP65.
- 3) The ground bus bar in the cabinet maybe installed at the bottom of the cabinet, close to the cable inlet position. The working grounding and protection grounding shall be configured separately. The working grounding shall be insulated from other conductors in the cabinet. The fans and lights in the cabinet shall be powered by 230VAC and gated lights should be used. All cables entries shall be through the bottom of cabinet.
- 4) There shall be lifting lugs on the top of all cabinets, and door locks on the cabinet doors. Wiring duct shall be installed in the cabinet, and power cables and instrument signal cables are laid separately. Terminals are crimped with tubular connectors and marked with cable or terminal mark and number.
- 5) 20% of the installation space is reserved for each type of cabinet.
- 6) All kinds of cabinets, internal instruments and electrical equipment materials are purchased and integrated by DCS vendor.
- 7) The quantity of cabinets shall be determined by the DCS vendor, but the maximum quantity shall not exceed the quantity in the CCR and Rack Room layout drawing.
- 8) Drawing rack shall be configured in each cabinet, and the latest wiring diagram of the corresponding cabinet should be placed in the drawing rack before delivery.

- 9) This project requires an intermediate terminal cabinet to be used between the system cabinet and the field terminal box. Signals shall be arranged in intermediate terminal cabinet, and then sent to the system cabinet.
- 10) DCS vendor shall arrange power distribution cabinets according to the control and detection points and the power requirements of field instruments.

15.3 Terminals

- 1) All instrument signals from the site must be equipped with wiring terminals. The interface between DCS vendor and EPC Contractor is the wiring terminal in the cabinet. 20% spare of all type of terminals shall be installed in cabinet.
- 2) The integrated terminal board approved by DCS manufacturer are required in this project. The terminal board are connected to the system cabinet with bunched cable.
- 3) The terminal shall be made of Phoenix or Weidmuller company. The signal terminal shall be switch type or fuse type, and terminal products are moisture-proof, overvoltage proof, flame retardant and long life.
- 4) For each signal circuit, there shall be one terminal of switch type or fuse type. Each signal circuit shall be configured with a fuse terminal, fuse wire $\leq 1A$, unless there is overcurrent protection measure within the I/O card.

15.4 Relay

- 1) The digital signal from MCC or field Electrical Control Cabinet shall be isolated by relay. All field solenoid valve signals shall adopt relays. 20% spare of all relays type shall be installed in cabinet.
- 2) Relay board is used in this project. The relay board are connected to the system cabinet with bunched cable.
- 3) The contact capacity of relay shall meet the requirements of 230VAC @3A, at the same time, 24VDC @5A. An indicator lamp is required at the front side of the relay, and the supply voltage is 24VDC.
- 4) The contact type of relay shall be SPDT.
- 5) When the coil side or contact side of the relay adopts unsafe voltage, the relay terminal board shall be equipped with a safety cover, and an obvious mark shall be set on the cover.
- 6) For high-density relay board card (32 channels/board), DCS vendor shall provide two power supply.
- 7) Relay for wet contact such as field solenoid valve, each wet contact signal circuit shall provide a fuse, the size of the fuse is no more than 1A.

15.5 Safety Barrier

- 1) All intrinsic safety analog signals (AI/AO) shall be equipped with isolated safety barriers. Safety barriers shall be mounted with metal DIN rail. 20% spare of all safety barriers type shall be installed in

cabinet.

- 2) For safety barrier adopted in this project, the interface shall be directly connected to DCS I/O card, and the safety barrier shall be able to transmit various intelligent communication signals (such as HART) to the DCS I/O card port.
- 3) Safety barrier shall be 24VDC power supply type.

15.6 Isolator

- 1) Analog signals from electrical MCC or field electrical control cabinets shall be isolated by isolators. Isolators shall be mounted with metal DIN rail. 20% spare of all isolators type shall be installed in cabinet.
- 2) For isolator adopted in this project, the interface shall be directly connected to DCS I/O card, and the isolator shall be able to transmit various intelligent communication signals (such as HART) to the DCS I/O card port.
- 3) Isolator shall be 24VDC power supply type.

15.7 Surge Protection Device

Surge protection device shall be mounted with metal DIN rail and use the DIN rail as the ground bus bar. 20% spare of all surge protection devices type shall be installed in cabinet.

15.8 Cables and Connecting Accessories

- 1) Communication cables and connecting accessories shall be provided with DCS and supplied by DCS vendor.
- 2) Bunched cables and the connectors used in the system shall be supplied by DCS vendor, and the specific quantity and specifications shall be determined at the kick-off meeting.
- 3) The different wiring duct shall be used for intrinsic safety cables and non-intrinsic safety cables, and the wiring terminal or terminal board shall be set separately with the spacing greater than 50mm. The intrinsic safety cable and the wiring terminal board shall be marked blue. DCS vendor are responsible for on-site connection of signal and power cables between various cabinets.

15.9 Printer

- 1) Printer shall be able to realize screen printing, graphic printing, report printing and alarm printing requirements of man-machine interface such as operator station and engineer station.
- 2) Alarm printer and report printer shall be mutually standby. The operator station shall be able to switch the work of the printer in the way of instructions, and the bidding technical documents should explain the driving mode of alarm printer and report printer.
- 3) The printer should be network type.

16 APC Application Station

- 1) If it is necessary, Advanced Process Control (APC) application station could be used.
- 2) APC application station is the operating platform of the advanced control software, it shall be able to read and write the process variables through the OPC database interface in DCS network. The APC application station hardware configuration shall meet the requirements of the software operation, calculation, and data storage.
- 3) The APC application station shall be within the operation monitoring layer and be outside the hardware firewall. DCS vendor should provide APC engineering cases that are successfully used.
- 4) The hardware configuration shall be not lower than 8GB memory, 320 GB dual-mirror hard disk, 48XDVD RW and 256MB independent video card, with optical mouse and standard keyboard.

17 Software Configuration

17.1 Control and Operation Software

- 1) DCS shall provide a complete set of process control software, process detection software and operating software, the capacity of the software shall be equipped according to the maximum configuration of the equipment.
- 2) The capacity of operation points of the software equipped for each operator station shall not be less than 3 times of the corresponding system configuration capacity.
- 3) The system software license points of each engineer station shall be at least 3 times the I/O capacity configured for the system.
- 4) DCS vendor shall provide a list of optional control station, advanced control of operation station, batch control, data processing and statistical accounting and other available application software.
- 5) DCS shall include PID parameter self-tuning function, and PID self-tuning module of controller level is preferred. DCS vendor should introduce specific functions and application cases. If a separate configuration software package or license is required, itemized quotation is required in the bidding documents, and the software license of different quantity shall be quoted, one set for each license quantity level.

17.2 Configuration Software

- 1) DCS configuration software shall be able to modify and download the configuration data online.
- 2) DCS System and configuration software shall support off-line configuration and debugging.
- 3) In addition to the necessary configuration software, DCS vendor shall provide a list of other optional configuration tool software. Electronic instruction manuals for all types of software shall be provided free of charge.

- 4) In the scope of DCS 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.

17.3 Operating System Software and Tool Software

- 1) DCS shall provide a complete set of operating system software and necessary tool software.
- 2) The engineer station shall be equipped with legitimate common high-level language software, database management system, office software, network management software and other tool software.

17.4 Software Version

- 1) DCS software shall be a mature version that has been tested.
- 2) Unreleased beta software is strictly prohibited to use.
- 3) DCS vendor shall explain the software version upgrade plan in the bidding technical documents.
- 4) DCS shall adopt the latest computer technology, and the vendor shall ensure that the software up to the date of shipment is the latest version. During the contract guarantee period and one year thereafter, the vendor shall provide the latest version of system software, application software and upgrade services free of charge. For system failures caused by the software version, the vendor shall deal with the issues in time.

17.5 Software Licensing

- 1) All relevant DCS software shall be authorized official versions.
- 2) All hardware, including spare equipment, shall be used simultaneously without software license restrictions.
- 3) The bidding technical documents shall explain the corresponding software package or license, provide the software list of the system configuration (sub-region, sub-equipment list and explain the number of authorization points, should be detailed: name, version, function, product series number, sample number, quantity, etc.). Software license shall be quoted separately, including the communication point license between DCS and third party, such as SCADA license, OPC license, etc.
- 4) During the implementation of the project, if there are any software license that could not meet the system requirements, no matter how much I/O points changed, DCS vendor shall immediately replenish the software license free of charge and guarantee that there is still 20% license spare after the pre-acceptance of all units. The software license spare shall be checked by the man-machine interface.

18 Functional Design Specification

The functional design specification shall be prepared by DCS vendor, the Owner and design organization shall put forward their opinions according to the specific situation of the project, and finally reach an agreement and approve the implementation. The functional design specifications shall include hardware functional design specification and software functional design specification.

- 1) The main contents of the hardware functional design specification shall at least include:
 - a) Definitions, abbreviations, and standards for implementation
 - b) Operating, transportation and storage conditions of hardware equipment's
 - c) Electromagnetic compatibility EMC certification
 - d) General system appearance and network structure
 - e) Hardware functions and technical specifications of control station, I/O, power module, switch and other communication interfaces
 - f) Redundancy type description of redundant hardware
 - g) Setting of system fault alarm and fault safety mode
 - h) Hardware corrosion prevention measures
 - i) Typical cabinet layout diagram
 - j) Typical signal loop diagram and wiring diagram
 - k) Typical power supply wiring diagram
 - l) Instructions for installation and use of various accessories
- 2) The main contents of the software functional design specification shall at least include:
 - a) Definitions, abbreviations and standards for implementation
 - b) Introduction to the system software package and detailed instructions
 - c) Introduction of third-party software
 - d) Network introduction, maximum limit of system size, network address allocation principle and scope, network security policy
 - e) Description for system internal network data transmission
 - f) Naming principles for each network station
 - g) Instrument variable naming principles, including maximum string digit limit
 - h) General function block description
 - i) Description of common data items
 - j) Setting principle of analog filter and digital filter

- k) Pulse width requirements for pulse signals
- l) Calculation formula of steam and gas temperature and pressure compensation
- m) HMI display module description
- n) Setting principles and methods of permission operation
- o) Alarm mode and grade description
- p) Flowmeter square root instructions
- q) The principle of duration unit of the cumulative value, clearance digit and small flow cut
- r) Trend loop display, including group display principle
- s) Principles for marking logic loops and complex control loop in the system
- t) The color regulation of equipment's and pipelines on HMI, including dynamic jump color
- u) Scanning period of different control variables, including high-speed scanning and ordinary scanning period
- v) Startup instructions for control station, including system startup conditions, cold startup and restart
- w) Archiving instructions for historical data

19 Acceptance

19.1 Factory Acceptance Test

19.1.1 General

FAT is carried out at the DCS manufacturer plant with the participation of EPC Contractor and the Owner. FAT shall be carried out jointly by technicians of the three parties, mainly SIS vendor, who must ensure that all technical indicators of the equipment provided meet the requirements specified in the product specification, supply contract, system kick-off meeting and coordination meeting. After confirming that all the conditions listed in 19.1.2 have been met, DCS vendor shall notify EPC Contractor and Owner 15 days in advance for factory acceptance. FAT shall not relieve vendor's obligations under the contract.

19.1.2 The following conditions should be met before DCS FAT:

- 1) DCS has been debugged at the factory and the test report is available.
- 2) DCS manufacturer prepares the FAT procedures according to technical annex, functional design documents and relevant standards.
- 3) DCS manufacturer has prepared acceptance documents and records according to the acceptance procedure.

19.1.3 FAT shall include the following contents:

1) System configuration check:

- a) The model, specifications and appearance of each equipment and component shall meet the requirements.
- b) The specification, quantity and version of the software shall meet the requirements.

2) Configuration check:

- a) The configuration of standard functions, flow chart picture, grouping picture, alarm picture and trend display of the operator station shall meet the requirements.
- b) Engineer station, history recording workstation and other workstations and servers shall be put into operation in good condition, and the software functions and configuration functions shall meet the design requirements.
- c) Control function shall meet requirements.

3) System performance test:

- a) System signal processing accuracy test (AI, AO, DI, DO and other I/O modules shall be sampled 100%).
- b) Redundancy and fault tolerance test of the system.

19.1.4 The FAT report shall include the following contents:

- 1) FAT procedures.
- 2) Results of inspections and tests.
- 3) Final FAT conclusion.

19.2 Integration Factory Acceptance Test

19.2.1 General

In this project, the following third-party systems are determined to attend integration factory acceptance test with DCS.

- a) SIS system
- b) GDS system
- c) MMS system

Above mentioned third-party system vendors shall deliver the goods to the place designated by DCS vendor and assign personnel to unpack and install them. The connection between the systems should be done by third-party system vendors and DCS vendor. The third-party system vendors shall participate in the whole process of integration factory acceptance test and be responsible for packaging delivery to the designated place after completing the rectification of the final list.

19.2.2 The following conditions should be met before DCS IFAT:

- 1) The equipment's of DCS and third-party systems has been debugged at the factory and the test report is available.
- 2) For third-party systems equipment integrated in DCS factory, simulation test equipment should be equipped communication and related data testing should be completed in DCS factory, and test reports should be provided.
- 3) DCS has third-party communication or performance test equipment and software.
- 4) The DCS manufacturer should prepare the factory integration acceptance procedures according to the contract technical accessories, system hardware configuration, system software functions, third-party technical data and relevant standards.

19.2.3 IFAT shall include the following contents:

- 1) System configuration check:
 - a) The model, specifications and appearance of each equipment and component from third-party systems shall meet the requirements.
 - b) The specification, quantity, and version of the software from third-party systems shall meet the requirements.
- 2) Configuration check:
 - a) Standard functions of third-party systems integrated with DCS shall meet requirements.
 - b) Test the communication function and actual data exchange between DCS and third-party systems. The third-party communication equipment or analog communication equipment shall contain communication data for practical applications.

19.2.4 The IFAT report shall include the following contents:

- 1) IFAT procedures.
- 2) Results of inspections and tests.
- 3) Final IFAT conclusion.

19.3 Site Acceptance Test**19.3.1 The following conditions should be met before SAT:**

- 1) Specifications and quantity of each equipment and component shall be consistent with the packing list and shall not be damaged during transportation.
- 2) Equipment's installation meets requirements.
- 3) DCS equipment's should operate normally after software installation and configuration data loading.

- 4) All hardware should be tested according to the procedures provided by DCS manufacturer and all hardware's shall work 100% normally.

19.3.2 SAT shall include the following contents:

- 1) Review DCS FAT report and field debugging records.
- 2) Configuration check (Same with FAT).
- 3) System signal processing accuracy test, AI, AO, and other I/O modules shall be tested 100%.
- 4) Redundancy and fault tolerance test of the system.
- 5) Test the communication between DCS and third-party systems.

19.3.3 The SAT report shall include the following contents:

- 1) SAT procedures.
- 2) Results of inspections and tests.
- 3) Final SAT conclusion.

20 Project Implementation Plan

20.1 System Kick-off Meeting

DCS kick-off meeting should include the follow contents:

- 1) Determine the final configuration, specifications and quantity of DCS hardware and software and spare parts.
- 2) Determine the work scope and responsibilities of the Owner, the design organization, the vendor and the relevant third-party equipment's vendor in the project.
- 3) Determine the personnel and responsibilities of the principal persons in charge of each party during the project implementation.
- 4) Specify the content, format, quantity, and delivery method of all documents required by the project and designate the person in charge of document management.
- 5) Develop the work plan of the whole project, determine the delivery time of equipment's and documents, and the starting date of each working period.
- 6) Formulate the project schedule management plan, and define the content of the progress report, the submission period and the corresponding measure after the progress is delayed.
- 7) DCS vendor shall provide the topics to be discussed at the kick-off meeting based on the experience of previous similar projects.

20.2 Coordination Meeting

The project plans to hold two design coordination meetings, and the time will be determined at the kick-off meeting. The documents confirmed by both parties at coordination meeting and the modified versions of documents shall have the same effect as contract attachments.

20.3 Configuration

20.3.1 Configuration preparing

Before the DCS configuration work begins, the following working conditions shall be available:

- 1) Software and hardware required for offline or online configuration have been installed.
- 2) Configuration staff and engineering personnel are in place, and configuration technical data and other auxiliary data are fully prepared.
- 3) The function design documents have been completed.
- 4) I/O list, DCS instrument index, block diagram or description of complex loop, logic diagram or interlock table and sketch of interlock picture of the project have been completed.

20.3.2 System configuration

DCS configuration procedure includes the following contents:

- 1) Structure configuration: each node in DCS network is configured according to the established system structure, including name, description, address, mutual relationship, and function.
- 2) Parameter setting: hardware parameters of each DCS device, unit and module should be configured according to project requirements.
- 3) Security policies setting: configure the domains and user groups of DCS network, and define the access permissions and passwords of each group and its members, define database access restrictions and define firewall filtering rules.

The system configuration is completed by DCS vendor. During the on-site debugging, the configuration should be modified and improved based on the actual requirements, and this part of cost has been included in the on-site service cost and shall not be charged extra.

20.4 System Integration

The integration of DCS with the third-party equipment's shall be the responsibility of the DCS vendor and shall meet the following requirements.

- 1) DCS vendor shall be responsible for the installation and debugging of the integration of DCS and third-party equipment's.
- 2) DCS vendor shall be responsible for the reliability and stability of DCS after integration.
- 3) DCS vendor shall be responsible for the communication between DCS and third-party equipment's.
- 4) The third-party equipment vendors shall cooperate with DCS for the integration of DCS and third-party

equipment's.

21 Engineering Technical Services

21.1 Training

- 1) The trainer shall be able to teach in English, and the trainer's resume shall be submitted at the kick-off meeting and confirmed by EPC Contractor and the Owner. During configuration training, EPC Contractor and Owner have the right to require changing incompetent training and coaching staff.
- 2) The training course and content introduction shall be sent to EPC Contractor and the Owner for confirmation two weeks in advance.
- 3) During training, DCS vendor shall provide training material for everyone of EPC Contractor and the Owner.
- 4) During training, DCS vendor should be fully prepared, provide training computer terminal for everyone and ensure the time on the machine.
- 5) If increasing the quantity of trainees takes impact on the business quotation, DCS vendor shall provide the training cost for each additional person.
- 6) The training of this project is divided into three times:
 - a) Software configuration and maintenance training, for two weeks, XX person-time, training place: XXXXX.
 - b) System operation training, for one weeks, XX person-time, training place: XXXXX.
 - c) On-site operation training, for 3 days, XX person-time, training place: project site.

21.2 Technical Services

- 1) DCS vendor shall provide relevant technical consulting services during the whole process of project.
- 2) DCS vendor shall provide technical clarification services for all delivered documents, materials and equipment's.
- 3) DCS vendor shall provide relevant data in the process of factory acceptance and site acceptance and assign specialized engineering and technical personnel to cooperate with the acceptance work.

21.3 On-site Technical Services

21.3.1 On-Site Installation

On-site installation shall be carried out by the site construction team under the guidance of DCS vendor. DCS vendor shall provide consultation and assistance for the installation.

21.3.2 System power on

After DCS equipment's are installed and wired on site, the technical personnel of DCS vendor shall be responsible for system power on. Before power on, the technical personnel of DCS vendor shall check the installation, wiring, power supply and grounding of the system, and then power on and start.

21.3.3 Joint Debugging and Commissioning

Before the factory units put into operation, DCS vendor shall assign experienced engineers to the site, to carry out joint debugging and commissioning assisting EPC Contractor and Owner, to ensure all parts of the system could be work in normal condition and put into operation completely.

21.3.4 System Running

During the factory units put into operation, DCS vendor shall assign experienced engineers to the site, to ensure the normal operation during the system running period.

22 Documents

Documents Data Requirements					
No.	Document Name	Language	Qty.	Term of Delivery	Remarks
Engineering design documents delivered by vendor					
1	System general specification	English	6/2		
2	Control system architecture diagram	English	6/2		
3	Typical loop diagram	English	6/2		
4	Hardware function design specification	English	6/2		
5	Software function design specification	English	6/2		
6	System hardware and software materials list	English	6/2		
7	Layout of operation console and auxiliary console	English	6/2		
8	Cabinet arrangement drawing, including system cabinet, safety barrier cabinet, relay cabinet, terminal cabinet, marshalling cabinet, power distribution cabinet and network cabinet, etc.	English	6/2		
9	Detailed dimensions drawing of operation console, auxiliary console and printer console	English	6/2		
10	Detailed cabinet dimensions (including base dimensions)	English	6/2		
11	Input and output card distribution table	English	6/2		
12	Input, output card and terminal wiring drawing	English	6/2		
13	System power consumption and heat dissipation specification	English	6/2		

Documents Data Requirements					
No.	Document Name	Language	Qty.	Term of Delivery	Remarks
14	System grounding drawing	English	6/2		
15	System internal cable wiring drawing	English	6/2		
16	Hardware FAT test procedure and signature acceptance record	English	6/2		
17	Software FAT test procedure and signature acceptance record	English	6/2		
18	IFAT test procedure and signature acceptance record	English	6/2		
19	Test records of other equipment's	English	6/2		
20	IP address assignment table	English	6/2		
21	Switch port assignment table	English	6/2		
22	Optical fiber port assignment table	English	6/2		
23	System network cable list	English	6/2		
24	Certificate and instruction manual for all parts	English	6/2		
25	Paint color and specification	English	6/2		
26	Copy files of all display screen	English	6/2		
27	Configuration files of application software (including the main parameters, variables, I/O assignment table used by the loop diagram, programming, logic diagram software, etc.)	English	6/2		
28	Packing list	English	6/2		
29	Other intermediate documents	English	See notes		
30	Other engineering documents not listed	English	See notes		
31	Complete as-built drawings in accordance with standard and code	English	6/2		
Application manual and documents delivered by vendor					
1	Technical specifications for various equipment's	English	6/2		
2	System power distribution and grounding engineering manual	English	6/2		
3	Various process I/O terminal wiring drawings	English	6/2		
4	Equipment installation manual	English	6/2		

Documents Data Requirements					
No.	Document Name	Language	Qty.	Term of Delivery	Remarks
5	System software user manual	English	6/2		
6	Various application software user manual	English	6/2		
7	Operator manual	English	6/2		
8	Engineer manual	English	6/2		
9	System operation and maintenance manual	English	6/2		
10	Configuration training materials	English	6/2		
11	Catalog of packaged equipment or instruction manual	English	6/2		
12	Relevant data or tables required in DCS Technical Specification	English	6/2		
13	Other necessary documents	English	6/2		
Engineering design documents provided by EPC Contractor					
1	Control Room Layout Drawing	English	1/1		
2	Field Auxiliary Room Layout Drawing	English	1/1		
3	P&ID Drawing	English	1/1		
4	Instrument Index	English	1/1		
5	DCS I/O List	English	1/1		
6	DCS Supervision Data Sheet	English	1/1		
7	Instrument Cable List	English	1/1		
8	Junction Box Wiring Drawing	English	1/1		
9	Instrument Power Supply System Drawing	English	1/1		
10	Interlocking Data Sheet or Interlocking Diagram	English	1/1		
11	Sequence Control Program Diagram	English	1/1		
12	Description of Process Control and Complex Loop	English	1/1		
13	Communication Address Table of Third-Party Devices	English	1/1		

Notes:

1) Quantity x/x respectively represents the quantity of complete paper documents and the quantity of



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electronic documents, the electronic documents shall be editable.

- 2) The delivery time of documents shall be determined at kick-off meeting.
- 3) The detailed contents of intermediate documents and other engineering documents not listed, and the number of documents shall be determined at kick-off meeting.