Project No.	7G02
Contractor Doc No.	INS-7G02-00-85-010
Change No.	0
Revision No.	A
Page	1 / 47

Specification for
Package Unit Instrumentation Standard

Discipline: Instrument

A	2023.08.08	Issued for Review	Zhu X.D.	Liu Z.W.	Huang Y.		
Rev	Date	Purpose	ORIG. By	CHK'D By	APP'D By	F. APP'D By	Customer
Unit		Offsite & Utilities			Unit/Sub-unit Code		00
Sub-unit		General			Project Stage		FEED

Chemical Complex for Phosphates Processing Project

The copyright of this document belongs to China Tianchen Engineering Corporation (TCC) that shall neither be provided or disclosed in any form to any third party nor be used for any purpose other than what is specified herein without the prior written consent of TCC.

CONTENT

1 General

This specification defines the functional requirements related to package suppliers for Instrumentation & Control equipment of all units 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's.

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
ESD	Emergency Shutdown 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
NIS	Non Intrinsic Safety
OSBL	Outside Battery Limit
P&ID	Piping & Instrumentation Diagram
PLC	Programmable logic Controller
SAT	Site Acceptance Test
SIL	Safety Integrity Level
SIS	Safety instrumented system

Abbreviation	Description
SS	Stainless Steel
UPS	Uninterruptible Power Supply

3 Codes and Standards

1	GB 50093-2013	Code for construction and quality acceptance of automation instrumentation engineering
2	GB/T 50779-2022	Standard for blast resistant design of buildings in petrochemical engineering
3	GB/T 50493-2019	Standard for design of combustible gas and toxic gas detection and alarm for petrochemical industry
4	GB/T 50770-2013	Code for design of safety instrumented system in petrochemical engineering
5	GB 50058-2014	Code for design of electrical installations in explosive atmospheres
6	GB/T 4208-2017	Degrees of protection provided by enclosure (IP code)
7	HG/T 20505-2014	Functional identification and symbols for process measuring and controlling instrumentation
8	HG/T 20592~20635 -2009(2017 Review)	Steel pipe flanges, gaskets and bolting
9	SH/T 3005-2016	Design specification for instrumentation selection in petrochemical industry
10	SH/T 3006-2012	Specification for design of control room in petrochemical industry
11	SH/T 3007-2014	Design specification for tank farms of storage and transportation system in petrochemical industry
12	SH/T 3019-2016	Design specification for instrument tubing and wiring in petrochemical industry
13	SH/T 3020-2013	Design specification for instrument air supply system in petrochemical industry
14	SH/T 3081-2019	Design specification for instrumentation earthing in petrochemical industry
15	SH/T 3082-2019	Design specification for instrumentation power supply in petrochemical industry
16	SH/T 3092-2013	Spectification of design for distributed control system in petrochemical industry

17	SH/T 3104-2013	Specification for design of instrument installation in petrochemical industry
18	SH/T 3126-2013	Design specification for tracing and insulation of instrument and piping in petrochemical industry
19	SH/T 3164-2021	Specification for design of instrument system lightning surge protection in petrochemical industry
20	SH/T 3174-2013	Design specification for on-line analyzer systems in petrochemical industry
21	ANSI/FCI 70-2	Control Valve Seat Leakage
22	ANSI/FCI 70-3	Regulator Seat Leakage
23	API STD 598	Valve Inspecting and Testing
24	API STD 607	Fire Test for Quarter-turn Valves and Valves Equipped with Nonmetallic Seats
25	ISO 15848-1	Industrial valves - Measurement, test and qualification procedures for fugitive emissions - Part 1: Classification system and qualification procedures for type testing of valves
26	ISO 5167-1	Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full - Part 1: General principles and requirements
27	ISO 5167-2	Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full - Part 2: Orifice plates
28	ISO 5167-3	Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full -Part 3:Nozzles and venturi nozzles
29	ISO 5167-4	Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full -Part 4: Venturi tubes
30	ISO 5167-5	Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full -Part 5: Cone meters
31	ISO 5167-6	Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full - Part 6: Wedge meters

32	ASME B16.36	Orifice Flanges
33	GOST 2405-88 (гост 2405-88)	Pressure gauges, vacuum gauges, pressure-and-vacuum gauges, draught gauges and draught-and-pressure gauges
34	GOST 18140-84 (гост 18140-84)	SSI differential pressure gauges
35	GOST 14254-2015 (гост 14254-2015)	Degrees of protection provided by enclosures (IP Code)
36	СТ РК 2.401-2016	PUE RoK Regulations for the Design and Construction of Electrical Installations of RoK
37	No.345 Order (No.345 Приказ)	Order of the Minister for Investment and Development of the Republic of Kazakhstan on 30 December 2014 the year No. 345
38	Gas-86 (ТУ-Газ-86)	The requirements to installation of signaling devices and gas sensors

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.

4 Units of Measurement

Component	%v, ppm(v)
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	μs/cm
Weigh	kg, t
Viscosity	mPa.s (cP)
Distance(Length)	m, mm
Power	W, kW
Force	N, kN
Current	A, mA

5 Numbering

5.1 Instrument Numbering

Instrumentation shall be numbered as follows:

AA-FFFF-BB-XXXS

- AA: Plant code (The last two digits of Plant number), refer to Units & Sub-units List.
- FFFF: Instrument function code, consisting of first letter and succeeding letters, refer to the table - Instrument Function Code. For the instrument number of ESD, there shall be a letter “Z” closely follow the first letter.
- BB: Unit/Sub-unit number, refer to Units & Sub-units List.
- XXX: A sequential number or equipment number abbreviation.
- S: An optional character suffix, one or two letters.

Example: 16-PZT-25-001A

Instrument Function Code

	First Letter			Succeeding Letters	
	Measured or Initiating Variable	Variable Modifier	Readout or Passive Function	Output or Active Function	Function Modifier
A	Analysis		Alarm		
B	Burner, combustion		User’s choice	User’s choice	User’s choice
C	Conductivity			Control	Close
D	Density	Differential			Deviation
E	Voltage		Sensor, Primary element		
F	Flow, Flow rate	Ratio			
G	Combustible /Toxic Gas		Glass, Gauge, Viewing device		
H	Hand				High
I	Current		Indicate		
J	Power		Scan		
K	Time, Schedule	Time rate of change		Control station	
L	Level		Light		Low
M	Moisture, Humidity				Middle, Intermediate
N	User’s choice		User’s choice	User’s choice	User’s choice

	First Letter			Succeeding Letters	
	Measured or Initiating Variable	Variable Modifier	Readout or Passive Function	Output or Active Function	Function Modifier
O	User's choice		Orifice, Restriction		Open
P	Pressure		Point (Test connection)		
Q	Quantity	Integrate, Totalize	Integrate, Totalize		
R	Radiation		Record		Run
S	Speed, Frequency	Safety		Switch	Stop
T	Temperature			Transmit	
U	Multivariable		Multifunction	Multifunction	
V	Vibration, Mechanical Analysis			Valve, Amper, Louver	
W	Weight, Force		Well, Probe		
X	On/off valves	X Axis	Accessory Devices Unclassified	Unclassified	Unclassified
Y	Event, State or Presence	Y Axis		Auxiliary Devices	
Z	Position, Dimension	Z Axis, Safety Instrument System		Driver, Actuator, Unclassified final control element	

Note 1: For motor use letter "Y" as first letter, this also is shown on P&ID.

YXS - Start motor command

YXP - Stop motor command

YXR - Permit to start motor

YL - Motor running status

YA - Motor fault status

YR – Motor local/remote status

YS - Motor speed measurement

YC - Motor speed control

YI - Motor current

YJ - Motor power

Note 2: For solenoid valve use letter “SOV” as succeeding letters, this also is shown on P&ID. Example: XSOV, TSOV, PSOV.

Note 3: For interposing relay, isolator, safety barrier and surge protective device, one, two or three letters are used as the last succeeding letters, these will be shown on Instrument Index.

1) For interposing relay use letter “Y” as the last succeeding letter, Example: XSOVY, YXPY, YLY.
2) For isolator use letter “N” as the last succeeding letter, Example: YSN, YCN, YIN.
3) For input safety barrier use letter “BI” as the last succeeding letters, Example: PTBI, FTBI. For output safety barrier use letter “BO” as the last succeeding letters, Example: PVBO, FVBO.
4) For surge protective device use letter “SPD” as the last succeeding letters, Example: PTSPD, FTSPD.

5.2 Instrument Loop Numbering

Instrument loop shall be numbered as follows:

AA-FFFF-BB-XXXS

- AA: Plant code (The last two digits of Plant number), refer to Units & Sub-units List.
- FFFF: The first letter of instrument function code, refer to the table - Instrument Function Code. For the loop number of SIS, there shall be a letter “Z” closely follow the first letter. When apply to local gauge, loop number is not required.
- BB: Unit/Sub-unit number, refer to Units & Sub-units List.
- XXX: A sequential number or equipment number abbreviation.
- S: An optional character suffix, one or two letters.

Example: 16-P-25-001A

5.3 Local Panel or Cabinet Numbering

Local panel or cabinet shall be numbered as follows:

AA-CC-BBXXXS

- AA: Plant code (The last two digits of Plant number), refer to Units & Sub-units List.
- CC: Code LP for local panel or cabinet.
- BB: Unit/Sub-unit number, refer to Units & Sub-units List.
- XXX: A sequential number or equipment number abbreviation.
- S: An optional character suffix, one or two letters.

Example: 16-LP-78E01

5.4 Analyzer House Numbering

Analyzer house shall be numbered as follows:

AA-CC-BBXXXS

- AA: Plant code (The last two digits of Plant number), refer to Units & Sub-units List.
- CC: Code AH for analyzer house.
- BB: Unit/Sub-unit number, refer to Units & Sub-units List.
- XXX: A sequential number or equipment number abbreviation.

Example: 16-AH-25E01

5.5 I.A Manifold Numbering

I.A manifold shall be numbered as follows:

AA-CC-BBGXX

- AA: Plant code (The last two digits of Plant number), refer to Units & Sub-units List.
- CC: Code IA for I.A Manifold.
- BB: Unit/Sub-unit number, refer to Units & Sub-units List.
- G: Floor number, 1 for ground floor.
- XX: A two-digit sequential number starting with 01

Example: 16-IA-25101

5.6 Panel or Cabinet Numbering in Control Room / Rack Room

Panel or cabinet numbering in control room / rack room shall be numbered as follows:

AA-G-CCC-BBXXS

- AA: Plant code (The last two digits of Plant number), refer to Units & Sub-units List.
- G: Control system

  D - DCS

  Z - ESD

  G - GDS

  K - MMS

  P - PLC

- CCC: Cabinet function code

  System Cabinet – SYS

  Safety Barrier Cabinet - BAR

  Interpose Relay Cabinet - REL

  Terminal Block Cabinet - TBC

  Power Distribution Cabinet - PDC

  Network Cabinet - NET

  Operator Workstation - OPS

  Engineer Workstation - EWS

  Server Workstation - SVR

  Data server station – OPC

  Printer – PRT

  Auxiliary console - AUX

- BB: Unit/Sub-unit number, refer to Units & Sub-units List.
- XX: A two-digit sequential number starting with 01.
- S: An optional character suffix, F for front and R for rear.

Example: 16-Z-SYS-1101F, 16-D-OPS-1101.

5.7 Junction Box Numbering

Junction Box shall be numbered as follows:

AA-GCCUUCC-BBGXX

- AA: Plant code (The last two digits of Plant number), refer to Units & Sub-units List.
- G: Control system

  D - DCS

  Z - ESD

  G - GDS

  K - MMS

- CC: Code JB for Junction Box.
- CC: Cabinet function code

S - Analog Signal (4~20mA DC)

Si - Intrinsic Safety Analog Signal (4~20mA DC)

R - RTD Signal

T - T/C Digital

Ri - Intrinsic Safety RTD Signal

Ti - Intrinsic Safety T/C Signal

CE - Solenoid Valve Signal 24VDC Loop

CD - Contact Signal 24VDC Loop

CA - Contact Signal 230VAC Loop

ED - 24VDC Power Supply

EA - 230VAC Power Supply

- BB: Unit/Sub-unit number, refer to Units & Sub-units List.
- G: Floor number, 1 for ground floor.
- XX: A two-digit sequential number starting with 01.

Example: 16-DJBS-25101

5.8 Cable Numbering

1) Cable numbering of field instrument cable shall be numbered as Instrument Tag No. - Cable letter code. Example: 16-PZT-25-001A-SC.

2) Cable numbering of junction box shall be numbered as Junction Box No. - Cable letter code. Example: 16-DJBS-25101-SC.

3) Cable numbering of Local panel or cabinet shall be numbered as Local panel or cabinet No. - Cable letter code - sequential number starting with 1. Example: 16-LP-78E01-CDC-1.

4) Cable numbering of panel/cabinet shall be numbered as start panel/cabinet - end panel/cabinet - Cable letter code - sequential number starting with 1. Example: 16DBAR1101-16DSYS1102-CDC-1.

5) The cable letter code is as following:

SC - Analog Signal (4~20mA DC)

SiC - Intrinsic Safety Analog Signal (4~20mA DC)

RC - RTD Signal

TC - T/C Digital

PC - Pulse signal

RiC - Intrinsic Safety RTD Signal

PiC - Intrinsic Safety Pulse signal

CDC - Contact Signal 24VDC Loop

CAC - Contact Signal 230VAC Loop

EDC - 24VDC Power Supply

EAC - 230VAC Power Supply

GC - Grounding Cable

FOC - Optical Fiber

MC - Modbus Communication Cable

Prc - Profibus Communication Cable

IPC - Ethernet Cable

6 Environment Conditions

Maximum temperature	47 °C
Minimum temperature	-33.4 °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	14.4 km/h
Earthquake seismic factor	Intensity 7 on the MSK-64 scale
Snow Load	180 kg/m2
Snow Freezing depth	For IGE-1 - 0.78m / For IGE-2,3,4 - 1,1 m
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.

7 General Requirements / Design Basis

7.1 Scope

This specification defines the scope of supply of field instrumentation and control system, and emphasizes on the requirements of instrumentation design, procurement, installation, and test to be provided by the package unit Supplier.

All instrumentation shall be in accordance with the specifications, codes and standards defined hereafter.

The main Supplier's responsibilities and duties are here below listed:

- To define the package required monitoring and control function.
- To define the package required alarm function.
- To define the monitoring and control location.
- To define the package start/stop sequences if the presence of a local operator is not strictly necessary.
- In case start/stop sequences require the presence of a local operator, then appropriate field instrument shall be provided to allow control and safety logics implementation in order to reduce manual operations and risk of errors.
- To design and select the required instrumentation system components.
- It shall notably include and cover the instrumentation required to check the whole package equipment performance and to perform its maintenance.
- To design and select the required instrument installation system.
- To install (shall be implemented by Supplier or TCC) and test the whole instrumentation system. The Supplier shall provide on-site guidance for installation, commissioning and start-up services.
- All the instruments shall be easily accessible and clearly identified.
- In the case of PLC supply, on-site services shall be included, including on-site installation, commissioning, start-up and other services until the project is delivered. When there is communication between the PLC provided by the Supplier and other systems in the whole factory, the Supplier shall provide on-site communication technical services until the communication between the two parties is successful.
- To prepare a complete and comprehensive set of documentation relevant to the instrumentation system.

- It cannot relieve the responsibility of supplier that TCC confirm product selection, calculation and other aspects.
- If there is any technical deviation, whether positive or negative, the supplier must indicate it in the technical deviation list. If no deviation is listed, it shall be deemed to be in full compliance with the technical requirements and shall be inspected accordingly.
- The supplier shall list the tools and software that are not mentioned in this specification but are necessary for the installation, commissioning and operation of the instrument for TCC confirmation.
- The selection of instrument and the design documentations must be approved by the TCC during the project implementation stage, otherwise all adverse consequences caused shall be borne by the Supplier.
- The third-party equipment provided by the Supplier shall meet the same requirements as the complete set of equipment, and the Supplier shall be responsible for the relevant documentation examination.

The Supplier, basing on his experience and specific application knowledge, is requested to define the basic Package operating and conducting requirements that means that the Supplier shall define the following:

- Which process variable is to be locally monitored and/or controlled.
- Which process variable is to be monitored and/or controlled from a remote location.
- If for the package operation a field installed local panel is to be provided.(if applicable)
- Which of the process variables is to be monitored for alarm purposes.
- The eventually needed interlock and protective system logic.

In case of conflicting requirements or incomplete technical information, it shall be the responsibility of the Supplier to bring these conflicts or deficiencies to TCC attention prior to the submission of the proposal or the execution of any work.

7.2 Electrical Execution for Hazardous Area

The plant areas will be subjected to classification, for the determination of zones with explosion risk.

Instrumentation and components shall meet the requirements of hazardous area classification in which they are installed.

All electrical / electronic instrumentation items and system components of instrumentation shall be certified by a recognized certifying authority for operation in hazardous area.

The preferred protection against explosion in hazardous areas is Intrinsic Safety. Flameproof (EEx d) shall be used for digital signal instruments and where no IS device is available. Increased safety (EEx e) or intrinsic safety (EEx i) shall be used for junction and terminal boxes.

7.3 Protection Degree

All components shall be designed to withstand the environment specified. The protection degree for outdoor mounted instrumentation and cabinets shall be minimum IP65. The protection degree for indoor mounted cabinets shall be minimum IP24.

7.4 Common Requirements

7.4.1 General

All instruments and process connections shall be suitable for either process fluid or environment conditions and be protected against the adverse effects of corrosion; also properties of process fluid, such as viscosity, possible solidification, etc. may affect the reliability of instrument and of the measurement.

Therefore, the necessary technical solutions will be provided to prevent those adverse effects, such as suitable materials, special coatings or paints, chemical seals, heating or tracing lines, liquid drains, installation of condensing pots and sealing, etc.

7.4.2 Signal Types

Signal transmission between instruments and Control System are standardized as follows:

- Analog signals (input/output) 4-20 mA
- Digital dry contact signals (input/output) Contact capacity 24VDC @5A
  Contact capacity 230VAC @3A
- Digital dry contact signals (output) Contact capacity 24VDC @5A

Any package unit which includes its own Control System (PLC) shall comply with the above requirements.

Use of pneumatic instrumentation is reserved to the final control elements, such as on/off or control valves.

During normal plant operation, contacts shall be closed (opening for alarm or trip) and relays and solenoids shall be energized.

The failure action of pneumatic control valves and on/off valves shall be selected to preserve the safety of the plant in the case of loss of instrument air supply. Solenoid valve of pneumatic valves shall be energized during normal operation, de-energized on trip case.

The transmitter electronics with NAMUR NE43 function should be prior selected to detect the transmitter fault during normal operation.

7.4.3 Instrument Characteristics

Transmitters shall be microprocessor based type, programmable, with diagnostic and capability of remote calibration.

Basically, transmitters shall be loop powered type (2 wires technology). For any instrument with external power, it shall be 24VDC or 230VAC.

Digital instruments shall be switching (SPDT).

The design and installation of all electrical / electronic equipment shall meet the radio frequency interference (RFI) or electromagnetic interference (EMI) (EN 61000), emission (EN 61000-6-4) and immunity (EN 61000-6-2) requirements for an industrial environment.

All instruments including valves and actuators used in safety applications shall be certified as SIL capable to the appropriate SIL classification which results from SIL assement.

Instruments should have an external earth stud connection for safety grounding as far as possible.

All instruments which require instrument air (valves, analysers, etc.) shall be provided with pressure gauge on air supply.

8 Instruments Selection

8.1 Flow Instruments

8.1.1 General

Selected type of flow instruments is always indicated on P&ID's.

Flow totalization shall be performed by 4-20 mA signal integration inside the DCS. Impulse counting system shall not permitted.

8.1.2 Primary Elements

Bore calculation for orifice plates shall be in accordance with ISO 5167.

The calculation accuracy of orifice plates should be ±1.0%.

The design and construction requirement of orifice plates shall be in accordance with ISO 5167.

Orifice plates material shall be at least stainless steel AISI 316, if no better quality is required by process.

Beta ratio shall not exceed 0,7 and be less than 0,20.

All flanges and diaphragms shall be min. ASME class 300 RF (or equivalent).

Normally orifice plates shall be square edge concentric type; different shapes shall be used according to the prescriptions of calculation code.

The orientation of the tapping on horizontal line shall be generally as follows:

- Gas Service: Vertical (Top) or 45° Upward.
- Liquid Service: Horizontal or 45° Downward.
- Steam Service: Horizontal or 45° Upward.

Installation shall be generally on horizontal piping; vertical installation is possible observing downward flow for gases and vapours, upward flow for liquids.

Whenever a control function and a trip function are combined in one single primary flow measurement element, individual flow transmitters shall be installed (individual tapping connections on the orifice flange).

The straight run length for orifices with flange taps shall be as per ISO-5167. Flow straighteners shall be installed if straight run is inadequate to reach required accuracy of measurement.

Orifice flange shall conform to ANSI/ASME B16.36.

The process connection of wedge type flow meter and balanced orifice flow meter should be flanged. The process connection of restriction orifice plates should be flanged, the flanges are supplied by Piping.

For orifice plate measurement in lines smaller than 50 mm (2”), corner taps, integral orifices and/or meter runs should be used.

8.1.3 Differential Pressure Flow Transmitters

Differential Pressure Type Flow Transmitters shall be designed in accordance with requirements for pressure instruments described at Para. 9.3.3.

Square root flow signals from the primary element shall be linearized in the flow transmitter and not in Control System. Square root extraction outside field transmitter is allowed only for specific cases.

All instruments shall be provided with a digital type integral indicator.

8.1.4 Vortex Flow Transmitters

Vortex flow meter may be used for liquid, steam and gas where it has the benefits of high accuracy and high turndown ratio. However vortex flow meter shall not be applied in wet steam and wet gas applications.

The accuracy should be in ±1.0% of rate of flow.

In-line flanged version shall be used.

Wetted parts, body and flanges shall be stainless steel AISI 316 as a minimum, if no better quality is required by process.

Preferably all instruments shall be provided with digital type indicator.

Terminal head shall have 1/2NPT electrical entry, female thread.

8.1.5 Magnetic Flow Transmitters

Electromagnetic flow meters may be used for all liquid and slurry applications, viscous and abrasive services, but also have sufficient levels of electrical conductivity.

The accuracy should be ±1.0% of full scale.

In-line flanged version shall be used.

Internal coating shall be PTFE or PFA.

In case of installation on non-metallic piping, grounding rings shall be provided to ensure proper grounding of process fluid. Grounding rings material shall be suitable to the process fluid properties.

Empty pipe detection capability is required.

Preferably all instruments shall be provided with digital type indicator.

Terminal head shall have 1/2NPT electrical entry, female thread.

8.1.6 Coriolis Mass Flow Transmitters

Coriolis type flow meters may also be used for flow or density measurement.

Depending on the required precision, allowable pressure drop, or physical fluid characteristics, single or double tube with straight or “omega” form may be used.

The accuracy for liquid should be ±0.2% of full scale, and the accuracy for gas should be ±0.5% of full scale.

In-line flanged version shall be used.

Wetted parts shall be stainless steel AISI 316 if no better quality is required by process.

Preferably all instruments shall be provided with digital type indicator.

Terminal head shall have 1/2NPT electrical entry, female thread.

8.1.7 Local Flow Indicators

Local Flow indicators shall be variable area type (rotameter). Use shall be limited to clean fluids, and for service requiring low accuracy (i.e. purging or flushing). They may be equipped with electronic transmitter or alarm contact.

According to the service conditions measurement tube may be glass or metallic with magnetic transmission.

The accuracy of local rotameter should be ±2.5% of full scale, and the accuracy of rotameter transmitter should be ±1.5% of full scale.

In general, for pipe size less than or equal to DN100, rotameter should be used, for pipe size greater than DN100, baffle flow meter should be used.

Installation shall be always vertical.

Process connections type and rating shall be chosen accordingly to the piping classes.

8.2 Level Instruments

8.2.1 General

For level measurement should be used the meter that best suits the characteristics of the product and the required accuracy. For the same application different measurement technologies may be equally suitable.

As general rule, the following measurement principles may be used: radar, ultrasonic, differential pressure, buoyancy, float, vibrating forks, servo tank gauging, glass level gauges and magnetic. Selected technology shall be clearly indicated in the piping and instrumentation diagrams (P&ID's).

The use of nuclear level instruments shall be avoided unless no other option exists.

Each level application shall be fully reviewed and selection shall be made taking into consideration process data such as fluid phase, dielectric constant, pressure, temperature, density and viscosity for minimum, normal and maximum process conditions as well as for alternative operating modes and abnormal operating conditions such as start-up, commissioning, regeneration, emergency and the like.

8.2.2 Differential Pressure Level Transmitters

Differential Pressure Type Level Transmitter shall be designed in accordance with requirements for pressure instruments described at Para. 9.3.3.

For measurements of viscous fluids, highly corrosive fluids and where the process temperature is higher than the differential pressure transmitter sensing element working limit, remote diaphragm seals shall be applied as specified of diaphragm seals.

The range, elevation and suppression shall be selected depend on the physical dimensions of the installation and densities of the various fluids. Design data shall be verified during loop testing and corrected as per actual installation where necessary.

8.2.3 Radar Level Transmitters

The radar level instruments shall be of the guided wave radar type (GWR) or free wave (non-contact) radar type.

The accuracy should be ±5mm up to 15 m.

All radar level instruments shall be top mounted flanged on the vessel. A level chamber shall be used if external installation is required.

Process wetted parts shall be at least stainless steel AISI 316, if no better quality is required by process.

Material and rating for level chamber shall be selected according to piping specifications.

All instruments shall be provided with a digital type integral indicator.

Terminal head shall have 1/2NPT electrical entry, female thread.

8.2.4 Ultrasonic Level Transmitters

Ultrasonic type shall not be applied for interface level measurement.

Ultrasonic type may be applicable for corrosive fluids as the sensor body can be fabricated from corrosion resistant material such as plastics.

The accuracy should be ±0.5% of full scale.

All instruments shall be provided with a digital type integral indicator.

Terminal head shall have 1/2NPT electrical entry, female thread.

8.2.5 Level Switches

Any typology of level switches is not allowed. Nonetheless, they may be applied if it’s justified by licensor requirements or process requirements providing that each case of relay application will be agreed with the Customer.

Terminal head shall have 1/2NPT electrical entry, female thread.

8.2.6 Level Indicators

Level indicators may be of glass or magnetic levels and magnetic level indicators shall be the first choice.

Magnetic type level gauges shall be used for the measurement of all liquids, including dangerous, toxic or flammable fluids where glass breakage would cause a hazard.

The span of visual meter (level gauge) should cover the operating range of the associated transmitter (if any). If the level is too long to measure for one meter, will be used more, they must overlap at least 25 mm each other.

Glass level gauges shall heavy duty armored type. They may be transparent or reflection type.

Generally, reflection type shall be used, except in cases where there could be interface, suspended solids, etc., in these cases the transparent levels shall be selected.

Transparent type level gauge shall be equipped with an illuminator covering the entire gauge length. The type and power of the illuminator will be defined in the data sheet of the instrument.

Size and quantity of crystals shall be standardized as much as possible.

Construction of the gauge shall be as follows. The liquid chamber encloses a float, which is magnetically coupled to a rotary wafer-type indicator. The liquid chamber shall be a one piece construction with a minimum internal diameter of 50 mm, provided with a bottom flange for removal of the float, vent and drain connections. Indicator shall be adjustable around the chamber.

8.3 Pressure Instruments

8.3.1 General

Sharing the same process connection between two or more pressure instruments (i.e. pressure transmitter and gauge) is not permitted. Each instrument shall be connected to its own pressure tap.

Pressure instruments shall be provided with suitable accessories for the process in which they are installed (remote seals, pulsation dampers, cooling fins, syphon, etc.).

All valves for mounting pressure instruments should be fitted with a relief/pressure equalization valve.

8.3.2 Diaphragm Seals

Instruments may be provided with integral or remote diaphragm seals. Diaphragm seals shall be ordered as an integral part of the instrument.

The complete diaphragm seal assembly shall be of welded or screwed construction.

Where required, the capillary material shall be stainless steel AISI 304 and shall be mechanically protected by flexible stainless steel armouring.

For differential pressure applications with two remote seals, the two parts of the capillary tubing shall be of the same length.

Special attention shall be paid to the use of diaphragm seals handling small ranges and interface level measurement.

If required, by fluid properties or process conditions, flushing rings or drip rings shall be installed.

The process temperature of diaphragm seal filling fluid shall be suitable for the ambient temperature.

8.3.3 Pressure Transmitters

The material of the transmitter body shall be stainless steel AISI 316, diaphragm material shall be stainless steel AISI 316 as minimum, unless otherwise specified in the instrument specification sheets.

Where no diaphragm seal is required, process connections shall be 1/2NPT female threaded.

Where process medium has the potential to separate, solidify or deposit in impulse lines, the lines shall be purged or heat traced as appropriate. Alternatively, direct mounting diaphragms may be used. Adequate mechanical protection for capillaries shall be provided and measurement accuracy requirements shall be met.

The accuracy of diaphragm seal type should be ±0.25% of full scale, the accuracy of threaded type should be ±0.1% of full scale.

For absolute and gauge pressure transmitters, the transmitter body shall have a minimum static pressure rating of 150% of the sensor upper range limit (URL) at the operating temperature.

Pressure transmitters shall have over-range (for pressure) and under-range (for vacuum) protection to prevent mechanical damage or shift in calibration.

Differential pressure transmitters shall be capable of withstanding full static pressure on either port without temporary or permanent detrimental effect.

All instruments shall be provided with a digital type integral indicator.

Terminal head shall have 1/2NPT electrical entry, female thread.

8.3.4 Pressure Switches

Any typology of pressure switches is not allowed. Nonetheless, they may be applied if it’s justified by licensor requirements or process requirements providing that each case of relay application will be agreed with the Customer.

8.3.5 Pressure and Differential Pressure Gauges

Pressure gauges shall generally be of bourdon tube type. Gauges for the measurement of differential pressure should be of the bellows, piston or diaphragm type.

Instrument range **shall** be selected that the normal operating pressure is between 1/3 and 2/3 of scale.

The nominal dial size of pressure gauges **shall** be greater than 100 mm if the gauges are installed not exceed 2m from the operating platform. And the nominal dial size of pressure gauges **must** be greater than 160 mm if the gauges are installed exceed 2m from the operating platform.

A red line **shall** be applied to the pressure gauges dial scale dividing the operating pressure. Instead of the red line, a metal plate painted in red and closely adjacent to the glass of the pressure gauges dial is attached to the pressure gauges body.

Bellows or diaphragm sealed gauges may be used as necessary.

Gauges will normally be of direct mount type with M20x1.5(M) male bottom connection.

Movement for all gauges shall be made of metals.

Gauge case shall be stainless steel with bayonet type bezel ring and gasket.

Dials shall be white with black numerals and markings.

Screw pointer zero adjustment is required.

Gauge shall be provided with shatterproof glass and a blowout plug. For the design pressure of fluid greater than or equal to 6 MPaG or gas greater than or equal to 2.5 MPaG, a rupture hole at the back of the case shall be used.

In processes with the possibility of vibration, pulsating services, pump deliveries, etc. liquid filled gauges (silicon oil) may be used, if suitable for the environmental conditions.

Flanged pressure gauges with diaphragm seal shall be used where the materials are not suitable for bourdon tube (e.g. high viscosity, slurry).

Pressure elements shall be capable of withstanding intermittent overrange to 1,3 times the maximum scale reading.

When the pressure gauges cannot withstand the maximum pressure expected during the operation, adequate protection for overpressure (gauge saver etc.) shall be provided.

Accuracy shall be 1.6% of full scale for bourdon type, 2.5% for diaphragm and bellows.

8.4 Temperature Instruments

8.4.1 Temperature Transmitters

Signal transmission to Control System shall be through 4…20 mA smart HART transmitters and 4…20 mA - 2-wire should be preferred. Nonetheless, RTD or Thermocouple without temperature transmitter may be applied if it’s justified by licensor requirements or process requirements providing that each case of relay application will be agreed with the Customer.

The accuracy should be ±0.75% of full scale.

Transmitters shall be direct head mounted type, unless otherwise specified on the instrument specification sheets. The remote type temperature transmitters should be used only for specific cases: to protect electronic parts for high temperature or vibration service or in case head mounted transmitter is located in an inaccessible location.

In case of remote mounted transmitters, suitable cable shall be used to connect the thermoelement to the transmitter. Especially for thermocouples, proper extension cables shall be selected.

Transmitters shall be suitable for input from either RTD or thermocouple and shall isolate the input from the output.

Digital to analogue conversion accuracy for milliamp outputs shall be less than 0,05% of calibrated span.

Temperature output shall be linear.

Temperature transmitters shall have upscale or downscale selectable element burnout function.

Terminal head shall have 1/2NPT electrical entry, female thread.

8.4.2 Temperature Elements

Temperature elements shall come assembled as a complete unit together with the thermowell and terminal head.

Temperature elements shall firmly contact the bottom of the thermowell. To avoid stress on the element, spring loaded type shall be used.

Temperature elements shall be insulated with magnesium oxide and protected by a stainless steel AISI 304 sheath, if no better quality is required by service conditions.

Double elements in the same assembly are permitted only for spare purposes. If a second measurement is needed, it shall be achieved with a distinct instrument.

Temperature element for high-temperature process (for example, a sulfur furnace) shall take into account the effects of high temperature & movement of the process, which can deform (bend) the sleeve and the element.

Terminal head shall have 1/2NPT electrical entry, female thread.

1) Resistance Temperature Detector (RTD)

PT100 ohm RTD elements shall be used where the temperature is 300 °C and below.

RTD element with 3-wires shall be designed in accordance with EN 60751 with tolerances as per class “A”.

2) Thermocouple Elements (TC)

Type “K” thermocouple shall be used where the temperature is above 300 up to 1000 °C. The accuracy should be Class I.

Other thermocouple types may be selected depending on process temperature, accuracy and process conditions, taking in account the proper solutions to ensure reliability and lifetime.

Skin type thermocouples typically to be provided at furnace tubes or reactors where standard well construction is not feasible. Skin thermocouples shall measure the surface temperature of the tube

wall and shall not be in contact with the fluid medium. The connection of the thermocouple to the tube shall be welded to provide maximum surface contact.

3) Temperature Switches

Any typology of temperature switches is not allowed. Nonetheless, they may be applied if it's justified by licensor requirements or process requirements providing that each case of relay application will be agreed with the Customer.

4) Thermometers

Thermometers shall generally be bi-metallic type with nominal dial size of 100 mm.

Dial thermometers shall be preferred with adjustable every angle type for obtaining good reading position. Dial can be rotated 180°.

The accuracy should be ±1.0% of full scale.

Connection to thermowell shall be 1/2NPT male thread with compression fitting.

Internal movement shall be made of metals.

Gauge case shall be stainless steel with bayonet type bezel ring and gasket.

Dials shall be white with black numerals and markings.

Screw pointer zero adjustment is required.

Thermometers shall be provided with shatterproof glass.

Instrument range shall be selected such as the normal operating temperature is between 30% and 70% of scale.

8.4.3 Thermowells

Standard flanged thermowell shall be used; threaded connection is allowed only for low pressure and non-dangerous fluids.

In general, flanged thermowells shall be DN 40.

Rating of the whole thermowell assembly shall be according to piping classes.

All thermowell material shall be stainless steel AISI 316 as minimum, unless otherwise specified on the instrument specification sheets.

Internal diameter of thermowell shall be suitable for insertion of the thermoelement.

Thermowells shall be fabricated from bar stock material.

A union and nipples shall be provided between thermowell and terminal head/transmitter. Extension length (between flange and terminal head) shall be min. 150 mm for RTD and Thermocouple primary element, and 250 mm for high temperature case.

Tag, material, connection diameter and rating shall be stamped on flange side.

For proper temperature measurement, the tip of the thermowell shall normally be immersed in the process medium at a position between 1/3 and 2/3 of the pipe diameter. Pipes smaller than DN 100 shall be swaged up to DN 100.

Fixed immersion length in the medium shall be selected as per below table:

INSTALLATION	STD insertion well length (U)
DN 100 pipe	220 mm
DN 150 pipe	220 mm
DN 200 pipe	270 mm
DN 250 pipe	270 mm
DN 300 pipe and larger	350 mm

NOTE: Above insertion lengths are valid for a standard projection of metal pipelines nozzle from external surface of pipe of 150 mm and for pipeline pressure class less than or equal to PN100. If non-metal pipelines or different conditions, insertion length shall be corrected accordingly. The final insertion length should be checked with the pipe major.

The Karman vortex effect shall be calculated, where it is required, and thermowell shall have enough strength to withstand it.

Thermowells shall be designed for vibration and stress according to ASME PTC 19.3. Where the result of the calculation is not satisfied, the thermowell design shall be modified with reducing the well length, furthermore increasing of the diameter.

8.5 Analyzers

8.5.1 General

The installation process analyzers will be indicated by project requirements, i.e., when indicated on P&ID's.

8.5.2 Analysis Systems

Analyzer system is intended as the assembly formed by the sampling system, transport, conditioning, analysis, and return (if applicable) of the sample.

For sampling point, transport line and sample conditioning, manufacturer's recommendations shall be followed, but system shall be designed to allow a minimum and easy maintenance.

Orientation of sample taps on process line shall generally follow the same recommendations for pressure instruments, depending on whether the products analyzed are gases or liquids.

Sample transport line shall be as much short as possible, in order to minimize the measurement response time. Fast loop shall be provided to meet this requirement.

Fast loop will not be installed if it would interfere with the measurement or operation of other equipment in which the pressure is an important factor as primary flow elements, restriction orifices or control valves.

Fast loop line will be equipped with rotameter and manual control.

All sampling lines must be heated traced (forced heating or self-regulating heating cable). This is necessary in case of moisture in the sample during transients, even if the presence of moisture in the sample is excluded. Pressure will be reduced at the analyzer input and system shall be designed to prevent biphasic sample entering the analyzer.

Sample transport tubing shall be made in stainless steel AISI 316, unless otherwise indicated.

The analyzers shall be installed inside enclosures or in the field, but must always comply with the area classification where they will be located.

The output signals shall be 4…20 mA. In those cases where analysis is discontinuous, due to calibration or cleaning process, the last measured value shall be maintained.

Power supply to the analysis systems will be from UPS. Any deviation to this requirement will be evaluated for each case.

Reference samples for analyzer calibration shall be supplied together with the equipment and must have a certificate issued by an independent laboratory.

Reference samples which may deteriorate over the time, are not acceptable for field calibration. For this function, the supplier shall provide an alternative field calibration.

Each analyzer will be delivered together with the calibration curve done at workshop.

All analyzers must be able to extract from the process while the process is running.

If the repeatability of readings can be maintained within the recommended values of the service interval, it is necessary to provide an auto-calibration function (with automatic sample feeding).

8.5.3 Analysis Systems Housing

The housing arrangement for analyzers systems will be defined in the detailed engineering phase, depending on various circumstances such as:

- Environmental protection

- Operating Requirements
- Maintenance requirements, accessibility, safety, etc.
- Optimization of use of ancillary services, etc.
- Law or regulatory requirements

Enclosures for analyzers may be open (canopy) or closed (shelter, cabinet, etc.); boxes could also be used, it will depend mainly on the size of the analyzers and associated conditioning systems samples.

Closed enclosures shall meet some basic requirements, which are mainly:

- Environmental conditions are taken into account.
- In case of installing air conditioning, the air intake will be held in safe area and never in hazardous areas.
- Construction materials shall be resistant to fire.
- Shelters, cabinets and boxes shall be supplied fully factory assembled and ready for installation on the floor.
- Enclosures shall have the utilities necessary for the proper maintenance and operation, such as lighting, sockets, etc.
- Shelters and cabinets shall be provided with necessary safety equipment (i.e. gas detection sensors, escape routes, safety disconnect switch, etc.).
- Dimensions of the enclosures shall be designed such as they can perfectly accommodate all devices, can be operated and maintained properly, and if possible make them transportable.
- Proper venting shall be designed considering that samples products may be toxic or flammable.
- Sampling system for laboratory analysis shall be available.
- Wherever possible, analyzers housings shall be installed outside hazardous areas.
- Possible systems should be safe for personnel. All gas supply systems or aggressive media must be equipped with safety valves. Cylinders with mixtures must be carried out and prevent the possibility of leakage or explosion. The release must be distributed in a safe place.

8.5.4 In Line Analyzers

In line analyzers (i.e. pH, ORP, conductivity, etc.) shall be in separate execution between sensor and transmitter. They shall be equipped with digital display; local configuration, adjustment and calibration shall be available.

Wherever sample temperature may affect measurement, sensors shall be equipped with automatic temperature compensation.

In case sensor holder is required, it shall be selected and installed to allow a correct measurement without deadlocks or bubble formation.

All conductivity and pH (ORP) meters must be equipped with an internal ATC.

Terminal head shall have 1/2NPT electrical entry, female thread.

8.6 Valves

8.6.1 General

Valves type and material shall follow the prescriptions of piping classes. In addition, for control valves, this specification shall apply, especially for sizing, selection criteria, and construction characteristics.

As a general rule, all on/off and control valves shall be equipped with pneumatic actuators, except in special cases where electric actuators may be selected.

8.6.2 Control Valves

Control valves shall preferably globe style, single seat, double guided stem. Double seat shall be selected only if single seat valve is not practicable.

For dirty or high viscosity products may be used eccentric ball valve (V-Notch ball) or segmented ball (spherical cap valve).

For very high pressure drops angle valves are allowed.

Self-regulating valves are permitted only when small control accuracy is required.

As a general rule valves shall be flanged to the rating corresponding to the piping specification, except in special cases, such as licensors requirements, where they could be welded.

of -to-Face and end-to-end Dimensions of valves as well as end connection flanges shall be according to piping specifications.

It is recommended that where possibility of flashing exists, valve body size shall be larger of selected trim size. A good practice is that the body is line size with reduced trim. However, the supplier shall design and calculate the valve to avoid critical physical phenomena such as cavitation, flashing, etc.

Valve trim shall be replaceable without need to dismount body from line.

Where handwheel is required, it shall be detachable. No additional effort on actuator shall be induced by handwheel.

Handwheel clockwise rotation shall lead to the closing of the valve.

Control valves shall be designed based on the general maximum permissible noise level of 85dBA measured at 1 meter away from the piping.

The maximum noise limit for control valves of pulsating or intermittent operations such as discharge and blowoff shall not exceed 105 dBA, otherwise external noise reduction measures shall be taken.

Valves shall be generally installed with actuator's axis in vertical orientation.

Bonnet type, plain, extended or finned, shall be selected according to the operating temperature. Unless otherwise recommended by the manufacturer, ordinary bonnets shall be used in services over -18°C and under 232°C, extension bonnets shall be used in services over 232°C or under -18°C.

Generally, flow-to-open fluid direction is preferable for better control action.

Valves shall be designed so that, against a failure of the air supply, it reaches the position that is considered safe. In case it is required that valve remains in its current position on air failure, it will be provided with an air-lock relay between the air outlet of the positioner and the actuator.

Valves shall be equipped with a visual position indication, irrespective if a position transmitter or limit switch are installed.

It is preferable that the actuator action can be inverted without any additional element.

Valve packing shall meet the following recommendations:

- Environmental seal (Zero Leak Certification) shall be provided for toxic services.
- PTFE packing for normal products and temperatures below 204 °C.
- Flexible graphite packing for temperatures above 204 °C.

Internal parts shall be at least stainless steel AISI 316, if no better quality is required by process. For severe working conditions, hardened parts shall be provided. Special attention shall be paid to the choice of materials in case of corrosive fluids.

In general, control valves shall be designed with equal percentage characteristics. Linear characteristics shall be selected for the following cases:

- When two valves are used to replace a three-way one.
- In case of pressure reducing valves working at constant pressure.
- For compressors or pumps recycle valves.
- Valves working in split range.

Pneumatic spring diaphragm actuators shall be normally selected. Piston may be used when the travel cannot be achieved with a diaphragm. Actuators shall be sized to ensure a good control and reliability of the valve under the worst operating condition. Sizing shall be done at the minimum instrument air pressure and maximum pressure drop across the valve.

Where a pneumatic double acting actuator is selected, suitable air volume tank and switching devices shall be provided to bring the valve to its safe position.

The control valve shall be with a smart electro-pneumatic (E/P) positioner with signal 4...20 mA with Hart protocol for modulating the control valve. Terminal head shall have 1/2NPT electrical entry, female thread.

An air filter regulator shall be provided to each positioner with an integral input and output gauge. Where the positioner is provided with a pressure gauge to indicate setting pressure of the air filter regulator, the pressure gauge on the air filter regulator may be omitted.

Pneumatic connections shall be 1/4NPT female thread, unless stroking time demands other sizes.

Stainless steel tubing and fittings shall be used for connecting the accessories on the valve.

If required, the limit stops shall be a mechanical type and lockable.

8.6.3 On/Off Valves

On-off valves shall always be line size valves. Body pressure rating as well as flange type and rating, shall conform to the relevant piping material specification.

Spring return type piston actuators shall be selected as much as practical. Pneumatic double acting piston actuator shall be selected only where the spring return actuator cannot cover the required thrust, length of stroke or stroking speed requirements.

Use of double acting pneumatic actuators, as well as electrical actuators shall all be evaluated case by case.

Actuators shall be sized to produce sufficient thrust against the shutoff pressure or maximum upstream pressure with the downstream pressure being zero.

Actuators shall have a mechanical position indicator.

Handwheel shall only be provided when indicated on the P&ID.

All on/off valves shall be equipped with limit switches for open and closed position. Terminal head shall have two 1/2NPT electrical entries, female thread.

Solenoid valves shall be stainless steel body and internals with NAMUR connection to the actuator body. Terminal head shall have 1/2NPT electrical entry, female thread.

Anti-bug filters shall be provided for vent connections to atmosphere.

During normal plant operation solenoids shall be energized.

Pneumatic connections shall be 1/4NPT female thread, unless stroking time demands other sizes.

Where required, stainless steel tubing and fittings shall be used for connecting the accessories on the valve.

8.6.4 Electrical Actuators

Electrical actuators shall be used in place of pneumatic only where indicated on P&ID.

Motors insulation shall be class F. It shall be designed to allow at least 60 starting per minute.

Motor starter shall be integrated inside actuator head; it shall include a device to ensure that the engine has the correct direction of rotation, regardless of the phase sequence of the supply.

The dimensions of the actuator shall be in accordance with the size of the actuated element and designed to operate under the maximum differential pressure across the valve.

The actuators can be repaired and disassembled without being necessary to remove the actuated element from the process.

If actuator is provided with handwheel, running of the motor, under no circumstances will cause the rotation of the handwheel.

Signal exchange between actuators and Control System shall be defined during detail engineering; in addition, actuators shall be equipped with a local control station which permits the manual operation of the valve.

Actuator motors shall be protected for over temperature and loss of phase.

Actuators shall be equipped by backup battery in order to keep on the auxiliary circuits, also in case of failure of power feeding.

If required for control purposes, actuators shall be equipped with positioner and position transmitter, both 4…20 mA.

Actuators shall have built-in open/close position indicators.

9 Instruments Installation

9.1 General

All instruments shall be mounted as close as possible to the process connection provided maintenance and accessibility requirements are taken into account. The length of the impulse line shall be minimal, consistent with good practice and accessibility.

Where transmitters(except temperature transmitters) have a local integral indicator, it shall be readable.

The location of instruments shall be designed in such a way that direct drainage/vent of condensate, water gas or process fluids from adjacent equipment has no adverse effect.

Field instruments and electronic transmitters shall be mounted on independent pipe stands or attached by brackets to suitable steelwork and/or concrete structures. These instruments shall be mounted with centerline at approximately 1500 mm above the platform or floor in a position accessible for operation and maintenance.

Exception shall be made for close coupled and inline instruments, these shall be mounted on the pipe as per P&ID / isometric. Escape and maintenance routes shall be taken into account for the final design and installation.

All devices that are installed with flanges and other methods of connection must be equipped with counter flanges or parts.

9.2 Process Connections

9.2.1 Process Impulse Lines

Instrument impulse lines shall be realized according to the applicable pipe specifications.

Where impulse tubing is required, it shall be 14 mm O.D x 2 mm wall thickness stainless steel AISI 316, cold drawn seamless and fully annealed. Tubing fittings shall be stainless steel AISI 316, screwed NPT.

Where the above tubing and fittings are not suitable for the process fluid or the process conditions and/or specific project requirements, other materials equal or better than the piping class specification shall be used.

Bourdon tubes of pressure gauges shall be welded to socket. Materials of all wetted parts shall be type 316 stainless steel unless otherwise specified.

Final orientation of tapping shall be determined in conjunction with process conditions on the project.

Differential pressure instruments shall be located above the taps for gas and non-condensable fluids. For liquids and condensable fluids mounting shall be below the tapping point. Special conditions such as particles shall be clearly defined.

For steam services, pressure gauges and pressure switches shall be mounted with steam siphon. Condensate pots shall be used in case of electronic transmitter hook-ups.

Instrument and capillaries shall be plumb and level. Impulse lines which run at a slope shall be continuously sloped in not less than one (1) in ten (10) except where otherwise specified. Direction of slope shall be downward from the process for liquid service and upward from the process for gas service.

Impulse lines shall be supported and protected from vibration and physical damage. No mechanical stress shall be induced upon an instrument that shall cause a malfunction or error in the readout.

Impulse lines shall not be secured directly to machinery or pipes but via supporting steel connected to columns, structure, steelworks, etc.

9.3 Pneumatic Connections

Instrument air distribution network shall be realized using as much as possible air distribution pots. Instrument (sub)-headers from main header to distribution pots shall be executed in accordance with the piping specification.

Air distribution pots shall be realized in stainless steel AISI 304, having inlet connection DN25; a number of 6 or 12 outlet connections with 1/2NPT male thread are possible.

Inlet, outlets and drains shall be equipped with valves, ball type for inlet and needle type for outlets and drain.

Individual instrument air supply and pneumatic transmission lines to and from instruments shall be stainless steel AISI 304. Tubing shall be generally 8 or 10 mm OD, for large air consumers tubing shall be 12 or 14 mm OD.

Fittings shall be 304 compression type, screwed NPT.

Individual tube runs shall be supported by existing structures and steelwork. Tubing runs for instrument air lines shall be kept as short as possible, consistent with good practice and accessibility.

Tubing shall be supported and protected from vibration and physical damage. The tubing runs shall be kept clear from hot environments, potential fire risk areas, drainage points of condensate, water and process fluids.

Intermediate tubing connections shall be kept to a minimum.

9.4 Electrical Connections

9.4.1 Instrument Wiring System Installation

In general, field mounted instruments should be wired to Control System by means of junction box, and cabling between junction boxes and Control System cabinets shall be carried out by multicore cables.

Cable joints (splices) shall not be used.

9.4.2 Types of Cable

As a general rule, the number of different cable types shall be restricted to a minimum. Cable sizes and characteristics for instrumentation are listed in the following table:

No.	Specification	Size	Color	Service

No.	Specification	Size	Color	Service
1	Intrinsic safety computer cable: Single-core cable, Class B flame-retardant, intrinsic safety, PVC insulation, PVC sheath, 7-strands copper conductor, AL/plastic shield, long term temp.70℃, no less than -10℃ for installation, U0/U:300/500V, 0.5mm2 tinned copper drain wire.	1x2x1,0 mm^2 1x3x1,0 mm^2	Sheath: blue Core: 2-wire: black(+), white(-) 3-wire: red(24V), black(+), white(-)	Analog signals Digital signals
2	Intrinsic safety computer cable: Multi-core cable, Class B flame-retardant, intrinsic safety, PVC insulation, PVC sheath, 7-strands copper conductor, AL/plastic shield overall shield, long term temp.70℃, no less than -10℃ for installation, U0/U:300/500V, 0.5mm2 tinned copper drain wire.	6x2x1,0 mm^2 6x3x1,0 mm^2 10x2x1,0 mm^2 10x3x1,0 mm^2 20x2x1,0 mm^2	Sheath: blue Core: 2-wire: black(+), white(-) 3-wire: red(24V), black(+), white(-)	Analog signals Digital signals
3	Non intrinsic safety computer cable: Single-core cable, Class B flame-retardant, non intrinsic safety, PVC insulation, PVC sheath, 7-strands copper conductor, AL/plastic shield, long term temp.70℃, no less than -10℃ for installation, U0/U:300/500V, 0.5mm2 tinned copper drain wire.	1x2x1,5 mm^2 1x3x1,5 mm^2	Sheath: black Core: 2-wire: black(+), white(-) 3-wire: red(24V), black(+), white(-)	Analog signals Digital signals
4	Non intrinsic safety computer cable: Multi-core cable, Class B flame-retardant, non intrinsic safety, PVC insulation, PVC sheath, 7-strands copper conductor, AL/plastic shield overall shield, long term temp.70℃, no less than -10℃ for installation, U0/U:300/500V, 0.5mm2 tinned copper drain wire.	6x2x1,0 mm^2 6x3x1,0 mm^2 10x2x1,0 mm^2 10x3x1,0 mm^2 20x2x1,0 mm^2	Sheath: black Core: 2-wire: black(+), white(-) 3-wire: red(24V), black(+), white(-)	Analog signals Digital signals

No.	Specification	Size	Color	Service
5	Non intrinsic safety computer cable: Single-core cable, Class B flame-retardant, non intrinsic safety, PVC insulation, PVC sheath, 7-strands copper conductor, AL/plastic shield, long term temp.70℃, no less than -10℃ for installation, U0/U:300/500V, 0.5mm2 tinned copper drain wire.	1x2x2,5 mm^2 (Note 1)	Sheath: black Core: 2-wire: black(+), white(-) 3-wire: red(24V), black(+), white(-)	Feeding to 24VDC for Solenoid valves and Instruments
6	Non intrinsic safety computer cable: Multi-core cable, Class B flame-retardant, non intrinsic safety, PVC insulation, PVC sheath, 7-strands copper conductor, AL/plastic shield overall shield, long term temp.70℃, no less than -10℃ for installation, U0/U:300/500V, 0.5mm2 tinned copper drain wire.	10x2x2,5 mm^2 20x2x2,5 mm^2 (Note 1)	Sheath: black Core: 2-wire: black(+), white(-) 3-wire: red(24V), black(+), white(-)	Feeding to 24VDC for Solenoid valves and Instruments
7	Control cable: Class B flame-retardant, PVC insulation, PVC sheath,7-strands copper conductor, AL/plastic shield, long term temp.70℃, no less than -10℃ for installation, U0/U:450/750V, 0.5mm2 tinned copper drain wire.	3x2,5 mm^2 30x2,5 mm^2 (Note 1)	Sheath: black Core: blue(L), Brown(N), Green/Yellow(PE)	Feeding to 230VDC for Instruments
8	Single-mode fibre: Class B flame-retardant, for outdoor, metal construction, packed structure, aluminium tape-PE bonded inner sheath, corrugated steel tape armour, PVC sheath, 1310nm(8.6～9.5)μm/125μm	8 cores	Sheath: black	For serial links, Single-mode fibre

No.	Specification	Size	Color	Service
9	Multi-mode fibre: Class B flame-retardant, for outdoor, metal construction, packed structure, aluminum tape-PE bonded inner sheath, corrugated steel tape armour, PVC sheath, multi-mode, 62.5μm/125μm	8 cores	Sheath: black	For serial links, Multi-mode fibre
10	Profibus DP cable, 2x2x18 AWG		Sheath: purple	For serial links, Profibus DP
11	CAT5E+4STP-P		Sheath: gray	For serial links, Ethernet

Note (1): Conductor cross section shall be adapted according to instrument power consumptions.

9.4.3 Cable Glands

All cables in the field shall be equipped with cable glands. Cable glands shall be selected such that they suit the selected instrument cable and are suitable for the area classification concerned.

All cables terminated at the equipment/rack room in floor mounted cabinets do not require glands but shall be securely supported at the base of the cabinet using a cable clamping bar.

Cable gland shall be by stainless steel, with NPT thread for instruments and M thread for junction boxes. Minimum protection degree shall be IP65.

For hazardous area use, the cable glands shall be Ex e.

All glands shall be fitted in the bottom of equipment located in the field. Top cable entries shall not be used. Any unused cable entries shall be sealed using a proprietary stainless steel plug, certified as necessary to suit the equipment and location.

9.4.4 Cable Routes

Instrument cables shall be suitably supported and protected by means of cable trays or conduits.

Particular attention shall be paid to hazardous areas, where cables shall be protected along their entire length against mechanical damages.

No underground cable routing shall be foreseen.

9.4.5 Cable Trays

Instrument cable trays shall be hot dip galvanized steel or glass steel(with approval by TCC), and suitable for industrial plant where the security and reliability are required.

Cable trays horizontal and vertical bends shall be suitable for cables bending radius.

Instrument cable trays filling shall not exceed 40%.

Minimum distance between vertical cable tray installations (parallel routes) shall be 200 mm from the cover to the bottom of the above tray; this distance may be reduced in the branches and intersections of cable trays.

Cable trays shall be supported every 3 m. Process pipes, conduit or other cable trays shall in no case be used as a support or anchor point.

Intrinsic safety circuits and non-intrinsic safety circuits shall not be contained within the same cable. Intrinsic safety cables and non-intrinsic safety cables shall be laid in separate cable trays or use division board in the same cable tray.

9.4.6 Junction Boxes

Instrument signal cables wiring shall be separated in different junction boxes, the principle shall be as following:

- Analogue IS cables;
- Analogue Non-IS cables;
- Digital Non-IS cables;
- Instrument power cables if necessary to use power supply junction box.

The material of junction boxes shall be stainless steel.

Junction boxes shall be suitable with the hazardous area classification and environmental conditions. The protection against explosion in hazardous areas is EEx e. Junction boxes shall be weather protected to a minimum of IP65 and shall be suitable for surface mounting.

Access to terminals shall be via a hinged front door. The cover will be provided with a sealing gasket and fastened to the body by SS screws.

Screw clamp DIN rail mounted terminals shall be mounted within each junction box.

All terminals shall include number identification markers and shall be manufactured from polyamide or similar. Terminals shall be sized to suit the cable conductor size but shall not be less than 2.5mm2. The terminals of junction boxes for intrinsic safety duty shall be colored blue.

Each junction box shall be provided with an earthing grounding stud which shall have electrical continuity with all cable entries.

The junction boxes shall be drilled for cable glands entries and suitable for the required cable glands.

Cable entries shall only be made on the base of the boxes. All unused entries in junction boxes and other instrument equipment shall be plugged using manufactured, certified as necessary threaded plugs.

All junction boxes shall be provided with a stainless steel label giving JB number and a stainless steel identification label marked as follow: Manufacturer, Model, Protection degree. The stainless steel labels will be sticked on front of the cover. Junction boxes will be supported by external brackets.

9.5 Instrument Supports

Instrument stands, plates welded/bolted/clamped to structures, yokes and similar support arrangements shall be used for mounting of off-line instruments. Instrument supports mounted to process piping or vessels are not allowed, nor instrument mounted directly on handrails.

Instrument supports, cable ladders/trays, conduits and other steel supporting materials shall be galvanized carbon steel. Fasteners such as bolts, nuts and washers shall at least be of corrosion treated steel (e.g. Galvanized or Stainless Steel). In any case, they shall be resistant to the effects of the environment in which they are to be used as per project environmental specification.

All instruments shall be mounted and supported so that it is free from vibration and misalignment.

9.6 Earthing

Two types of earthing systems are foreseen for instrumentation:

- Safety earthing
- Instrument earthing

All earthing points/connections shall be fitted with locking devices; crimp/compression type lugs shall be used for bolted connections.

9.6.1 Safety Earth

All equipment shall be earthed for personal safety reasons and for minimize electrical interference. This includes instruments, enclosures, cables, cable trays/ladders.

All metal frames, cable tray/ladder, box racks junction boxes, local panels, etc., shall be connected to the safe earth by earthing cable whose size shall be as indicated in the applicable electrical project documentation, but with minimum of 4 mm2.

9.6.2 Instrument Earth

Cable screens shall be electrically continuous through the cable run and shall be earthed at one point only. This point is normally the panel reference bar in the panel or cabinet which the cable is connected to.

The instrument earth (clean earth) in each cabinet/console shall be connected to the central earthing point with an earthing cable, size as indicated on the relevant electrical drawings.

10 Packaged Instrument Control Philosophy

10.1 Introduction

Control functions & alarms as well as operation logics are assimilated to main process control applications. They shall be implemented or performed by the plant DCS or by a programmable logic controller (PLC) provided by the package supplier. If these functions will be executed by PLC, the indicating and monitoring signal shall be communicated to DCS.

Local control panels for packages shall be provided to allow control and monitoring if essential for start-up or local instrumentation purposes.

10.2 Programmable Logic Controller (PLC)

The design of PLC should follow the following principles:

1）PLC Brand and Type selected in accordance with the project agreed Supplier's list.

2）Safety PLC system will be SIL2 as minimum.

3）Control signals between package PLC and DCS shall not be transferred using serial links; instead hardwired I/O connections shall be provided for control and interlocking, for example, stop and start, emergency stop, running status, fault status, etc. The hardwired signal should be proposed by the Supplier in the design stage, otherwise all adverse consequences caused shall be borne by the Supplier. The signals not related to the process should be connected to the PLC control system, instead hardwired to DCS, including but not limited to cabinet temperature alarm, fan alarm, PLC power or system fault alarm, etc.

4）The indicating and monitoring signals of PLC shall be communicated to DCS by means of serial link. The serial links between package PLC and DCS shall be with two communication channels, if one of the serial link failures, the second serial link could be kept in touch. Links shall be implemented with a proven (with the systems selected) and industry standard protocol e.g. Profinet, Modbus RTU (via RS-485), Modbus TCP/IP, Profibus DP, OPC.

5）The PLC shall receive the time synchronization signal from DCS, via the serial link.

6）In general, PLC cabinets should generally be set separately from electrical control cabinets.

7）In general, PLC cabinets inside Rack Room 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.

8）Local control panels shall be suitable for industrial area. Local control panels generally adopt front door type and with cable glands and plugs on bottom of cabinets.

9）The cables between PLC cabinets shall be supplied by Supplier, including communication cables, special cables, optical cables, signal cables and power cables.

10） All systems, components, installations, cabinets, cabling, earthing, etc. shall be in compliance with IEC 61000, Electromagnetic Compatibility (EMC).

10.3 Sparing & Performance Requirements

PLC shall be designed and engineered to include the following spares criteria:

- Spares shall be made available and distributed over process units. It is not allowed to lump them into only one section.

- Minimum 20% installed spare I/O capacity shall be available after successful Factory Acceptance Test (FAT). Installed spare capacity shall include wiring between termination panels, I/O slots and hardware modules. Spares shall be evenly distributed over the various types of IO cards.

- Minimum of 20% spare space or card slots (for each type of cards) for further increase in I/O shall be available after FAT.

The following loading figures shall apply at the completion of FAT:

- Operator stations: If there are operator stations for PLC, operator stations shall be able to accept an increase of 20% in the number of points without any hardware (including licensing) modification. This 20% spare capacity shall be usable without modification of the system except for any relevant cabling.

- Communications systems: Loading of communication highways shall not exceed 50% of total time under all loading conditions, including upset, and with "spares" installed. Data highway loading measurements shall be performed when all IO is connected to the systems, e.g. at the end of loop check period, and at the completion of commissioning.

- The final configuration loadings of CPU's, RAM's, etc. shall not exceed Supplier recommendations. Supplier recommendations shall be clearly documented early in the EPC phase of the project and be part of the APCS Specification.

- CPU loads: when taking into account spare I/O quantities, shall not exceed 50% load irrespective of Supplier recommendation.

- Power supplies: Power supply units shall include 20% spare capacity assuming all system “installed spare” capacity fully utilized and under peak loading conditions.

10.4 The Signal Between MCC or Local Switchgear and PLC

1) Isolation

All the signals between MCC or local switchgear and DCS/ESD shall be isolated before I/O channel. Digital signals shall be isolated by 24VDC interposing relay and analog signals shall be isolated by isolator.

2) Analog signals

The analog signals from MCC shall be 4-20mA DC.

3) Digital signals

ü Motor running status

- DCS receive “1” (closed contact) means that motor is running. DCS receive “0” means that motor is stopped.
- Contact of interposing relay is N.O.

ü Motor fault status

- DCS receive “1” (closed contact) means that motor is in good status without fault. DCS receive “0” means that motor is fault.
- Contact of interposing relay is N.O.

ü Motor local/remote status

- DCS receive “1” (closed contact) means that motor is in remote status. DCS receive “0” means that motor is in local status.
- Contact of interposing relay is N.O.

ü Start and stop motor command

- DCS outputs a pulse “1” to start motor.
- DCS outputs a trip “0” to stop motor.
- Start signal and stop signal are two independent signals
- For low voltage motor, both start and stop Contact of interposing relay are N.O.
- For high voltage motor, start contact of interposing relay is N.O. and stop Contact of interposing relay are N.C.

ü Permit to start motor signal

- DCS outputs “1”, permit motor to start.
- Contact of interposing relay is N.O.

11 The Interface of Installation Working

1）For installation materials of packages, the complete supply list (including software) shall be supplied by Supplier, including the materials not supplied by Supplier, necessary descriptions shall be remarked.

2）The Supplier is responsible for calibration, installation and testing of all supplied instruments. Unless otherwise stated, the Supplier shall provide all the installation materials of packages,

including root valves, tubing and fittings, cables, cable trays, cable glands, grounding wires, etc. If the instruments need to be removed during transportation, it should be clearly marked with the position of the instruments, installation drawing and other information that need to be used when reinstalling on site.

3）If there are less than 4 signals of same type on the skid, junction box may not be used, and the electrical interface between Supplier and TCC is the cable entry of instruments. The cable glands shall be supplied by Supplier. If there are great than or equal to 4 signals of same type on the skid, the electrical interface is the junction boxes. The Supplier shall provide the stainless steel junction boxes and all cable glands and plugs on junction boxes.

12 Manufacturer Internal Test, FAT and SAT

Package unit instrumentation manufacturer internal test shall be implemented in instrument manufacturer's factory, Each PLC shall be subject to a full functional test on full simulation basis of all inputs and outputs during FAT. Customer's and/or TCC's Inspector shall witness and approve all factory tests and reserves the right to approve the test procedure.

The SAT shall be a comprehensive operating test conducted on site with all components of the package unit installed and commissioned and running as designed under normal plant operating conditions. It is especially important at this time to test the proper functioning of the entire package unit.

Package unit material requisition and contract related parts shall be respected as the principle of manufacturer internal test, FAT and SAT.

13 Spare parts

All spare parts shall be listed by Supplier with his bid.

13.1 Start-Up and Commissioning Spare Parts

The Supplier shall include for and price separately all spare parts required during commissioning and start-up of the equipment. These shall include gaskets, consumables, etc. Parts shall be individually identified.

13.2 Spare Parts for Normal Operation

The Supplier shall list separately all spare parts required during normal operation of the equipment for 2 years. These shall include any consumables. Parts should be individually identified.

14 Documentation

The official language shall be English. The Russian and/or Kazakh language shall be used in operation manual and human manual interface. All text documents shall be generated from Microsoft Word, Excel 2010 and AutoCAD. All the documents shall use standard formats (A0, A1, A2, A3, and A4) and use the graphic symbols defined in the applicable international norms.

The Supplier shall provide a list of documents fully completed including but not limited to the following documents:

Ø Instrument design documents in below table.

No.	Document Title
1	Contents of Instrument Documents
2	Piping and Instrumentation Diagram (P&ID)
3	Instrument Engineering Specification
4	Control Description (Requirement of Interlock and Control)
5	Instrument Index
6	Instrument Data Sheet
7	Alarm & Interlock Set Point List
8	SIS Interlock Logic Diagram
9	Interlock And Sequence Control Diagram
10	Complex Control Loop Diagram
11	Local Control Panel Arrangement Drawing
12	Local Control Panel Wiring Diagram
13	Instrument Cable Tray Routing Drawing
14	Instrument Arrangement Drawing
15	Filed Instrument Cabling Drawing
16	Instrument Air Pipe Layout
17	Instrument Hook-Up Drawing
18	Junction Box Wiring Diagram
19	Instrument Material Take-Off
20	Instrument Cable List
21	DCS I/O List
22	ESD I/O List
23	DCS Supervision Data Sheet
24	PLC Communication Mapping List
25	Gas Detector Layout
26	Product Assurance and Guarantee

No.	Document Title
27	Explosion Proof Certification
28	SIL Certification and Others
29	Inspection, Test Record and Report
30	Instrument Air and Power Assumption
31	Supplier List and Sub-contractor List
32	Recommended Spare Parts

- Hardware documentation.
- Interconnection Diagram.
- Software documentation.
- Operating manual instruction for installation, commissioning, operation, maintenance.
- As built documents.
- Others if necessary.

QA/QC plan, certificates, passport etc., all the documents shall be provided by Supplier wherever necessary.

When supplying instrumentation and automation (measuring instruments, measuring complexes, etc.), in addition to the applicable documentation specified in above table, the Vendor must submit to Contractor, and finally transfer to the Owner, the following information, including but not limited to:

- Operating manual;
- Maintenance manual;
- Instructions for installation, start-up, regulation;
- Technical Regulations of the Eurasian Economic Union (TR EAEU/ TR CU)012/2011;
- List of operational documents, catalog/specification of parts and assembly units, consumption rates of Spare Parts, consumption rates of materials, other operational documents;
- Repair documents, including, but not limited to:
  - repair manual;
  - repair specifications;
  - repair drawings;
  - Spare Parts consumption rates for repairs;

- ü list of Spare Parts for overhaul;
- ü list of Spare Parts for repair (list of Spare Parts, materials, fixtures and tools, including special tools);
- ü list of repair documents;
- ü technical documentation for repair equipment (in accordance with the requirements of the Unified system for design documentation and Unified system for technological documentation standards);

- Certificate of type approval of the Register of the State system of ensuring the uniformity of measurements of the Republic of Kazakhstan measuring instruments with a description of the type of measuring instruments;
- Methodology of verification of measuring instruments;
- Certificate and protocols of initial verification (the period for verification of instrumentation is no more than six (6) months as of the date of equipment delivery); (note on initial verification in the data sheet). FZ No. 102 dated 28.01.2009;
- Certificates of initial verification by the Register of the State system of ensuring the uniformity of measurements of the Republic of Kazakhstan bodies, in case of import of measuring instruments – a certificate of initial verification of the manufacturer's plant, drawn up in accordance with Kazakh legislation;
- Certificate/declaration of safety with the attachment of a safety guide in accordance with GOST R IEC 61508, GOST R IEC 61511 for all measuring instruments and operating devices involved in safety loops;
- Functional diagram of automation with a full list of parameters to be monitored, controlled and protected by the control system (CS) (if necessary).