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Specification for General Instrument Standard

Discipline: Instrument

Rev	Date	Purpose	ORIG. By	CHK'D By	APP'D By	F. APP'D By	Customer
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Unit	Offsite & Utilities	Unit/Sub-unit Code	00
Sub-unit	General	Project Stage	FEED

EuroChem

Chemical Complex for Phosphates Processing Project

CONTENT

1 General & Project Description

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

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

2 Abbreviations

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

List of Abbreviations

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

Abbreviation	Description
~~PAS~~	~~Process Automation Systems~~
P&ID	Piping & Instrumentation Diagram
PLC	Programmable logic Controller
SAT	Site Acceptance Test
SIL	Safety Integrity Level
SIS	Safety instrumented system
SS	Stainless Steel
UPS	Uninterruptible Power Supply

3 Introduction

This specification defines the functional requirements of 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.

4 Codes and Standards

1	GB 50093-2013	Code for construction and quality acceptance of automation instrumentation engineering
2	GB 50779-2012	Code for design of blast resistant control building in petrochemical industry
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	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 70-2-2013	Control Valve Seat Leakage
22	ANSI/FCI 70-3-2016	Regulator Seat Leakage
23	API STD 598-2016	Valve Inspecting and Testing
24	API STD 607-2016	Fire Test for Quarter-turn Valves and Valves Equipped with Nonmetallic Seats
25	ISO 15848-1:2015	Industrial valves - Measurement, test and qualification procedures for fugitive emissions - Part 1: Classification system and qualification procedures for type testing of valves
26	ISO 5167-1:2003	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 5167-2:2003	Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full - Part 2: Orifice plates

28	ISO 5167-3:2020	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 5167-4:2003	Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full -Part 4: Venturi tubes
30	ISO 5167-5:2016	Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full -Part 5: Cone meters
31	ISO 5167-6:2019	Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full - Part 6: Wedge meters
31	ASME B16.36-2006	Orifice Flanges

5 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

6 Environment Conditions

Maximum temperature	39.1 °C
Minimum temperature	-26.7 °C
Summer average relative humidity	32% for month
Winter average relative humidity	85% for month

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

7 General Requirements / Design Basis

7.1 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.

7.2 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 IP30.

7.3 Common Requirements

7.3.1 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.

7.3.2 Signal Types

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

- Analog signals (input/output) 4-20 mA
- Digital input signals Voltage free contact
- Digital output signals 24V DC

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

For monitoring purposes only, the important package status signals shall be transmitted to the main Control System by means of serial link. Allowable communication protocols are:

- Modbus TCP/IP
- Modbus RTU
- Profibus DP
- OPC

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 control valves and on/off valves shall be selected to preserve the safety of the plant in the case of loss of electrical energy and / or instrument air supply.

The transmitter electronics shall be capable of monitoring its performance during normal operation. The diagnostics shall be able to detect both an input sensor failure and transmitter electronics failure.

7.3.3 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 have adjustable set point over the entire calibration range. Contacts shall be switching (SPDT). Contacts shall be gold-plated and sealed.

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 evaluation.

Electronic transmitter shall be usually integral mounted together with its primary measurement elements. In particular cases (for better accessibility, high temperature, etc.), transmitter and sensor can be in separate execution.

Instruments shall have an external earth stud connection for safety grounding.

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

7.3.4 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.

8 Instruments Selection

8.1 Flow Instruments

8.1.1 General

~~The first choice for flow measurement is Orifice meters, however in specific services or requirements other measurement principles may be used.~~ 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 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. ANSI 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.

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. 6.3.2.

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.

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.

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.

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.

8.1.6 Thermal Mass Flow Transmitters

Thermal dispersion mass-flow meters may be used for the measurement of single phase fluids with well-known physical properties.

Both in-line flanged or insertion version may be used.

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

Electronic transmitter shall be capable to manage up to four sensors.

Preferably all instruments shall be provided with digital type indicator.

8.1.7 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.

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.

8.1.8 Flow Indicators

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.

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. 6.3.2.

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.

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.

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.

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

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.

8.2.6 Level Indicators

Level indicators may be of glass or magnetic levels.

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 armoured 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.

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.

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 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 1/2"–NPT 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.

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.

8.3.3 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.

8.3.4 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 **must** be selected that the normal operating pressure is between 1/3 and 2/3 of scale.

The nominal dial size of pressure gauges **must** 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 **must** 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(F) ~~1/2" NPT~~ male bottom connection.

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

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 or a rupture hole at the back of the case.

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.

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.

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 1/2"–NPT electrical entry, female thread.

8.4.3 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".

8.4.4 Thermocouple Elements (TC)

Type "K" thermocouple shall be used where the temperature is above 300 up to 1000 °C.

Other thermocouples 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.

8.4.5 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.

8.4.6 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°.

Connection to thermowell shall be 1/2"–NPT 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.

8.4.7 Thermowells

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

Flanged thermowells shall be DN 40.

~~Threaded thermowells shall be 1.1/2" NPT.~~

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 generally 8 mm; in any case it 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 250 mm for Thermocouple primary element.

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 nozzle from external surface of pipe of 150 mm and for pipeline pressure class less than or equal to Class 600. If different, 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 analysers will be indicated by project requirements, i.e., when indicated on P&ID's.

8.5.2 Analysis Systems

Analyser 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 analysed 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.

~~If required by the characteristics of the sample, transport lines shall be heat traced;~~ 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 analyser input and system shall be designed to prevent biphasic sample entering the analyser.

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

The analysers 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 analyser 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 analyser 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 analysers 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 analysers may be open (canopy) or closed (shelter, cabinet, etc.); boxes could also be used, it will depend mainly on the size of the analysers 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 are toxic or flammable.

- Sampling system for laboratory analysis shall be available.

- Wherever possible, analysers 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 analysers (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.

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.

Face-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 -20°C and under 232°C, extension bonnets shall be used in services over 232°C or under -20°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 200 °C.
- Grafoil packing for temperatures above 200 °C.

Internal parts shall be 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 can not 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.

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 1/4"–NPT 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.

Solenoid valves shall be stainless steel body and internals with NAMUR connection to the actuator body.

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

During normal plant operation solenoids shall be energized.

Pneumatic connections shall be 1/4"–NPT 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 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.

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, from DN40 pipe, having inlet connection 1"; a number of 6 or 12 outlet connections with 1/2"–NPT 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
1	Signal cable: 7-strands copper conductor, twisted pair, PVC sheath, PVC insulated, overall screen of aluminum / plastic wrapped shield, 0.5mm2 tinned copper drain wire, flame retardant class ZC, Insulation voltage Rating 300/500V, long term operating temperature of conductor is 70℃. Meter identification.	1x2x1,5 mm^2 1x3x1,5 mm^2 2x2x1,5 mm^2 6x2x1,5 mm^2 12x2x1,5 mm^2 16x2x1,5 mm^2	Sheath: IS-Light Blue NIS-Black Core: 2-wire: black(+), white(-) 3-wire: red(24V), black(+), white(-)	Analog signals Digital signals
2	Signal cable: 7-strands copper conductor, twisted pair, PVC sheath, PVC insulated, overall screen of aluminum / plastic wrapped shield, 0.5mm2 tinned copper drain wire, flame retardant class ZC, Insulation voltage Rating 300/500V, long term operating temperature of conductor is 70℃. Meter identification.	1x2x2,5 mm^2 6x2x2,5 mm^2 12x2x2,5 mm^2 (note 1)	Sheath: Black Core: black(+), white(-)	Feeding to 24VDC for Solenoid valves and Instruments
3	Control cable: 7-strands copper conductor, twisted pair, PVC sheath, PVC insulated, flame retardant class ZC, Insulation voltage Rating 450/750V, long term operating temperature of conductor is 70℃. Meter identification.	3x2,5 mm^2 3x4,0 mm^2 18x4,0 mm^2 (note 1)	Sheath: Black Core: blue(L), brown(N), Green/Yellow(PE)	Feeding to 230VDC for Instruments
4	Multi-mode fibre, flame resistance, PVC sheathed, steel wire armoured, G62.5/125,1300nm, long term operating temperature of conductor is 60℃. Meter identification.	4 cores	Sheath: Black	For serial links, Multi-mode fibre

No.	Specification	Size	Color	Service
5	Single-mode fibre, flame-resistance, PVC sheathed, steel wire armoured, E9/125, 1310nm, long term operating temperature of conductor is 60℃. Meter identification.	4 cores	Sheath: Black	For serial links, Single-mode fibre
6	Profibus DP cable: twisted pair, PVC sheath, PVC insulated, screen of aluminum / plastic wrapped shield, 0.5mm2 tinned copper drain wire, flame retardant class ZC, Insulation voltage Rating 300/500V, long term operating temperature of conductor is 75℃. Meter identification.	2x2x18 AWG	Sheath: Purple	For serial links, Profibus DP
7	RS-485 cable: 7-strands copper conductor, twisted pair, PVC sheath, PVC insulated, screen of aluminum / plastic wrapped shield, 0.5mm2 tinned copper drain wire, flame retardant class ZC, Insulation voltage Rating 300/500V, long term operating temperature of conductor is 70℃. Meter identification.	2x1,5 mm^2	Sheath: Black	For serial links, RS-485
8	CAT5E+4-STP		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, 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.

~~7.4.6 Conduit And Fittings~~

~~For the mechanical protection of cables, rigid hot-dip galvanized conduits may be used. Minimum conduit size shall be 3/4".~~

~~Maximum distance between two supports shall be 1,5 m.~~

~~Conduit and relevant fittings shall be threaded and shall be suitable with the hazardous area classification and environmental conditions.~~

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 containing a voltage level (power supply or signal) over 36 ~~50~~ V, 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 Instrument Control Philosophy

10.1 Introduction

Automatic Process Control System (APCS) ~~Process Automation Systems (PAS)~~ shall be provided for safe and efficient operation of the new facilities. The new APCS~~PAS~~ shall consist of a Distributed Control System (DCS), a Safety Instrumented System (SIS), as well as the necessary interfaces to other systems and information management systems.

For interfacing with the operators, each plant shall be provided with its own Control Room. All information accessible to the operators in plant control rooms will also be accessible in the Central Control Room through the general supervisory system.

Each plant of the Chemical Complex for Phosphate Processing is controlled, monitored and protected by the following major systems:

- Distributed Control System (DCS)
- Safety Instrumented System (SIS) (if any) (note 1)
- Gas Detection & Alarm System (GDS) (if any)
- PLC based control systems (if any)
- Machine Monitoring System (MMS) (if any)

(Note 1): Where required, subjected to the results of Safety Assessment Evaluation, a Safety Instrumented System (SIS) will be integrated into the control system architecture.

The APCS~~PAS~~ will be an integrated system, where the DCS provides the primary control and monitoring of the plant.

For each plant, the control bus or data highway of the APCS~~PAS~~ shall be a redundant Ethernet based network routed via fiber-optic (FO) network infrastructure between the various control devices.

For package units (i.e. utilities), controls may be integrated into APCS~~PAS~~ or into a dedicated standalone PLC system which is serial or hardwired linked to the APCS~~PAS~~.

10.2 Plant Safety

Dedicated Safety Instrumented Functions (SIF) independent from the DCS shall be provided where malfunction or mis-operation of plant equipment or control system can give rise to:

- Hazards to personnel and/or environment

- Considerable economical loss (e.g. damage to main plant equipment or severe production loss)

The SIS shall be designed to be fail safe.

10.3 Systems Segregation

Major units or plant areas which can be operated independently shall have their instrumentation systems control and I/O processing hardware separated and segregated to enable maintenance, testing and card replacements to be carried out without having to physically interfere with or disturb the control and I/O processing hardware of other units/plant which may remain operating.

Within plant units, signals shall be distributed throughout the control and I/O processing hardware such that the number of critical control loops or outputs which could be affected by common mode failures is minimized.

10.4 Serial Communication

Serial links shall be used for cost-effective transmission of bulk information. Proprietary links shall not be used. Serial links between different systems shall be based on open, industry standard, protocols.

Applications shall as a minimum comply with the following:

- Links shall not be utilized to transfer critical safety signals between the APCS~~PAS~~ and other systems. Safety critical signals shall be exchanged via hardwired I/O connections or SIS network (final configuration defined during detail engineering).

- 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.

- Links shall be implemented with a proven (with the systems selected) and industry standard protocol e.g. Ethernet, Modbus RTU (via RS-485), Modbus TCP, Profibus, OPC.

- Functionality of each serial link shall be fully tested with the project hardware and software during a FAT prior to delivery. Final test configuration shall include all components of the final system architecture like firewalls, routers, etc.

- Communication between DCS and SIS shall be redundant.

10.5 Fiber Optic Network

A plant wide integrated fiber optic (FO) network infrastructure shall be provided.

Routing between buildings shall be via diverse routing providing the required redundancy.

The FO network shall have 100% spare capacity (spare fibers installed and terminated).

FO connectors shall be standardized throughout the project.

10.6 Instrumentation Systems Sparing & Performance Requirements

DCS, SIS, and other instrument systems 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; Operator stations must 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 60% 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 VENDORs recommendations. VENDORs recommendations shall be clearly documented early in the EPC phase of the project and be part of the APCS~~PAS~~ Specification.

- CPU loads, when taking into account spare I/O quantities, shall not exceed 70% load irrespective of VENDORs recommendation.

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

10.7 Power Supply Systems

Electrical supplies available for APCS~~PAS~~ shall be as follows:

- AC uninterruptible, maintained power supply derived from AC UPS units – Back up time 30 minutes.

- AC general purpose supply.

In general, AC supplies shall be 230V- 50Hz and shall be distributed via separate AC distribution boards.

Each instrument system or cabinet requiring power supply shall be fed by 2 separate feeders, both from the AC UPS distribution board. The voltage conversion to signal level shall be via redundant power supply units serving each system or cabinet. 230V-50Hz UPS power distribution within cabinets shall be redundant.

10.8 Package Units

The control and safeguarding of the package units may be implemented in the package itself by means of PLC.

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

In case a dedicated 3rd party control system is included in the scope of the package units, the following shall be applicable:

- SIF related signals between package unit SIS and main plant SIS shall be hard wired.

- Signals between package unit PLC and the main plant DCS shall be hard wired for control and interlocking IOs.

- Serial links shall be provided for transfer of monitoring signals from PLC to the DCS.

Package unit PLC manufacturer and model shall be standardized as much as possible throughout the plant.

10.9 Electrical Interfaces

The interface between the DCS and electrical systems shall be based on hardwired signal exchange. As a general rule, control System remote I/O cabinets shall be located at each Electrical Substations.

The commands/status information available for DCS shall be defined during detail engineering.

10.10 Availability

All parts of the systems shall be designed to achieve a high availability. This performance, which necessitates minimizing planned and unplanned stoppages and spurious failures, shall be achieved by installing control and safeguarding systems electronic modules and data communication links, which incorporate redundancy and fault tolerant technology. Additionally, the systems shall be provided with self-checking and diagnostic capabilities for simplified fault finding.

10.11 System Hardware, Cabinets And Marshalling

For APCS~~PAS~~, vendor standard hardware shall be selected for CPUs, I/O Cards, etc. All hardware supplied shall be of proven technology.

If IS barriers (isolators) are required, they shall be active devices.

IS isolators shall be single channel devices and on-line replacement of faulty devices shall not impact the availability of other I/Os.

Equipment shall preferably be 19" rack mounted. System cabinets shall be prewired and factory tested.

Fused terminals shall be used where necessary to protect I/O processing hardware as well as for powered outputs.

Each cabinet (part of control system, local panels, etc.) shall be equipped with one common fault alarm contact wired to the nearest DCS I/O cabinet. Each common cabinet alarm shall include monitoring of cabinet temperature, extract fan failure, etc. The cabinet design shall be such that it shall allow local trouble shooting.

Cabinet cable entries shall be provided with protection against cable damage by rodents.

All cabinets for the project shall be as much as possible of the same manufacturer. For further details of cabinet construction, refer to specifications issued for detail engineering.

10.12 Electromagnetic Compatibility

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

10.13 Control Buildings

System cabinets of the APCS~~PAS~~, other instrumentation systems and electronic equipment shall generally be located inside dedicated Control Buildings provided for each plant part of the Chemical Complex.

Each building shall have air conditioning units to reliably maintain suitable environmental conditions for the installed equipment and operators / technicians. Fresh air intake shall be provided with suitable means to protect ingress of sand, dust and toxic / explosive gas mixtures into the building.

The APCS~~PAS~~ related areas of the control buildings are Instrument Rack Rooms and Control Rooms.

10.13.1 Instrument Rack Rooms

Inside the Instrument Rack Room, are located, basically, the following equipments:

- Communications interface equipment for DCS, SIS, and other systems.
- DCS and SIS I/O cabinets with cable termination.
- Fiber optic cabinets with patch panels.
- APCS~~PAS~~ equipment, like network servers, backup servers, client PCs, etc.
- Power distribution cabinets (UPS and non-UPS) for above mentioned equipment.

System cabinets shall be spaced with approximately 1,2 m between rows. Cabinets will be free-standing.

Cabinets in Rack Rooms shall be supported on frames. The cabinet support frames shall be provided for the complete length of a cabinet row. Computer floor tiling shall be continued over spare unused cabinet positions.

Each Instrument Technical Room shall have a minimum of 25% spare floor space for future installations.

10.13.2 Control Rooms

Control Rooms shall house all the Human Machine Interface (HMI) equipments related to the operation and management of each plant.

All engineering work stations that are required for the plant shall be installed in a dedicated area of this room. If enough space is available, it shall be preferable to have this area segregated in one dedicated room.

Design of Control Room shall be based to achieve a comfortable, safe and efficient environment for operators.

Considerations about plant operation tasks and organization shall be taken in account when define number and location of operator workstations.

Layout, lighting, operator console design, selection of furniture and materials shall be based on ergonomics considerations to achieve optimal working conditions.

Each Control Room shall have a minimum of 25% spare floor space for future installations.