Base Load Power Hub (BLPH)

Instrumentation for Package Unit Specification

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1. INTRODUCTION

1.1. PROJECT OVERVIEW

Crosswind, a Shell and Eneco joint venture, was awarded the tender to develop the offshore Hollandse Kust Noord (HKN) wind farm, located 18.5km off the coast of Netherlands near the town of Egmond aan Zee. The consortium plans to have HKN operational in 2023 with an installed capacity of 759MW generating at least 3.3TWh per year. This is sufficient renewable power to supply more than 1 million Dutch households with green electricity.

Offshore wind farms produce intermittent electricity and balancing these dips and peaks and integrating this electricity into the national energy system requires new technologies. For this reason, the offshore wind farm will include several new technologies that could be implemented at full-scale in the future. The new technologies being explored include a floating solar park, a short-duration battery storage as well as long-term storage via green hydrogen produced by water electrolysis and subsequently consumed in a fuel cell. The combination of these individual measures, herein referred to as the Base Load Power Hub (BLPH) will ensure a continuous power supply regardless of the wind situation.

Project Location

The Hollandse Kust Noord (HKN) wind farm is located 18.5km off the coast of the Netherlands near the town of Egmond aan Zee.

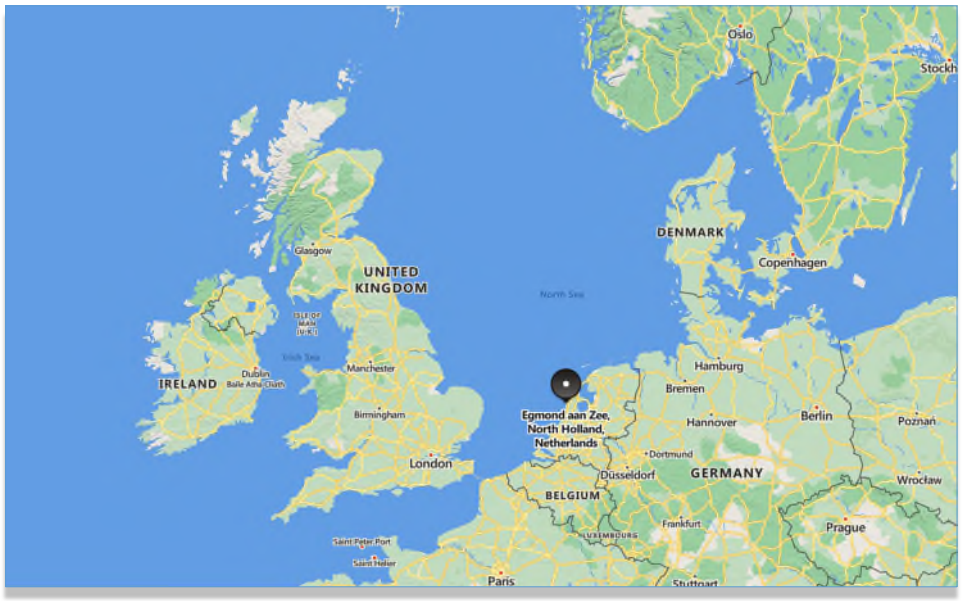


Figure 1 - HOLLANDSE KUST NOORD WIND PARK Location Map

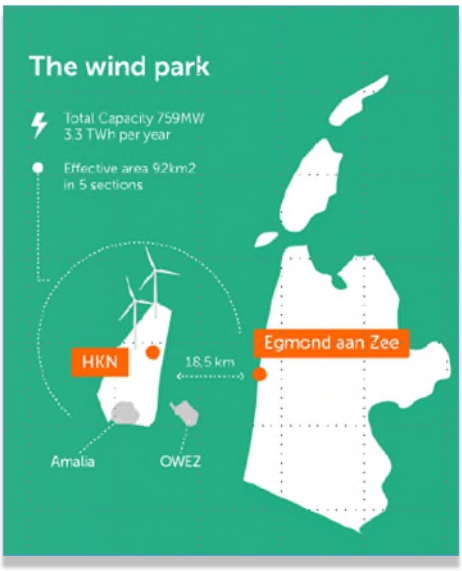


Figure 2 - Wind Park Details

The wind farm will consist of No. 69 x 11.5MW wind turbine generators each to be installed on a dedicated monopile structure. A 70th monopile located on coordinates E 590719.1, N 5841602.3 is reserved for installing the platform accommodating the BLPH. The monopile structure was designed and installed by Van Oord Offshore Wind (VooW) and therefore not part of the BLPH scope.

Project Concept

All components included in the BLPH will be integrated onshore on a topsides and installed in an offshore location within the boundaries of the HKN wind farm. At its simplest, the BLPH will store energy during periods of high electricity generation from renewable sources (a wind turbine generator and the floating solar PV farm) and release it during periods of low generation. In practice. It is expected that the energy stored will supplement generation from renewable sources to ensure that at least 1.0MWe of power is exported to the electrical grid regardless of wind/solar availability.

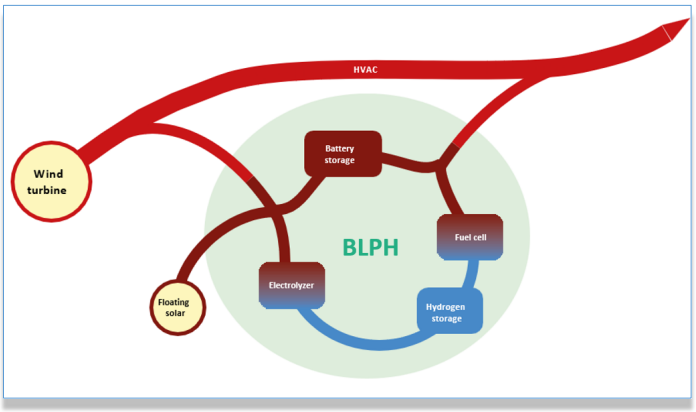


Figure 3 - BLPH Concept

Electricity in the BLPH will be stored in the form of electrons in a battery energy storage system (BESS) as well as converted into green hydrogen via water electrolysis. When the power output from the connecting wind turbine drops to below 1 MWe, the BLPH will return its stored energy to supplement the remaining power output. This will be by discharging the BESS, while stored hydrogen will be converted back into electricity using a fuel cell to extend the discharge duration.

The purpose of the BLPH s to function as a testbed for the integration of energy storage technologies with renewable generation. It is expected that equipment installed on the BLPH will operate as Normally Unmanned Installation for at least two (2) years with no or minimal maintenance and it will have its own independent control room with the ability to communicate with Crosswind's control room.

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2. DOCUMENT SCOPE

The purpose of this document is to cover the works, equipment, services and responsibilities that shall be provided or executed by package VENDOR for instrumentation associated with major mechanical or process equipment, systems or units.

In the present specification it is understood that a package unit is a prefabricated process unit or utility unit which can operate on its own or some of them requires external inputs (e.g. Water, Hydrogen, Nitrogen etc.), and which is normally a standard skid mounted (or equivalent) unit.

It shall be supplied complete with all instrumentation fully piped, wired and tested to ensure safe, reliable, maintainable and effective operation.

All the instrumentation and/or control to be installed on the packaged unit shall conform to the present specification and to the "Automation Detailed Design and Construction Package", referenced 123A90-DDL-IN-DD-40029.

Any deviation with this specification at any stage of the project will require to be approved by COMPANY.

It is not the intent to specify herein all details of design and construction. CONTRACTOR shall take the responsibility of ensuring that the equipment has been designed, manufactured and tested in accordance with all engineering codes and rules, standards and governmental applicable regulations.

Any requirement, here in specified, that can be optimized and provide a fastest solution in engineering or lead time, can be proposed by VENDOR and can be authorized by CONTRACTOR.

2.1. REFERENCES

Doc. No.	Description
K559-2254-PM-PLN-003	Basic Design Engineering Package
K559-2254-PM-PLN-001	Tagging Philosophy
123A90-DDL-PR-DG-80004	BLPH Process Flow Scheme Hydrogen Storage
123A90-DDL-PR-DG-80005	BLPH Process Flow Scheme Fuel Cell Package
123A90-DDL-PR-UFD-80006	BLPH Utility Flow Diagram Water Treatment Plant
123A90-DDL-PR-UFD-80007	BLPH Utility Flow Diagram Instrument Air And Nitrogen Systems
123A90-DDL-PR-UFD-80008	BLPH Utility Flow Diagram Vent Systems
123A90-DDL-PP-SP-70000	Pipe Material Classes
123A90-DDL-PP-DD-70057	Typical Piping Assembly
123A90-DDL-PP-DS-70003	DS - Manual Valves
123A90-DDL-IN-DD-40017	Instrument Installation Details

123A90-DDL-PR-LIS-80035	Process Line List
123A90-DDL-IN-DD-40029	Automation Detailed Design and Construction Package
123A90-PML-DIG-PRO-00002	Equipment and System Tag Numbering

Table 1 - Reference Documents

2.2. DEFINITIONS AND ABBREVIATIONS

COMPANY or Client (CPY):	Crosswind
CONTRACTOR (CTR):	ROSETTI MARINO S.p.A.
PROJECT:	HOLLANDSE KUST NOORD WIND PARK Project
AMS	Alarm Management System
BESS	Battery Energy Storage System
BLPH	Base Load Power Hub
CAT	Category
CCN	Central Control Network
CCR	Central Control Room
CCS	Central Control System
CCTV	Closed Circuit Television
DEM	Design Engineering Manual
DEP	Design and Engineering Practice
EMC	Electromagnetic Compatibility
EN	Engineering Notice
EPC	Engineering Procurement Construction
Ex	Explosion Proof
FC	Fuel Cell
FEED	Front End Engineering Design
FGS	Fire & Gas System
FO	Fibre Optic
FOPP	Fibre Optic Patch Panel
GPS	Global Positional Satellite
HART	Highway Addressable Remote Transducer

HKN	Hollandse Kust Noord
HMI	Human Machine Interface
HVAC	Heating, Ventilation and Air Conditioning
IACS	Industrial Automation and Control Systems
IAMS	Instrument Asset Management System
IP	Ingress Protection
IP	Internet Protocol
IS	Intrinsically Safe
ISO	International Organization for Standardization
ITER	Instrument & Telecoms Equipment Room
LACS	Local Access Control System
LAN	Local Area Network
LOPA	Layers of Protection Analysis
LHVS	Land High Voltage Station
LV	Low Voltage
MAC	Main Automation Contractor
MCC	Motor Control Centre
NAMUR	Interessengemeinschaft Automatisierungstechnik der Prozessindustrie (User Association of Automation Technology in Process Industries)
NIS	Non-Intrinsically Safe
OHVS	Offshore High Voltage Station
OWS	Operator Workstation
P&ID	Piping and Instrument Diagram
PACO	Process, Automation, Control and Optimisation
PV	Photo Voltaic
RVO	Rijksdienst voor ondernemend Nederland – The Netherlands
SCADA	Supervisory Control and Data Acquisition
SIF	Safety Instrumented Function
SIL	Safety Instrumented Level
SIS	Safety Instrumented System
TQ	Technical Query

UCP	Unit Control Panel
UPS	Uninterruptible Power Supply
VHF	Very High Frequency
VooW	Van Oord Offshore Wind
WTG	Wind Turbine Generator

Table 2 - Definitions and Abbreviations

3. APPLICABLE CODES, STANDARDS, AND REGULATIONS

3.1. GENERAL

The equipment shall be designed, manufactured, tested, and delivered in accordance with this philosophy and the Project documents, codes, standards, and regulations listed below. It is the Vendors responsibility to ensure complete compliance in their design, inclusive of all sub-vendors. The normative documents listed below contain requirements that, through reference in this text, constitute the requirements of this Project. Latest editions of all referenced documents shall apply.

The following requirements shall apply as a minimum with the design being fit for purpose for the technical requirements listed in section 4.

The project shall apply relevant standards and codes in the following order:

1. Dutch Standards and Regulatory Requirements
2. Selected DEM-1 and DEM-2 requirements.
3. Industry Codes and Standards.

The codes, standards and specifications referenced in this specification shall be taken to mean the latest edition and addenda. It is not a definitive list and does not preclude the use of other Codes if approved in writing by CONTRACTOR.

In case of conflict between this specification, other referenced specifications and the codes and standards, this shall be brought to the COMPANY's attention for resolution in writing. In all cases the most stringent requirements shall apply.

3.2. EXTERNAL, INDUSTRY AND/OR VENDOR STANDARDS

2014/30/EU	Electromagnetic Compatibility (EMC) Directive
1999/92/EC	ATEX 153 Workplace Directive
2011/65/EU	Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment
2014/34/EU	ATEX Directive
2014/35/EU	Low Voltage Directive
94/9/EC	Equipment intended for use in Potentially Explosive Atmospheres
2004/22/EC	Measuring Instruments (MID)
2014/68/EU	Pressure Equipment (PED)

(previously 97/23/EC)	
API 520	Sizing, Selection, and Installation of Pressure-relieving Devices - Part 1 – Sizing and Selection
API 521	Pressure-relieving and Depressuring Systems
API 526	Flanged Steel Pressure-relief Valves
ASME B16.34	Valves – Flanged, Threaded and Welding Ends
IEC 60529	Degrees of Protection Provided by Enclosures (IP Code)
IEC 60534	Industrial-Process Control Valves
IEC 61508	Functional safety of electrical/electronic/programmable electronic safety-related systems
IEC 61511	Functional Safety – Safety Instrumented Systems for the Process Industry
IEC 62443	Cyber Security for Industrial Automation and Control Systems
ISO 5167	Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full
ASME PTC 19.3 TW	Thermowells
IEC 61158	Industrial communication networks - Fieldbus specifications
IEC 60079-14	Explosive atmospheres - Part 14: Electrical installations design, selection and erection
IEC 60751.	Industrial platinum resistance thermometers and platinum temperature sensors
IEC 60331	Tests for electric cables under fire conditions - Circuit integrity
IEC 60332	Tests on electric and optical fibre cables under fire conditions
IEC 60092-376	Electrical installations in ships - Part 376: Cables for control and instrumentation circuits 150/250 V (300 V)
IEC 60228	Conductors of insulated cables
IEC 61892	Mobile and fixed offshore units - Electrical installations
IEC 60754	Test on gases evolved during combustion of materials from cables
HKN2018 data @ (1979-2018)	Meteorological and Oceanographic Data
Miller, R. W. (Richard W.)	Flow measurement engineering handbook

Table 3 – External, Industry and/or Vendor Standard

4. GENERAL TECHNICAL INFORMATION

4.1. DESIGN LIFE

The design life of the facility is 2 years as this is a proof-of-concept project.

4.2. ENVIRONMENTAL CONDITIONS

The facility shall be located in a harsh marine environment in the North Sea. All equipment shall be suitable for installation, operation and for the environmental conditions in the Meteorological and Oceanographic Data (source: HKN2018 data @ (1979-2018) stated in the following table:

Description	Unit	Value
Ambient Conditions		
Ambient Temperature (min/nom/max) – hourly @ +10m	°C	-8.4 / 10.5 / 25.0
Atmospheric Pressure (nominal) – hourly @ +10m	mbar	1013.7
Specific Humidity (min/nom/max) – hourly @ +10m	x 10^{-3}	4.2/6.5/9.5
Wind Conditions		
Annual average wind speed (at 100 m)	m/s	9.56
Extreme Wind Speed for 1-Year Recurrence Period (at 100 m)	m/s	33.1
Extreme Wind Speed for 50-Year Recurrence Period (at 100 m)	m/s	41.0
Marine Conditions		
Sea Water Temperature (min/max)	°C	1.3 / 20.2
Average Sea Water Density	kg/m^3	1025

Table 4 – Environmental Conditions

4.3. UNITS OF MEASUREMENT

The international System of Units are to be used for the project, with the following limited exceptions which are conventional in the hydrocarbon industry. The Units of Measurement for:

- Pressure will be in barg;
- Nominal Pipe size will be in inches;
- Conventional volumetric flow rate will be used e.g., m^3/h; and
- Conventional mass flow rate will be used kg/h.

4.4. LANGUAGE

The project language shall be in English. This includes all correspondence, deliverables, hardware tagging /signage and control systems software.

4.5. FUNCTIONAL OVERVIEW

BLPH is an unmanned facility with planned maintenance schedules expected to be at six (6) month intervals.

The platform must be capable of autonomously operating without the need for local operator intervention for that period, with the remote operator largely providing oversight only.

4.6. GENERAL ELECTRICAL EQUIPMENT DESIGN

BLPH is located in the North Sea, under the authority of the government of The Netherlands. As such, IEC regulations apply to the project in full.

4.7. INGRESS PROTECTION RATING

The Ingress Protection code, for equipment exposed to the environment, shall be IP66 in accordance with IEC 60529.

4.8. EQUIPMENT INTENDED FOR USE IN EXPLOSIVE ATMOSHERES

All equipment shall be certified for use in hazardous areas. Design shall comply with IEC 60079 and be ATEX

rated for IIC or rated for IIB + H2. All equipment specified for use in a hazardous area shall be suitable for hydrogen production.

All outdoor electrical and instrumentation equipment shall, as minimum, be suitable for use in hazardous area zone 2, gas group 2C (or 2B+H2), Temperature Class T1 max.surface.

4.9. INSTRUMENT AIR

Instruments air will have the following Process Operating and Design conditions:

P min= 5 barg

Pmax= 9 barg

Pdes=11 barg

Top= Amb.

Tdes= 50 °C

4.10. PED 2014/68/EU

Pressure Equipment Directive 2014/68/EU shall apply for all piping materials where Category is applicable.

4.11. EMC COMPLIANCE

The specifications, design, testing, installation, operation and maintenance of all electrical power systems, electrical / electronic instrumentation and control equipment / systems shall comply with EMC directives. This is to ensure that the requirements for electromagnetic compatibility are considered during the various stages of design, construction, and installation. All as aspects of the control system shall be certified to 2014/30/EU. The vendor shall provide a Declaration of Conformity for their package stating as such.

5. PACKAGES TYPE

A package is equipment that provides a specific function (examples: BESS, Fuel Cell, HVAC, etc…).

The different types of package are depending of process and safety functionality's of these packages.

The main subdivision will be "Packages UCP Controlled" and "Packages Non-UCP Controlled".

5.1. PACKAGES UCP CONTROLLED

The Electrolyser, the BESS and the Fuel Cell shall all be controlled via UCP.

The communication protocol between the CCS and the Electrolyser, BESS and Fuel Cell systems shall be in accordance with IEC 61158, preferably Profinet (alternatively Modbus TCP/IP).

All Safety System communications shall be 4-20mA Smart HART revision 7 protocol.

Local interfaces are to be included by the Electrolyser, BESS and Fuel Cell systems, by Vendors.

The UCPs for this equipment shall be included in packaged vendor skid.

The function of the UCP shall include for normal operations and any safety requirements associated with SIS. The design of the vendor UCP shall be compliant with IEC61508.

The communications (4-20mA) between UCP and Safety System shall be through relays SIL 2 minimum certified installed inside UCP.

Fire and Gas devices shall be wired to CPI Packages UCPs (Electrolyser, BESS and Fuel Cell) and the cumulative alarms shall be routed back to the BLPH Safety System. This allows the operator to have visibility during any loss of containment issues.

The following utility systems shall be also delivered with UCPs:

- Fresh Water;
- Instrument Air
- Nitrogen.
- HVACs

The communication protocol between the CCS and these units shall be designed to IEC 61158, specifically Profinet (alternatively Modbus TCP/IP).

All Safety System communications shall be 4-20mA Smart HART revision 7 protocol. The communications (4-20mA) between UCP and Safety System shall be through relays SIL 2 minimum certified installed inside UCP.

5.2. PACKAGES NON-UCP CONTROLLED

The following utility systems are not supplied with a UCP and shall be controlled directly from the CCS, point to-point:

- Sea Water;
- De-Mineralised Water: and
- Wastewater.

All CCS and Safety System communications shall be 4-20mA Smart HART revision 7 protocol.

6. INSTRUMENTATION TECHNICAL REQUIREMENTS

6.1. GENERAL

Instrumentation on BLPH shall be 4-20mA Smart HART Revision 7. Any discrete contacts shall be line monitored to avoid single point of failure.

Foundation Fieldbus shall not be used on BLPH.

All devices shall be thoroughly investigated as to their suitability with the MAC control system. Equipment vendor packages shall be supplied with their own standard instrumentation and as such interfacing and aligning with these vendors shall be required.

HART Revision 7 and wireless device diagnostic information shall be presented and be available on EWS.

All transmitters shall be NAMUR NE43 compliant for defining and differentiating when the process variable is within normal range, out of range but fault-free or when fault detection has occurred.

Instrument signals shall be segregated earthing for protective, reference and intrinsically safe earths.

Earthing in hazardous areas shall adhere to IEC 60079-14.

All instrumentation shall be loop powered 24VDC.

Installed and wired spare I/O shall be 20%.

The transmitter range shall cover the entire operating window including start-up, shutdown, abnormal operations.

The SIS transmitter range shall normally coincide with that of the CCS transmitter. If accuracy of SIF must be increased adaptation of the range is allowed.

In general, any instrumentation that is part of the SIS, including final elements (e.g., valves), shall, as a minimum, be certified for use in a Safety Integrity Level (SIL) 2 SIF with a minimum proof test interval of two (2) years (to be developed during HAZOP and LOPA exercises).

Transmitters sharing control and trip initiations shall not be permitted.

All electronic transmitters will typically be provided with integral local digital indicators

Tagging convention is as per project equipment and system tagging philosophy, 123A90-PML-DIG-PRO-00002.

All instruments shall be suitable for the heavy salty sea-weather conditions and if necessary be installed with a weather-cap or housing. This counts also for junction boxes, cabling, ducts, and glands.

All outdoor electrical and instrumentation equipment shall, as minimum, be suitable for use in hazardous area zone 2, gas group 2C (or 2B+H2), Temperature Class T1 max.surface.

Instruments located in the hazardous area (hydrogen environment) shall be explosion-proof EEx(d)-certified.

EEx(I)-technique shall be avoided. Junction boxes in the hazardous area shall be EEx(e)-certified. ATEX marking shall be on the instruments and junction boxes.

Materials of the instruments shall be based on fluid properties, process conditions, piping class and material selection. For hydrogen and coolant applications, the wetted parts can be made of SS-316, however for the seawater intake higher resistant material shall be selected according to document Pipe Material Classes.

Strong electromagnetic fields are expected at transformers, electrolyser, battery, etc. All instrumentation shall be designed accordingly.

For marine environments, electronic instrument housings shall be made from 316 stainless steel.

All electronic transmitters will be factory calibrated and calibration certificates will be provided for each device.

6.2. INSTRUMENT REQUIREMENTS

Instrument requirements shall include the following:

a. accessibility and physical location in relation to process equipment and piping;
b. orientation of instruments;
c. mechanical protection (e.g., vibration);
d. electrical safety;
e. electromagnetic compatibility (EMC) requirements;
f. environmental conditions;

6.3. LOCAL PANEL REQUIREMENTS

For the cases where a Local Panel is required, the following requirements apply:

- Local panels located outdoors shall be 316 stainless steel or fibreglass.
- Local panels shall have an ingress protection class of IP66 as specified in IEC 60529 (in North America, NEMA-4X as specified in NEMA-250).
- Local panels located in marine environments shall be secured to withstand the worst-case storm force for the site where they will be installed.
- Local panels should be located away from steam outlets and dripping water.
- Where the local panel or cubicle requires openings for ventilation, these openings shall be provided with screens to prevent the entry of animals or insects.
- There shall be no direct process connections between process fluids and enclosed instrument panels (e.g., impulse lines entering an enclosed instrument panel present a risk of leak).

- Cable entries shall be from the bottom or side.

6.4. SELECTION OF MATERIALS

For in-line instruments, the selection of materials (including bolts and gaskets) used in pressure retention components of the instrument shall meet the minimum requirements of the document Pipe Material Classes.

Material for instrument wetted parts shall be in according with the Pipe Material Classes and as a minimum shall be grade 316 stainless steel.

Grade 304 stainless steel shall not be used. Alternative materials or alloys of a higher grade than the pipe specification may be offered for standardisation purposes.

As a general rule, AISI 316(L) is suitable in systems with austenitic stainless steel or carbon steel equipment, but might not be suitable for certain process environments such as chloride containing systems.

For marine environments, electronic instrument housings shall be made from 316 stainless steel.

6.5. INSTRUMENT PROCESS CONNECTIONS

Process connections of on-line instruments shall be as determined by the document Typical Piping Assembly and be one of the following:

a. flanged connection (e.g., on a primary isolation valve, level measuring chamber or nozzle on a vessel);

b. threaded connection NPT (e.g., monoflange, tubing fitting) with size in inch. NPT Threaded according the piping philosophy where threaded joints (where piping class will permitt) shall be NPT pipe threads in accordance with ASME B1.20.1.

6.6. INSTRUMENT ELECTRICAL CONNECTIONS

Electrical Connections shall be ISO Metric type.

6.7. INSTRUMENT NAMEPLATES AND WARNING PLATES

1. All instruments shall be provided with nameplates indicating the tag number and the service description for the instrument.
2. All junction boxes, cabinets, panels and ancillary equipment shall be provided with nameplates indicating the tag number.
3. Tag numbers and service descriptions shall be aligned with the instrumentation database and instrument data sheets.
4. The text on nameplates for manual selector switches shall repeat the switch position markings and describe what each switch position represents.

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5. The text on nameplates for push buttons shall describe what action results when the push button is activated.
6. Where abbreviations are necessary, they shall be standardised and consistent for all nameplates.
7. All field-mounted instruments shall be provided with one of the following, in order of preference:
   a) nameplates;
   b) stainless steel tags.
8. Nameplates, if used, shall be attached to instrument supports or brackets by means of stainless steel screws or rivets.
9. No holes shall be drilled into instruments for fixing nameplates or stainless steel tags.
10. If nameplates are used, then transmitters used in a safety instrumented function (SIF) shall have red nameplates with white lettering.
11. If stainless steel tags are used, then transmitters used in a safety instrumented function (SIF) shall have red painted stainless steel tags

6.8. INSPECTION AND CERTIFICATION

1. For in-line instruments, the following requirements shall be in accordance with the piping class or equipment in which or on which the instruments are installed:
   a. the traceability and associated material certification for pressure retaining parts (including bolting on pressure retaining parts);
   b. testing such as hydrotesting non-destructive testing (NDT).
2. The Contractor shall include the certification and testing requirements in the instrument data sheet.

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7. FLOW INSTRUMENTS

7.1. SELECTION

The selection of flow measurement technique shall be guided by fluid flow design conditions taking into account flow turndown, accuracy and uncertainties requirements. Other criteria to affect the selection of flow measurement devices are the possible formation of hydrates.

Flow Meters shall be dP-type according to ISO-5167. Other types might be selected (ultrasonic, variable area etc.) if dP-type does not meet the requirements. In the sizing calculations attention shall be given to the low flow-cut-off value.

7.2. DIFFERENTIAL PRESSURE FLOW METERS

Calculations for differential pressure flow meters shall be based on ISO 5167 (outside North America) or AGA 3 (inside North America).

The beta ratio (d/D) shall be kept between 0,2 and 0,7.

Flowrate to be measured shall be kept between 30% and 90% of the design flow.

Pressure taps shall be on the flanges.

Concentric sharp edged orifice plates installed between flanged taps shall be the standard selection unless viscosity, process conditions or Reynolds number dictate otherwise.

Orifice flanges (minimum ANSI 300 rated flange) with 316 stainless steel (minimum), square edge, and paddle type orifice plate shall be used.

Generally orifice taps will be 45 degrees from the horizontal, upward for gases and downward for liquids to reduce required clearance between pipes.

The following requirements shall be followed for installation of differential pressure flow meters:

- Install the straight length and other installation requirements for orifice plates in accordance with Table 3 in ISO 5167-2.
- Provide sufficient space to allow removal of orifice plate, nuts and bolts.

Accuracy shall be:

- Better than 2% of reading (for liquid)
- Better than 3% of reading (for gas/steam)

7.3. RESTRICTION ORIFICES PLATES

Restriction orifice plate shall be used to regulate flow by creating pressure drop.

The minimum thickness of all restriction orifices shall be calculated based on the orifice being completely blocked.

The orifice bore sizing calculation shall be based on ISO 5167 and when not applicable e.g. for sonic flow R.W. Miller can be used. The sizing and thickness calculation shall be reviewed by Buyer. Restriction orifice plates shall be mounted between piping flanges. The surface finish shall match the flange surface finish.

8. LEVEL INSTRUMENTS

8.1. INSTRUMENT CONNECTIONS

- Instrument connections shall be positioned horizontally in the liquid phase and on the same side of the equipment.
- Instrument connections shall not branch off the bottom of equipment.
- Instrument connections shall not branch from normally flowing lines entering or leaving the vessel.
- Instrument connections in the gas phase may be positioned vertically upwards as well as horizontally.
- If more than one instrument shares the same connection to the vessel, each connection shall be provided with a dedicated primary isolation valve such that it can be removed without interfering with neighbouring instruments.
- The potential for common mode failures (e.g., loss of fill fluid or plugging) shall be evaluated.

8.2. SELECTION

The Contractor shall select level instruments based on a documented process taking into account the following:

a. application requirements;

b. service conditions;

c. on-line maintenance capability;

Level measurements based on nucleonic devices shall be subject to approval by the Company.

A specific level instrument is fully defined by the data sheet for that instrument.

Accuracy shall be better than 10 mm.

- Differential Pressure Level Transmitters

Differential pressure level measurement should be considered for most applications with liquid-gas or liquid-liquid interface level measurement.

Differential pressure level instruments can be used in severely turbulent, dirty, foaming or fouling service with diaphragm seals and capillaries.

Process connections shall be on the same side of the equipment capillaries length shall be equal on High Side and Low Side. For open tank level measurement direct mounted DP transmitter shall be considered.

Where there is need of remote installation, remote flanges via capillary tube can be used. Capillary tubes shall be welded and shall have mechanical protection of 6mm OD with stainless steel (minimum) spiral wound armour. Capillary tube length shall be suitable with application but should be limited to 5m.

All ratings, connections and materials shall conform to the specification of the equipment on which the instruments are installed.

- Radar Level Transmitters

Non-contact type Radar level transmitters can be based on either pulse type or frequency modulated carrier wave (FMCW) technology of time of flight principle.

Where vapor condensation and deposits may affect performance, a round piece of PTFE shall be installed in the mounting flange to prevent the accumulating on the radar gauge cone.

Contacting Radar (Guided Wave Radar) instruments shall be based on Time Domain Reflectometry (TDR) technology.

On interface service the dielectric difference between both media shall be at least 10.

Guided wave radar instruments shall be preferably externally mounted and supplied with vent and drain facilities of the sensor cage.

In turbulent applications, GWR shall be used with stilling well, when sensor cage cannot be used.

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9. PRESSURE INSTRUMENTS

Pressure Instruments shall be direct mounting where possible. Accessibility shall be investigated.

Pressure switches shall not be used., Pressure transmitters with signal transmission to the Control and Safety systems shall be used for switching functions.

Gold plating (5 µm - 30 µm) of the diaphragm or ceramic sensor shall be specified for any hydrogen service above a hydrogen partial pressure of 35 bara (500 psia).

Accuracy shall be better than 0,25% of adjusted span.

All the pressure instruments shall be suitably rated for the test pressures. Pressure elements shall be suitable to withstand 130% of full range without rupture of any components or the need to recalibrate the instrument.

Pressure transmitters will typically be ordered with two valve manifolds.

Separate process taps will be provided for process control and safety pressure transmitters. Multiple safety transmitters (two out of three voting as an example) are not allowed on a single common process tap.

Where a pressure transmitter is installed within a dirty service line a suitably sized diaphragm seal shall be used.

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10. TEMPERATURE INSTRUMENTS

10.1. GENERAL

Temperature measurements shall be RTD-type, 3 wires or Platinum type 100, resistance tolerance class A, IEC 60751. Head transmitter shall have 4-20mA, HART, NAMUR NE43.

Temperature measurement devices shall be selected to suit the environmental conditions of the facilities and the process fluid flow design conditions taking into account a range choice that is inclusive of normal operating temperature and design temperature and accuracy requirements. Other criteria to affect the selection of devices are the erosion, corrosion; high velocities and debris build up owing to possible formation of hydrates and wax, etc.

Filled thermal systems, such as those with alcohol or mercury, shall not be used.

10.2. THERMOWELLS

The following installation requirements (if applicable in BLPH project) for thermowells shall be met:

- located at least 10 pipe diameters downstream of a liquid mixing point;
- located at least 30 pipe diameters downstream of the mixing point in mixed gas/vapour streams and for steam desuperheaters;
- located upstream of flashing or cavitating valves in order to avoid excessive vibration;
- located outside the straight length of flow meters;
- provided with insulation on the nozzle, in case the pipe is insulated; If the pipe is not insulated, the nozzle does not need insulation.
- provided with a tag plate indicating its tag number;
- provided with a plug when no element or gauge is installed, in order to prevent corrosion. This also applies to the period between installation of the thermowell and installation of the element or gauge.

Thermowell shall be of the flanged type, size 1 1/2" and inline with the document Pipe Material Classes.

Details shall be as detailed in the document Typical Piping Assembly for instrument connection.

Thermowell insertion length may be reduced at no loss of accuracy where the flow regime is of a high Reynolds number in order to satisfy ASME PTC 19.3 TW requirements.

Thermowell will be the tapered-type unless straight or stepped types are required for vibration resistance.

Each Thermowell will be provided with hydrotest certificates.

Thermowell shall not be longer than strictly necessary to obtain required accuracy and to avoid vibration "cracking".

Thermowell strength calculations shall be performed for process systems according to ANSI/ASME Performance Test Codes ASME PTC 19.3 TW requirements.

Thermowell inner diameter suitable for TE/TI elements of 6.5 mm should be used.

Thermowells for vessels shall be typically 450mm insertion length to allow adequate protrusion through the nozzle.

10.3. RESISTANCE ELEMENTS

Temperature measurements shall be RTD-type, 3 wires or Platinum type 100, resistance tolerance class A, IEC 60751. Head transmitter shall have 4-20mA, HART, NAMUR NE43.

11. VALVE REQUIREMENTS

11.1. ON/OFF VALVES ACTUATED

On/Off valves actuated (ESDV, BDV, XV) shall comply with the project data sheets.

Automated On / Off valves typically shall be ball type full bore and comply with the project Pipe Material Classes.

On/Off valves actuated (ESDV, BDV, XV) on Hydrogen application shall be Tight Shut-off type (Project P&ID's will be utilized to identity requirements).

Necessary PACO control system software shall be included to support advanced valve control, partial stroke

testing and diagnostics for any safety critical on / off valves. These applications shall be identified by HAZOP

and LOPA evaluations.

The following valve requirements shall apply:

- Each actuator shall be pneumatic and single acting (with scotch-yoke design for protective application).
- Air pressure regulators shall be used where applicable according to calculations. They shall not be used as a protection device against overpressure.
- For shut down and blow down valves, the actuator sizing shall be calculated according to specified criteria. Actuators shall be sized such that it is able to close/open the valve with the maximum operating pressure acting upstream and atmospheric pressure acting downstream (max. differential pressure) within the specified time, taking into consideration minimum actuation medium supply pressure.
- Torque requirements and safety factors shall be calculated. For the valve actuators safety factors shall be included in the specifications that shall also include the Torque table.
- On / Off shutdown safety valve actuators will be sized to produce twice of the required valve torque at each of valve unseating, run, and valve reseating torques (in both directions), calculated at the valve body design differential pressure with zero pressure downstream.
- Non-Critical On / Off valve actuators shall be as per above safety system actuators, except sizing safety factor can be 1.5 times.
- The actuator output shall be less than the Maximum Allowable Valve Input Torque to minimize issues with actuators being oversized.
- Solenoid valves shall be direct-operated, have magnetically actuated plunger, spring return, auto-reset, NAMUR NE 19 mounting, whilst exhaust shall be protected from blockage by ice, insects etc.

Solenoid valves will be 24 VDC low power.

- The solenoid coil and spring shall be selected to provide sufficient operational power to position the valve stem correctly under all process conditions. Coils shall be rated for continuous operation and fitted with surge suppression diode.
- Unless otherwise stated, SOVs shall normally be energised and de-energised when tripped by the control and/or safety system. When de-energised the valve shall move to its designated failure position.
- For Protective applications, solenoid shall be a direct-operated solenoid valve that contains a magnetically actuated plunger that switches a port through which flows the medium used to switch and control;
- Two limit-switches shall be installed on each valves, one for open and one for close position.
- Limit Switches shall be proximity type (IEC 60947-5-2/3/6).
- Wherever specified, valve open, valve close and partial stroke limit switches shall be mounted on the valve and operate at less than 5 % of the valve travel from their respective limits.
- The valve shall be in accordance with the document Pipe Material Classes.
- In general valve trim materials shall comply with the relevant Pipe Material Classes. In potentially erosive service e.g. flashing duties, trim components shall be "hard faced".
- All valves, including actuator assemblies, shall as a minimum have an engineered solution for how to safely strap and lift the valve. The lifting procedures shall be detailed in the Operating Manual.
- The actuators can be fail-safe to close, or open dependent on the safety application (Project P&ID's will be utilized to identity requirements).
- For Protective Applications, the actuator and valve assembly, including the position control accessory (e.g., solenoid), shall meet the integrity requirement of the SIF or SIFs of which it forms a part, as defined in accordance with IEC 61511. Where used by more than one SIF, the most onerous integrity requirement applies.
- For Protective Applications, hand wheels shall not be fitted.
- Actuators on valves used in Protective Applications shall not be fitted with locking devices.
- The required valve opening and closing time shall be specified on the instrument datasheet.
- Where no specific opening/closing times are given, the Supplier shall confirm the valve opening/closing time.

11.2. CONTROL VALVES

Control valves shall comply with the project data sheets.

Control Valves shall be compliant with IEC 60534.

- Where valve positions are transmitted electrically, two sets of proximity type DPDT, hermetically sealed switches shall be provided on valve actuators to indicate the fully open and fully closed positions.
- Default seat leakage class, process conditions, end connections, stroke time etc. shall be suitable for the application.
- Control Valve body materials of construction shall comply with Pipe Material Classes.
- Globe valves will generally be sized so that the maximum flow does not exceed 90% of the valve capacity. Minimum flow should not be less than 10% of the valve capacity.
- For high pressure drop and other difficult applications, special trim will be used as recommended by the valve manufacturer.
- Typically shut off classification for general service control valves will be class IV. For applications involving (safety / environmental issues, product loss etc.) where valve leakage is required to be near zero, class V or class VI shall be used.
- In hydrogen service control valves shall be class B
- Required characteristics shall be achieved using the appropriate trim design. Where the characteristic cannot be achieved using the trim design, unless specified on the instrument datasheets, control valves shall generally have equal percentage characteristics.
- Noise limitation on all control valves is 85 dBA at 1 meter.
- Supplier shall select control valve trim design that facilitates maximum reduction of control valve induced vibration and trim wear.

11.3. SAFETY RELIEF VALVES

Safety relief valves shall comply with the project data sheets.

Safety Relief Valve shall be designed based on the requirements of the process application, operating and design conditions and piping specification.

- The material pressure-temperature ratings for the valve body, bonnet shall be in accordance with the associated piping class. Design of the safety relief valve shall be such that no liquid can collect on the discharge side of the device. Safety relief valves shall not be fitted with manual seat lifting devices, or with test gags, unless specifically mentioned in the datasheets.
- The relief valve supplier will provide certified sizing calculations for each valve based on the process data provided. Sizes shall be identified in accordance with API STD 526 showing inlet size - orifice area - outlet size (e.g. 1D2, 2H3, etc.).
- Valves shall be sized in accordance with sizing formula contained in API STD 520, latest edition. Sizing for 2-phase conditions shall be in accordance with ISO 4126-10 & shall be submitted for review & approval.

- The orifice designation and area, valve size and inlet / outlet rating, pressure and temperature limits and center to face dimension shall be in accordance to API 526.
- Vendor shall carryout the noise (Max. allowed 85 Dba at 1 meter) calculation and shall be submitted for review.
- In general, conventional spring-operated Safety Relief Valves shall be used when superimposed and/or build-up back pressure is below 10% of set pressure for application of gas or liquid service or as specified in the data sheets.
- If superimposed and/or build-up back pressure exceed 10% of set pressure, then conventional spring-operated Pressure Safety valves shall not be used. For such application balanced bellow seal type Safety Relief Valves shall be used.
- The set pressure of a pressure relief valve shall never exceed the maximum allowable working pressure of the vessel it protects.
- The materials for valve body and trim shall comply with piping material specification.
- The trim shall include (as a minimum):
  - The Nozzle;
  - The disc and disc holder;
  - The stem and guide;
  - The blowdown ring, ring pin and bushing;
  - All other parts in contact with the process fluid.
- The inlet side of all safety relief valves (flange, nozzle, disc and seat) shall be rated equal to the pressure temperature rating of the inlet flange. The outlet side of all safety relief valves (flange, body, bonnet, packing etc.) shall be equal to the pressure temperature rating of the piping class flange.
- Safety relief valves shall be of "full nozzle" design.
- All internal components (including spring adjustment assembly) shall be corrosion resistant materials, with a minimum of AISI 316 SS.
- For seawater or corrosive service, all process-wetted internal components shall be made of alloy 400 (UNS N04400), alloy 625 (UNS N06625), alloy C-276 (UNS N10276) or alloy 25-07 (UNS S32750), while non-wetted internal components shall be minimum AISI 316 SS. Material of Construction for trim material shall be of a grade equal to or higher than the relevant piping class valve trims.
- The following test shall be considered as a minimum:
  - Hydrostatic testing certificate
  - Material traceability certification

  - Seat Leakage Test as per API STD 527
  - Set Pressure Test Certificate
  - Tightness Test
- Vendor shall submit following documents as minimum:
  - Material test Reports and Certificates
  - IP Certificates
  - Vendor data sheets
  - Pressure test Certificate
  - General Arrangement Drawings
  - Equipment brochures / catalogue
  - Certificate of compliance

12. INSTRUMENT BULK MATERIAL

12.1. TUBING, FITTING AND ACCESSORIES

Tubing and Fitting: Two ferrule compression type shall be used.

Material shall be SS316 with exception of seawater (intake) systems for which the proper material alloy 2507 (UNS S32750) shall be considered.

Rating shall be above upper design pressure of process line or pneumatic supply.

Sufficient supports shall be designed for installation.

Imperial system shall be used for dimensions of tubing and fittings.

Tubing sizes and wall thickness shall be determined based on suitable allowable working pressures, derived from material stress values as specified by ASME B31.3, including the derating factor for elevated temperature.

Tubing entering to the panel shall be through the bottom/side of the panel via bulk head fittings suitable for field tubing.

All threaded connections will be of NPT type as per ASME B16.11. All instrument tube fittings shall be double-ferrule compression type.

Fitting rating shall be determined based on suitable allowable working pressures.

The hardness of the fitting shall be greater than that of the tubing.

The instrument manifold is a combination of instrument isolation valves together with bleed/vent or drain facilities. Wetted parts shall be able to withstand the fluid composition.

Instrument manifolds may be supplied as 2 or 5 valve and shall have internal bore of minimum 6 mm.

Valves shall be made of similar material as fittings.

Needle valves shall have internal bore of 5 mm minimum.

12.2. CABLES

Single cables are used to connect field instruments to field mounted junction boxes.

Multicore cabling subsequently connects the junction box to a marshalling cabinet or system cabinet in the control room (ITER).

- Signal Segregation in Multicore Cables

When electric signals are assigned to multicore cables, the following signal segregation rules shall be followed:

a. Different Signal levels and classes as defined in IEC/TR 61000-5-2
b. Intrinsically safe and non-intrinsically safe signals as required by IEC 60079-14;

c. The supply and return conductors of a signal shall be contained in the same cable pair.

- Selection and Specification of Instrument Cables

1. Instrument signal cables shall not be used for direct connection to a low impedance source, e.g., the public mains electricity supply.
2. Instrument cable types shall be selected based on the following factors:
   a. signal level classification
   b. number of signals in the same cable;
   c. type of environment in which the cable is installed:
   - Indoor;
   - Outdoor
   - the EMC requirements.
3. The maximum permissible current rating and allowable voltage drop criteria shall be observed in selecting the conductor size of signal cables.
4. Wires of the same signal loop shall be twisted in pairs.
5. For signals for the same signal loop requiring four wires, either two individually twisted pairs or a single twisted quad shall be used.

- Cable construction

1. All the Instrument cables shall be of proven design and suitable for operation in a marine environment.
2. Instrument cable shall be constructed in accordance with EN 50288-7. or EPR in accordance with IEC 60502-1
3. The insulation material shall be cross linked Polyethylene applied to comply with EN 60228
4. Outer sheathing material shall be of type TM1 PVC compound in accordance with EN 50363-4-1 or TI51 PVC compound in accordance with EN 50290-2-21 for outdoor cables. For indoor cables, outer sheathing shall be a halogen free flame retardant compound to EN 50290-2-27.
5. Inner sheath material shall be PVC to EN 50290-2-22 for aboveground cables. polyethylene-nylon sheathed according to EN 50290-2-24.
6. Cables used aboveground in the plant shall be protected with steel wire braiding (SWB) even if they are used in cable trays.
7. The intrinsically safe cables shall be blue in colour and the non-IS cables shall have grey colour for outer sheath.

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8. All cables shall have flame retardant sheath in accordance with IEC 60332.
9. As a minimum, the following system cabling is identified for Fire Resistant cable types (in accordance with IEC 60331):
   - ESD system cables
   - F & G system cables

10 Cables shall be supplied in the following standardized number of pairs and cores as recommended by IEC 60092-376.

- Pairs, triples or quads: 1, 3, 7, 12, 19, 27, 37.
- Cores: 2, 4, 7, 12, 19, 27, 37.

10. Instrument cables shall be as a minimum rated voltage Uo/U (Um) = 150V/250V (300V) according to IEC 60092-376.
11. Conductors shall be stranded, tinned, circular copper wire according to IEC 60228 class 2.
12. The cable core size recommended for various signals are given below.
    - Analog signals (4-20mA) – 0.5 mm^2
    - Digital inputs (NAMUR, Dry Contact) – 0.5 mm^2
    - Digital output (Solenoid valve, General visual alarm) – 2.5 mm^2 (field cables)
    - Gas detector / Flame detector - 2.5 mm^2 (field cables)
    - Conductors' nominal cross-sectional area shall be as follows:
      - In Single pair cables
        - 0.5 mm^2 minimum for all analogue, discrete (on/off) input and thermocouple signals.
      - In Multi-pair/multi-core cables
        - 0.5 mm^2 minimum for all analogue, discrete (on/off) input and thermocouple signals
        - 0.75 mm^2 minimum for all discrete (on/off) outputs, command and solenoid valve signal cables.

- Cable Colour

Outer Sheath Colours

The following colours shall be used:

- Flame retardant type (non-intrinsically safe) Grey
- Fire resistant type (non-intrinsically safe) Grey
- Flame retardant (intrinsically safe) Blue

- Fire resistant (intrinsically safe) Blue

Core/Pair Colours shall be in accordance with relevant IEC.

The below Table provides a summary of the various instrument cable types based on the above construction details.

Table 2 Summary of different cable types

	Type 1	Type 2	Type 3	Type 4
Description	Cross linked Polyethylene insulated, overall screened, low smoke zero halogen sheathed	Cross linked Polyethylene insulated, overall screened, PVC bedded, steelwire braiding, armoured, PVC oversheathed	Cross linked Polyethylene insulated, overall screened, laminated aluminium-high density polyethylene-nylon sheathed, single wire armoured, PVC oversheathed	Cross linked Polyethylene insulated, individually screened, laminated aluminium-high density polyethylene-nylon sheathed, single wire armoured, PVC oversheathed
Type ID (note 1)	XLPE-MS-LSZH	XLPE-MS-PVC-SWB-PVC	XLPE-AL/HDPE/PA-SWA-PVC	XLPE-MS-AL/HDPE/PA-SWA-PVC
Application	Indoor use in an EM zone 2/1 protected environment, such as CCR/FAR	Aboveground cabling in a plant	Underground multicore cabling	Underground cabling PIMF/TIMF
Conductor insulation	XLPE	XLPE	XLPE	XLPE
Screen	Overall MS with drain wire	Overall MS with drain wire		MS per pair/triplet
Moisture barrier	-	-	AL/HDPE/PA acting as overall MS	AL/HDPE/PA acting as overall MS
Inner sheath	-	PVC	-	-
Mechanical protection	-	SWB	SWA	SWA
Oversheath	LSZH	PVC	PVC	PVC
NOTE: 1. Description of cable construction is from the centre to the outside.				

- SEGREGATION
  1. segregate intrinsically safe and non-intrinsically safe cabling if so dictated by IEC 60079-14;

2. cables for very sensitive and sensitive signals may be combined in the same trench and on the same cable tray without physical separation.
3. Cabling and junctions boxes shall be segregated by signal type and voltage level, i.e. IS, non-IS, ESD, F&G, analogue, digital, 24 V DC, etc. Thermocouple and RTD signals shall use separate cables and junction boxes.
4. Cables shall be segregated on separate trays/racks as a minimum for the following two groups of cables:

- Instrument and telecom cables, 24 V DC and below.
- Low voltage power, lighting and control cables, 400 V /230 V AC

- ROUTING

1. Single cables connecting field instruments to junction boxes shall be supported and protected against mechanical damage, for example, by cable trays, steel angles, beams, open conduits.
2. Cables and cable trays shall not be supported by or attached to process equipment or piping.
3. For separation distances see IEC 61892.
4. When power cables intersect instrument signal cables, the crossing shall be at right angles, with a minimum separation distance of 0.3 m.
5. keep trenches away from buried hot surfaces (e.g., pipes) so that the properties of the cable are not adversely affected.
6. Maintain a minimum separation distance of 0.2 m plus 0.1 m for every 100 °C temperature of the non-insulated surface.

12.3. JUNCTION BOXES FOR MULTICORE CABLES

1. Junction boxes should be designed for one multicore cable and segregated. Cabling and junctions boxes shall be segregated by signal type and voltage level, i.e. IS, non-IS, ESD, F&G, analogue, digital, 24 V DC, etc. Thermocouple and RTD signals shall use separate cables and junction boxes.
2. The minimum degree of protection for junction boxes (containing terminals only) shall be IP 65.
3. Junction boxes shall be made of fiberglass reinforced polyester (GRP) or AISI 316 with 316 or 316L stainless steel screw fastenings and shall be AISI 316 or AISI 316L Junction boxes shall not be painted.
4. Junction boxes in the hazardous area shall be EEx(e)-certified. ATEX marking shall be on the instruments and junction boxes.

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5. The terminals with unused cores shall be connected to intrinsically safe earth (IS) for cables used for intrinsically safe signals, instrument earth (IE) for cables used for non-intrinsically safe signals.

12.4. CABLE GLANDS

1. Cables glands shall be Double compression explosion proof Ex 'd/e' type made of nickel-plated brass, certified for area classification Zone-1, IIC (or B+H), T1, and with an ingress protection of IP66. Glands shall be designed to withstand deluge.
2. For instruments that are not designed for cable entry by a metal cable gland (e.g., proximitors with flying leads), the Manufacturer/Supplier's installation instructions should be followed.
3. If cable glands are installed in the side wall of the instruments, the cables shall approach the cable gland from below.
4. Cables between cabinets inside ITER shall be anchored with clamps and fixtures to take their weight before they are connected to terminals or sockets.

12.5. CABLE TRAY

For indoor and outdoor application, cable ladders and trays shall have FRP materials manufactured to comply with NEMA FG 1 destruction tests and IEC 60079-0 Section 7.4.2.a regarding protection against electrostatic effects taking into account the humidity rating and the local environment of the project. When specified for indoor installation, the FRP shall be zero halogen when tested in accordance with IEC 60754.

Cable Ladder & trays shall be installed with covers of FRP material when exposed to sun radiations and mechanical damages at vertical installations.

Where trays enter buildings, special measures (e.g., MCT frames, cable glands) shall be taken to support the cables and to prevent ingress of water or gas.

12.6. EARTHING (GROUNDING) AND BONDING

1. The Instrumentation earthing (grounding) systems shall be split as follows:

a. protective Earth for personnel safety;

b. functional Earth, for surge suppression and EMC:

- Instrument Earth (IE).
- Intrinsically Safe Earth (IS).

The instrument earth/intrinsically safe earth shall be connected at a single point only.

2. Instrument earth cables shall connect the instrument earth bar of the marshalling and instrument cabinets.
3. Looping of instrument earth cables between cabinets shall not be applied.

4. Connections of instrument earth cables shall be made using cable lugs and not terminals.
5. Dedicated earth rods should not be applied.
6. Manufacturers/Suppliers' recommendations on the arrangement of functional earthing (grounding) and maximum allowable resistance to earth shall be followed.
7. The star point earthing shall be connected to the overall plant earth grid inside equipment rooms.
8. For Insulation colours refer to the below Table:

Description	Colour
Protective Earth	Green (RAL 6018) and Yellow (RAL 1021)
Instrument Earth	Green (RAL 6018)
Intrinsically Safe Earth	White (RAL 9010)

Table 5 – Earthing (Grounding) and Bonding