**WBD DOO, Belgrade Serbia**

**NIS AD, Novi Sad, Serbia**

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## 1.0 INTRODUCTION

This specification defines the minimal technical requirements for the supply, design, configuration, implementation, and testing of instrumentation and control systems on packaged equipment (PE). This specification shall be used to assure that instrumentation provided by PE Suppliers conforms to the instrument design philosophy of the project, and to specify interfaces between PE and plant control systems. Features not covered by this specification or requisition requirements shall be Supplier's standard suitable for the intended application and shall be approved by Buyer.

## 2.0 REFERENCES

The following documents are referenced herein and form part of the technical requirements. Additional documents, when applicable, will be listed in the requisition. Current editions of the referenced documents including all mandatory addenda in effect at the time of the order shall apply unless otherwise indicated.

| | | |
|---|---|---|
| 2.1.1.1 | U211-IC-SP-0003 | Instrumentation - General |
| 2.1.1.2 | U211-IC-SP-0004 | Instrumentation - Design |

## 3.0 DEFINITIONS

| Term | Definition |
|---|---|
| Client | NIS a.d., Novi Sad, Serbia |
| Buyer | To be specified during Detailed Design |
| Supplier | Party to which the packed equipment purchase order was issued and is responsible for the supply of materials, equipment, and services |
| Goods | Means any and ancillary design and engineering services, warranty related services, technical assistance, all items, articles, materials, apparatus, equipment, spare parts, labour or other supplies including but not limited to manuals, operating instructions, reports and all other documents to be supplied or performed by Supplier, as specified, listed, mentioned, scheduled or implied in the Order or any revision thereof. |
| Order | Means the written Purchase Order between Supplier and Buyer which refers to and incorporates these terms and conditions together with any appendices or attachments thereto for supply of the Goods. |
| Shall | Wherever the word "shall" has been used, its meaning is to be understood as mandatory. |
| Should | Wherever the word "should" has been used, its meaning is to be understood as strongly recommended or advised. |
| May | Wherever the wording "may be" has been used, its meaning is to be understood as a freedom of choice. |

## 4.0 AREA CLASSIFICATION

The unit shall be installed within the hazardous area due to explosive gas atmosphere.

Hazardous area classification: Zone 2 IIA T3

Explosion protection shall be provided according to the following requirements:

- Field instruments in intrinsically safe loops: Ex ia IIA T4-T6
- Pushbuttons, switches, signal lights: Ex de IIA T4-T6
- Junction boxes: Ex e IIA T6
- Solenoid valves: Ex d IIA T4-T6

## 5.0 CODES AND STANDARDS

The instrumentation shall be designed, constructed and tested in accordance with the requirements of this specifications and the edition of the applicable National and/or International Codes and Standards.

Where a conflict between the codes, etc., might exist, the most stringent requirements shall govern.

For list of codes and standards see section 3.0 “Codes and Standards” of document U211-IC-SP-0003 Instrumentation – General.

### 5.1 CE MARKING

Where applicable, all equipment, materials and components shall be CE certified, shall bear CE marking and shall be compliant to applicable EC directives.

### 5.2 SERBIAN AUTHORITY REQUIREMENTS

All equipment shall be in compliance with Serbian legislation and law requirements. Equipment vendors shall deliver all documentation requested by Serbian law (e.g. Serbian Ex Certificate) to be able to put equipment in operation in Serbia.

## 6.0 CONTROL CONCEPT

The blower within the Supplier’s scope is very high importance non-spared equipment requiring high availability.

The machine load control shall be mutually agreed between the Supplier and Buyer/Client during the bid clarification phase.

Because of the blower process severity and availability requirements, two options of centralized control concept utilizing the plant DCS control and ESD safeguarding systems (preferred) or Supplier’s PLC subsystem (**as OPTION**) shall be applied. In case of Supplier’s PLC all signals from this PLC must be integrated to existing DCS/ESD thorough Modbus TCP/IP communication and hardwired connection especially for ESD. In both cases, the dedicated specialized controls shall be used for the monitoring, load / anti surge control and safeguarding functions impossible to be implemented within the standard DCS and ESD systems. The system designation shall be in accordance with the following tables:

*1) Blower control utilizing Plant DCS and ESD system:*

| System | Delivery | Purpose, designation |
|---|---|---|
| **DCS** | Buyer | Machine visualization, presentation to the operators. Simple control and indication loops implementation. Remote speed set point adjustment. Auxiliary oil and seal gas heater control. |
| **ESD** | Buyer | Machine safeguarding and start-up interlocking. Lube oil pump control. |
| **Anti-surge controller** | Supplier | Blower anti-surge protective control. |
| **Performance controller** | Supplier | Blower suction pressure control by manipulating machine speed (variable drive) or anti-surge valves at low loads. |
| **Machine monitoring** | Supplier | Machine vibration, axial displacement and bearing temperature monitoring including API 670 machinery protective functions, overspeed protection. |

*2) Blower control utilizing Supplier's PLC subsystem (**OPTION**):*

| System | Delivery | Purpose, designation |
|---|---|---|
| **PLC** | Supplier | Simple control and indication loops implementation. Auxiliary oil and seal gas heater controls.<br>Machine safeguarding and start-up interlocking. Lube oil pump control. |
| **DCS** | Buyer | Machine visualization, presentation to the operators via communication link. |
| **ESD** | Buyer | Plant safeguarding, hardwired interfaces between Supplier's PLC. |
| **Anti-surge controller** | Supplier | Blower anti-surge protective control. |
| **Performance controller** | Supplier | Blower suction pressure control by manipulating machine speed (variable drive) or anti-surge valves at low loads. |
| **Machine monitoring** | Supplier | Machine vibration, axial displacement and bearing temperature monitoring including API 670 machinery protective functions, overspeed protection. |

## 7.0 SUPPLIER'S SCOPE OF SUPPLY

The Supplier's scope of supply shall be the design and engineering, delivery of material, software configuration, and supply of documentation of the centrifugal blower instrumentation including control room equipment as described below:

7.1.1.1. Fully pre-assembled and pre-wired instruments, vibration, axial displacement, bearing temperature and speed sensors with oscillators including instrument junction boxes installed on machine skid.

7.1.1.2. Loose supplied blower anti-surge control valves including electric and pneumatic accessories to be installed in process piping (delivery and installation by others).

7.1.1.3. Detailed specification and sizing for process gas instrumentation (to be supplied by Buyer) related to anti surge and performance controller.

7.1.1.4. Fully pre-assembled and pre-wired dry seal gas instrument panel including interconnection junction boxes.

7.1.1.5. Fully pre-assembled and pre-wired instrumentation on seal gas booster blower assembly including interconnection junction boxes.

7.1.1.6. Fully pre-assembled and pre-wired instruments located on lube oil skid, including interconnection boxes.

7.1.1.7. Loose supplied instruments to be mounted on lube oil run down tank and other loose supplied equipment.

7.1.1.8. Machine local control panel (1 pc.), including remote explosion proofed HMI interface for the machine start-up / shut down operations.

7.1.1.9. All interconnection cabling between the machine mounted instruments and machine junction boxes.

7.1.1.10. Specification for the design of electrical winterizing of the unit instrumentation.

7.1.1.11. Documentation in accordance with chapter 10.0 and "Requirements for Documents" attached to the requisition.

7.1.1.12. The fully equipped and tested control room cabinet containing the following major items:

- Fail safe, fault tolerant machine PLC system (OPTION).
- Bently Nevada machine condition monitoring system.
- Blower anti surge and performance controller.

7.1.1.13. The machine PLC subsystem (OPTION) shall perform the following functions:

- Machine train control and safeguarding.
- Machine train start-up / shut-down sequencing.
- Performance control as recommended by Supplier.
- Anti surge control and performance control as recommended by Supplier.
- The PLC subsystem shall be connected to the plant DCS system via communication link.
- The PLC subsystem shall be connected to the plant ESD system via direct wired connection.

The Supplier's scope of supply is not limited to the instrument and controls as mentioned above and it is the Supplier's responsibility to provide the necessary instrumentation to guarantee the PE trouble free operation and start-up as demanded by mechanical specification.

The Supplier shall provide control narratives and trip / start logic for Buyer.

Supplier shall inform the Buyer of any irregularities found in this specification.

7.1 KICK OFF MEETING

If necessary, an instrumentation and control system specific kick-off meeting should be scheduled shortly after purchase order award. Alternately, a portion of the overall kick-off meeting can be designated to address instrumentation and control system topics. The kick-off meeting should designate all known deadlines and freeze dates for the project, and establish final list of deliverables.

7.2 SAFETY REVIEWS

When required, Supplier shall participate in Buyer's safety review meetings and Safety Integrity Level (SIL) classification meetings to determine the level of safety provided, assign target SILs, and develop resolutions for adding layers of protection, decreasing spurious trips, or increasing safety availability if required. Supplier shall supply the failure rate data of instruments used in safeguarding logic for review and acceptance by Buyer, and for use in SIL verification report.

## 8.0 SUPPLIER'S SCOPE EXCLUSIONS

The Supplier shall be responsible for the delivery of the all necessary components as described above with the following exceptions, to be handed over by Buyer / Client:

8.1.1.1 Process gas instrumentation as indicated on process P&ID's and agreed between
the Supplier and Buyer.
8.1.1.2 Other auxiliary instrumentation as marked up on the P&ID's attached to the requisition and agreed between the Supplier and Buyer.
8.1.1.3 Interconnection cabling between the PE junction boxes and plant control room
8.1.1.4 Power supply feeders and utilities at specified points.
8.1.1.5 MCC feeders for main or auxiliary electrical drives including control circuits.
8.1.1.6 Plant DCS / ESD system including application software configuration.
8.1.1.7 Site instrument installation for the loose supplied items.

## 9.0 DESIGN REQUIREMENTS

9.1 INSTRUMENT IDENTIFICATION

All instruments and instrument related equipment shall be numbered in accordance with project requirements. Buyer will assign all instrument and instrument related tag numbers. Supplier shall submit documents for Buyer to add project specific instrument tag numbers, junction box numbers, cabinet numbers, and other instrument and control system related tag numbers. Supplier shall include Buyer tag numbers on all documentation and control system programming. If Supplier needs to include their typical tagging for internal purposes, those tags can be included on the documents, however, Buyer's tags shall always be shown. Details will be finalized at the kick-off meeting following the placement of the order.

9.2 UNITS OF MEASUREMENT

Unless otherwise approved by Buyer, the following units of measure shall be used for instrumentation:

| Description | Unit of Measure |
|---|---|
| Flow: Gas / Vapor | Nm3/h, kg/h, t/h |
| Flow: Steam | kg/h, t/h |
| Flow: Liquid | m3/h, l/h |
| Level - Relative | % |
| Level - Absolute | m, mm |
| Pressure: Gauge | barg, mbarg |
| Pressure: Absolute | bara |
| Pressure: Flow Differential | Flow units as above, square root by transmitter - unless otherwise required by application (e.g. anti surge control) |
| Temperature | °C |
| Length | m, mm |
| Pipe / Tubing Diameter | inch |
| Conductivity | µS/m |
| Density | kg/m³ |
| Velocity | m/s |
| Viscosity | cP |
| Analysis | % or PPM |
| Axial displacement | mm |
| Speed | rpm |
| Vibration (absolute) | mm/s (RMS) |
| Vibration (relative) | µm |

9.3 FIELD INSTRUMENTATION

9.3.1 General Requirements

The instruments make / types shall be in accordance with Vendor list attached to the requisition. The commodities, not mentioned in Vendor list shall be in accordance with Supplier's standard. All of instruments and instrument accessories shall be subject of Buyer's approval. Vendor lists shall be aligned with client.

The all of machine mounted instruments shall be designed to meet -20°C..+40°C (+50°C during summer period due to solar radiation) ambient temperature limits. Mechanical design temperature limit is -28°C.

All analog instruments shall provide the standard 4-20 mA signal output with superimposed HART protocol communication.

The analog instruments and control valve positioners shall be intrinsic safe execution Ex ia in accordance with IEC 60079.

Instruments shall be suitable for outdoor installation, hazardous area. The instruments shall comply the directive 2014/34/EU (ATEX). The minimum ingress protection shall be IP65 (IEC 60529).

The cable entries shall be of metric thread (IEC 60423). Termination shall be by means of screwed terminal blocks.

Material trace ability reports / pressure test reports shall be provided for all of the inline instruments (e.g. valves, flow meters) in accordance with EN 10204 3.1.

Separate instruments with separate process connections shall be used for process control and safety related functions.

The instruments intended to the emergency shutdown service shall be in compliance with IEC 61508 SIL 2 safety integrity level requirements.

Each instrument shall be equipped with SS manufacturer's identification plate showing Instrument Tag number and information in accordance with ATEX directive 2014/34/EU.

In addition to manufacturer's plate, each instrument shall be provided with stainless-steel tag plate showing the instrument tag number, securely attached to the instrument by means of a stainless-steel wire.

The instruments / instrument scales shall be calibrated with the engineering units as specified in subsection 9.2.

In-line flow and Level transmitters shall include an integral digital meter, to display the process measurement in engineering units, remaining transmitter types may be blind unless otherwise required by application.

Transmitters shall be used in place of switches wherever practicable.

9.3.2 Flow Instruments

For specific requirements see section 2.0 "References".

9.3.3 Level Instruments

For specific requirements see section 2.0 "References".

9.3.4 Pressure Instruments

For specific requirements see section 2.0 "References".

9.3.5 Temperature Instruments

For specific requirements see section 2.0 "References".

9.3.6 Control and On/Off valves

For general requirements see section 2.0 "References".

*Blower anti surge control valves:*

The Supplier shall be fully responsible for the valve sizing to fit the blower performance maps. The special care shall be paid to ensure the smooth control response when operating close to the surge margin. The control valve oversizing shall be avoided due to the instabilities seriously influencing downstream process equipment.

Where specified in the blower data sheet the valve body including the wetted parts shall comply the NACE MR 0103 requirements on corrosive service.

The valve shall be of linear characteristics.

The blower anti-surge valve noise (while fully open) may be higher than 85 dB(A), but shall not exceed 95 dB(A). However, if the anti-surge valve is assumed to be utilized for the blower load throttling, the valve noise shall not exceed 85 dB(A) when operating within the expected continuous service operating region.

The valve actuator quick opening time shall be less than 2 seconds. In order to avoid control overshoots by uneven valve opening and closing time, the valve closing stroke time (control action) shall not be higher than 1.5 times of valve opening time. The quick opening exhaust relays for the solenoid valve action shall be avoided.

The diaphragm actuator should be preferred instead of piston one.

The two volume boosters directly piped to the actuator shall be used. The attention shall be paid to sufficient diaphragm air opposed compartment venting.

The valve air set shall provide the sufficient capacity to achieve the valve stroking time as specified. Supplier shall advise the recommended air supply tubing diameter.

The valve shall be equipped with digital valve positioner accepting the 4-20 mA drive signal with integrated position feedback transmitter (4-20 mA).

*Solenoid valves:*

The solenoid valve body shall be made of AISI 316 stainless steel.

The solenoid valves shall be direct operated. The pilot operated solenoid valves shall not be used.

The solenoid valve coils shall be designed for continuous service, insulation class F (IEC 60085).

The solenoid valve explosion protection shall be Ex d.

The solenoid valve ingress protection shall be IP 65 as minimum (IEC 60529).

The solenoid valves shall be either low power 24V DC or 230V AC 50 Hz standard power. The Supplier shall confirm the power requirements during the early design stage.

*Limit switches:*

The limit switches shall be of proximity type, intrinsically safe execution Ex ia. The mechanical limit switches shall be avoided.

The limit switch shall provide the positive (NC) signal with sensor/line fault diagnostics in accordance with EN 60947-5-6:2000 NAMUR standard (e.g. Pepperl Fuchs -N or -N0 series switches).

The limit switches shall be installed within the housing providing a cable terminal connection. Flying leads shall not be used.

### 9.3.7 Relief Valves

For specific requirements see section 2.0 “References”.

### 9.3.8 Protection Boxes

Instrument protection boxes shall be designed to protect the field equipment against frost and temperature loss of measured fluid.

Instrument protection boxes shall be fabricated from graphite glass fiber reinforced polyester as a complete assembly. Two - part construction shall be used. The lower part for installation of equipment, upper part as swivel lid, locked in open position by mechanical support. The lid shall be locked stainless steel clamps.

Protection box sealing gasket shall be made of elastic material resistant to UV radiation, ozone and chemicals.

The minimum degree of protection for instrument protection housing shall be IP65 according to IEC 60529.

Required design features:

9.8.1.1 flame retardant and self-extinguishing
9.8.1.2 UV stabilized
9.8.1.3 anti-static execution

Instrument protection boxes shall be equipped with stainless steel mounting plate at the back side. Bolts, nuts hinges and other fittings shall be made from stainless steel.

Instrument protection boxes shall be equipped with bracket for 2" stand pipe mounting. Protection box shall be equipped with one external ground screw (shall be internal connected to instrument ground screw).

Complete assembled with instruments and accessories before shipment designed for easy maintenance and removal of transmitter

Boxes shall be fitted with the box heating block and terminal box for two power (incoming / outgoing) and up to two heating tape connections.

Power cable glands shall be M20x1.5, heating tape glands M25x1.5.

The connection box terminals shall be designed to accommodate the power cables up to 6 $mm^2$ cross section.

The unused cable entries or cable entries to be utilized by others shall be plugged by means of explosion certified plugs.

9.3.9 Instrument Tubing

Tubing with compression type fittings (twin ferrule type) shall be used.

Instrument process impulse lines should be ½" O.D. x 0.065" wall thickness, stainless steel 316 annealed seamless. Fittings will be compatible with the tubing size and selected material will be equal or better than the tubing material specifications.

Tubing runs for instrument impulse lines will be kept as short as possible, consistent with good practise and accessibility.

At the instrument side of the first block valve, tubing will be used for instrument connections. Where applicable, piping take-offs shall be provided with flanges with ½" O.D. tube connector to accommodate instrument connection requirements.

Pressure gauges shall be installed with direct mounted manifold unless otherwise required by application.

All pressure instruments will be provided with a block valve and a drain/vent facility, except for those instruments with diaphragm seals, to provide the capability of depressurizing the impulse line.

Tubing will be supported and protected from vibration and physical damage by means of tubing clamps.

Individual instrument air supply and pneumatic transmission lines should be ½" O.D. x 0.065" wall thickness (or ¼" O.D. x 0.035" wall thickness where required), stainless steel 316 annealed seamless.

9.3.10 Instrument Wiring

Wiring practices shall follow IEC 60079.

Field cables shall be installed in cable trays with cover. Cable trays and fixings shall be hot dip galvanized.

All off-tray cables shall be adequately supported by OPEN conduit.

Signal cables shall be segregated from power cables. IS cables should be run on separate trays from other signals, but may be in same tray if segregated by means of a mechanical barrier.

*Junction Boxes:*

All junction boxes shall be of stainless steel material.

Junction box explosion protection shall be Ex e in accordance with ATEX Directive 2014/34/EU. The box shall be suitable for wall mounting and shall be fitted with external earth screw M8 and breather.

Bolts, nuts and other fittings shall be made of corrosion-resistant material.

Ingress protection class of junction boxes shall be at least IP 65 (IEC 60529).

For a different kind of signals separate junction boxes shall be used. The signal segregation shall be as follows:

9.10.1.1 4-20 mA analog signals, ESD system, intrinsic safe.
9.10.1.2 Digital input signals, ESD system, intrinsic safe.
9.10.1.3 4-20 mA analog signals, DCS system, intrinsic safe.
9.10.1.4 Digital input signals, DCS system, intrinsic safe.
9.10.1.5 4-20 mA analog signals, PLC system (OPTION), intrinsic safe.
9.10.1.6 Digital input signals, PLC system (OPTION), intrinsic safe.
9.10.1.7 230 V AC solenoid valve outputs, ESD system.
9.10.1.8 230 V AC solenoid valve outputs, PLC system (OPTION).
9.10.1.9 24 V DC solenoid valve outputs, ESD system.
9.10.1.10 24 V DC solenoid valve outputs, PLC system (OPTION).
9.10.1.11 Vibration monitoring voltage signals, intrinsic safe.
9.10.1.12 Temperature monitoring RTD / 4-20 mA signals, intrinsic safe.

Termination of wiring shall be screwed connection type. Terminal rows shall be arranged horizontally. The box shall be fitted with 10% of the spare terminals. All terminals shall be numbered on both sides. The junction boxes shall be fitted with insulated bar for shield drain wire connections.

If required, the terminal boxes shall be equipped with mounting plate and C rail suitable for the Bently Nevada proximity transducers or temperature transducers installation.

All boxes shall be equipped with cable glands, intended for the cables within the Supplier's scope of supply. The cable glands shall be of double compression type, nickel coated brass or stainless steel, and suitable for steel wire armor (SWA) signal cables.

All cable entries shall be located on the box bottom. All unused cable entries shall be plugged by certified plugs.

The cable glands, intended for the Bently Nevada proximity probes and bearing temperature sensors shall be suitable for the flexible conduit system used (e.g. Anaconda).

The cable glands for Buyer's control room multi core cables shall be included within the Supplier's scope. The appropriate cable size (inner and outer sheath diameter, SWA diameter) will be specified in later design stage.

The box size shall be standardized to suit the multi core cables within the Buyer's scope in accordance with the following table:

| Signal designation | Buyer cable size | Terminals |
|---|---|---|
| Electronic signals (4-20 mA, digital inputs) | 12 x 2 x 0.5 $mm^2$ | 30 |
| | 16 x 2 x 0.5 $mm^2$ | 40 |
| | 24 x 2 x 0.5 $mm^2$ | 60 |
| Vibration voltage signals | 6 x 3 x 1.0 $mm^2$ | 18 + shields |
| | 12 x 3 x 1.0 $mm^2$ | 36 + shields |
| 230V AC Solenoid valve signals | 12 x 1.5 $mm^2$ | 19 |
| 24 V DC Solenoid valve signals | 6 x 2 x 2.5 mm2 | 16 |
| | 12 x 2 x 2.5 mm2 | 30 |

*Instrument cables:*

The all of electronic signal cables within the Supplier's scope of supply shall be in accordance with the following specification:

| | |
|---|---|
| Installation: | outdoor, laid in cable trays |
| Temperature: | -20 .. 70 °C. |
| Environment: | oil refinery, sulfur containing atmosphere |
| Area: | hazardous, Zone 2 IIA T3 |
| Type: | flame retardant, low smoke, per EN 60332 |
| Nominal voltage: | 500 V |
| Conductor: | copper, annealed, 7 stranded wires |
| Cross section: | 0.5 $mm^2$ mutli-core cables, 1.5 $mm^2$ signal cables |
| Insulation: | PVC or XLPE |
| Cable elements: | twisted pairs (triads), 13 twists / m |
| № of elements: | 24, 12, 2, 1 pairs<br>12, 6, 1 triads<br>3 x 1.5 $mm^2$,12 x 1.5 $mm^2$ 230 V AC solenoid power supply cables |
| Colour code: | black/white wire pairs (black/white/red wire triads), pairs (triads) continuously numbered, black (numbered) solenoid 230 V AC power supply cables |
| Collective screen: | Aluminum / PET tape, tinned copper drain wire 0.5 $mm^2$ |
| Inner jacket: | PVC (halogen free) |
| Armor / braid: | zinc coated steel wires, galvanized braiding |
| Outer sheath: | PVC (halogen free) |

The cable outer sheath colour shall be in accordance with the signal type as summarized within the table below:

| Default Cable Colours | |
|---|---|
| Instrument Cables Non IS | Grey or Black |
| Instrument Cables IS | Light Blue |
| Thermocouple Cables | As per thermocouple type/Code (IS with blue strip) |
| Instrument Solenoid valve 230 V AC power cables | Black |

The wire colour coding shall be in accordance with table as follows:

| Configuration | Polarity | Wire colour |
|---|---|---|
| Pair | + | black |
| | - | white |
| Thermocouple | + | IEC 60584 |
| | - | |
| Triad | + / Signal | black |
| | - / Common | white |
| | Power | red |
| 230 V AC power cable | L | brown |
| | N | blue |
| | PE | green / yellow |
| 230 V AC solenoid control cable | L | black |
| | N | black |
| | PE | green / yellow |
| 24 V DC power supply | + | red |
| | - | dark blue |

## 9.4 LOCAL PANELS

The machine local panel shall provide the basic start up and shut down functions including the possibility of manual control of blower auxiliary drives.

The amount of controls / indicators shall be minimized as far as practicable. The panel layout shall be agreed between the Supplier and Buyer.

The machine local panel should preferably contain the explosion proofed remote HMI interface, equipped with touch screen LCD display, providing the operator's interface for the machine operation. Alternatively, the Supplier shall deliver the machine gauge panel as specified below. The final concept shall be agreed on the kick off meeting with Supplier.

The panel shall be either the machine skid (lube oil skid) mounted or loose supplied (up to agreement between the Supplier and Buyer).

The panel shall be equipped with provision for indication of motor current load.

The local panel shall be of stainless steel design, explosion protection Ex edm in accordance with ATEX Directive 2014/34/EU. The panel shall be suitable for wall mounting and shall be fitted with external earth screw M8 and breather.

Bolts, nuts and other fittings shall be made of corrosion-resistant material.

The push-buttons shall have hermetically sealed dual contacts (make and break contact sensing). The contact rating shall be 24 V /0.5 A.

All signal lamps shall be LED type. The power supply shall be 24 V DC.

All ESD switches shall be of mushroom type, stay-put action, and red colour with protective cover or shroud. The ESD switches shall be equipped with protective covers to prevent accidental initiation.

The required colour of indicators / controls shall be as follows:

| | |
|---|---|
| running light | - green |
| alarm light | - yellow |
| trip light | - red |
| permissive light | - blue |
| start button | - green |
| stop button | - red |
| unspecified button/switch | - black |
| unspecified signal light | - white |
| ESD button | - red |

The field local panel key switches shall not be used.

The local panel controls shall be pre-wired to the terminal row. The panel internal wiring shall be bundled and routed to ensure smooth panel opening.

The local panel shall be equipped with plastic laminated engraved nameplates. The nameplate descriptions shall be bilingual in English and Serbian language, Latin letters. Supplier shall manage the translations accordingly. The nameplate shall be of black letters / white background, minimum character size 5 mm.

## 9.5 GAUGE BOARDS, DRY GAS SEAL PANEL

The instrument location on panel / gauge board shall be clearly and fully identified on Supplier's P&ID's.

Dry seal gas panel shall be according to state of the art concept and with electronic transmitters.

If the LCD type remote HMI is specified (preferred solution), it will be considered as an adequate replacement of the local gauges.

The instrument gauge panel or dry gas seal panel shall be of stainless steel, freestanding type. The panel design shall be in accordance with Supplier's standard.

All of instrument tubing shall be of imperial sizes in line with subsection 9.3.9.

The panel design shall guarantee free access for maintenance and easy single instrument removal from one (front) side.

To save the space requirement, the amount of flanged mounted equipment mainly on the dry seal gas panel may be minimized.

The panel shall be designed to achieve necessary rigidity during lifting and installation. The panels shall be equipped with lifting lugs.

Each instrument shall be identified by means of nameplate with tag number and service description in English and Serbian language, Latin letters.

The Supplier shall supply the interconnection instrument tubing, including necessary supporting material for the all panel items installed.

## 9.6 CONDITION MONITORING SYSTEM

In order to ensure the machinery protection and to allow the diagnostics of the plant critical machinery, the machine condition monitoring system shall be applied.

### 9.6.1 Machine Probes and Sensors

Temperature sensors shall be sheathed, magnesium oxide insulated, Pt100 IEC 60751 RTD's, duplex type with increased mechanical resistance.

The temperature elements shall be equipped with C rail mounted 4-20 mA temperature converters, installed within the machine junction boxes.

Where used, the instrument leads shall be of silicone or PTFE to withstand the increased temperatures. The Supplier shall be fully responsible to design the sufficient lead length to freely accommodate the sensors within the machine junction boxes.

The proximity probes shall be of standard BN3300 XL 8 mm, metric, 9 meter system. The extension cable connector shall be located in easily accessible junction box, directly mounted on the machine. The junction box shall have sufficient space to accommodate proximity probe cable spare coil.

The proximity probes should be preferably adjustable from outside of the machine.

The Supplier shall supply the fully equipped stainless steel proximitor boxes installed on the machine skid. The proximitor transducers shall be C rail mounting style.

Absolute vibration probes should be of Bently Nevada accelerometers. The probes mounted outside the machine casing shall be protected by Bently Nevada mounting kit. The probe extension cable shall be stainless steel armoured.

All electrical equipment installed in machine train shall be intrinsic safe execution, Ex ia certified according to the ATEX Directive 2014/34/EU. Non incendive Ex n type of explosion protection shall not be used.

The Supplier shall be fully responsible for cable routing and sufficient lead supporting inside the machine. The Supplier shall design and deliver all necessary supports and strain anchors required.

The probe leads outside the machine shall be protected by means of flexible conduits. The conduits shall be of stainless steel or galvanized steel core, thermoplastic coated (Anaconda or equivalent).

The Ex d rigid conduit system shall not be used.

9.6.2 Monitoring Racks

The machine condition monitoring system shall be Bently Nevada 3500 (GE Energy). The monitoring rack shall be in accordance with API 670-4 requirements.

The rack shall be equipped with 230V 50 Hz redundant power supplies.

All intrinsic safe field inputs shall be equipped with galvanic isolators. Zener barriers shall be not be used.

The intrinsic safety converters should be preferably installed on the back planes interconnected with the monitoring rack by Bently Nevada system cables.

Each rack shall be equipped with configurable ModBus interface module BN3500/92 providing the Ethernet / RS serial interface. The Ethernet ModBus TCP protocol is foreseen to be connected to the plant DCS system.

The trip / safeguarding functions shall be realized via the configurable relay contacts BN3500/32, conforming to API 670 requirements, hardwired to the plant ESD system (or PLC - OPTION) due to the sequence of event recording.

The rack shall have sufficient spare slots allowing the future extension. No additional spare monitor channels are required.

The Supplier shall fully configure/parameterize the monitors (range setting, alarm and trip setting, delays, alarm drive logic adjustment, trip multiply set up, etc.).

The Supplier shall parameterize the output relay cards in order to provide the machinery shutdown contacts in accordance with Supplier’s cause and effect diagram.

The following parameters shall be transmitted to the DCS system (or PLC system - OPTION) via the ModBus/TCP link (per each measuring point):

9.12.1.1 direct value
9.12.1.2 alert set point
9.12.1.3 danger set point
9.12.1.4 alert status
9.12.1.5 danger status
9.12.1.6 channel status

The Supplier shall be fully responsible for the communication gateway configuration, including the ModBus register assignment.

## 9.7 ANTI SURGE CONTROL SYSTEM

The blower anti surge controller shall be electronic, in accordance with Supplier's standard. The anti-surge controller may be integrated together with the performance controller within the common PLC based subsystem.

The Supplier shall be fully responsible for the control algorithm design to achieve the control line best fit to blower predicted surge line.

The Supplier shall provide the detailed specification of the anti-surge controller instrumentation to be installed on the blower process piping (within the Buyers's scope).

Preliminary the following anti-surge instrumentation is foreseen:

9.12.1.7 1st stage suction pressure
9.12.1.8 1st stage suction temperature
9.12.1.9 1st stage discharge flow (DP across the flow element)
9.12.1.10 1st stage discharge pressure
9.12.1.11 1st stage discharge temperature

The Supplier shall clarify the anti-surge control parameters during the bid clarification phase.

The Supplier shall provide the anti-surge orifice (or venturi tube or ISA 1932 flow nozzle) calculations for all specified blower design cases including rated, maximum and minimum speed. The anti surge flow meter shall cover all blower operating regions between the maximum/minimum surge/choke blower operating regions. Because of the wide range of instrument differential pressure, the Supplier may propose the dual span transmitter installation.

Any failure of the anti-surge controller instrumentation should not cause the machine driver trip.

The anti-surge controller shall have semi-automatic start up and shut down sequencing, distinguishing the following operational modes:

STOP mode - anti surge valve fully open
RUN mode - anti surge valve on P&I control
PURGE mode - anti surge valve fully closed, when the blower is depressurized

The controller algorithm shall ensure the automatic bump less transfer between the specified operational modes, considering the ramp functionality. The DCS manual output override functionality shall be avoided.

The controller shall have the internal valve diagnostic functionality; an alarm shall be provided, when the controller output and valve position feedback differs more that 2-3% (Supplier to advise) with reasonable time delay.

The controller fall back strategies, when any of anti-surge parameter measurement fails shall be agreed between the Supplier and Buyer. Preferred control strategy is to continue control with the substituted parameters or freeze the controller's output in the last known value depending on Supplier's requirements.

All of controller shutdown contacts and solenoid valve shall be of normally de-energized arrangement, so that the single power or wiring failure shall not drive the anti-surge control valve to the fully open position.

The anti-surge controller shall be installed within the control room cabinet.

The power supply of the controller and its interfaces shall be fully redundant.

The anti-surge controller shall be equipped with ModBus interface providing the process parameters, controller status and diagnostic information to the plant DCS system (or PLC system - OPTION). The communication link shall be based either on serial RS485 RTU interface with ModBus TCP converter / server or direct Ethernet TCP ModBus interface. The interface shall be agreed between the Supplier and Buyer.

The controller parameters to be displayed in the DCS system (or PLC - OPTION) shall be but not limited to the following:

- controller process value (anti-surge parameter), controller set point, control deviation and controller output
- anti-surge control parameters (differential pressure, pressures, temperatures)
- control valve actual position
- blower flow rates
- controller status (run / stop), manual override status
- controller alarms
- input transmitter bad status

The Supplier shall be fully responsible for the communication gateway configuration, including the ModBus register assignment.

## 9.8 PERFORMANCE CONTROL SYSTEM

The blower performance controller shall be electronic, in accordance with Supplier's standard. The performance controller may be integrated together with the anti-surge controller within the common PLC based subsystem.

The Supplier shall be fully responsible for the control algorithm design to achieve the control line best fit to blower predicted performance line.

A performance control application shall regulate blower suction pressure.

The Supplier shall provide the detailed specification of the performance controller instrumentation to be installed on the blower process piping (within the Buyers's scope).

Transmitters may be shared for both anti-surge and performance controller. Supplier to advise.

The loop decoupling coordinating start-up and shut-down sequences with designated anti-surge and performance control is required.

The controller performer can vary the machine speed, suspend its automatic actions when the machine speed is limited or otherwise unable to vary the train speed as needed to maintain the desired blower throughput.

## 9.9 CONTROL ROOM CABINET

### 9.9.1 General

The Supplier shall deliver the blower unit control cabinet, to be installed in the unmanned instrument room ~250 m distant from the blower unit. The control cabinet shall contain the following major items:

9.13.1.1 Blower anti surge and Performance controller.
9.13.1.2 Bently Nevada machine condition monitoring rack.
9.13.1.3 Machine train control and safeguarding PLC, as described in section 9.10 (OPTION)
9.13.1.4 Intrinsically safe converters, auxiliary relays, redundant power supplies etc.
9.13.1.5 Ethernet switch / router
9.13.1.6 Cabinet auxiliaries

### 9.9.2 Cabinet Requirements

The cabinet(s) shall be of standard modular size 800 x 800 x 2100, Rittal TS8808 series, RAL7035 light gray colour.

The minimum protection degree of cabinet and its accessories shall be IP42.

The cabinet(s) shall be equipped with front and rear lockable doors (width 400 mm) on both front and rear sides if no door mounted LCD panel is foreseen. Cabinet handles shall be of Rittal TS8611.010 series. 2 keys shall be provided per door.

Each door shall be fitted with a 130 degree opening hinges and mechanical door stays. All doors shall have three point latching mechanisms.

Each cabinet shall be equipped with fans, fault tolerant to single power supply failure (e.g. 24V powered). The ventilation system should be Rittal SK3325 or equivalent.

Each cabinet side shall be equipped with fluorescent light, including door operated switch and service socket.

Each cabinet part shall be bonded to the safety earth screw.

Each cabinet shall be fitted with rail for cable clamping and Rittal standard removable 3-piece sliding gland plate fitted with a foam rubber sealant that will allow penetration of incoming cables, to a rating of IP 55.

Each cabinet intended for the field wiring shall be equipped with separated instrument and protective earth strips with sufficient capacity to accommodate the cable shields and steel wire braiding.

All cabinets shall be identified with front and rear of panel screw fixed laminated plastic labels. All labels shall state the full cabinet tag number and have black letters on a white background.

Each cabinet door on the both sides shall be equipped with A4 drawing holder.

### 9.9.3 Power Supply Requirements

All vital consumers shall be powered from redundant power supplies, each sized for the full load with the sufficient spare. Each power supply shall be removable for maintenance without disturbing the system operation. Each consumer shall be individually fused. The power supply distribution shall be arranged so that no single fuse failure can disturb the system availability.

The power supplies shall be overload and short circuit protected.

The use of melt fuses shall be minimized as far as practicable. The essential system components shall be protected by circuit breakers. Melt fuses shall have blown indication. The Buyer will provide the two UPS AC power feeders for each cabinet with the following parameters:

9.15.1.1 Power supply: single phase, TN-S
9.15.1.2 Nominal voltage: 230 V ± 5%
9.15.1.3 Frequency: 50 Hz ± 1%

In addition to, Buyer may provide the unsecured power supply, intended for the service sockets, lightning and other non-vital auxiliaries.

The detailed requirements on AC power feeders shall be specified by Supplier.

The maximum cabinet circuit breaker rating shall be 20A, C characteristics.

The Supplier shall specify the rated / maximum inrush current for the each power supply used with respect to feeder fusing. The power supply start up shall not cause the circuit breaker trip in the whole power supply line.

The incoming power feeder terminals intended for the Buyer's connection shall be designed for wire cross section to 6 $mm^2$.

9.9.4 Wiring Requirements

Signal wiring shall be separated from power or high voltage wiring and shall be run in separate cable ducts. Terminals and ducts for the intrinsically safe loops shall be blue coloured and segregated in the cabinet from the other wiring.

The wiring capacities shall be provided as follows:

| | |
|---|---|
| multi-core cables | - 20% spare capacity terminated on both ends |
| terminals | - 20% free space on C-rails |
| cable ducting | - 30% free space |

Terminal block arrangement shall be such that all single cores, including spares, of the multi-core cables can be connected in the sequential order as the pattern and layout of the cores in the cable.

The terminals shall be of screwed type. The input terminals intended for the field signals shall be of disconnect type. The terminals for the intrinsic safe signals shall be blue colour.

Multi-level terminal blocks shall not be used.

All terminals shall be numbered at the both ends.

Each wire connected to the terminal shall be marked to identify the point of connection for both ends (source-destination).

Each cabinet component and individual card locations shall be identified. The nameplates shall be engraved laminated plastics, white/black/white coloured. PVC stick on (DYMO) labels shall not be used.

Power terminals carrying voltages higher than 50 volts shall be protected against accidental contact by having removable cover plates and shall be labelled to indicate high voltage.

9.9.5 ModBus Communication

Preliminary, the redundant ModBus TCP link to the plant DCS is foreseen as shown in the attached block diagram. The multi drop ModBus link shall collect all of communication data from all ModBus slaves within the Supplier's scope.

The Supplier shall provide the industrial grade Ethernet switch, providing a connection to all slave devices.

Alternatively, the router providing a network address translation may be supplied by Supplier to avoid the IP conflicts.

The switch / router shall be 24V DC powered from the redundant sources.

## 9.10 CONTROL / SAFEGUARDING PLC SYSTEM (OPTION)

The PLC blower control / safeguarding system, located in the Supplier's control room cabinet shall basically provide the following functionality:

9.17.1.1 Machine semi automatic start up and controlled shut down sequencing.
9.17.1.2 Machine emergency shut down logic.
9.17.1.3 Blower anti surge control, as described in 9.7
9.17.1.4 Blower performance control, as described in 9.8
9.17.1.5 Machine safeguarding in accordance with IEC61511, IEC 61508 SIL 2 safety integrity level (whole safeguarding loop) requirements.
9.17.1.6 Possibility of manual control of all blower auxiliaries (e.g. lube oil pump) for testing / maintenance purposes.
9.17.1.7 The machine PLC shall be integrated within the plant DCS system via the communication link, providing the plant operators full overview about the machine train status.

*The Supplier shall provide the PLC configuration and on-line monitoring software package for the maintenance purposes, including all of the blower application software backup files.*

### 9.10.1 PLC Hardware Requirements

The PLC central part (CPU) shall be redundant - fault tolerant.

The PLC power supply units shall be fully redundant.

The PLC I/O modules shall be of single arrangement.

The data link to the PLC I/O modules shall be redundant.

The emergency shut down part of the system shall be connected to dedicated fail-safe modules in accordance with IEC 61508 to maintain required safety integrity level. The ESD part of the PLC subsystem shall be in compliance with at least SIL2 safety integrity level (Depending on SIL assessment).

The whole system should be preferably integrated within one PLC.

The PLC system shall provide the communication link to the plant DCS system. The data link should be based either on ModBus TCP (Ethernet) or ProfiBus solution, Supplier to advice in the bid.

The communication interface shall allow the functionality as follows:

9.18.1.1 visualization of all PLC I/O's
9.18.1.2 visualization of all PLC alarm status
9.18.1.3 visualization of all PLC sequence/logic status
9.18.1.4 full operator control of PID controllers implemented within the PLC
9.18.1.5 motor control, where specified by Supplier

The PLC system shall be designed to connect the following blower preliminary specified instrumentation outside the Supplier's scope in accordance with process P&ID's:

9.18.1.6 Suction / Discharge line isolation motor operated valves, including LCP controls.
9.18.1.7 Discharge temperatures.
9.18.1.8 Suction / Interstage drums level instrumentation.
9.18.1.9 Complete anti-surge and performance control system instrumentation and accessories.

The whole PLC subsystem architecture including type / make of major components shall be approved by Buyer.

9.10.2 PLC I/O Requirements

Blower PLC I/O modules and accessories shall handle the following standard signals as described bellow. The following signal types shall be physically segregated each other:

9.19.1.1 Intrinsically safe signals.
9.19.1.2 24 V DC non-intrinsically safe signals.
9.19.1.3 230 V AC power wiring and MCC controls

Each type of signal shall be separated by means of dedicated I/O modules and separate cable ducting. All intrinsically safe I/O's shall be suitable for instruments located in zone 1, gas group C, temperature class T1..T6.

The following standard signals shall be used:

*Analogue inputs (AI)*

9.19.1.4 Intrinsically safe 4-20 mA signal, loop powered transmitters, HART communicating. The system components shall allow the HART communication by means of hand held communicator.
9.19.1.5 Non-intrinsically safe 4-20 mA signal, loop or externally powered (source / sink, to be selectable). The signals shall be galvanically isolated from each other.
9.19.1.6 Required A/D conversion accuracy 0.1%.
9.19.1.7 Double channel intrinsically safe converters shall not be used.

*Digital inputs (DI)*

9.19.1.8 Non-intrinsically safe potential free dry contacts (non-isolated), wetting voltage 10-30V.
9.19.1.9 The signal loop power supply shall be equipped with electronic short circuit protection.
9.19.1.10 Intrinsically safe digital input loops shall have the signal levels according to the EN 60947-5-6 (NAMUR, 2.1/1.2 mA threshold levels). The i.s. isolators may be double channel and shall be equipped with signal sense reversal switches.
9.19.1.11 The ESD part of system digital inputs shall be suitable for the SIL approved proximity sensors (2.9/1.9 mA threshold levels). The i.s. converters shall provide the line fault detection.

*MCC control signals (DI, DO)*

9.19.1.12 The motor status signalling (DI) shall be equipped with interposing relays, coil rating 230V AC in order to sense the MCC switchboard control voltage. All of interposing relays shall be equipped with RC-network modules to suppress the induced line AC voltage. Alternatively, the opto-couplers may be used.
9.19.1.13 The motor control commands (DO) shall be equipped with interposing relays able to switch 230V 6A inductive load (AC-3).
9.19.1.14 All interposing relays shall be of insulation class II (coil-contact), rated 5000 V.

*Digital outputs (DO, 24V)*

9.19.1.15 Where specified, the PLC control system shall accommodate 24 V DC internal powered digital output signals, intended primarily to signal lamps or signalling relays.
9.19.1.16 The single output rated current shall be 40 mA. The single output short circuit shall not affect the performance of the other output channels.

9.10.3 PLC Application Software Requirements

PLC SAFEGUARDING PART

The PLC safeguarding logic shall be implemented by means of functional logic diagrams in accordance with IEC 61131-3:2003 using the standard function block library as far as practicable. The software shall be in compliance with the IEC 61508 requirements to achieve the specified safety integrity level.

The safeguarding program block shall be structured as follows:

9.20.1.1 analogue input processing
9.20.1.2 binary input processing
9.20.1.3 trip logic
9.20.1.4 start up permissive logic
9.20.1.5 start up/shutdown control logic (applicable for SIL classified functions)
9.20.1.6 auxiliary drive control logic (applicable for SIL classified functions)
9.20.1.7 binary output processing
9.20.1.8 first out alarm logic

Each of the trip initiators shall be equipped with the following override functionality:

9.20.1.9 Maintenance override switches (MOS), in order to override the safeguarding transmitter (applicable to PLC logic only) to provide the regular maintenance / testing during the machine operation. The MOS switches shall be either hard wired within the PLC cabinet or implemented within the HMI subsystem, conditioned by means of hardwired switch. The trip initiators, connected to the condition monitoring system shall not be overridden in accordance with API 670 requirements.

9.20.1.10 Automatic process overrides conditioned by safeguarding logic states to allow the implementation of start-up / shut down logic. Delay timers, longer than 5 seconds shall be visible on the operator's HMI (countdown).

9.20.1.11 The system shall provide the "intelligent" alarm masking/suppressing, when the machine is shut down.

The safeguarding logic shall provide the first out alarm evaluation in accordance with ISA S18.1 standards.

PLC CONTROL / SEQUENCING PART

The PLC control logic shall the standard PLC Supplier function block library. Basically, the software shall be in compliance with the following requirements:

9.20.1.12 The controllers must be automatically switched to the manual mode with controller output kept in the last known position in case of transmitter failure.

9.20.1.13 The controller implementation shall consider the bumpless transfer between the auto, manual and cascade controller modes.

9.20.1.14 The anti-reset windup controller logic shall be applied.

9.20.1.15 The PID constants and alarm levels shall be adjustable from the PLC HMI interface (password protected).

9.20.1.16 The motor control logic shall perform bumpless transfer between the local, manual and auto modes.

9.20.1.17 Motor status tracking when operated in local mode shall be implemented.

9.20.1.18 Mismatch timeout alarming if the MCC running feedback signal does not match the requested start/stop operation within the defined period shall be applied.

9.20.1.19 Running hour's accumulation for the maintenance purposes shall be considered to be implemented.

DCS COMMUNICATION INTERFACE

The Supplier shall be fully responsible for the definition of the communication interface to the plant DCS system (Buyer's responsibility). The Supplier shall specify and issue the following design documents to configure the plant DCS communication gateways:

9.20.1.20 Detailed definition of communication interface, slave address assignment, specification of communication parameters.
9.20.1.21 Detailed tag list of communication points including addressing and service descriptions.
9.20.1.22 Functional specification of advanced structures (e.g. motor control via communication), including required timing.

The following items for the each PLC point shall be available to the plant DCS system:

- process value
- alarm set points
- alarm status (binary)
- channel status (BAD PV)
- controller set point (actual, set from DCS)
- controller mode (AUT, MAN, CAS)
- controller output
- motor running status
- motor desired status (as driven by PLC logic)
- motor mode (AUT, MAN, CAS)
- motor alarms

HMI INTERFACE

The Supplier shall provide the PLC HMI interface, based on control room cabinet door mounted LCD touch screen panel (industrial PC station). The HMI interface shall contain the following features:

9.20.1.23 Schematic machine train display with all measurements.
9.20.1.24 Graphic overview of machine trip logic status.
9.20.1.25 Graphic overview of machine start-up / shut down sequence status.
9.20.1.26 Alarm overview.
9.20.1.27 All of free configurable texts shall be in Serbian language, Latin letters. Buyer will provide the translations on demand.
9.20.1.28 Access to the basic controller / indicator parameter, adjustment of the alarm values and PID constants (password protected).

ALARM LOGGING, SEQUENCE OF EVENTS

The Supplier shall design, configure and deliver the event logging computer providing the following functionality:

9.20.1.29 Time stamped logging of alarms and operator's actions.
9.20.1.30 Time synchronization with the plant DCS system.
9.20.1.31 Sufficient hard drive data storage for 30 days of operation.
9.20.1.32 The system shall be resistant against the alarm flooding.
9.20.1.33 Possibility of alarm filtering and export to the MS Office file format.

The alarm logger may be combined with PLC HMI computer.

## 10.0 DOCUMENTATION

The Supplier shall provide the printed and electronic documentation in accordance with the requisition attached requirements.

In addition to the following items shall be handed over as mandatory to the Client immediately after the machine commissioning (as built state):

10.1.1.1 The as built list of all user configurable parameter setting for the solid state controllers having a fixed variability programming.

10.1.1.2 All software tools, licenses and special interface cables required for the configuring, service maintenance and operation trouble shooting for the PLC based subsystems.

10.1.1.3 All source codes of the application logic and freely configurable HMI interfaces for the PLC based subsystems.

10.1.1.4 All operator's, supervisory and engineering passwords for the all of controller equipment and HMI stations shall be provided as mandatory without the impact on equipment warranty.

10.1.1.5 All Equipment certificates, data sheets, installation manuals, operation and maintenance and other user manuals as part of manufacturing data book.

## 11.0 TESTING

The machine control room cabinet (hardware & software) shall undergo formal testing according to the Supplier's standard factory acceptance test procedures.

Site acceptance tests as well as System integration testing shall be done.

Depending on control concept selection, the factory acceptance test performed shall be subjected to the following items as a minimum:

HARDWARE:

11.1.1.1 Hardware inventory
11.1.1.2 Visual inspection of all cabinets
11.1.1.3 100% power supply tests (including redundancy)
11.1.1.4 earth integrity tests
11.1.1.5 simulated I/O spot tests

SOFTWARE:

11.1.1.6 100 % simulated function tests of safeguarding logic
11.1.1.7 100 % simulated function tests of start up logic
11.1.1.8 100 % simulated function tests of the machine controls
11.1.1.9 100 % check of HMI interfaces
11.1.1.10 verification of Bently Nevada rack set up
11.1.1.11 20% spot check of sequence of event recording

## 12.0 SITE INSTALLATION

In general, the control room equipment, interconnecting cabling and loose supplied instrument equipment and accessories will be installed by Buyer in accordance with Supplier's project documentation.

The Supplier shall be fully responsible for the instrument installation inside the machine skid.

Supplier's site activities and services related to performance and anti-surge control systems shall be as follows:

12.1.1.1 Initial system setup, verification.
12.1.1.2 Verification of instrument installation.
12.1.1.3 Verification of anti-surge instrument installation (outside the Supplier's scope).
12.1.1.4 Controllers tuning.
12.1.1.5 Auto start sequence functional test.
12.1.1.6 Blower surge line verification.

The other Supplier's site activities and services related to the machine instrumentation shall be as follows, depending on control concept selection:

12.1.1.7 Unless otherwise agreed, the Supplier's representative shall be present at the machine control cabinet power up.
12.1.1.8 The Supplier's representative shall conduct 100% of PLC loop checking.
12.1.1.9 The Supplier's representative shall assist during the initial set up and checking of the communication lines to the plant DCS system.
12.1.1.10 The Supplier's representative shall witness the 100% of plant ESD / DCS (PLC) blower trip and start up logic functional tests especially with regards to other machine subsystems within the Supplier's scope.
12.1.1.11 The Supplier shall perform 100% of functional PLC tests with respect to other machine subsystems prior to machine start-up.
12.1.1.12 The Supplier's representative shall verify and confirm the machine alarm and trip set point adjustment including controller tuning during the machine commissioning.

The Supplier shall propose the supervisor site assignment schedule and training for process and maintenance staff, with expected man hours expressed.