

The design of the alarm annunciator system shall be such that transient alarms of less than 330 milliseconds duration shall be automatically rejected.

4.2 Panel Design

4.2.1 All panels shall be supplied in pre-tubed/pre-wired condition and shall be completely tested at manufacturer's works prior to dispatch.

4.2.2 Panels shall be free standing type. Panels with instruments mounted on the front shall be fabricated from 3 mm thick cold rolled steel sheet. If the same is not available, 4 mm thick hot rolled steel sheet shall be used. All other panels shall be fabricated from 2mm thick cold rolled steel sheet. Angle iron framework shall use a minimum section of 50 x 50 x 4 mm angle. Panel painting procedure shall include blast cleaning, grinding, chemical cleaning, surface finishing by suitable filler and two coats of high grade lacquer with wet blasting wherever required. Two coats of paint in the panel colour shall be provided for non-glossy high satin finish. Final coat shall be given after assembly at site.

Unless otherwise specified, exterior/interior portion of all panels and closed cabinets shall have a colour as per RAL-7035. Channel base shall be of black colour.

4.2.3 Panel shall be enclosed cubicle type with each section of typically 2100 mm high, 1200 mm wide and 800 mm deep mounted on 100 mm channel base.

4.2.4 Enclosed cubicle panels shall have removable hinged doors for easy maintenance and accessibility of the instruments. Doors shall be double leaved type with handle and shall be provided with lock and key. Adequate illumination shall be provided inside the panel. All light fittings shall be suitable for 240 V, 50 Hz AC. Power supply greater than 240 V shall also not enter the control panel.

4.2.5 All cable entries to the panel shall be from panel bottom only using cable glands of adequate size. Cable gland plate thickness shall be a minimum of 3 mm cold rolled cold annealed (CRCA) as a minimum. All unused cable entries must be plugged.

4.2.6 Space heater shall be provided where condensation is expected. The space heater provided shall be with temperature cut off and manual control.

4.2.7 The design of panel shall incorporate provision for expansion by installing adequate spare capacity. Each panel shall be designed to accommodate the following additional equipment, as a minimum:

- a) 20% of panel front/inside mounted instruments including lamps, push buttons, switches, relays etc.
- b) 20% additional power feeders each provided with switch fuse assembly.
- c) 20% additional spare windows in alarm annunciators.
- d) 20% spare cable entry points.

4.2.8 Panel layout shall be designed considering ease of operation. No push button or hand switch shall be located below 600 mm. Instrument mounting heights, in general, shall be as follows:

a)	Electronic Instruments	Bottom row	1100 mm
		Middle row	1350 mm
		Top row	1600 mm
b)	Annunciators	-	1950 mm
c)	Electric push buttons/	-	700 mm

switches, lamps etc.

- 4.2.9 The internal panel layout shall be designed considering proper approach for instruments, terminals and other accessories for maintenance, easy removal and online calibration. No instrument, terminals, power distribution box etc shall be mounted on the panel side plates inside the panel.
- 4.2.10 All lamps, status as well as alarm, shall be provided with lamp test facility. One single lamp test push button shall be used for each panel. Logic for lamp test shall not be implemented through relay logic in the panel.
- 4.2.11 **Colour Scheme**
- a) Status Lamps

On/Open/Permissive	:	Green
Off/Close/Emergency	:	Red
 - b) Alarms

Normal/Pre-trip alarms	:	Amber
Shutdown alarms	:	Red
 - c) Push/Pull buttons

On/Open	:	Green
Off/Close	:	Red
Emergency shut-down (ESD) (Push-button with cover/ Mushroom push button)	:	Red
- 4.2.12 **Panel Piping and Tubing**
- 4.2.12.1 The instrument air header shall be adequately sized with 1/2" branches, SS packless isolation valves and shall be complete with suitable dual filter-cum-air reducing station.
- 4.2.12.2 Panel tubing from the bulk head to the panel instruments and instrument air supply to the panel instruments shall be of 6 mm x 1mm thick SS 316L tubing.
- 4.2.12.3 The tubing shall be laid in plastic slotted ducts. Panel air header and tube fittings shall be of SS 316.
- 4.2.12.4 Each tube shall be identified at both the terminating ends.
- 4.2.13 **Panel Wiring**
- 4.2.13.1 Open terminals shall generally be avoided. Terminal strips shall preferably be mounted in an enclosure. Fused terminal may be used wherever necessary. All terminals shall be of mechanical screw clamp/screwless type with pressure plates as per the job specification. Self-insulating crimping wire lugs shall be used for all terminations on terminal blocks, whereas forked tongue type or lug with eyehole type shall be used for termination on screwed terminals such as on relays, push buttons, lamp etc. Terminal blocks shall be rated for 600 V.
- 4.2.13.2 A minimum of 1 mm² multi stranded PVC insulated copper conductor shall be used in general. All wiring shall be laid in the PVC troughs. No trough shall be more than 70% full.

- 4.2.13.3 Wires carrying measurement signals associated with thermocouples, resistance thermometers and other low level signals shall be routed in separate troughs/wire ways and not along with power cables. Power wiring and control wiring shall be separated by not less than 150 mm. The crossing, if unavoidable, shall be as close to right angles as possible.
- 4.2.13.4 Extension cables/wires shall be used for all thermocouple inputs. These wires shall be routed in separate troughs/wire-ways.
- 4.2.13.5 All intrinsically safe wires shall be routed in separate wire ways from non-intrinsically safe and power wiring. Intrinsically safe wiring and terminals shall be light blue in colour and shall be separated from non-intrinsically safe terminals atleast by 50 mm.
- 4.2.13.6 All incoming power feeders shall be terminated on separate terminals suitable for the incoming feeder size. These shall be located at the bottom of the panel and shall be suitably covered for protection against accidental shorting and for human safety.
- 4.2.13.7 Power supply shall be made available at one point. Further power distribution network shall be designed such that a single power fault in any instrument branch system shall not cause a trip of the entire system. Each consumer shall be provided with a separate switch and fuse for isolation and protection of the system.

4.2.14 Electrical Wiring

All the cabinets, consoles and panels shall be completely wired. Interconnections shall preferably be done with the help of pre-tracked cables. Vendor may follow their standard wiring practices, however the requirements specified herein must be complied.

- a) All wiring shall conform to API RP 552- Transmission Systems. Different signal level cables shall be routed with separation distances as recommended by code.
- b) All wiring inside racks, cabinets, and back of the panels shall be housed in covered, non-flammable plastic raceways arranged to permit easy assembly to various instruments for maintenance, adjustments, repair and removal.
- c) All wiring in the raceways shall be properly clamped. All incoming cable shall be terminated by vendor at marshalling rack with cable glanding including supply of cable glands. Total wiring cross-sectional area shall not exceed 50% of the raceway cross sectional area.
- d) Separate wiring raceways shall be used for power supply wiring, DC and low level signal wiring, and intrinsically safe wiring. Parallel runs of AC and DC wiring closer than 300mm shall be avoided.
- e) Vendor can alternately offer prefabricated cables for interconnection between different cabinets and panels.
- f) Wire termination shall be done using self-insulating crimping lugs. More than two wires shall not be terminated on one side of single terminal. The use of shorting links for looping shall not be done.
- g) No splicing is allowed in between wire / cable straight run.

4.2.15 Terminals and Terminal Blocks

- a) Terminals shall be non-hygroscopic type made up of unbreakable, fire-retardant, safe extinguishable, halogen free polyamide compound.
- b) Terminals shall be suitable for wires up to 2.5 sq. mm base solid or stranded conductor in general. For power cables, higher size terminals shall be used.
- c) The metal parts of terminals shall be of high quality (pure electrolytic) copper and shall be tin or nickel plated (of thickness up to 15 micron).

- d) The spring material for all terminals shall be chrome nickel spring steel of high tensile strength and of excellent corrosion resistance. All terminal / terminal blocks shall be DIN Rail mounted type and shall be easily removable. The size of the terminal blocks / terminals of different types shall be consistent and identical.
- e) All terminal blocks shall be mounted on suitable anodised metallic or plastic stand-off.
- f) Terminal strips shall be arranged group-wise for incoming and outgoing cables separately. Terminal blocks for intrinsically safe wiring shall be separate. 20% spare terminals shall be provided, as a minimum, preferably in each terminal strip.

4.2.16 Following design philosophy shall be followed while deciding the internal layout of panels, as a minimum;

- a) Distance between terminal strip and side of the panel upto 50 terminals : 100 mm (min.)+ trough width
- b) Distance between two adjacent terminal strips : 100mm (min.)+trough width
- c) Distance between gland plate and bottom of the strip : 300mm (min.)
- d) Distance of terminal strip from instrument/trough/panel top : 100mm (min.)

4.3 Local Control Panel (LCP)

4.3.1 Local control panel for the package units shall be installed within the battery limit of the package considering operational and maintenance requirements and accessibility. In case of skid mounted packages, panel shall be located away from the skid.

In case local control panel is housed outdoor i.e. not in a local control room, it shall be designed to meet IP-55 requirements. In addition, panel must be provided with a rain cum sun shade/canopy.

4.3.2 Local control panel/panels shall be totally enclosed cubicles. Panel sizing shall be carried out based on equipment being installed keeping in view the maintenance clearances and easiness of operation. Although the panel dimensions shall be guided by the actual requirements, typical dimensions shall be 2100 mm height x 1200 mm width x 1000 mm depth. In any case, vendor shall not proceed with panel manufacturing before getting prior approval from the purchaser.

4.3.3 Local control panels located in the hazardous area shall either be purged type or flame proof Ex'd' or weather proof with Ex'd' components such as lamps, push buttons, switches etc. as specified in job specification. In case pressurized panels are specified the same shall be purged and pressurized as per NFPA 496 requirements to render space within the panel non hazardous. For panels located in IEC Zone 2, hazardous area type Z purging shall be used with a purge fail alarm in main control room. In case, panels are located in Zone 1, the power shall be cut off on perssurisation failure as per x-purge requirements of NFPA-496.

An alarm shall be provided on local panel and a contact shall be provided for remote annunciation, whenever the panel pressurization falls below 2.5 mm of H₂O. A protective device to protect the panel from over pressure must be provided.

- 4.3.4 Panel pressurisation with start-up panel purging scheme shall be fully automatic however it shall be started manually from a push button. Solenoid valves and differential pressure switch required for panel purging shall be flameproof, however other items like relays, switches/pushbuttons, timers etc. shall be located in a flameproof housing. Other items like valves, restriction orifice plates, dual filter regulators, pressure gauges, rotameters etc required for pressurization shall also be located in the non-pressurized section of the panel.
- 4.3.5 It shall be possible to switch off incoming power to panel from panel front. All such power on/off switches shall be flameproof type.
- In addition, all those devices and terminals, which cannot be powered off from on/off switches shall also be located inside flameproof enclosures.
- 4.3.6 All hinges, screws and other non-painted metallic parts shall be of stainless steel material.
- 4.3.7 All other requirements as specified in clause 4.2 of this specification shall also be applicable for local control panels.
- 4.3.8 Whenever weatherproof local panel is provided by vendor for classified area, the Alarm Annunciator shall be intrinsically safe and push button, lamps; selector switches shall be flame-proof "Exd" type mounted on LCP. IS Barriers/ relays for IS alarm annunciator shall be supplied by vendor along with IS annunciator and potential free non-flameproof contact for the same shall be considered from the PLC / DCS/ control systems. The IS power supply module for alarm annunciator shall be installed in a flameproof box in local panel by bidder. For Lamps, wet contact shall be considered from the PLC/ control system and the lamp test logic shall be realised in PLC/ control system. The Power supply distribution box inside the Local Panel shall also be flame-proof "Exd". IS PCs for display of loop powered indicators shall be used in weather-proof local panels in case no. of tag local display more than Five tags. The same IS PC can also be used for local display of vibration and temperature monitoring system parameters at field instead of separate display unit at field. For 5 or less number of tags for local indication, normal IS loop powered indicators shall be provided on weather proof local panel.

Intrinsically Safe (IS) type with minimum 15" Display (Remote interactive PC terminal) unit certified suitable for the hazardous area shall be mounted on the panel front of local control panel of the package, wherever IS PC is considered. All local control panel mounted field remote output indicators, wherever required as per approved P&IDs, shall be displayed in this remote PC. Single serial interface (RS 485 with Modbus RTU protocol) corresponding to these signals from control system shall be considered and vendor's scope shall include all necessary converters, power supply module, connectors at both ends along with serial communication cables for connecting to serial interface cards.

The PC terminal shall be equipped with necessary keyboard suitable for specified hazardous area.

4.4 Local Gauge Board

- 4.4.1 Local gauge board shall be used to install skid-mounted instruments like pressure gauges, temperature gauges and transmitters.
- 4.4.2 Location of local gauge boards, when provided, shall be decided to allow easy access at the rear and front for all instruments and accessories for maintenance and operation.
- 4.4.3 Gauge board shall be constructed from 3 mm stainless steel sheet with other necessary SS supporting structure.

- 4.4.4 Local gauge board shall be supplied with all instruments installed and completely in tubed/wired condition before shipment.
- 4.4.5 All pressure transmitters and gauges shall be provided with block and bleed valves securely fastened. Identification tags shall be securely fastened for easy identification. Wherever local temperature indicator is required with temperature transmitter, Loop powered indicator shall be provided.

4.5 Temperature Instruments

4.5.1 Thermowells

- a) All temperature elements shall be provided with thermowells fabricated out of bar stock of minimum SS 316 material as per EIL Standard 7-52-0035. The base of the thermowells shall be chosen to fit the instrument without air gap for minimizing measurement lag.
- b) Built-up thermowells shall be used in low pressure and low velocity services like in fired heaters and also where thermowell immersion lengths greater than 500 mm are required.
- c) Immersion length of thermowells shall be as follows:

Line Size	Immersion length
From 4" to 6"	280 mm
From 8" to 20"	320 mm
>20" and Vessels / columns	400 mm

In special applications, not covered above, vendor shall decide the immersion length based on actual requirements. Immersion length is based on 200 mm length between flange face and outer wall of pipe and 200 mm length between flange face and outer wall of the vessel.

- d) Any pipe line less than 4" nominal bore shall be blown to 4" size to install thermowell.
- e) Thermowell flange and well material shall be as per material selection chart.
- f) The vibration analysis shall be carried out as per PTC 19.3 TW:2010 (latest version) and corrective measures shall be taken as necessary.

4.5.2 Temperature Gauges

- a) Local temperature gauges shall be in general bimetallic type. The temperature bulb shall be of stainless steel construction. The gauge connection shall be all angles adjustable. Gas filled type shall be used when measuring range is beyond the limits of Bimetallic gauge or thermowell length exceeds 550 mm or in applications involving excessive vibrations. Mercury filled type temperature gauge shall not be used.
- b) All local temperature gauges shall have 150 mm dial size. The bulb size shall be selected to suit the thermowell.
- c) Cases shall be minimum 304 SS and weatherproof to IP-65 as per IS/IEC-60529.
- d) Temperature gauges shall have accuracy of $\pm 1\%$ URV (upper range value).
- e) Bimetallic type dial thermometers shall be avoided where excessive vibrations are encountered, such as reciprocating compressor discharge. Only filled type with

capillary extension shall be used in such cases. Capillary tubing shall be a minimum of 304 SS with stainless steel flexible armouring, and PVC covering over armour. Filled type gauges shall be manufactured as per relevant SAMA class.

- f) Thermometer stem adjustable gland with union connection and bushing shall be suitable for 1/2" NPTF connection.

4.5.3 Temperature Elements

- a) For remote temperature indication/recording/control/switch etc., resistance temperature detector (RTD) shall be used upto 400 deg C (operating) and above 400 deg C (operating) thermocouples shall be used. Elements shall be spring loaded, mineral insulated and shall have stainless steel sheath as a minimum.
- c) Thermocouple assemblies shall be furnished with weatherproof screw type heads as per EIL Standard 7-52-0036.
- d) Thermocouples shall be as per IEC-60584-2 and shall have a wire size of 18 AWG for single and 20 AWG for duplex thermocouples. These shall be magnesium oxide (MgO) filled grounded type, unless necessary otherwise. The type of thermocouple shall be selected based on temperature. The selection of type shall be as per following guidelines:

Copper-Constantan (ISA-Type-T)	:	(-) 200 to 200°C
Chromel-Constantan (ISA-Type-E)	:	(-) 200 to 600°C
Iron-Constantan (ISA-Type-J)	:	0 to 600°C
Chromel-Alumel (ISA-Type-K)	:	600 to 1200°C
Platinum Rhodium-Platinum (ISA Type-S)	:	600 to 1600°C

- d) The design of thermocouple assemblies shall be such that replacement on line is possible.
- e) RTD (Resistance Temperature Detector) shall be platinum element 3 wire type with 100 ohms resistance at 0°C calibrated as per IEC 60751. RTD shall be used within a temperature range of -200 to 650°C. Three-wire system shall be adopted in connecting the element.
- f) RTD shall be used where accuracies of the order of 0.25% or better and smaller measuring spans are required.
- g) Duplex element sensors shall be supplied. Two separate cable entries shall be provided with plugs.

4.5.4 Temperature Transmitter

- a) Temperature transmitters shall have a built-in linearising function to produce an output linear to temperature range.
- b) The Temperature transmitters with RTD shall have an accuracy of 0.075% of URV as a minimum for range above 350°C, 0.15% of URV for temperature range 350°C to 150°C and 0.25% for calibrated range below 150°C.

The Temperature transmitters with cold junction compensation for thermocouple shall have an accuracy of 0.25% of URV as a minimum for range above 350°C, 0.5% of URV for temperature range between 350°C to 150°C and 0.75% for calibrated range below 150°C.

c) Transmitters shall be provided with dual compartment.

4.5.5 Burn out protection must be provided with temperature transmitters. Upscale or downscale protection shall be decided based on its application to ensure fail-safe operation.

4.6 Pressure Instruments

4.6.1 Pressure Gauges

- a) Pressure gauge dial shall be white with black figures. The dial face shall be marked with pressure element material. Pointers shall have micrometer adjustment.
- b) Pressure gauges shall be weatherproof with dial size of 150 mm and shall have features like over range protection (at least 130% of max. operating pressure) and blowout discs. Glass shall be shatter proof. Pressure gauge sensing element shall be of SS 316 and movement of SS 304, as a minimum.
- c) Pressure gauges shall have an accuracy of $\pm 1\%$ of URV as a minimum. Differential pressures gauges, diaphragm seal pressure gauges and draft gauges may have an accuracy of $\pm 2\%$ of URV.
- d) Over range protector and pulsation dampener, whenever used, shall be of SS 304, as a minimum. Pulsation dampener shall be used for all pulsating services. It shall be floating pin type, externally mounted and externally adjustable.
- e) Pressure gauges with range 0-100 kg/cm²g and more shall have safety type solid front case.
- f) Connection shall normally be 1/2" NPTM bottom.
- g) Cases shall be minimum 304 SS and weatherproof to IP-65 as per IS/IEC-60529.
- h) Ranges shall be so specified that the gauge normally operates in the middle third of the scale and shall conform to IS-3624 standard dials, wherever possible.
- i) Diaphragm seals shall be furnished where plugging of the element may occur or where suitable material is not available in highly corrosive services. When chemical seals are required, they shall be of the clean out type with flushing connection.
- j) Where vibrations and pressure fluctuations are expected, glycerin filled type and snubber shall be used.
- k) Receiver pressure gauges for local transmitter output indication shall have 100 mm dial with stainless steel element and 1/4" NPTM connection.
- l) The pressure element shall be bourdon, diaphragm or bellows depending upon process condition. Single diaphragm type Differential pressure gauges shall not be considered, Instead double diaphragm type or bellows shall be considered.

4.6.2 Pressure/Differential Pressure Transmitters

- a) Pressure/differential pressure transmitter shall have electronic state-of-art capacitance or any other type of sensor meeting all functional specifications as per clause 2.16. Element material for transmitters shall be 316 SS, as a minimum.
- b) All transmitters shall have an integral output meter. Remote mounted meters may be provided if required in addition.

- c) Diaphragm seal element with capillary shall be used for congealing, corrosive and highly viscous services.

4.6.3 Pressure Switches

- a) Process switches shall not be considered unless its use is unavoidable and the same shall be subject to purchaser's approval
- b) Pressure switches shall have either diaphragm or bellow type of process element with SS 316 material of construction as a minimum. Switch type shall be sealed micro-type with contact rating suitable for specific application. Also contacts shall be SPDT type unless otherwise specified. Contacts used in intrinsically safe applications shall be suitable as per the process condition.
- c) Pressure switches shall be blind type with 1/2 NPTF process connection and shall be operative in full-specified range. The switch differential shall be selected as per operating conditions.
- d) Pressure switches shall have repeatability of $\pm 0.5\%$ of URV, as a minimum. Pressure switch shall have over range protection of at least 130% of maximum working pressure. The set pressure shall fall in the middle third (between 35% to 65%) of the adjustable range in general. Set point shall be field adjustable.

4.7 Level Instruments

4.7.1 Level gauges

- a) All gauge glasses shall be steel armoured reflex or transparent type with body and cover material of forged carbon steel as a minimum and shall have tempered borosilicate glass with asbestos or other suitable gasket. Transparent type of gauges shall be provided with integral illuminators operating at 240 V 50 H z supply and shall be suitable for electrical area classification specified. All gauge glasses must have a rating equal to or more than the vessel design pressure and temperature.
- b) Reflex type will be used for clean and colourless liquids, except liquids level interface. For low temperature, low boiling point service, large chamber type will be used. Transparent type will be used on acid, caustic, dirty or viscous, coloured liquids and liquid interface. Transparent type with Mica or Kel-F shields shall be used for treated water, boiler and condensate services, and for corrosive liquids, which will attack glass. Tubular gauge glasses shall, in general, not be used in Hydrocarbon/hazardous services. They may be used for non-hazardous services at ambient temperature and low pressures (less than 10 kg/cm²g operating).
- c) Large chamber gauges with frost shields shall be provided for cold services below 0° C. Heating jacket shall be provided for viscous liquids with 1/2" flanged connection.
- d) All gauges shall have top and bottom chamber connections, unless otherwise specified. However side-side chamber connection is acceptable where nozzle installation is a constraint. In addition each gauge shall be provided with ball check valves and pipe union.
- e) The visible range of level gauge shall be selected to cover the complete operating level as well as measuring range of the other level instruments provided for the same purpose. In general, the visible length and C to C distance of the top and bottom level gauges shall be selected from the following:

Visible length

Centre to Centre Length

220	470
470	720
720	970
980	1230
1230	1480
1490	1740

For side-side level gauge C to C distance shall be 10 mm less than visible length.

- f) For level gauging in very viscous, corrosive liquids, liquids with crystals and high pressure service, float operated magnetic gauges with 2" (50 mm) flanged end connections, shall be used. C to C length of single magnetic level gauge shall not be more than 2500mm.

4.7.2 Level Transmitter

- a) Guided Wave Radar type instruments with external cage and side-side connections shall normally be used for level and for interface level measurement upto 2400 mm.
- b) Guided wave radar inst shall have ± 3 mm accuracy.
- c) Differential pressure transmitter shall be used for level measurement above 2400 mm, for services requiring purge or where liquid might boil in external portion.
- d) Differential Pressure transmitters for use on corrosive or fouling service shall generally be diaphragm wafer with extended filled capillary type. Flush or extended diaphragm type differential pressure transmitter shall be considered for special applications only. Diaphragm material shall normally be stainless steel or any other special alloy.
- e) For sump levels, Guided wave radar or non- contact type radar level instrument shall be used depending on the application within accuracy ± 3 mm.
- f) Generally for top mounted level transmitters, internal guided wave radar type instruments shall be used for level measurement upto 3000mm. Above that non-contact type radar shall be used.
- g) Level transmitters shall meet all requirements specified in clause 2.16.

4.7.3 Other Special types of level instruments like ultrasonic, hydrostatic, nucleonic, capacitance, conductivity type shall be used as necessitated by application requirements.

4.7.4 For high pressure steam drum application at least one number conductivity type (Hydrastep or equivalent) level instrument shall be provided. Also level gauges shall be of bi-color type for such application.

4.7.5 For solid level measurement, type of instrument shall be ultrasonic/electromechanical/capacitance/nucleonic/non-contact type radar as per the process condition. The actual type selection shall be carried out based on the provenness of the selected type for similar type of application.

4.8 Tank Level Instruments

- a) Each tank shall be provided with minimum 2 types of tank level instruments operating on different principles like one servo and other one radar (Antenna) type.

- b) Radar type transmitter shall be provided with ± 3 mm accuracy for storage tanks and ± 1 mm for custody transfer. Whenever ± 3.0 mm accuracy is required, process connection on vessel/ tank/ equipment for non-contact radar gauge can be 4" with 4" Carbon Steel / Stainless Steel (depending on the pipe schedule requirement) still well. However wherever ± 1.0 mm accuracy is required (e.g. in custody application), process connection on vessel/ tank/ equipment for non-contact radar gauge shall be 8" with 8" Carbon Steel / Stainless Steel (depending on the pipe schedule requirement) still well. For viscous service, nozzle connection shall be 24".
- c) Servo type instruments shall have 6" process connection with 6" diameter still well, with accuracy ± 3 mm for storage tanks and ± 1 mm for custody transfer. Raising or lowering of displacer for calibration shall be possible on-line with the design of still-well.
- d) The wetted material like float, displacer, tape, wire etc. shall generally be 316 SS.
- e) The accessories for servo-controlled level gauge shall include isolation ball valves for pressurized tanks and calibration/maintenance chamber for all tanks. Each calibration chamber shall be provided with a viewable window of blast proof glass. The calibration chamber can be either integral to the instrument or separate. Whenever calibration chamber is separate i.e. not integral to the tank level instrument, the material of construction of calibration chamber shall be stainless steel. The calibration chamber shall also permit insertion / removal of displacer for maintenance without removing the instruments.
- f) Servo and Radar type instruments shall be capable of providing serial output as per vendor standard protocol or field bus protocol as per IEC-61158 in addition to analog 4-20 mA DC current output. These instruments shall also be capable of accepting input from multi element tank temperature sensors (thermocouple/ RTD), water cut probes and transmit the same as a part of serial signal from the transmitter. Multi-element tank temperature sensors when used shall be provided with 3" stillwell and 3" process connection.

4.9 Flow Instruments

The selection of flow measurement instruments shall be based on the requirement of accuracy, repeatability, location, physical properties of the flowing fluids handled, pressure drop and ease of maintenance.

In-line flow instruments shall have a direction of flow indication clearly marked and easily visible in the final installed position.

Flow switches shall not be used without prior approval from the purchaser.

4.9.1 Orifice Plates

- a) Flow measurement shall normally be carried out by using thin square edged concentric orifice plate mounted between a pair of weld neck flanges of minimum 300 pounds ANSI rating for line size 2" and above. Flange taps shall be used for line sizes upto 14" while D-D/2 taps shall be used for line sizes more than 14". The material of the orifice plates shall be normally 316 SS, as a minimum.

Quadrant edge or quarter circle orifice plates shall be used for highly viscous liquids and for pipe Reynold number below 10,000.

Conical entrance type of orifice plates shall preferably be used for very highly viscous liquids upto throat Reynolds number of 250. These plates shall be fabricated as per Flow Measurement Hand Book by RW Miller.

Vent and Drain holes shall be provided for bore dia above 25.4 mm.

- b) Sizing of orifice plate shall be carried out in accordance with ISO-5167 (Latest Edition). For orifice plates not covered in ISO 5167, sizing methods shall be ASME MFC-14M (latest Edition) or AGA Report No. 3 or 'Flow measurement-Engineering Handbook' by RW Miller.
- d) Honed metering runs or integral orifice type transmitter shall be used in line size with 1.5" (40 mm) nominal diameter or below.
- e) Upstream and downstream straight length shall be provided based on maximum d/D ratio of 0.75, in general. Where it is difficult to meet this requirement, the actual d/D ratio can be considered for reducing the straight length as permitted by the codes. Flow straighteners are to be considered, where straight runs are difficult to achieve otherwise.
- f) Meter taps shall be horizontal for liquids, condensible vapours and steam. The taps shall be on top for gas, non-condensable vapour, or liquids which boil at or below the maximum design ambient temperature at operating pressure. Where piping clearances are a factor, taps may be located upto 45 degree below the horizontal center line for condensible vapour and liquid. The taps may be located upto 60 degree from vertical for gas, non-condensable vapour and steam.

4.9.2 Venturi Flowmeters

- a) Venturi shall be designed and constructed as per ISO 5167-4 (Latest Edition) or ASME MFC-3M.
- b) The Venturi Flow element shall be classical, machined, non truncated type.
- c) Impulse piping connection for venturi tubes shall be provided with 1/2" NPTF connection, unless otherwise specified in the data sheet.
- d) Venturi tube shall be forged/cast construction in general. However fabricated construction shall also be acceptable, wherever allowed as per ISO-5167.
- e) Venturi tube shall be provided with Annular chamber / Piezo-metric Ring. Material of construction of Annular chamber / Piezo-metric Ring shall be same as material of Venturi tube.
- f) Material of construction of Venturi tube shall be SS316 as a minimum. Material of construction for Throat, Divergent section and Convergent section shall also be SS316 as a minimum. Flanges shall be provided as per the material specified in the datasheet.
- g) Flow calibration for those Venturi tubes, which are necessitated due to their installations outside the limits as defined in ISO 5167 for D (Pipe Inside Diameter), beta and Reynolds numbers shall be considered in the base quote

4.9.3 Averaging Pitot Tube

Averaging pitot tube in general shall not be considered unless specifically required by the purchaser. Averaging pitot tube shall meet the following requirements:

- a) The flow sensor shall be continuous averaging velocity head producing type of pitot tube with four or more equal averaging pitot tube sensing ports or continuous slots to

suit line velocity profile. The sensor shall also incorporate a rear port for the measurement of line static pressure.

- b) Averaging pitot tube shall be of 3" flanged connection with isolation ball valve.
- c) The insert retract mechanism shall be provided to allow on line removal and insertion of the average Pitot tube under maximum pressure and flow condition.
- d) Vibration analysis for each averaging pitot tube element shall be done for the indicated flow condition to ensure that the averaging pitot tube is of sufficient thickness and strength to withstand the vibration effects created due to Karman vortex shedding in the fluid stream.
- e) The free end of the averaging Pitot tube shall be pressure supported at the pipe wall. However, for the large pipe sizes and where vibration analysis recommends the requirement of end support, the end support/weld cap support shall be provided.
- f) The offered averaging pitot tubes shall have $\pm 1\%$ accuracy of actual value and repeatability of $\pm 0.1\%$ of actual value.

4.9.4 Variable area Flow Meters

Variable area flow meters or rotameters shall be provided as per the P&ID or where rangeability in flow precludes the use of an orifice. Variable area flow meters shall be as per ISA-RP 16.1, 16.2, 16.3, 16.4, 16.5 and 16.6. Metal tube rotameters shall be used for all fluids. External devices for indicating or transmitting shall be magnetically coupled to the float or extension.

Glass tube rotameters shall not be used unless it is necessitated for low range or for low pressure utility services for local indication and where line size is 1-1/2" (40mm) or less with the approval of purchaser.

Reducer shall be considered, in case the size of the flowmeter is less than the line size.

4.9.5 Mass Flow Meters

The mass flow meters shall meet the following requirement:

- a) Flow meter shall be of in-line mounting design and shall be of flanged body construction with stainless steel as minimum material of construction.
- b) The mass flow meter shall be provided with the external flow tube housing. In all such cases, the flow tube housing shall have provision to monitor housing pressure continuously.
- c) The mass flow meter shall have high vibration immunity.
- d) The meter electronics shall be protected against transients induced by lightning and power supply surges. Transient protection electronics shall preferably be provided in the terminal block.
- e) Flow meter electronics shall be microprocessor based and shall include pre-amplifier, converter, transmitter electronics and integral output meter. The indication on the output meter shall be digital with engineering units.
- f) The mass flow meter shall be capable of computing field density and shall incorporate temperature sensor flow fluid temperature measurement. Whenever required, the flow meter electronics shall have capability to compute volumetric flow rates.

- g) The meter electronics shall be protected against transients induced by lightning and power supply surges. Transient protection electronics shall preferably be provided in the terminal block. The transient protection shall meet the requirements specified in IEC-60587.
- h) Unless specified otherwise in the job specification, the performance requirements for the mass flow meter shall be as follows:
- i. Flow meter accuracy: $\pm 0.2\%$ of mass flow rate for liquid service.
 $\pm 0.5\%$ of mass flow rate for gas / vapour service.
 - ii. Flow meter repeatability: $\pm 0.1\%$ of mass flow rate for liquid service.
 $\pm 0.25\%$ of mass flow rate for gas / vapour service.

The performance requirements specified above excludes the effect of zero stability of the flow meter on these parameters.

Flow accuracy shall be maintained between the minimum and maximum flow. Where only normal flow is specified, the maximum and minimum flows considered for the purpose of sizing shall be:

Maximum flow = 1.4 times the normal flow

Minimum flow = 0.4 times the normal flow

When only maximum flow is specified minimum flow shall be considered as 0.2 times the maximum flow for sizing the meter.

The maximum pressure drop at meter maximum shall not exceed the allowable pressure drop across the meter specified in the data sheet.

The meter shall be selected such that both accuracy and allowable pressure differential across the meter are complied.

4.9.6 Ultrasonic flowmeter

Ultrasonic flow measurement shall be considered where non-intrusive flow measuring is required.

The Ultrasonic flow meter shall be based on transit time technology.

The design used shall provide maximum reliability, maximum on-line performance and minimum maintenance. It shall be immune to other impurities in the fluid stream.

Ultrasonic flow meters and the meter runs/flow conditioners shall be rated for the maximum design pressure.

Spool piece type Ultrasonic flow meters shall have flanged end connections. Weld joints, if any, shall be of radiographic quality.

Meter Sizing:

Selected meter size shall ensure that flow meter operates within 85% of their standard range considering density and viscosity of the fluid. Extended range shall not be referred for the meter selection.

Vendor to ensure the velocity in the Ultrasonic flow meter and meter run shall not exceed maximum permissible velocity.

4.9.7 Target meters shall be considered for highly viscous hydrocarbon streams such as asphalt, tar, polymers etc.

- 4.9.8 Vortex meter shall be considered where high rangeability is the prime requirement.
- 4.9.9 Differential Pressure type flow transmitter shall meet all the requirements specified in clause 2.16.
- 4.9.10 Wedge flow meter shall be considered in slurry services or where powder deposits may form. However, Diaphragm seal type DP transmitter shall be provided along with wedge flow meter duly calibrated with both sensor and the transmitter.
- 4.10 Control Valves**
- 4.10.1 Control valves shall normally be globe type. Other valve types like butterfly, ball, rotary plug, angle or 3way etc., shall be selected as per service and process requirements.
- 4.10.2 Control valve sizing shall be carried out as per ISA S75-01. The valve shall permit upto 150% of normal flow or 110% of maximum flow, whichever is higher. In general, control valves shall be sized so that the valve opening is as noted below:
- | | | |
|-----------------|---|-----------------|
| At max. flow | : | about 90% open |
| At normal flow | : | about 75% open |
| At minimum flow | : | about 20% open. |
- 4.10.3 Flanged control valves shall be used. Body material, body rating and flange rating shall be as per piping specifications. However body and flange rating shall be minimum 300#.
- 4.10.4 Minimum control valve body size shall be 1" in general. Reduced trims can also be considered.
- 4.10.5 For globe valves trim characteristics shall be equal percentage type unless required otherwise. Control valve plugs shall be heavy top guided for single seated valves. Cage guiding may be used in clean applications.
- 4.10.6 Anti-cavitation trim shall be selected wherever cavitation is expected in the valve. For flashing services and hardened trim shall be used and anti-cavitation trim shall not be provided.
- 4.10.7 Noise from control valve during operation shall be limited to OSHA specified level or better. The maximum allowable noise is 85 dBA SPL (Sound Pressure Level). Source treatment for noise may be performed by using special trims like low noise trims, in case noise exceeds the specified level. Other methods based on merit are also permissible.
- 4.10.8 Valve seat leakage shall be minimum class IV as per ANSI/FCI 70.2 unless tight shutoff requirement is required as per the P&ID.
- 4.10.9 Flanged bolted type gland packing boxes shall be used. Packing shall normally be PTFE on liquid and gas service up to 200°C (design). Graphite/graphofoil shall be used above 200°C(design) temperature. Asbestos based packing material shall not be used.
- 4.10.10 Bellows seal shall be used where it is required to isolate the packing from the process fluid or where no leakage to atmosphere can be tolerated like toxic, explosive and precious fluids.
- 4.10.11 Material used for trim shall be minimum SS 316, with guide bushing of hardened stainless steel like 440 C, 17-4 PH. For higher pressure drops (more than 10 kg/cm²) or erosive and slurry services and in general for all steam services, flashing and cavitating services, plug and seat shall be stellite.

Special cases may require 17-4 PH seat ring and 440 C solid plugs or other materials like Hastelloy, Monel etc.

- 4.10.12 Valve actuator shall be pneumatic spring opposed diaphragm type, in general. Piston type actuators may be used for very high shut off pressure requirements. Additional equipment including volume bottle necessary to meet fail safe condition shall also be included in case double acting piston type actuator is selected. In either case, actuator shall be able to withstand maximum shut-off pressure (1.5 times of design pressure) with the minimum instrument air pressure specified.
- 4.10.13 Whenever limit switches are specified as inductive proximity type, these shall meet NAMUR (DIN-19234) requirements.
- 4.10.14 Solenoid valves, wherever used, shall be universal and continuous rated type with class H coil insulation. These shall be SS body as a minimum.
- 4.10.15 Self-actuating regulators for flow, pressure and temperature shall be used where loads are constant and requirements of precision and accurate controls are not stringent.
- 4.10.16 The actuator shall be painted as below:
- | | | |
|---|---|--------|
| Direct action (open on air failure) valves | - | Green |
| Reverse acting (close on air failure) valve | - | Yellow |
| Actuator for shutdown valves | - | Red |

Items like air volume tanks etc., supplied as an accessory along with the actuators, shall be painted as per corresponding actuator.

4.11 ON-OFF VALVE

- 4.11.1 On-off valves shall have flanged end connections integral to the valve body. Top entry valve design shall not be offered unless specifically indicated. Body rating of valve shall be minimum 300#.

Whenever flangeless on-off valve body design is specified, following shall apply:

- a) Wafer type or lug type body design for butterfly type on-off valves body size up to 6 inches.
- b) Lug type body design for butterfly type of on-off valve body size more than 6 inches.
- 4.11.2 For on-off valves with fire safe design, flanged body construction shall only be acceptable.
- 4.11.3 For all services where full port valves are specified, following shall apply:
- a) Port size shall be equal to line size for rating up to ASME Class 1500.
- b) Port size shall not be less than one size than the line size for rating ASME Class 2500 and above.
- 4.11.4 For steam jacketed valves, the body and port size shall be one size lower than the on-off valve end connections.
- 4.11.5 On-off valve body, bonnet, bottom flange, line flanges and other pressure containing assemblies shall be of the same material of construction as specified for valve body.

- 4.11.6 In case of ball-type of on-off valves;
- a) The valve design shall ensure valve seat and body protection against thermal expansion of the entrapped fluid when the on-off valve is fully close.
 - b) For size up to 4" and rating up to ASME Class 300, the on-off valve shall have floating ball design. For ratings ASME Class 600 and above, floating ball is acceptable for sizes less than 2". For higher sizes trunion mounted ball design shall be provided.
- 4.11.7 Rotary type on-off valves like Ball valves, butterfly valves etc. shall have blow out proof shaft guiding design.
- 4.11.8 Guide bushing shall be of a sufficiently hard material to resist side thrust on the plug or shaft.
- 4.11.9 Vendor shall be responsible for trim design and selection of the on-off valve. However, it must meet the following minimum requirements:
- a) The valve characteristics shall be quick-opening (on-off) type.
 - b) Vendor shall select proper material pairs, surface finish, hardness and clearances to avoid galling.
 - c) Valves operating under extreme temperature conditions, vendor shall consider increased clearances at room temperature and seal welding of threaded seat rings etc whenever required. Hard facing of trim including guide bushing shall be considered for all valves operating at high temperatures (i.e. temperature more than 200°C). For very low temperature application, material used shall have adequate cold impact strength.
 - d) For all on-off valves including 3-way type of valves, stem and plug shall be detachable and shall be attached together by suitable threaded design secured with a pin to avoid plug rotation during operation.
- 4.11.10 Trim material and actuator colour shall be as specified for the control valve.
- 4.11.11 Leakage class of on-off valves shall be as specified in data sheet, where no class is specified it shall be Class IV.
- 4.11.12 For on-off valves specified with Class VI / bubble tight (as per API) leakage class, vendor shall select the soft seat (elastomer) material suitable for the process conditions i.e., shut off pressure, maximum temperature and process fluid. Metal seated on-off valves meeting the leakage class shall also be acceptable.
- 4.11.13 For application in vacuum service, vendor to provide inverted packing design suitable for vacuum service. For pressure-cum-vacuum service, the on-off valve shall have dual packing design suitable for the application. Dual packing design shall also be provided for on-off valves in toxic service, with a facility to connect inert fluid between the packings.
- 4.11.14 Valve actuator shall be designed to move the valve to the failure position as specified. For failure position specified as 'fail-locked', vendor shall provide air reservoir with all required accessories to meet the fail lock position of the valve.
- 4.11.15 Whenever double acting springless type of actuator is unavoidable, all accessories like pilot valves, booster relays, non-return valve, pressure gauge, volume tank etc. shall be provided to ensure desired action on air failure.

- 4.11.16 The volume tank shall be of carbon steel construction and sized as per ASME Section VIII with design pressure of $10\text{kg/cm}^2\text{g}$ as a minimum. Each volume bottle shall be sized for a minimum of 3 valve strokes
- 4.11.17 The actuator casings and diaphragms shall be designed for minimum twice the maximum pneumatic operating pressure of the on-off valve.
- 4.11.18 Vendor shall be fully responsible for sizing and selection of correct actuator, while sizing the actuator vendor shall consider minimum actuator thrust equal to two times (2) the total force induced by shut off condition and the force required to overcome packing friction.
- 4.11.19 Wherever the valves are indicated as fire safe, they shall be tested for fire safe as per BS 6755 (Part-2) when the valves are supplied with metal-to-metal seats and shall be tested as per API 607 latest edition when the valves are provided with soft seats.
- 4.11.20 Wherever fire safe actuator and controls have been asked for, actuators and all accessories such as solenoid valves, air volume bottles etc. shall meet the fire proof requirement to ensure normal valve operation even during and after exposure to fire. Vendor shall clearly define the schemes they propose to achieve the above requirements and ensure that the proposed schemes shall meet the requirement in terms of type of exposure and exposure time of the testing procedure given in BS 6755/API 607.
- 4.11.21 Vendor shall furnish type test certificate duly witnessed by third party inspection agency like M/S LRIS, BV, DNV, TUV etc. for fire safe testing of valve, actuator and controls for the offered models.

4.12 Smart Type and Field Bus Type Positioners

Digital smart positioners or field bus type of positioners with diagnostic capabilities shall be provided as per job specific requirement. These shall meet the following minimum requirements:

- a) The positioner sensor and sensing mechanism shall be rugged and shall not be affected by the line/valve vibration. The performance of the positioners shall be immune to above vibration.
- b) The positioner's output and input range shall be field adjustable without any hardware modification. The output from the positioners shall be available for both single acting as well as double acting actuator.
- c) Each positioner shall be operable, configurable and accessible through HART compatible hand held configurator/field bus configurator as applicable. Smart positioners shall also have dedicated buttons for the above functions.
- d) Control valve's operating signatures in the form of hard copy and soft copy for each control valve provided with smart positioners shall be supplied. The necessary software for advanced control valve diagnostics like seat ring condition, gland packing condition, actuator leakage etc. shall also be included.
- e) Fieldbus positioner shall have the capability to perform functions like PID etc.
- f) All positioners shall have metallic casing and cover.

4.13 Pressure Relief Valves and Rupture Discs

- 4.13.1 **Pressure Relief Valves**
- 4.13.1.1 All pressure relieving devices shall be designed in accordance with ASME code for 'Boilers and Pressure Vessels', API-521 and Indian Boiler Regulations. The pressure relief valve sizing shall be as per API 520. For mixed phase fluids, sizing shall be as per Leung-Omega method (or Diers) sizing shall be followed. The orifice sizing, area and designation, valve size and rating shall be as per API RP 526.
- 4.13.1.2 Pressure relief valves shall be full nozzle full lift type except for thermal relief valves.
- 4.13.1.3 Conventional valves shall be specified for constant back pressure while bellows seal type valves shall be specified for variable back pressure. Pilot operated pressure relief valves shall be used when Back pressure is greater than 50% of set pressure or when the difference between operating pressure and set pressure is within 10% of the set pressure.
- 4.13.1.4 Lifting lever shall be specified for steam, air or water above 65 degree service. Open bonnet shall be used for steam service.
- 4.13.1.5 The percentage accumulation in case of pressure relief valves/safety valves shall be as follows:
- | | |
|--|--------------------------------------|
| a) Steam Service | |
| - ASME SEC I (steam generation/consumption) | 3% |
| - IBR (Before steam let-down station) | 5% |
| - IBR (Distribution & utilities) and | 10% |
| ASME Section VIII | |
| b) Gas, Vapour or liquid for process service | 10% |
| c) Liquid for thermal Relief | 25/ 10% (as per Process requirement) |
| d) Fire exposure on unfired vessels | 21% |
- 4.13.1.6 3/4" x 1" threaded (NPT) modified nozzle type valves with typically 0.38 cm² orifice size shall be specified for thermal relief. However, if discharge is connected to flare or with variable back pressure more than 10% of set pressure, 1D2 flanged valves as per API-526 as a minimum to be provided.
- 4.13.1.7 The body material shall, as a minimum, be as per piping specifications. Nozzle and disc material shall be SS 316 as a minimum with machined stainless steel guide and spindle. Whenever semi nozzle designs are unavoidable, body material shall be atleast same as nozzle and disc material.
- 4.13.1.8 The spring material of pressure relief valves shall be as follows unless otherwise necessary because of process conditions;
- | | | |
|--|---|---|
| (-)29 ⁰ C to 230 ⁰ C | : | Carbon steel with weather protective coating. |
| above 230 ⁰ C | : | Tungsten alloy steel. |
| Below (-)29 ⁰ C | : | 316 Stainless Steel |
- 4.13.1.9 Flanged connection shall be for standard sizes 1" or larger.
- 4.13.1.10 Where permissible, screwed connections shall be used on sizes 3/4" and below.

4.13.2 Rupture Disc

- 4.13.2.1 Rupture discs shall be reverse buckling type, in general and shall be supplied in pre-torqued holder assembly, which shall fit inside the inner diameter of the bolt circle of standard flanges. Disc material shall be compatible with the vessel contents and shall be consistent with the bursting requirements. Inconel discs shall be used above 100°C if compatible with the process fluid.
- 4.13.2.2 When rupture disc is used upstream of a pressure relief valve, a pressure gauge shall be provided on the downstream of the disc to indicate any rupture of the disc in addition to an excess flow check valve. In addition combination capacity factor of 0.9 shall be used for sizing unless the combination has been tested and approved for any other combination capacity factor.
- 4.13.2.3 The bursting tolerance of the rupture disc shall be 5% of the specified bursting pressure or less, unless otherwise specified.
- 4.13.2.4 Vendor shall consider 5 nos. rupture discs (1 for testing + 1 for installation + 3 nos. spare) of the same specifications.

4.14 Interlock and Shutdown System

- 4.14.1 Interlock and Shutdown System shall be an independent system with its own dedicated primary element except for orifice flow measurement. For orifice flow element, separate set of tapping for each flow transmitter for shut down / interlock shall be considered.
- 4.14.2 The system shall be designed fail safe and shall meet the following requirements, as a minimum:
- All initiating contacts shall be close (except limit switches for which contact shall close when the limit reaches) under normal conditions and shall open under abnormal conditions.
 - All relays and solenoid valves shall be energised under normal conditions and shall de-energize under abnormal conditions.
 - If desired, because of operational or maintenance requirements, adequate trip by-pass facilities are to be provided with warning lights to indicate that the trip has been bypassed. Trip bypass alarms shall be provided ~~in local as well as in remote location~~. All such by-pass switches shall be key-operated type.
- 4.14.3 Each shutdown circuit and solenoid valve shall be provided with a switch-fuse unit separately.

4.15 Instrumentation for Rotating Equipments

Rotating Equipment vendor shall be completely responsible for providing adequate instrumentation for safe and efficient operation of the machine. The commonly used instruments are being detailed out in the following clauses, however this does not absolve the vendor of providing additional instrumentation, if required.

4.15.1 Anti surge and performance control system (ASC)

- Vendor shall be fully responsible for the complete design of Anti surge/performance control system (ASC) including selection of type of flow element, controller Algorithm, type of explosion protection, type and operating timings of final control element. Vendor shall guarantee the performance of machine with the offered ASC system. Wherever required, ASC system shall be designed in such a way that it is capable of correcting the

compressor operating point so as to avoid surge in order to protect machine from possible damage, to minimize process upsets and to minimize recirculation.

- b) ASC system shall typically consist of but not limited to flow element, flow transmitter, differential pressure transmitter, ASC controller, control valve and other accessories as felt necessary by the vendor.
- c) Vendor shall supply all the hardware and software related to the operation and safety of the equipment. This shall include but not limited to the following:
 - i. Design and operation of surge control loop scheme based on offered equipment performance.
 - ii. Supply of all hardwares in antisurge control loop including dedicated controller, transmitters, measuring elements, final control element etc.
 - iii. Fast response transmitter and control valve etc. as required.
 - iv. Algorithm required for antisurge/ Performance control application.
- d) The ASC shall be a dedicated single loop controller on proprietary Hardware Platform or single/multi loop controllers of common hardware platform such as PLC. The single loop controller shall be dedicated controller for each Anti-surge or Performance control application/Tag. Dedicated panel mounted facia shall be provided. The ASC system when provided on common hardware platform shall be with redundant configuration as minimum viz-dual processor, dual input/output, redundant communication & dual power supply system. The multiloop controller/system shall be dedicated for Anti-surge/Performance applications/Tags of each machine/each machine tag. Unless specified otherwise dedicated panel facia for each application shall be provided to mount on hardwired console in control room
- e) It should be able to accept 4-20 mA signal from field or from HIC at purchaser DCS or at LCP as a manual override to anti-surge control system with bump less transfer.
- f) Auto-manual operation with bump less transfer shall be provided.
- g) The controller response time (total time to read input, processing time and output) shall be as per the machine dynamics and safety and shall be of the order of max. 40-milisec. Any faster response required based on machine dynamics shall be considered by vendor. The input sampling interval shall be as per machine dynamics within the controller response time as above. The processor cycle time shall be considered to meet the overall response time.
- h) The ASC shall be field proven, specific to the make of machine and for the similar application in hydrocarbon industries. Vendor shall provide the proven track record for the offered ASC meeting the above.
- i) The anti surge/performance control algorithm shall be implemented using standard firmware in the controller/processor system.
- j) The algorithm developed by vendor shall be specific for given application, surge control, performance, load sharing etc. and shall be field proven for the compressor make.
- k) The algorithm implemented in the system shall be protected against any modifications/changes.

- l) The configuration shall be stored in non-volatile memory or battery back-up for configuration shall be provided (minimum 48 hours) in case of volatile memory along with battery drain indication.
- m) In case of ASC on common hardwired platform separate configurator with necessary hard ware/ soft ware shall be provided for application programming.
- n) Anti surge controller shall not be used for performing any other machine related inter locks/logics.
- o) All the instruments (transmitters, Positioner and temperature elements and / or transmitters) connected with anti-surge control loop shall be flame proof "EExd" type suitable for the area as specified. The suitability of smart transmitter/ Positioner shall be confirmed by vendor and to be provided accordingly.
- p) The ASC system vendor shall be fully responsible for the sizing and selection of the anti-surge valve. Vendor to provide the sizing calculations duly vetted by ASC system manufacturer.

4.15.2 Machine Monitoring System (MMS)

Machine Monitoring system shall be provided for continuous monitoring and indication of machine parameters like vibration & axial displacement, bearing and winding temperature, key-phasor etc.

- 4.15.2.1 Vibration and displacement monitoring system shall be as per API-670. The extent and type of monitoring shall be as defined elsewhere. However, vendor shall furnish any additional requirements for monitoring deemed essential by them with reasons. Two probes at 90 degree apart for each location shall be provided and connected to same dual channel monitor for vibration monitoring.
- 4.15.2.2 The machine monitoring system shall be provided with preferably built in intrinsically safe barrier and shall be duly mounted in separate panel. However, separate terminal blocks shall be provided for terminating the field cables for maintenance purpose. Direct cable termination on modules shall not be considered.
- 4.15.2.3 For MMS the display unit shall be provided at local control panel with necessary statutory certification. Alternatively purged enclosure is also acceptable with necessary certification.
- 4.15.2.4 The sensing probe shall be accessible for adjustment, repair and replacement without dismantling the machine.
- 4.15.2.5 Vendor shall provide hardwired Voted contact output of each parameter for Pre trip and trip alarms for alarms/ interlock in purchaser's control system. The alarms/trips of the channels within each monitor/ Module can be grouped together and common pre-trip alarm and common trip contact for each monitor/ Module shall be provided. 4-20 mA signals from Vibration & Temperature Monitoring System racks to DCS system are not required separately, unless specified and vendor to ensure that all the parameters are available through serial interface. For multi racks, vendor shall provide common serial interface through multi drop link.
- 4.15.2.6 In addition to this, it shall be provided with necessary hardware (communication gateway module) including the cable for serial data communication from monitoring system to purchaser's DCS for machine monitoring through purchaser's DCS via redundant serial data interface. This serial link shall be RS 422 / RS 485 with MODBUS RTU protocol. Vendor shall furnish all details like pin configuration and tag number wise MODBUS address mapping list etc. for smooth interfacing of this communication link with DCS.

Vendor shall also provide necessary hardware and software for providing raw data to conditioning monitoring system for each rack.

4.15.2.7 Vendor shall also supply one common laptop based configuration unit for the package unit with required configuration software (refer clause 4.17) and hardware for configuration of MMS system including the serial communication cable required between configuration unit (laptop) & MMS monitors.

4.15.2.8 Key Phasor

Key phasor system shall be provided by vendor for performing analysis of vibration signals to determine machine malfunctions. It shall consist of a proximity probe and transmitter, extension cable etc. and other accessories to make the system complete. Vendor shall provide necessary reference on the shaft to determine one-per-turn occurrence.

4.15.2.9 Vibration and Axial Displacement Monitoring

Monitors shall be four channel types and shall meet the following specifications as a minimum:

- a) Continuous channel monitoring with each channel input from one probe. Readout scale shall read higher of the sensors.
- b) Each channel shall have two independent alarm levels one for pre trip alarm and one for each trip and that can be set continuously over measurement range. Two relay contacts for each pre-trip alarm and trip alarm per channel shall be provided.
- c) Broken sensor failure detection without causing shut down.
- d) LED lamps on monitor front for each channel to indicate pre-trip alarm, trip-alarm and circuit fault conditions.
- e) Selector switches on monitor front to read vibration/ displacement pre-trip alarm and trip set points for each channel shall be provided.

4.15.2.10 Bearing & Winding Temperature Monitoring

- a) Sensor shall be three wires RTD element of platinum having 100 ohms resistance at 0°C.
- b) The temperature sensor, cables, terminal heads, junction boxes etc. shall be capable of withstanding the mechanical vibration and environment of a rotating machinery atmosphere.
- c) Bearing and Winding temperature shall be monitored by means of a temperature monitor. It shall meet following requirements:
 - i. Accept RTD inputs (platinum, 100ohm at 0°C).
 - ii. Continuous six channel monitoring with each channel input from each RTD. Read out scale shall read higher of the six temperatures.
 - iii. Each channel shall have two independent alarm levels one for pre-trip alarm and one for trip alarm and that can be set continuously over measurement range.
 - iv. Broken sensor failure detection without causing shut down.

- v. Selector switches on monitor front, to read temperature, pre-trip alarm and trip set points for each channel shall be provided.
- vi. Analog output 4-20 mA DC isolated signals shall be provided for each channel for remote indication, if specified.
- 4.15.2.11 Wherever MMS is not specified, vendor shall provide suitable transmitter for all the vibration and axial displacement, temperature, key phasor to provide 4-20mA signal to purchaser's control system.
- 4.15.3 **Speed Governor System**
- 4.15.3.1 Digital microprocessor based system mounted in standalone cabinet and located in rack room shall be provided. Fault tolerant triple modular redundant (TMR) system shall be supplied unless otherwise specified in Job Specification.
- 4.15.3.2 HMI for operator interface shall be supplied loose with all mounting accessories for mounting this HMI in purchaser's hardwired console in general. This shall include all basic features of governor to enable operator to do all control and monitoring operations from console itself.
- 4.15.3.3 This shall include features like assignable speed range, adjustable speed set point, remote speed set point input, digital speed indication, adjustable speed ramp, override for testing the external over speed trip system etc.
- 4.15.3.4 It should be able to accept 4-20 mA signal from HIC at purchaser's DCS or LCP as a manual override to governor and pass on the same, after a bump less auto / manual selection and local / remote selector switches configured in speed governor (shall be possible through HMI) to governor valve as manual control.
- 4.15.3.5 Vendor shall provide all hardware & software in the system (including the cable for serial data communication from system to purchaser's DCS) for serial communication link for all data transfer from governor to purchaser's DCS. This serial link shall be RS 422 / RS 485 with MODBUS RTU protocol, vendor shall furnish all details like pin configuration and tag number wise MODBUS address mapping list etc. For smooth interfacing of this communication link with DCS.
- 4.15.4 **Accumulator of Lube Oil System**
- 4.15.4.1 If accumulators are used with nitrogen for lube oil dampening at the desired pressure to meet the system requirement the following instrumentation with the accumulator to be provided by vendor:
- a) Accumulator shall have charge kit with isolation valves and connection hoses.
- b) Standard nitrogen cylinders available in India are at pressure of 140 kg/cm²g with standard connection sizes. Vendor shall provide the complete regulator system with protection for charging nitrogen from nitrogen cylinder to accumulator at the desired pressure. Regulator shall be suitable for the inlet pressure variation of 140 to 150 kg/cm²g while charging with suitable inlet connection to match the Nitrogen cylinder connection. Regulator system shall have pressure indicator, regulator, relief valve, needle valve etc. as a minimum. Material of construction shall be stainless steel.
- 4.15.5 The compressor loading-unloading scheme for reciprocating compressors shall be provided as per the minimum requirements specified in the job specifications. Manual as well as automatic schemes shall be provided.

4.15.6 Emergency switch shall be provided in the local panel/local. All such switches shall have a protective cover to avoid inadvertent shutdown.

4.15.7 Vendor shall provide the following common alarms for purchaser:

- a) Common machine pre-trip alarms.
- b) Common machine trip alarm.

4.16 System Cabinets, Racks and Consoles

4.16.1 All system cabinets, marshalling racks and hardwired consoles shall be free standing and enclosed cubicles type. All these items shall have bottom cable entry.

4.16.2 Cabinets shall be fabricated from cold rolled steel sheet (CRCA) of minimum 2.0mm thickness suitably reinforced to prevent warping and buckling. Doors shall be fabricated out of 1.6 mm thick CRCA sheet. Cabinets having modular construction and with basic frame structure of heavy duty aluminium shall also be acceptable.

4.16.3 Cabinet/Console finish shall include sand blasting, grinding, chemical cleaning, surface finishing by suitable filler and two coats of high-grade lacquer with sanding between coats. Two coats of paint in the cabinet colour and a final coat after assembly at site, shall be given for non-glossy high satin finish.

4.16.4 In order to remove dissipated heat effectively vent louvers backed by wire fly screen shall be provided. Further, ventilation fans shall be provided wherever required. High temperature annunciation shall be provided on operator console.

4.16.5 Illumination shall be provided for all cabinets by fluorescent lamps, which shall be operated by door switch.

4.16.6 All cabinets/racks/consoles shall be adequately sized to avoid any congestion. Wiring shall be done as per guidelines provided in clause 4.2.14 of this specification.

4.16.7 The height and colour of the cabinets shall be inline with other equipments being installed in the control room.

4.17 System software / License

Systems (like PLC, ASC, Speed Governor etc.) software shall include the operating system and application program. The application program shall include software for performing functions like interlock and shutdown logic, programming/program modification, documentation etc. Two copies of application program and two sets of licensed system software shall be supplied. The program language shall be English.

The licenses and application program shall allow:

- Monitoring of system program for troubleshooting purpose.
- Carrying out any modifications to the PLC/system program if need arises (engineering license with proper validity)
- Troubleshooting of any system related failures.
- Monitoring of the system healthiness

The system shall be supplied with programming tools and related accessories.

1.0 INSTALLATION MATERIALS

1.1 Vendor shall ensure and supply all erection hardware required for the installation of complete instrumentation which form a part of the package unit. This includes items like cables, cable glands, junction boxes, instrument valves and manifolds, mounting accessories, impulse piping/tubing, pipe/tube fittings, pneumatic signal tubes, air line pipes and fittings, filter regulators, steam/electrical tracing, insulation materials, cable duct and trays, conduits, prefabricated canopies for instruments, identification tags, structural material required for instrument supports and trays etc.

1.2 Clause 1.1 above broadly covers the items required for any typical plant, however vendor shall supply all necessary items to make the installation and commissioning work complete in all respect, irrespective of whether these have been explicitly included in their scope or not.

1.3 Salient feature and minimum requirement for some of the main installation materials is being described in the following paragraphs. For items for which no specification has been provided, vendor may follow their own specifications and prevailing international standards.

1.4 Cables

1.4.1 All cables shall have PVC insulated primary insulation of cable shall be 85°C Polyvinyl Chloride type as per IS-5831 and inner and outer sheath of cable shall be flame retardant made of extruded PVC Type ST-2 at 90°C as per IS-5831. Oxygen index of PVC shall be over 30% at 27°C ± 2°C and temperature index shall be over 250°C. However, Polyethylene (PE) insulation shall be provided in IIC area classification.

1.4.2 In general cables shall be flame retardant as per standard IEC 60332 Part 3 Cat.A. However, cables with fire-safe valves shall be fire resistant also as per the following.

1.4.2.1 The insulation grade shall be 650 V/1100 V as a minimum and shall meet insulation resistance, voltage and spark test requirements as per BS-5308 Part-II.

1.4.2.2 All cables shall be twisted and armoured. Armour over inner jacket shall be of galvanised steel wire/flat as per IS-1554 part I.

1.4.3 For signal and control cables, inner jacket colour shall be black. Outer jacket colour shall be light blue for intrinsically safe application and black for others. For thermocouple extension cables the inner and outer jacket colour shall be as per IEC.

1.4.4 Maximum DC resistance of the conductor of the completed cable shall not exceed the following:

a) 12.3 ohms/km at 20°C for cables with 1.5 mm² conductor.

b) 39.7 ohms/km at 20°C for cables with 0.5 mm² conductor.

1.4.5 The mutual capacitance of the pair or adjacent cores shall not exceed 250 pF/m at a frequency of 1 kHz whereas the same shall not exceed 100 pF/m for PE insulated cables. The capacitance between any core and screen shall not exceed 400 pF/m at a frequency of 1 kHz.

1.4.6 L/R ratio of adjacent cores shall not exceed 40 μH/Ω for cables with 1.5 mm² conductor and 25 μH / Ω for cables with 0.5 mm² conductor.

1.4.7 The drain wire resistance including shield shall not exceed 30 ohms/km.

- 1.4.8 A pair of communication wire shall be provided for multipair/multitraid cables. Each wire shall be 0.5 mm^2 of plain annealed single or multi-strand copper conductor with 0.4 mm thick 85°C PVC insulation. Insulation shall be green and red colour coded.
- 1.4.9 Each multipair cables shall have 20% pairs as spare.
- 1.4.10 Running length of the cable shall be printed on the outer sheath at least at every 5 metre interval.
- 1.4.11 **Signal Cables**
- Single pair shielded signal/alarm cables shall be used between field instruments and junction boxes/local control panels.
 - Multipair individually and overall shielded signal/alarm cables shall be used between junction boxes/local control panels and control room, in general.
 - The single pair and triad cables shall be of 1.5 mm^2 conductor size made of electrolytic copper conductor of 7 strands with each strand of 0.53 mm diameter, multipair cables with 0.5 mm^2 conductor size shall have 16 strands of annealed electrolytic grade copper conductor with each strand of 0.2 mm diameter, multi triad cable or multi pair cable with 1.5 mm^2 conductor shall have 7 strands with each strand of 0.53 mm diameter, as per the job specification.
 - Shield shall be aluminium backed mylar/polyester tape bonded together with the metallic side down helically applied with either side having 25% overlap and 100% coverage. The minimum shield thickness shall be 0.05 mm in case of single pair/triad and 0.075 mm incase of multipair/triad cable.
 - Drain wire shall be provided for individual pair and overall shield which shall be 0.5 mm^2 multi stranded bare tinned annealed copper conductor. The drain wire shall be in continuous contact with aluminium side of the shield.
 - All multi pair cables shall have 6 pair/12 pairs only while multitriad cable shall have 6 triads/8 triads only.
- 1.4.12 **Control Cables**
- Single pair control cables shall be used between field mounted solenoid valves and junction boxes/local control panels and shall meet the requirements specified in para 1.4.11 above.
 - Multipair control cables shall be used between junction boxes/local control panel and control room mounted devices in general. These cables shall have only overall shielding.
 - These control cables shall have 1.5 sq mm conductor size with 7 stranded conductors of annealed electrolytic grade copper, with each strand of 0.53 mm diameter.
- 1.4.13 **Fieldbus Cables**
- Fieldbus cables shall be 16AWG (1.31 mm^2) for trunk and 18 AWG (0.82 mm^2) for spur twisted in pair individually and overall shielded with aluminium mylar tape with drain wire and armoured. Other parameters shall be as per Type A defined in IEC-61158-2.
 - Fieldbus cables shall be single pair or two pairs.
 - Field bus cable shall be field proven for FF applications.
 - Fieldbus cable shall comply with H1 cable test specification FF 844.
 - Outer jacket color shall be orange with 3 longitudinal blue stripes for spur cables and black stripes for trunk cables.

1.4.14 Thermocouple Extension Cables

- a) Single pair shielded thermocouple extension cables shall be used between thermocouple head and junction boxes/ transmitters/local control panel mounted instruments.
- b) Multipair individually and overall shielded thermocouple extension cables shall be used between junction boxes and control room mounted devices.
- c) The type of thermocouple extension cables shall be compatible with thermocouple used. In addition the colour coding of the primary insulation shall be as per IS-8784-1987 (R2004).
- d) The cable shall have 16 AWG and 20AWG solid conductors for single and multipairs respectively.
- e) All thermocouple extension cable shall be matched and calibrated in accordance with IEC-60584-2.
- f) Shield shall be aluminium backed by mylar/polyester tape bonded together helically applied with the metallic side down with either side having 25% overlap and 100% coverage. Minimum shield thickness shall be 0.05 mm for single pair and 0.075 mm for multipair cable. Drain wire shall be similar to individual pair and shall be in continuous contact with the aluminium side of the overall shield.
- g) Inductance shall not exceed 4mH/Km. However for J-type thermocouple inductance could be 8 mH/km.
- h) Electrostatic noise rejection ratio shall be over 76dB.
- i) All multi-pair cables shall have 6 pairs/12 pairs only.

1.4.17 Power Supply and Other Cables

- a) All power supply cables shall be as per IS-1554 Part I and shall have copper/aluminium conductors depending on conductor size. Minimum conductor size shall be 2.5 mm² of copper conductor. For higher sizes (above 16 mm²), aluminium conductor can be considered. All these cables shall be PVC insulated and armoured.

1.4.18 Any other special cable required for instruments shall also be supplied as per the requirement. Vendor shall ensure that these cables are armoured type and shall meet all other requirements specified in para 1.4.1 through 1.4.10, as applicable.

1.5 Cable Glands

- a) Vendor shall supply all cable glands required for glanding the above mentioned cables at field instrument side, local control panel side, junction boxes side and at control room side.
- b) All cables glands shall be of nickel-plated brass and shall be double compression type suitable for armoured cables.
- c) Flame proof glands wherever required shall be supplied with Ex (d) certification.
- d) PVC Cable shrouds shall be provided with all the cable glands.

1.6 Junction Boxes (Non-Fieldbus loops)

- a) Vendor shall supply junction boxes as per the cables selected, wherever required. These shall be of die cast aluminium alloy (min. LM-6) body and shall be weather proof to IP65 as a minimum.
- b) These boxes shall have terminals suitable for minimum 4.0 mm² cable termination mounted on rails. 20% spare terminals shall be supplied in each junction box.

- c) Telephone sockets and plugs shall be provided in junction boxes.
- d) Flame proof junction boxes shall be used in explosion proof/ flame-proof instruments circuits and supplied with Ex (d) certification. All such boxes shall be weatherproof also.
- e) Each junction box shall have a minimum 12 numbers of entries with 20% or 2 Nos. as spare entries for branch cable and minimum 2 numbers of entries for multipair cable with 1 No. spare. All entries shall be provided with suitable plugs.
- f) Suitable 3-way power junction box shall be considered for higher size of incomer power cable, which is not matching with the terminals provided in the control panel.

1.7 Junction Boxes for Fieldbus Loops

- 1.7.1 For Fieldbus segment, junction box shall be used for mounting the wiring/ terminal blocks to terminate the trunk and spurs in the fieldbus networks.

Unless otherwise specified, vendor must use the following type of terminal blocks:

For all FISCO signals	:	Weatherproof terminal blocks
For all safe signals	:	Weather proof terminal blocks
For all Explosion proof signals	:	Explosion proof/Flameproof terminal blocks

- 1.7.2 Junction box for Fieldbus field barrier concept:

Fieldbus junction boxes with field barrier assembly/ assemblies shall be provided. Not more than 12 spurs shall be considered in one junction box. Each junction shall not have more than two segments and no. of field barrier assemblies shall be considered accordingly. Field barrier assemblies in a segment shall be multidropped (shall not be daisy chained in a trunk). Only one closed loop can be considered per segment. Remaining spur connections in the segment can be used for open loop. For multi field barrier assembly in a junction box, Field barrier assemblies shall be DIN rail mounted. Vendor shall terminate the spare pair of trunk cable in DIN rail mounted terminal in junction box. One field barrier assembly shall contain:

- a) Isolation facilities (EEx de) for isolating the field barrier assembly from fieldbus trunk.
- b) Not more than 6 spur / barriers connections and Not more than one field device in each spur connection.
- c) Internal short circuit protection for each spur (short circuit current ≤ 45 mA)
- d) LED indicator for each spur short circuit.
- e) Each spur shall be galvanically isolated from trunk.
- f) Fieldbus terminator for each segment shall be inside junction box.

- 1.7.3 Housing of the fieldbus junction boxes shall be electropolished type SS 316.

- 1.7.4 Surge protectors on the field side shall be provided whenever specifically mentioned in job specification either within the FFJB or along with the instrument.

- 1.7.5 Sufficient spacing shall be provided inside the Junction Boxes for mounting of field barrier assemblies, termination and routing of Trunk/ Spur cables to the barrier/Megablocks, sufficient space shall be provided for installing terminator etc. inside the Junction Box.

- 1.7.6 For spur and trunk cables, 20 % addition cable entries must be provided. Unused entries shall be plugged.

1.7.7 Each junction box shall be provided with sufficient entries with weatherproof, flameproof plugs, as required. Trunk and spur entries shall be from the bottom.

1.8 Instrument Valves and Manifolds

- a) Vendor shall supply instrument valves (miniature type) and valve manifolds wherever required.
- b) The hydrostatic test pressure for instrument miniature valves shall be 153 Kg/cm²g for pipe class upto 600 and whereas for Instrument air lines, it shall be 41 Kg/cm²g. All valves and manifolds shall be forged type only.
- c) Valve body and trim material shall be 316 SS unless otherwise specified. Superior trim material shall be selected as required by process conditions. Packing material in general shall be of PTFE.

1.9 Impulse Piping/Tubing

- a) Vendor shall supply 1/2" OD x 0.065" thick ASTM A 269 TP 316 L stainless steel seamless tubes as a minimum for impulse lines.
- b) Where the pressure (operating) exceeds 70kg/cm²g or if piping is specified as impulse line, seamless pipes of size 1/2" NB of required thickness shall be supplied with material as per piping class.
- c) Seamless tubes shall have a hardness of max 80 RB as typical.
- d) Steam tracing shall be 10 mm OD copper tubes of electrolytic grade copper.
- e) Instrument air tubing shall be 6 mm SS316L.

1.10 Pipes and Tube Fittings

- a) Vendor shall supply flareless compression type of tube fitting and of three piece construction.
- b) The fitting/ferrule hardness shall not be less than RB 90 so as to ensure a minimum hardness difference of 5 to 10 between tube and fittings. The fitting/ferrule shall be of SS316 material.
- c) Socket-weld type forged pipe fittings of suitable material and rating shall be supplied for pipe fittings as per Piping Material Specification. The minimum rating shall be 3000 Lbs. Weld neck fittings shall be used where socket weld type are not allowed by piping class.
- d) Brass fittings, wherever used as per job specification, shall be suitable for use on copper tubes conforming to ASTM B68 /B68M hardness not exceeding RB 50. All fitting parts shall be manufactured from Brass as per IS-319 bar stock or equivalent and shall be nickel plated.
- e) All threaded fittings shall have NPT threads as per ANSI/ASME B 1.20.1 only.

1.11 Pneumatic Signal Tubes

- a) Vendor shall supply 6mm OD x 1mm thick SS316L tube for pneumatic signal tubes.
- b) Vendor shall avoid use of intermediate connections and shall estimate single length for each instrument location.

1.12 Instrument Air Lines Fittings and Valves

- a) Seamless galvanised, inside and outside, carbon steel pipes used for instrument air distribution shall be as per IS 1239 class Heavy. In view of difficulty in bending such pipes, elbows shall be used wherever bending is expected or A106 Gr B pipe shall be supplied.
- b) Galvanised forged screwed carbon steel screwed fittings of 2000 lbs rating fittings shall be used.
- c) Isolation valves on instrument air service shall be packless gland type full bore ball valves.

1.13 Air Filter Regulators

- a) Instrument air filter regulator of suitable size, range and capacity shall be supplied for each pneumatic instrument.
- b) The body of the filter shall be anodised aluminium.
- c) The filter shall have 5 micron sintered bronze filter element and shall be provided with manual drain and 2" nominal size pressure gauge.

1.14 Cable Trays and Cable Ducts

- a) All cables on the main pipe rack shall be laid in cable duct. Cable ducts shall be of galvanised mild steel with SS bolts and shall be fabricated as per 'Duct Fabrication-bolted Construction Details' standard No. 7-52-0254.
- b) All branch cables/tubes shall run on cable trays.
- c) These cable trays shall be made out of galvanised mild steel sheets of 2.5 mm thickness. Ladder trays shall be of galvanised mild steel. 50 mm x 50 mm x 6mm thick angle shall be used as a minimum.
- d) The width shall be so selected that 50% of tray space is available for future use.
- e) Suitable SS wire cable clamps shall be supplied for binding the cables/tubes at every 500 mm. Nuts/Bolts used for cable trays fixing shall be SS.
- f) FRP cable trays shall be provided when specified.

1.15 Instrument Support/Structural Steel

- a) Vendor shall supply instrument stands, stanchions and other structural steel material required for supporting the cable trays, impulse lines and instruments.

1.16 Heat Tracing and Insulation

- a) Heat tracing and insulation of line mounted instrument impulse lines shall be carried out as per line specifications. Similar philosophy shall also be followed for equipment mounted instruments. However, impulse lines for instruments/level instrument in congealing, viscous services shall also be steam traced even though the pipe/equipment not traced.
- b) Instruments mounted on jacketed lines and jacketed equipments shall be jacketed only. In case the jacketing of any particular instrument item is not possible, heat tracing may be selected after intimation to Owner/ Owner Representative before proceeding ahead.
- c) For all steam traced lines and steam jackets, a suitable type of steam trap must be provided for proper and efficient tracing. Separate dedicated steam trap shall be used for each instrument. Steam trap shall preferably be located on ground level with its

- outlet connected to drain funnel or as advised elsewhere in the package. Each instrument to be traced shall be provided with steam isolation valve.
- d) Wherever electric tracing is shown in the approved P&ID and selected for instruments and instrument lines, this must be suitable for the line temperature rating.
 - e) Steam tracing shall be avoided inside any room/ or shelter. The heat tracing required for analyzers shall be carried out by electrical tracing using prefabricated tube tracers.
 - f) Insulation of all in-line instruments like control valves, safety valves etc. shall be done as per the line requirements. Also all direct equipment mounted instruments like level gauge, displacer/float type instruments etc. shall be properly insulated as per insulation requirements of the equipment on which these are installed.
 - g) The insulation with 25 mm dia. Sodium silicate inhibited ceramic fiber rope (fiber glass / SS wire braided) by spiral winding in position, wrapping the rope around piping so as to cover the piping completely without leaving any gap, application of two layers of self adhesive aluminum foil tape (min 0.1 mm thick) spirally wound over the rope surface with the joints in two layers staggered. Ceramic fibre rope shall be of minimum density 250 kg/m³ shall be made up of ceramic fibre insulation with other properties of ceramic fibre rope confirming to 3.2.3 (1) of specification "6-44-0002 for hot insulation" work.
 - h) Steam tracing shall be considered for instrument impulse line for cryogenic services (i.e. operating temperature is less than 0°C).

2.0 INSTALLATION

- 2.1 Vendor shall be completely responsible for installation of all instruments within their battery limit, in line with the installation standards (typical) furnished alongwith package specification.
- 2.2 Whenever installation is beyond the scope of vendor/contractor, purchaser shall install the instruments as per the details/documents/drawings provided by the vendor/contractor. However, in such a case it must be ensured that complete installation materials shall be supplied.
- 2.3 All direct mounted instruments like thermocouples, thermowells, temperature gauges, pressure gauges, pressure switches etc. shall be installed in such a way that they have good readability and accessibility.
- 2.4 The capillary of all capillary type instruments shall be supported properly and shall be protected against mechanical damage.
- 2.5 All pressure/differential pressure instruments shall be provided with block and bleed/ bypass, drain/vent valves etc as per the installation standards, and shall have accessibility.
- 2.6 All primary piping/tubing (impulse lines) shall have a slope of 1 in 12 on the horizontal run.
- 2.7 All welding shall be carried out as per the relevant codes with proper electrodes. Any testing (non destructive) like DP test and radiography on root weld and final weld shall be carried out as applicable. All consumables shall be part of vendor's scope of supply. Any pre/post weld treatment as required by the relevant codes shall be carried out.
- 2.8 All threaded joints shall be joined by PTFE tapes only.
- 2.9 All impulse lines shall be supported at regular intervals.
- 2.10 Instrument drain/vent connections shall be piped to safe area like oily water sewer or above pipe racks to avoid accumulation of hazardous fluid in the plant atmosphere.

- 2.11 Steam tracing wherever required shall be carried out by 10 mm OD x 1 mm thick copper tubes and condensate traps shall be provided to collect all the condensate and shall be piped to the nearest pipe drain funnels.
- 2.12 All tubes/cables shall be properly laid on cable trays, which shall be supported at regular intervals.
- 2.13 Separate routing or physical separation shall be maintained between signal, shut down and power cables.
- 2.14 Wherever intrinsically safe system cabling is employed, the minimum separation of 150 mm shall be adhered between IS (intrinsically safe) and non- IS signal cables.
- 2.15 The cases of instruments shall be earthed by earthing wire to the nearest earth bus bar for safety reasons.
- 2.16 In case the cables are to be buried or laid in concrete trench the same shall be carried out by vendor. In case civil work is carried out by purchaser, requirement of trenches shall be provided with prior intimation to client.
- 2.17 Painting of angle trays, instrument supports and all structural supports shall be painted as under :-
- a) The surface to be painted shall be thoroughly cleaned with brush and sand paper to remove all scales. After cleaning, one coat of red oxide zinc chromate primer shall be given conforming to IS-2074 and allowed to dry. One coat of final paint shall be applied.
- Second and final coats of paint of final colour shall be given before handing over the plant/ commissioning.
- 2.18 **Installation of Systems (MMS, Analysers etc.)**
- 2.18.1 The system as applicable shall be installed by the system vendor who would be responsible for installation and termination of interconnecting cables in the system racks/cabinets. All interconnecting cables shall be identified and the individual cores/wires shall be properly identified using ferrules. Direct-cross ferruling method shall be used for identification.
- 2.18.2 All system communication cables shall be laid in covered GI (galvanised iron) trays away from power cables. Prefabricated cables shall be avoided for interconnection if these are to be routed outside the cabinets. If unavoidable these should be laid in covered GI trays.
- 2.18.3 All panels/cabinets shall be properly leveled and secured firmly with the base supporting structure. However, the consoles and printer stands need not be secured to base structure.
- 2.18.4 **Grounding**
- a) Each cabinet, console and other equipment supplied as a part of system shall have earthing lugs which shall be secured to the 'AC mains earthing bus'.
- b) All circuit grounds, shields and drain wires shall be connected to the 'system ground' bus which is isolated from 'AC mains earth'. This bus shall typically be 25 mm wide and 6 mm thick of copper.
- The total resistance of system ground shall be less than 5 ohms unless otherwise recommended by system manufacturer.
- c) Safety barriers, if used, shall be secured to 'Safety ground' which shall have typically ground resistance of less than 1 ohm. The bus shall be designed considering a fault level of 0.5 A at 250V r.m.s. per barrier.

- 2.18.5 All other installation guidelines as recommended by system manufacturer shall be followed.
- 3.0 TESTING AND CALIBRATION
- 3.1 All impulse lines shall be tested hydrostatically at 1.5 times the design pressure / maximum operating pressure. Ensure that instrument and vessel/piping is isolated during this test.
- 3.2 In case of special instruments/items where hydrotesting is not permitted due to service conditions, the impulse lines testing shall be carried out by using air or nitrogen.
- 3.3 After pressure testing, all these impulse lines shall be drained and dried with dry air for 15 minutes to remove any traces of moisture, oil and dust.
- 3.4 Instrument air lines shall be duly tested for any leak after pressurising and isolating the main root valve by soap solution and bubbler unit. After isolation, the rate of fall in pressure shall be less than 1 kPa for every 4.4 metre (1 psi for each 100 feet) of tubing for a test period of 2 minutes.
- 3.5 All instrument cables shall be tested for continuity and insulation. While meggering the cables for insulation testing, ensure that all instruments and barriers are isolated at both ends. The megger testing at site is not required to be carried out for the field bus cables and thermocouple extension cables. However, for field bus cables and thermocouple extension cables, the loop resistance and capacitance shall be checked by the contractor before and after the completion of cable laying.
- 3.6 All instruments supplied by the vendor shall be calibrated using proper test equipment.
- 3.7 All instruments shall be calibrated for 0%, 25%, 50%, 75%, 100% and vice versa.
- 3.8 All temperature gauges shall be calibrated using temperature baths.
- 3.9 All thermocouple activated instruments shall be calibrated by generating millivolts by a potentiometer.
- 3.10 All transmitters shall be calibrated as per instrument ranges.
- 3.11 All displacer type level transmitters shall be calibrated with water or suitable fluids and corrected for specific gravity.
- 3.12 All alarm and trip switches shall be calibrated over the entire range, finally set and checked for alarm/trip points and reset points as per the alarm/trip set point schedule. After setting, these shall be sealed.
- 3.13 All control valves, prior to stroke checking, shall be externally cleaned thoroughly. The full stroke of valve shall be checked for opening and closing. Any adjustment required for obtaining full stroke and reducing hysteresis shall be carried out. The hysteresis shall not be more than 1% URV (upper range value) with positioners and 5% URV without positioners.
- 3.14 Solenoid valve shall be checked functionally for its operation and also compatibility with respect to barrier.
- 3.15 Safety valves and relief valves shall be set/ tested by using dry air/nitrogen. Leakage if any shall be removed by proper lapping of seat and disc.
- 3.16 All electronic/pneumatic receiver instruments shall be calibrated as per the manufacturer's instructions. Controllers shall be aligned properly.

- 3.17 All special instruments like analyzer shall be checked and calibrated as per manufacturer's instructions. Prior to testing, all analyzer sample lines shall be thoroughly cleaned by carbon tetra chloride or any other cleaning liquid. After cleaning, these lines shall be thoroughly purged with dry nitrogen.
- 3.18 No oil should be used in oxygen and chlorine service lines.
- 3.19 The accuracy of overall loop shall be within 1% for electronic and 1.5% for pneumatic loops.
- 3.20 After performing the calibration of all instruments, the entire loop shall be checked for proper operation.
- 3.21 The entire shutdown scheme shall be simulated from the process trip switches/ control system and the scheme shall be tested for its proper operation prior to start up of the unit.
- 3.22 If no instrument air is available vendor shall provide necessary nitrogen cylinders with suitable regulators to carry out the above activity.

3.23 Testing Of Systems

- 3.23.1 All the system functions shall be checked thoroughly for proper functioning. These shall include but not limited to the following tests:

- a) Visual and mechanical.
- b) Complete system configuration loading.
- c) Demonstration of all system functions.
- d) Checking of all systems displays.
- e) Checking of correct functioning of all keyboards.
- f) Demonstration of all system diagnostics.
- g) Checking of proper functioning of all printers, hardcopy unit, and printing of all reports.
- h) Checking of all disc drives.
- i) Complete checking of logic system, loading of user's program and checkout of results.
- j) Checking of correct changeover of the back-up/redundant units in case of failure of main units.

Vendor shall also carryout the system checks as per respective items specifications wherever provided along with package.

- 3.23.2 The input signals shall be simulated by disconnecting the field wires for all inputs. Wherever control room mounted Transmitters/Converters/Receiver switches are used, the functioning of same shall also be checked.

3.24 Loop Checking

- 3.24.1 Loop checking shall be carried out by vendor, which shall include proper functioning and interconnection of all items in the loop.
- 3.24.2 All input signals shall be generated in the field and corresponding reading shall be checked at all corresponding displays.

All the outputs shall be checked in the field, by physical verification of valve stroke or operation of solenoid valve/pick-up of electrical contactor.

- 3.24.3 After loop checking is completed, vendor shall connect back any terminals and connections removed during loop checking.
- 3.24.4 For fieldbus loops the segment verification shall be carried out by DCS vendor. Any field side modifications required shall be carried out by vendor.
- 4.0 COMMISSIONING**
- 4.1 This activity shall be carried out in a systematic manner so as to avoid any accident to plant and operating personnel.
- 4.2 During the plant start up all the instruments calibration, controller alignment, trip point settings shall be trimmed so as to meet the operation requirements.
- 4.3 Prior to guarantee run of any package unit, the vital instruments as required by vendor have to be recalibrated and the results recorded.

Abbreviations:

CIF	:	Common Intermediate Format
CCD	:	Charge Coupled Device
CMOS	:	Complementary Metal Oxide Semiconductor
DCS	:	Distributed Control System
FRP	:	Fibre-Reinforced Plastic
FO	:	Fibre Optic
HDPE	:	High-Density Poly Ethylene
IP	:	Internet Protocol
ITU-T	:	International Telecommunication Union – Telecommunication
LED	:	Light Emitting Diode
MPEG	:	Moving Picture Experts Group
MJPEG	:	Motion Joint Photographic Experts Group
NTSC	:	National Television System Committee
NVMS	:	Network Video Management System
OSI	:	Open Systems Interconnection
PAL	:	Phase Alteration by Line
PLC	:	Programmable Logic Controller
SS	:	Stainless Steel
TAS	:	Terminal Automation System
TCP	:	Transmission Control Protocol
UDP	:	User Datagram Protocol

~~Instrumentation Standards Committee~~

~~Convener : Mr. Rajiv Gupta~~

~~Members : Mr. M. Nandi
Mr. ASD Barman
Mr. Sandeep Arora
Mr. S. Mahesh Kumar
Mr. N.P. Guha (Proj.)~~

1.0 GENERAL

1.1 Scope

1.1.1 This specification, defines the minimum functional requirements for the design, hardware, software and firmware specifications, nameplate marking, testing and shipping of Closed Circuit Television system (CCTV) designed for reliable, effective and optimum monitoring of a Plant / non-Plant area.

1.1.2 The related standards referred to herein and mentioned below shall be of the latest editions, unless otherwise specified.

ASME	American Society of Mechanical Engineers
B 1.20.1	Pipe Threads
B 16.5	Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard
EN 10204	Inspection Document for Metallic Products
IS/IEC	Indian Standards/ International Electro technical Commission
IS/IEC60079	Electrical Apparatus for Explosive Gas Atmospheres.
IS/IEC60529	Classification of degree of protection provided by enclosures.
IEC 60793-2	Optical Fibres, Part 2: Product specifications
IEC 60304	Standard colours for insulation for low-frequency cables and wires
IEC 60332	Tests on electric and optical fibre cables under fire conditions
IEC 60794-1-21	Optical Fibre Cables. Generic Specification - Basic optical cable test procedures - Mechanical tests methods
ITU-T G.652	Characteristics of a single-mode optical fibre and cable

1.1.3 In the event of any conflict between this standard specification, data sheets, statutory regulations, related standards, codes etc., the following order of priority shall govern:

- Statutory Regulations
- Job Specifications/ Data Sheets
- Standard Specification
- Codes and Standards

1.1.4 In addition to meeting purchaser's specifications in totality, vendor's extent of responsibility shall also include the following:

- Purchaser's data sheets indicate the minimum requirements of camera, video encoders, video management system, video recorders etc., however, this does not absolve the vendor of the responsibility for proper selection with respect to the following:
 - Selection of lens which shall have clear in focus image, brightness, contrast, focal length, camera, encoding techniques, selection of hardware and appropriate software for video management, selection of video recorder and its

sizing to meet the storage requirements mentioned in the datasheets, accessories etc for proper monitoring and control.

- ii) Selection of equipment suitable for the environmental conditions.
- b) Carryout complete application engineering so as to achieve the desired objectives with the stated performance requirements.
- c) Provide all hardware and latest secured version of software, as necessary, to meet functional requirements specified in the purchaser's specification.
- d) Adequacy of Bill of Material selected to meet purchaser's requirements including spares. Vendor to note that bill of material shall not be verified by the purchaser during evaluation stage. Any hardware, software and firmware required to meet the purchaser's specified requirements shall be provided by the vendor without any implication.

1.2 Bids

1.2.1 Vendor's quotation shall be strictly as per the bidding instructions to vendor attached with the requisition.

1.2.2 Vendor's technical offer shall include the following:

- a) Compliance to the specifications
- b) Detailed specification sheet for each item providing all the details regarding make and model, type, construction, Maximum and minimum viewable distance, Maximum tilt or pan angle possible, Pan and tilt speed, Allowable Voltage and frequency variations, Interconnecting cable and transceiver module specifications, utility requirement, Network Bandwidth requirements and calculations to support the same considering bus loading as 50% maximum, Hardware, software and licensing requirements, Storage calculations for video recorders.
- c) Detailed dimensional and sectional drawings including mounting details for all the units offered. All dimensions shall be in millimetres
- d) Block-diagram showing all units with model numbers
- e) Interconnection wiring diagram between the various components of CCTV system, including location of each item. The diagram shall show the size of cable and brief specification of the cable
- f) Proven references for the offered model of CCTV system in line with clause 1.2.3 of this specification
- g) A copy of approval from local statutory authority, as applicable, such as Petroleum and Explosives Safety Organization (PESO)/ Chief Controller of Explosives (CCOE), Nagpur or Director General of Mines Safety (DGMS) in India, for the electronic instruments installed in electrically hazardous area along with:
 - i) Test certificate from recognised test house like CIMFR (Central Institute of Mining and Fuel Research) / ERTL (Electronics Research & Test Laboratory) etc. for flameproof enclosure, as specified in the data sheet, as

per relevant standard for all Indian manufactured equipments or for items requiring DGMS approval.

ii) Certificate of conformity from agencies like LCIE (Laboratoire Central Des Industries Electriques), Baseefa, PTB, CSA, FM, UL (Underwriter's Laboratory), CE etc. for compliance to ATEX directives or other equivalent standards for all equipments manufactured outside India.

h) Power consumption for the complete CCTV system including accessories.

i) Deviations on technical requirements shall not be entertained. In case vendor has any valid technical reason, they must include a list of deviations clause wise, summing up all the deviations from the purchaser's data sheets and other technical specifications along with the technical reasons for each of these deviations

j) Catalogues giving detailed technical specifications, model decoding details and other information related to hardware and software for the items covered in the bid.

1.2.3 The equipment being offered / supplied shall be of latest proven version available in the current manufacturing range. The system hardware, software and firmware as offered, shall be field proven and should have been operating satisfactorily for a period of minimum 6 months continuously on the bid due date in the validly similar application specified in the purchaser's data sheet. Items with prototype design shall not be offered or supplied.

1.2.4 Vendor's quotation, catalogues, drawings, installation, operation and maintenance manuals shall be in English language.

1.2.5 Vendor shall also quote for the following:

a) All associated accessories and cables.

b) Two years operational and maintenance spares for all items including their accessories as per vendor's recommendation which shall include the following as a minimum:

i) Each type of electronic module

ii) Fuses

c) Any special tool or test equipment needed for calibration and maintenance work.

1.3 Drawings and Data

1.3.1 Detailed drawings, data, catalogues and manuals required shall be submitted by the vendor as per Vendor data requirement attached with the requisition.

1.3.2 Final documentation consisting of design data, installation manual, operation and maintenance manual etc. shall be submitted by vendor after placement of purchase order which shall include the following as a minimum:

a) Certified drawings for the CCTV system which shall provide the following information:

i) Overall dimensions in millimetres