

**INVITATION FOR TENDERS and TENDER DOCUMENT**

**For**

**SUPPLY AND INSTALL AND TEST AND COMMISSION OF SUBMERSIBLE PUMPAND PIPES WITH ALL ITS ACCESSORIES FRO TURRAH BORHOLE**

**TECHNICAL SPICIFICATION**

**ATTURAH BORHOLE –RAMTHA -IRBED**

**April 2019**

INVITATION FOR BIDS



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**SECTION I – TECHNICAL SPECIFICATIONS**

**FOR SUBMERSIBLE PUMPS**

**This specification covers the design, material, construction features, manufacture, inspection, testing the performance of Submersible Pumps.**

1. **Submersible Pump Description**

Pumping machinery should be supplied having standard ISO-9906 specifications, The pump type and material should be clearly mentioned, The characteristic curves showing the efficiency and performance of the pump and motor should be provided in the technical Data sheet and the quoted pump should be tested for its performance and certified as per ISO-9906 standard. The pump shall be centrifugal multistage type utilizing standard production parts and shall be well proven in design, quality of manufacturer and operational reliability.

1. The pump shall be free from unacceptable noise. The limiting sound pressure level of the pump-set with the motor coupled up at the pump closed valve head shall not exceed 94 dBA. measured to BS EN ISO 1680 at any point 1 m from the Pump set and shall be centrifugal type and of robust construction with all rotating parts carefully balanced to prevent undue vibration
2. The pump shall have stable characteristic performance over the entire head range mentioned. The pump shall be designed for the BEST EFFICIENCY at duty point that required at tender document.
3. **Pump Bowl:** The casting of bowl shall be free from blowholes and other defects. The pumpbowl / bowls shall be flanged with machine matching faces. The bowls shall be capable of withstanding a hydrostatic pressure equal to twice the pressure at rated capacity or 1.5 times the shut-off head whichever is greater.
4. **Pump impellers**: shall be properly machined with water passage hand finished to effect asmooth surface and minimum efficiency loss and shall be properly dynamically balanced on balancing equipment where applicable balance holes shall be provided in the impeller hub to reduce imposed axial thrust.
5. **Renewable wear ring:** The wear rings have to be fitted to the bowls to maintain goodefficiency while operation in different water quality conditions.



1. **Pump shaft and coupling:** The pump shaft diameter shall be sufficient to prevent distortionfrom the stresses imposed on them. Critical shaft speed shall be above maximum running speed.
2. **Shaft sleeve and shaft seal:** The pump shaft shall be protected by renewable sleeves ofgunmetal where in contact with water
3. **Guide bearing:** The shaft main guide bearing located in the suction and delivery housing of

the pump shall be provided with protection guards to prevent ingress of sand and incrustations (up to 25 g/m3).

1. **Pump bowl guide bearing:** shall be of approved abrasion-resistant materials. All bearingsshall be lubricated by water to be pumped.
2. **Pump delivery and housing**: shall incorporate a thrust washer of suitable material at theshaft end to absorb up-thrust that occur during pump starting.
3. **Check valve:** The pumps shall equipped with a reliable non-return valve in the vale casingto preventing back flow in connection with pump stoppage. and shall have short closing time to reduce the risk of destructive water hammer to a minimum. The valve casing shall designed for optimum hydraulic properties to minimize the pressure loss across the valve and thus to contribute to the high efficiency of the pump.
4. **Inlet strainer:** stainless steel strainer shall be provided on the pump suction housing castingfrom stainless steel to AISI 304.
5. **All screw, stud, nut, washer .. etc. :** stainless steel to AISI 316
6. The Pump efficiency shall not be less than 70% for pumps have shaft power more than 37kW and closest to 70% for pumps have shaft power less than 37kW.
7. The pump shall be provided with screwed connection **(no flange connection)** at the delivery housing (thread of riser pipes API-5L), adaptable to 4”,reducers should be provided
8. Priority of awarding will be to pump units complied with specifications and conditions and obtain less number of stages and length.
9. The difference between the borehole diameter given in the bill of quantities and the maximum diameter of the offered pump shall not be less than **37 mm**.
10. A certified factory performance test according to BS EN ISO 9906:2012 should be attached.
11. Every pumping unit shall provide with a reducer 4 inch or 6 inch depend on its flow capacity ( reducer 4 inch for flow less than 70 m3/h , and reducer 6 inch for flow more than 70 m3/h )



1. **Submersible Motor Description**

The Motor shall be manufactured in compliance with National Electrical Manufacturer Association (NEMA) standards required three-phase motor shall be capable of operating at rated voltage of 400 Volts at 50 Hz. The motor should be capable of handling 10% variance in voltage and service factor 1.15. Winding of the motor shall rewind-able type with **class-IC40 insulation** and IP68 protection. The synchronous speed for 2-poles 2850 – 2950 RPM. Motor shall be capable of operation in well water with temperature normally start from 40 ºC. Motor should be designed for continuous operation.

The origin, make and material of the motor should be clearly mentioned in the technical Data Sheet. The winding material should be 99.99% copper with (PE+PA) Insulation class Y . The motor should wet type, water cooled rewind-able/repairable stator. The motor should have non-disposable / non-hermetically sealed winding. The insulation class of the winding material should be mentioned. For each model quoted, all the technical parameters such as rated voltage, Power factor, efficiency, full load ampere, speed and other similar parameters should be provided in the technical data sheet.

1. The rated motor power output shall be not less than (110~125) % of the maximum power absorbed by the pump over the entire pump operating range specified. The foregoing power margin shall not be reduced by any factors such as tolerances of pump-set or accuracy of test equipment.
2. All motors have to be selected according to the borehole casing diameters given in the bill of quantities.
3. The Submersible Motor shall be "wet“ squirrel cage induction type designed to operate continuously under submerged conditions and shall comply with the requirements of the **IEC** **Publications 34** , rewind-able type
4. **The motors have to be designed to the following specifications:-**
   * Have to be selected for starting with Autotransformers - reduced voltage throughout the starting sequence (tapping about 70%),
   * The winding shall be insulated with an approved heat resistant material (PE2+PA) two layers.
   * Allow 8 to 10 consecutive starts in one hour when the motor is cold and 6 starts when the motor is hot.
   * Shall be provided with a heavy duty multi pad thrust bearing at the base of the motor to

absorb the shaft down thrust developed by the pump. The bearing design shall



incorporate tilting thrust pads of bronze or stainless steel arrange to self-adjustment according to thrust load. The thrust disc shall be of the same material sheltered with suitable carbon based (fibre, graphite) or similar approved material.

* Motor must be filled with water without any chemical additives hazards to health for cooling. The motor must be properly protected against the entry of well water sand … etc. by double mechanical seal one is rotating and other stationery and must be made of silicon carbide and must be protected with sand protection guards.
* All motors have to be equipped with thermal protections (3-wire PT-100 system) thermally contacted to the windings at the upper part of the motor to protect the windings and thrust bearing against damage.
* The excessive pressure due to heating up of the filled water must be compensated by a pressure equalizing Nitrile Rubber diaphragm in the lower part of motor.
* Has to be equipped with 5 meter EPDM cable (ethylene propylene diene monomer) and should be made of 99.9% copper double insulated marine cables, which are allowed to be used in drinking water, with tinned annealed copper conductors. The cable alongside the pump casing shall be covered with a stainless steel plate screwed on the pump bowls.

Working up to a cooling velocity of **0.2 m/s** - upstream the motor.



**Material of construction**

The pump shall be manufactured from the following materials or from material superior to the following.

**1.1**

|  |  |  |
| --- | --- | --- |
| Casing ( Pump Bowl ) | AISI 304, EN1.4301 | |
|  |  | |
| Impeller | AISI 304, EN1.4301 | |
|  |  | |
| Wear Rings | AISI 304, EN1.4301, NBR | |
|  |  | |
| Shaft and coupling | AISI 316, EN1.4401 | |
|  |  |  |
| Shaft sleeve | AISI 316, | EN1.4401 |
|  |  | |
| Bearing bush, Guide bearing | AISI 316, EN1.4401 | |
|  |  | |
| Pump delivery and Housing | AISI 304, EN1.4301 | |
|  |  | |
| Check valve ( None Return Valve ) | AISI 304, EN1.4301 | |
|  |  |  |
| Inlet strainer | AISI 304, | EN1.4301 |
|  |  |  |
| Screw, stud, nut, washer... etc. | AISI 316, | EN1.4401 |
|  |  |  |
|  |  |  |
| **1.2 General Specifications** |  |  |
|  |  | |
| Motor Service Factor ( SF ) | 1.15 | |
|  |  | |
| Wire Material | 99.9 Copper | |
|  |  | |
| Insulation Material and Class | PE2+PA, F | |
|  |  | |
| Motor Speed | 3000 RPM - 5% | |
|  |  | |
| Protection degree | IP 68 | |
|  |  | |
| Temperature sensor | PT100 | |
|  |  | |
| Water cooling | Water | |
|  |  | |
| Motor Cable | EPDM | |
|  |  |  |

Motor: 2 Pole, 3 ph, 400 V  10%, 50 Hz1%, cos ø ≥ 0.85, M eff ≥ 0.85%, NEMA Shaft

|  |  |  |  |
| --- | --- | --- | --- |
|  |  |  | |
|  |  |  |  |
| **1.3 Submersible Motor Material Specifications** | |  |  |
|  |  |  | |
| Shaft |  | AISI 304, EN1.4301, EN 1.0533 |  |
|  |  |  |  |
| Shaft Seal (Mechanical Seal ) |  | Tungsten carbide/ceramic |  |
|  |  |  |  |
| Motor Sleeve |  | AISI 304, EN 1.4301 |  |
|  |  |  |  |
| Motor Housing |  | GG20/GG25 |  |
|  |  |  |  |
| Diaphram |  | Nitrile Rubber |  |
|  |  |  |  |
| Radial Bearing ( Guide Bearing ) |  | Graphite |  |
|  |  |  |  |
| Axial Bearing ( Thrust Bearing ) |  | Graphite/ S.S Pads |  |
|  |  |  |  |
| Rubber Parts |  | NBR |  |
|  |  |  |  |

OR

The pump shall be manufactured from the following materials or from material superior to the following.

**1.1**

|  |  |
| --- | --- |
| Casing ( Pump Bowl ) | BS EN 1561 |
|  |  |
| Impeller | CC 480k |
|  |  |
| Wear Rings | CC 480K/NBR. AISI 316/ BS EN 1561 |
|  |  |
| Shaft and coupling | AISI 316, AISI 431, AISI 420 |
|  |  |
| Shaft sleeve | AISI 431, gunmetal, CC 491k |
|  |  |
| Bearing bush, Guide bearing | AISI 316, CC 480k, NBR |
|  |  |
| Pump delivery and Housing | BS EN 1561 |
|  |  |
| Check valve ( None Return Valve ) | BS EN 1561 |
|  |  |
| Inlet strainer | AISI 304 |
|  |  |
| Screw, stud, nut, washer.. etc | AISI 316 |
|  |  |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  |  |  | |
|  |  |  |  |  |  |
|  | **1.3 Submersible Motor Material Specifications** | | |  |  |
|  |  |  |  |  |  |
|  | Shaft | |  | AISI 304, EN1.4301, EN 1.0533 |  |
|  |  |  |  |  |  |
|  | Shaft Seal (Mechanical Seal ) | |  | Tungsten carbide/ceramic |  |
|  |  |  |  |  |  |
|  | Motor Sleeve | |  | AISI 304, EN 1.4301 |  |
|  |  |  |  |  |  |
|  | Motor Housing | |  | GG20/GG25 |  |
|  |  |  |  |  |  |
|  | Diaphram | |  | Nitrile Rubber |  |
|  |  |  |  |  |  |
|  | Radial Bearing ( Guide Bearing ) | |  | Graphite |  |
|  |  |  |  |  |  |
|  | Axial Bearing ( Thrust Bearing ) | |  | Graphite/ S.S Pads |  |
|  |  |  |  |  |  |
|  |  |  | |  | |
|  | Rubber Parts |  |  | NBR |  |
|  |  |  |  |  |  |
|  | **1.2 General Specifications** | | |  |  |
|  |  | | |  |  |
|  | Motor Service Factor ( SF ) | |  | 1.15 |  |
|  |  | |  |  |  |
|  | Wire Material | |  | 99.9 Copper | |
|  |  | |  |  |  |
|  | Insulation Material and Class | |  | PE2+PA, F | |
|  |  | |  |  |  |
|  | Motor Speed | |  | 3000 RPM - 5% | |
|  |  | |  |  |  |
|  | Protection degree | |  | IP 68 | |
|  |  | |  |  |  |
|  | Temperature sensor | |  | PT100 | |
|  |  | |  |  |  |
|  | Water cooling | |  | Water | |
|  |  | |  |  |  |
|  | Motor Cable | |  | EPDM | |
|  |  |  |  |  |  |



Motor: 2 Pole, 3 ph, 400 V  10%, 50 Hz1%, cos ø ≥ 0.85, M eff ≥ 0.85%, NEMA Shaft end

**Compliance Sheet for Submersible Pumps**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  | | |  |
|  |  |  |  |  |  | |  |  |  |  |
|  |  |  |  |  |  | |  |  |  |  |
|  |  |  |  |  | **Submersible Pump – Specifications sheet 1)** | | | |  |  |
|  |  | **Item NO.** | | **Q:** | **m3/h H:** | **m** | | **ISO STANDARDS** |  |  |
|  |  |  |  |  |  |  |  | **NO:** |  |  |
|  | **No.** |  |  |  | **DESCRIPTION** |  |  | **DATA** | **UNIT** |  |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  | |  |  |  |  |  |
|  | **1** |  |  | **Pump type** | |  |  |  |  |  |
|  | **2** |  |  |  | **Capacity** |  | **m3/h** |  |  |  |
|  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  | **3** |  |  |  | **Head** |  | **m** |  |  |  |
|  | **4** |  | **Pump Maximum Diameter As BOQ** | | |  |  |  |  |  |
|  |  |  |  |  |  |  | **≥37mm** |  |  |  |
|  | **5** |  | **Clearance(well dia-pump max dia)** | | |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
|  | **6** |  |  | **Number Of Stages** | |  |  |  |  |  |
|  | **7** |  | **Pump Efficiency At Duty Point** | | |  | **≥78%** |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  | **8** |  | **Pump Power At Duty Point** | | |  | **kW** |  |  |  |
|  | **9** |  | **Casing Material ( Pump Bowl )** | | |  |  |  |  |  |
|  | **10** |  |  | **Impeller Material** | |  |  |  |  |  |
|  | **11** |  |  | **Wear Rings Material** | |  |  |  |  |  |
|  | **12** |  | **Shaft Material and coupling** | | |  |  |  |  |  |
|  | **13** |  |  | **Shaft sleeve** | |  |  |  |  |  |
|  | **14** |  |  | **Bearings bush** | |  |  |  |  |  |
|  | **15** |  |  | **Strainer Material** | |  |  |  |  |  |
|  | **16** |  | **Screw, stud, nut, washer, ... etc.** | | |  |  |  |  |  |
|  | **17** |  |  | **Check valve** | |  |  |  |  |  |
|  | **18** |  |  | **Manufacturer** | |  |  |  |  |  |
|  | **19** |  |  | **Motor Type** | |  |  |  |  |  |
|  | **20** |  | **Motor Maximum Diameter** | | |  | **mm** |  | **mm** |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  | **21** |  |  | **Motor Power** | |  | **kW** |  | **kW** |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  | **22** |  |  | **Nominal Current** | |  | **A** |  | **A** |  |
|  | **23** |  | **Motor Efficiency At Duty Point** | | |  | **%** |  | **%** |  |
|  | **24** |  |  | **Motor Speed at duty point** | |  | **rpm** |  | **rpm** |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  |  | | |  |  |
|  |  |  |  | | |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  | **25** | **Diaphragm material** | **EPDM** |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |  |
|  | **26** | **Diaphragm bowl Cover Material** |  |  |  |  |
|  | **27** | **Mechanical Seal/Sand Guard** |  |  |  |  |
|  | **28** | **Thrust Bearing Material** |  |  |  |  |
|  |  |  | **EPDM** |  |  |  |
|  | **29** | M**otor cable insulation material** | **&EPR** |  |  |  |
|  |  |  |  |  |  |  |
|  | **30** | **Motor Feeder Cable Length** | **m** |  | **m** |  |
|  | **31** | **Motor Protection Class (IP)** | **IP68** |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  | **PE2+PA** |  |  |  |
|  | **32** | **Wire Winding Insulation Material** |  |  |  |  |
|  |  |  |  |  |  |  |
|  | **33** | **Motor Winding Insulation Class** | **F** |  |  |  |
|  | **34** | **Motor Guide Bearing material** |  |  |  |  |
|  | **35** | **Filling Cooling Liquid** |  |  |  |  |
|  |  |  |  |  |  |  |
|  | **36** | **Rubber parts** | **NBR90** |  |  |  |
|  |  |  |  |  |  |  |
|  | **37** | **Sensor Thermal Protection Type** | **PT100** |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |  |
|  | **38** | **Overall Efficiency At Duty Point** | **%** |  | **%** |  |
|  | **39** | **Withstanding Maximum water** | **OC** |  | **OC** |  |
|  |  | **Temperature** |  |  |  |  |
|  | **40** | **Pump overall length** |  |  |  |  |
|  |  | **Country OF Origin** |  |  |  |  |
|  |  | **Year Of Manufacture** |  |  |  |  |
|  |  | **Remark** |  |  |  |  |

1. **NOTES :**

***This specification sheet must be completely filled - in by the bidder and submitted with the offer.***

**The bidder shall submit along with his offer the following documents:**

* original characteristic curves showing flow, head, power consumption, efficiency, operation range and NPSH (a photo copy of the curves will not be accepted)



* Installation, operation of maintenance instructions, workshop manuals and two copies each. Relevant standards used in the material, production and testing Certificate of testing according to **ISO 9906c** grade 1. Complete offer has to be submitted containing the following technical documents.
* All parts and material are eligible to be tested according to standards and specifications at **Royal Scientific Society** mechanical design and technology center

**The attached details sheet must be completely filled for every item (all materials of the submersible pump and motor parts have to be specified).**

**Original characteristic curves have to be clearly marked at the duty point (specified in the bill of quantities) showing flow, head, power consumption, efficiency (motor & pump), operation range and NPSH. Incomplete offers will be rejected.**



|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| No. | Item | Description | Unit | Quantity | Unit Price | Total Price |
| 1 | Submersible Pump | Submersible pump with flow rate (Q)=50m³/h, Head (H)=380m, maximum Casing Diameter= 9 inch | No. |  |  |  |
| 2 | Motor | ------------------ |  |  |  |  |
|
| Total price | | |  | | | |

**SECTION II – BILL OF QUANTITIES FOR SUBMERSIBLE PUMP**

**TOTAL PRICE: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Total Price in Words: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Total Price after Discount (If any):\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Bidder Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Bidder Phone: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Bidder Email: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Stamp and Signature of the Bidder: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**THE DELIVERY PERIOD OF THE SUBMERSIBLE PUMPS SHALL NOT EXCEED 75 (SEVENTRY FIVE) CALENDAR DAYS**



**SECTION III – TECHNICAL SPECIFICATIONS**

**OF PIPES AND ACCESSORIES**

**A)** **Steel Riser (Column) Pipes**

The riser pipes shall be in accordance with Standard API-5L, GRADE-B (or equivalent) line Black Steel or galvanized steel or epoxy coated steel pipe. The pipe shall be seamless or seam welded by ERW and shall be threaded from both sides according to API-5L, 8 threads per inch, pipe length shall be 6m without coupling).

A) The thickness and the test pressure shall not be less than mentioned below.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Nominal Size** | | **Outside diameter** | **Wall Thickness** | **Test Pressure** |
| Inch | DN | mm | mm | PSI |
| 4 | 100 | 114.3 | 6.00 | 1300 |

**B) Working Pressure**:

The working pressure for the pipes shall not be less than 50 bars.

**C) Pipe joint and jointing:**

The pipes shall be threaded from both sides 8 threads per inch according to API – 5L. each pipe shall be provided with coupling. Long type coupling 20 – 25 cm. threaded from inside must be according to API – 5L; and provide with the other end with protector to prevent damage of thread.

The pipe and couplers when joint together must be aligned through the depth of the bore holes which reach to 600 m, and shall not have deflection through this distance.

The threading for both pipes and couplings shall be done by the manufacturer of the pipes and shall not have any failure during threading. The pipes and coupling must be suitable to be used with submersible pump and bore holes in which depth reach 600m. so it must be strong enough to carry the pump set, the weight of the pipes and water column to withstand the

Vibration of the pump set and the pressure of the water when the valves shut during the operation of the pump set.

**Marking**

The pipes shall be marked with the manufacture's symbol or mark plus the code number of standard specification and inspector stamp. The pipes shall also be stamped with the initials WAJ

EVERY COUPLING MUST BE FIXED VERY TIGHT TO THE END OF THREADING.

The bidder should provide the following data in his bid:

|  |  |
| --- | --- |
| Description | Data |
| Standard of pipe |  |
| Standard of threading |  |
| Standard Of coupling |  |
| Length of pipe |  |
| Length of threading on pipe side |  |
| Length of coupling |  |
| Thickness of pipe |  |
| Thickness of coupling |  |
| Test pressure of pipe |  |
| Total number of threads on pipe side |  |
| Number of threads per inch |  |
| Taper size of threads |  |





**B) PVC Pipes 2 inch**

Plastic piping systems should be Supplied, Installed, and Operated in accordance with ESTABLISHED DESIGN AND ENGINEERING STANDARDS AND PROCEDURES for plastic piping systems. The installer should determine suitability for the intended service application prior to installation of a plastic piping system.

The pipe and fittings shall be homogeneous, made of PVC (Polyvinyl chloride) throughout, and free of visible cracks, holes, foreign inclusions, or other injurious defects. The pipe shall be as uniform as commercially practicable in color, opacity, density, and other physical properties as per ASTM D 2665 Standards with 1-inch diameter pipes.

All piping system components should be inspected for damage or irregularities. Mating components should be checked to assure that tolerances and engagements are compatible.



**SECTION V – TECHNICAL SPECIFICATIONS**

**FOR ROUND AND FLAT RUBBER CABLES**

**Flexible Flat Cables for Submersible Pumps**

***Specification and Standard:*** The flexible FLAT cables shall be used for submersible pumps inboreholes and shall be suitable for underground water use. The flexible cables shall also be thermal resistant for constant operation at 60ºC. Conductor's temperature shall be not more than 90ºC. The minimum permissible working temperature shall not be more than (5ºC). Therefore, the cables must be suitable for these conditions of operations.

The cable shall be "3" core annealed tinned copper conductor. The cables shall have single layer insulation. The insulation material must be **Rubber.** It also must be sheathed with **double layer** sheath according to the specified standard.

The working voltage for the cables shall be 450/750 volts at 50 c/s.

The test voltage and other tests shall comply with the specified standard mentioned here or other approved standard and these tests shall be conducted, done, and certified from local laboratory at the cost of the Contractor. The cables must be highly flexible and physically resistive to shock, friction and bending.

The cables shall comply with BS6007/1983, or BS6899/1994, or other equivalent approved standard.

The Contractor shall fulfill all specifications mentioned herein, completely, in addition to all specifications according to the cable-applied standard which also must be submitted with the offer at the bedding time.

***Cable Length and Packing:*** Any one place of cable shall have a length of not less than 600meters and must be wrapped on wooden drum. In order to prevent moisture penetration; both ends must be sealed. All detail such as the size, weight, length, specifications, origin, date, manufacturer, etc. must be marked on the drum wood by non-erasable water proof painting, engravings, or pressed letters on a large metallic plate attached firmly to the drum side.

***Cable marking:*** The outer surface of the cable shall bear sequentially numbered length markersspaced one meter, this gradation shall be clear and non-rubbing off.

***Cross-Sectional Area:*** The cross-sectional area of copper in each core shall be according to whatmentioned in the Bill of Quantities.

***Submittals:*** The bidders must provide along with their bids full technical details and catalogues.A free sample should be submitted with the bid of each item. The bidders must also write down the complete information mentioned in the attached table (Item 5).



**Flexible Round Cables for External Use – Size 1\*2.5 mm2**

***Specification and Standards:*** The flexible Round or Sector cables shall be suitable forunderground water use. The flexible cables shall also be thermal resistant for constant operation at 60ºC, Conductor's temperature shall be not more than 90ºC.

The minimum permissible working temperature shall not be more than (5ºC). Therefore, the cables must be suitable for these conditions of operations.

The cable shall be one core annealed tinned copper conductor. The cables shall have single layer insulation. The insulation material must be Rubber. It also must be sheathed with single or double layer sheath according to the specified standard.

The working voltage for the cables shall be 450/750 volts at 50 c/s.

The test voltage and other tests shall comply with the specified standard mentioned here or other approved standard and these tests shall be conducted, done, and certified from local laboratory at the cost of the Contractor. The cables must be highly flexible and physically resistive to shock, friction and bending.

The cables shall comply with BS6007/1983, or BS6899/1994, or other equivalent approved standard.

The Contractor shall fulfill all specifications mentioned herein, completely, in addition to all specifications according to the cable-applied standard that also must be submitted with the offer at the bedding time.

***Cable Length and Packing:*** Any one place of cable shall have a length of not less than 600meters and must be wrapped on wooden drum. In order to prevent moisture penetration; both ends must be sealed. All detail such as the size, weight, length, specifications, origin, date, manufacturer, etc., must be marked on the drum wood by non-erasable waterproof painting, engravings, or pressed letters on a large metallic plate attached firmly to the drum side.

***Cross-Sectional Area:*** The cross-sectional area of copper in each core shall be according to whatmentioned in the Bill of Quantities.

***Submittals:*** The bidders must provide along with their bids full technical details and catalogues.A free sample should be submitted with the bid of each item. The bidders must also write down the complete information mentioned in the attached table (Item 5).



**Compliance Sheet for Round and Flat Rubber Cables**

**Flat Cables Details (This Part must be filled by the CONTRACTOR)**

**Conductor:**

Cross Sectional Area Copper

Material

Shape

Number of wires in Each Core

Dia. Of Wire

**Installation:**

Material

Thickness

Number of Insulation Layers

**Sheath:**

Material

Thickness

Overall Dia.

**Applications:**

Max Permissible Continuous Conductor Temp.

Min. Permissible Continuous Conductor Temp.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  | | | |
|  |  |  | |  | |
| Min. Bending Radius with fixed Installation | |  | |  | |
| Min. Bending Radius with flexible Installation | |  | |  | |
|  | |  | |
|  | |  |  | |  | |
| Net Weight | | *Kg/Km* | | | |
|  | |  |  | |  | |
| Max. Conductor Resistance at 20ºC | | *ohm/Km* | | | |
|  | |  |  | |  | |
| Current Rating Continuous at 25ºC Ambient | | *Amps* | | | |
| temp. | |  | |  | |
| Test Voltage | |  | |  | |
|  | |  | |
| Working Voltage | |  | |  | |
|  | |  | |
| Type of Cable | |  | |  | |
|  | |  | |
| Manufacturer | |  | |  | |
|  | |  | |
| Country of Origin | |  | |  | |
|  | |  | |
| Date of Delivery | |  | |  | |
|  | |  | |
|  | |  |  | |  | |



**Flat Cables Details (This Part must be filled by the Supplier)**

**Conductor:**

Cross Sectional Area Copper



Material



Shape



Number of wires in Each Core



Dia. Of Wire



**Installation:**

Material



Thickness



Number of Insulation Layers



**Sheath:**

Material



Thickness



Overall Dia.



**Applications:**

Max Permissible Continuous Conductor Temp.

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | | |
|  |  | GENRAL CONDITIONS OF CONTRACT | |
|  |  |  |  |
| Min. Permissible Continuous Conductor Temp. | |  |  |
| Min. Bending Radius with fixed Installation | |  |  |
|  |  |
| Min. Bending Radius with flexible Installation | |  |  |
|  |  |
|  | |  |  |
| Net Weight | | *Kg/Km* | |
|  | |  |  |
| Max. Conductor Resistance at 20ºC | | *ohm/Km* | |
|  | |  |  |
| Current Rating Continuous at 25ºC Ambient | | *Amps* | |

temp.

Test Voltage

Working Voltage

Type of Cable

Manufacturer

Country of Origin

Date of Delivery





**SECTION VII – TECHNICAL SPECIFICATIONS**

**FOR Variable speed drive**

* 1. **DESCRIPTION OF WORK**

**A.** Extent of Work: The work to be performed includes, but is not necessarily limited to, all electrical works involved with the construction and assembly of a complete electrical lighting and power system.

**B.** Electrical work for the lighting and power system construction includes the erection, assembly and testing of the following types of electrical equipment:

1. Electrical Raceways.

2. Cables, Wires and Connectors.

3. Variable speed drive and Electrical Boxes and Fittings.

4. Distribution Switchboards.

5. Wiring Devices.

**1.02 SUBMITTALS**

**A.** Manufacturer's data and drawings shall be submitted in the order of priority, which reflects the logical sequence of construction requirements and project schedule logistics and as agreed with the Engineer.

**B.** Submit dimensioned drawings of power and lighting systems showing layout of raceways and fittings, spatial relationships to associated equipment and adjoining raceways, if any. Show wiring and connection to electrical distribution boards and panel-boards schedules.

**2.01 MATERIALS, EQUIPMENT AND FABRICATION**

**A.** **Electrical Raceways:**

1. Scope:

This specification sets forth the requirements for the electrical raceways including, but not necessarily limited to, rigid steel conduit, flexible metal conduit, liquid-tight flexible metal conduit and plastic conduit.

2. Metal conduit:

Rigid Steel Conduits: Rigid steel conduit shall be used for exposed installations and shall be hot-dipped galvanized over the entire length, including the threads.

3. Installation Requirements:

a. General: Conduits shall be installed complete with all access, fittings and boxes in an approved and workmanlike manner, so as to provide proper raceways for electrical conductors.

Sleeves shall be for exposed conduits running through floor slabs or interior walls and they shall be properly sealed.

b. Exposed Conduits: Exposed conduits shall be installed parallel or at right angles to the walls and ceiling beams, with approved conduit bends or pull boxes where conduits change direction.

Steel conduits shall be securely held in place by suitable steel hangers or clips mounted at not more than 1.5m on centers. Expansion bolts shall be used in masonry or concrete, and bolts or machine screws in properly tapped holes in steel works. Cast-in-place inserts shall be used in concrete.

Exposed conduits installed in outdoor walls or interior walls in wet places shall be galvanized steel and shall be installed in a secure and weatherproof manner.

All exposed conduits used in a single run or circuit shall be of the same type and finish.



All hangers and other steel parts shall be galvanized.

4. Cutting and Threading:

All conduits where cut shall be carefully reamed to remove burrs.

5. Conduit Cleaning:

All conduits shall be carefully cleaned before and after installation, all ends shall be reamed free of burrs and inside surfaces shall be free from all imperfections likely to injure the cable.

6. Conduit Application:

Heavy gauge PVC conduits unless otherwise indicated on the Drawings, are to be used throughout embedded, in chases and underground installation for lighting, power circuits.

Flexible steel conduits with PVC sheath are to be used for terminating connections to motors and vibrating equipment where heavy gauge galvanized steel conduits are used.

Heavy gauge (rigid) galvanized steel conduits are to be used for all exposed installations and as shown on the drawings.

**B. Low Voltage Wire / Cable and Connectors:**

1. Wire and Cable Sizes:

Wire and cable sizes shall be as indicated on the drawings; the minimum conductor sizes shall be 1.5 mm² for lighting and 4 mm² power, 1.5 mm² for control circuits, supervisory controls, fire alarms and intercommunications.

2. Wire and Cable Types:

a. General: Unless otherwise specified, wires and cables shall be fabricated of stranded copper conductors in accordance with BS 6360.

i) General: Cables are single-core insulated or multicore insulated and sheathed conductors for indoor/outdoor use, for in ducts or direct buried applications.

Cables for indoor use shall be unarmored with a separate earth conductor. Cables for outdoor use shall be armored with galvanized steel wire.

ii) Low Voltage Cables shall be XLPE (cross-linked polyethylene) insulated, rated at 600/1000 V & shall comply with BS 5467. Armored cables shall be sheathed with PVC.

b. Wires and cables shall be factory color coded by integral pigmentation with a separate color for each phase and neutral conductor. The color code shall be used consistently throughout the electrical system.

3. Boxes:

a. Standard, steel-metal, outlet and junction boxes shall be constructed of code-gauge, galvanized sheet steel. The size of each box shall not be less than that required by the National Electrical Code. Boxes used for hanging fixtures shall contain fixture studs. Boxes for installation in concrete shall be concrete tight. Shallow boxes shall not be used unless building construction is such that it is impossible to use standard depth boxes.

b. Non-metallic PVC type boxes shall be used where rigid PVC conduit is used. Provisions for support or other mounting means for non-metallic boxes shall be outside of the box or the box shall be provided with grounding lugs for grounding all electrical devices installed in the box.

4. Fittings:

a. Fittings for all conduit types shall be of the same material as the conduit. When installed in wet locations and underground, they shall provide a watertight joint.

b. Fittings for rigid metal conduit shall be galvanized and have tapered threads to match those of the conduit.



c. Couplings and fittings for PVC externally coated, rigid steel conduit shall include an integral, bonded, overlapping pressure-sealing sleeve of the same insulation thickness. The sleeves shall extend one pipe diameter or the 50 mm (whichever is less) beyond the end of the coupling. When coupled together, the sleeve of the coupling shall make a watertight fit with the plastic jacket on the conduit.

5. Sleeves:

a. Sleeves shall be provided for exposed conduits or cables passing through interior floor slabs and walls. All openings shall be caulked with jute and suitable caulking compound. The compound shall not cause any corrosion or harmful effects to the conduit. Sleeves passing through floor slabs shall be flush with the bottom of the slab, extend approximately 25 mm above the surface of the floor, and be watertight between sleeve and floor slab.

**C. Main Distribution Board:**

1. Scope: This specification sets forth the requirements for the main distribution board to be installed indoors and to be used for the distribution of power to lighting, power, pumps & pumps control panels.

2. Description:

a. Distribution board shall be furnished with incoming line main circuit breaker in individually mounted construction, and the feeder circuit breakers in group-mounted construction. The incoming line main circuit breaker shall be front accessible through bolted-on covers. The group-mounted circuit breakers, front accessible per NEMA Standards, shall be furnished with wiring gutters on the front of the distribution vertical sections of the switchboard. The gutters shall be furnished with code gage, steel formed covers bolted to the structure frame. Unused space circuit breakers shall be covered with blank code gage steel formed covers.

b. Distribution board shall be completely self-supporting structure of the required number of vertical sections bolted together to form one metal enclosed switchboard. Sides, top and rear covers shall be code gage steel, bolted to the switchboard structure. The frame structure members shall be die-formed 12-gauge steel bolted together and reinforced at external corners with rugged gussets internal and external to the structure members. The switchboard frame shall be suitable for use as floor sills in indoor installations.

c. Switchboard shall include protective devices listed on drawings.

d. Main bus and riser bus shall be copper, supported with high impact, non-tracking insulation material, and shall be braced to withstand mechanical forces exerted during short circuit conditions to the rating of the protective devices specified

e. A copper ground bus shall be furnished secured to each vertical section structure, and shall extend the entire length of the switchboard.

f. All steel surfaces shall be chemically cleaned and treated, providing a bond between paint and metal surfaces to help prevent the entrance of moisture and formation of rust under the paint film. The switchboard exterior shall be finished with ANSI-61 light gray paint.

g. All hardware used on conductors shall have a high tensile strength, and a suitable protective finish.

3. Main Breaker:

a. Main breaker shall be a 600 Volt minimum Class; three poles molded case circuit breaker. Breaker shall be 100 percent rated.

b. Main breaker shall have a solid-state trip device with adjustable ground fault, long time, short time and instantaneous points.

4. Feeder Breakers: Molded case feeder breakers shall be 600-volt minimum Class, 3 pole, stationary mounted. Breakers shall be provided as indicated on the drawings.

5. Nameplates: Engraved laminated composition nameplates shall be provided for each circuit breaker. The plates with lettering numbering shall be positioned on front of door or panel adjacent to circuit breaker so as to be clearly visible. The letter or numerals shall be a minimum 3/16-inch in height with black, characters on a white background. Provide all information noted on schedule.



**D. Wiring Devices:**

1. Scope: This sets forth the requirements for receptacles, switches, wall plates, outlet boxes and fitting.

2. Description:

a. Receptacles:

(1) Single receptacle for 230 volts: Convenient receptacle 2 poles and ground, 13 ampere, 250-volts.

b. Switches:

(1) Single pole: Specification grade flush single-pole toggle switches, 10 ampere, 230-volts AC, with mounting yoke

a. Wall Plates: Wall plates for wiring devices shall be of ivory phenolic, equipped with metal screws for securing plates to devices, screw heads to match finish of plate.

d. Receptacles and switches shall be installed in electrical boxes which are clean and free from excess building materials, debris etc.

**E. Over-current Protective Devices:**

1. Scope:

This specification sets forth the requirement for individually mounted over-current protective devices for electrical equipment and motors.

2. Description:

a. Circuit Breakers: Circuit breakers shall be operated manually having quick-make / quick-break toggle mechanism and shall be thermal- magnetic inverse-time delay type for overload and short-circuit protection on all poles. Current operated earth leakage circuit breakers shall provide protection against leakage current. Frame sizes, current rating, trip settings and number of poles shall be as specified and indicated on drawings.

Automatic tripping shall be indicated by the breaker handle assuming a clearly distinctive position from the manual ON and OFF position. Breaker handles shall be trip-free on overload. The use of breaker handle ties in-lieu of multi-pole breakers shall not be permitted.

Following type of circuit breakers shall be considered depending upon the application as described elsewhere in this specification.

- Molded-case circuit breakers (mccb): Shall be bolt-on type, ambient compensated up to 50 C temperature, allowing the breaker to carry full rated current with uniform tripping characteristic throughout the temperature range from 25 C to 50 C.

- Miniature Circuit Breakers (mcb): shall be bolted type, having instantaneous short circuit rating of 6,000A. Breakers protecting motor circuits shall be motor rated to carry the starting current without tripping, as indicated on drawings.

H Lighting fittings

Lighting fittings shall comply with all relevant British standards or equivalent.

Fluorescent fittings shall be of switch start type with all control gear and be complete with a capacitor to ensure that the power factor is a minimum of 0.95 .the fittings shall have a high-grade paint finish suitable for installation in a hot climate.

**F. Power factor:**

The overall power factor of the plant under any load or operation condition shall not be lower than .9 lagging. Power factor correction capacitors rated at 85% of the no load KVA of the motor shall be provided for each motor of above 5kw rated output.

Bulkhead fittings shall be suitable for industrial installations and have a degree of protection IP 55.

**G. Variable Speed Drive:**

The Variable Speed Drive shall be rated at 400 Vac. The Variable Speed Drive shall provide a microprocessor-based adjustment of three-phase motors. The controllers shall be rated as shown in the drawings. As a minimum, the continuous full load output current of the drive shall be equal to 1.05 times the full load current of the equivalent motor horsepower as listed by National Electric Code Table 430-150. The continuous full load output current rating shall be based on 50oC ambient and 12 kHz switching frequency for 15 and 20hp, 6 kHz for 30 through 100 hp, not lower switching frequencies.

The Variable Speed Drive shall be of the Pulse Width Modulated (MWP) design converting the utility input voltage and frequency to a variable voltage and frequency output via a two-step operation. Adjustable Current Source Variable Speed Drive are not acceptable. Insulated Gate Bipolar Transistors (IGBTs) shall be used in the inverter section, bipolar junction transistors, GTOs or SCRs are not acceptable. The Variable Speed Drive shall run at 6 kHz switching frequency and shall be programmable on over temperature to either fold back the switching frequency to a minimum of 3 kHz or fold back the speed, without shut down, until the over-temperature, condition has passed.

The Variable Speed Drive shall have an efficiency that exceeds 97% at 100% speed and load. The efficiency shall exceed 80% at 50% speed and load. The Variable Speed Drive shall maintain the line side displacement power factor no less than 0.95 regardless of speed and load. The Variable Speed Drive shall have one (1) minute overload current rating of 150% for constant torque drives. Variable torque drives. Variable Speed Drive shall have one (1) minute overload current rating of 110% for Variable torque drives.

The Variable Speed Drive shall be capable of operating any NEMA design B squirrel cage induction motor, regardless of manufacturer, with a load rating within the capacity of the Variable Speed Drive.

The Variable Speed Drive shall limit the drives contribution to total harmonic distortion reflected onto the distribution system to a voltage and current distortion level as defined by IEEE 519 for general system applications. Harmonic attenuation shall be provided by the addition of driveline reactance or multi=converter phase shifting arrangement. Harmonic calculations shall be provided upon request.

Any harmonic calculations shall be done based on the kVA capacity, X/R and impedance of the transformer supplying the Variable Speed Drive as shown on the drawings.

The Variable Speed Drive shall be able to start into a spinning motor. The Variable Speed Drive shall be able to determine the motor speed in any direction and resume operation without tripping. If the motor is spinning in the reverse direction, the Variable Speed Drive shall start into the motor in the reverse direction, bring the motor to a controlled stop, and then accelerate the motor in the preset method of starting.

Standard operating conditions shall be:

a) Incoming Power: three phase, 400 Vac (+10% to -10%) and 50Hz (+/-2Hz) power to a fixed potential dc bus level.

b) Frequency stability of +/-0.5% for 24 hours with voltage regulation of +/-2% of maximum rated output voltage.

c) Motor slip dependent speed regulation of 3% (0.5% with slip compensation).

d) Five Cycle carry over during utility loss

e) Insensitive to input line rotation.

f) Humidity: 0 95% (non condensing and non-corrosive).

g) Altitude: 0 to 3,300 feet above sea level.

h) Ambient Temperature: 0 to 50oC (NEMA 1, 12, 4).

i) Storage Temperature: -20 to 70oC



**H. Control Functions**

Frequently accessed Variable Speed Drive programmable parameters shall be adjustable from a digital operator keypad located on the front door of the Variable Speed Drive Parameters shall include:

1) Programmable speed command (Keypad, remote) with two pilot lights and selector switch.

2) Programmable start command (Keypad, remote) with two pilot lights and selector switch.

3) Forward or reverse control with two pilot lights and selector switch (on AF Models only).

4) Two pilot lights to indicate display in operation or diagnosis.

5) Two pilot lights to indicate setup is in scroll or change mode.

6) Increase/decrease buttons to change speed or setup or display diagnose.

7) Programmable maximum and minimum speed limits.

8) Programmable acceleration and deceleration times (2 each)

9) Programmable critical frequency avoidance lockout zones (5 each)

10) Programmable electronic overload and torque limits

11) Programmable multiple attempt restart

12) Programmable jog and preset speeds

13) Programmable "Catch a Spinning motor" function

14) Programmable output digital replay (2)

15) Programmable analog output (2)

16) Programmable dc Injection Braking Time

17) Full Proportional/Integral/Derivative (PID) process control built in.

**The Variable Speed Drive shall have the following system interfaces:**

**Inputs**- A minimum of eight (8) programmable digital inputs and two (2) programmable analog inputs shall be provided with the following available as a minimum.

Remote manual/auto contacts. Remote start and stop contacts. Remote forward/reverse contacts. Remote preset speed contact. Remote external trip contact. Remote reset contact. Remote jog contact. Process control speed reference interface to receive either a 0-10 Vdc 4-20 mAdc. Speed potentiometer signal.

**Outputs**- A minimum of two (2) discrete programmable digital outputs and two (2) programmable analog outputs shall be provided with the following available as a minimum.

Programmable relays outputs (2) with one (1) set of Form C contacts each, selectable with the following available as a minimum; Fault, Run, Ready, At Speed, Stopped, Current Limit, Auto Reference, and Reverse.

Programmable analog output signals (2), selectable with following available as a minimum; Speed, Load, Kilowatts, Motor Voltage, Motor Amps, Line Voltage, Bus Current, Speed Reference.

**Monitoring and Displays:** The Variable Speed Drive shall have a 2-line by 16-character programmable display indicting as a minimum the monitored functions described in the following: Output current, Output Frequency, Speed, Output Voltage, Kilowatts. Load, Run Time. Trip cause. Flash memory programmed via RS 232 or USB port with windows based configuration software included for advanced programming and troubleshooting. User display functions shall be selectable from a list to avoid displaying unused functions.

**Protection Functions:** The Variable Speed Drive shall include the following protective features:

1) Over current protection

2) Over Voltage Protection

3) Under Voltage Protection

4) Over frequency Protection

5) Phase Loss Protection

6) Over Temperature Protection. The Variable Speed Drive shall run at 6 kHz switching frequency. On first stage over temperature, the Variable Speed Drive shall be programmable to fold back the switching frequency to a minimum of 3 kHz or reduce the current limit setting automatically, without Variable Speed Drive shut down. It shall automatically return to the primary setting upon cooler temperature. Second stage over temperature shall stop the Variable Speed Drive.

7) Ground fault protection.

8) Adjustable current limit.

9) Line-to-line and line-to-ground output short circuit protection.

10) Over load capability shall be 150% of the motor FLA based on the NEC ratings for 60 seconds on Constant torque drives. (110% on Variable torque drives).

11) Dc injection braking shall be included.

**Diagnostic Features:**

a) Fault history. Record and log faults in English Language, most recent first, by date, time, item and description of the item. Store up to 15 faults.

b) Warning history. Record and log the last 15 warnings by date, time, item and description of the item.

c) Event history, Record, and log the last 15 command events by date, time, command and description of that command.

d) Trends files. Record 500 msec of trend data before each of the records faults. Display any four of eight parameters both digitally and in four-color graphics via the windows based program

e) Real time buffer. Select one of ten items to rigger input. Select four of the thirteen turning parameters to capture four of fifteen signals. The time base shall be adjustable from five to 60 msec.

f) I/O monitor. Provide a block monitor to aid in troubleshooting by showing I/O Status.

