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SECTION 17200
INSTRUMENTATION, MONITORING AND CONTROL REQUIREMENTS

1. GENERAL

The clauses in this section define the general requirements and standards of workmanship for the manufacture, supply, installation and commissioning of all instrumentation, monitoring and control equipments, and shall be applicable to these works.

1.1. WORK INCLUDED

Various types of detectors and measuring instrument must be installed in the various sites in the dinkable water Distribution System of Yerevan.

They are listed below :

1) Ultra-Sonic flow meter.

2) Transducer for mechanical flow meter.

3) Pressure sensor.

4) Chlorine injector.

5) Chlorination dosimeters.

1.2. DEFINITION AND LOCATION OF THE NEW EQUIPMENTS FOR INSTRUMENTATION

1.2.1. FLOW METER

Flowmeters envisaged within the framework of the implementation of the remote processing system are listed in the board below.

Drinkable Water Distribution System	Installation Location	Quantity	Pipe Size (mm)	Comments
GARNI (1)	Main Line Noubarashen Petrol (1.2.A)	1		Transducer for Sensus Mechanical Flow meter
	Tank Abovian Purak (1.9)	2	300	Ultrasonic Flow meter for Two Channels
KATNAGHBYUR (2)	Pumping Station Katnaghbyur (2.0)	14		Transducer for Sensus Mechanical Flow meter
	Tank Jrvejh (2.1.4)	2	400	Ultrasonic Flow meter
		1	700	Ultrasonic Flow meter
	Tank Sari Tagh (2.1.6)	1	200	Ultrasonic Flow meter
		1	300	Ultrasonic Flow meter
	Tank Zeytun Jramb (2.3.1)	1	300	Ultrasonic Flow meter
	Tank Mhub (2.4.1)	1	300	Ultrasonic Flow meter
		1	500	Ultrasonic Flow meter
		1	800	Ultrasonic Flow meter
	Tank Qanaqer Verin (2.4.3)	2	400	Ultrasonic Flow meter

TSARAVAGHBYUR (5)	Tank Tsitshernakaberd (5.1)	2	300	Ultrasonic Flow meter for Two Channels in the Same Chamber
	Network Boiler (1.13)	1	150	Ultrasonic Flow meter for Three Channels in the Same Chamber
		1	200	
		1	300	
SHOR – SHOR (6)	Main Line Cloratun (6.1)	1	500	Ultrasonic Flow meter
	Tank Kati Kombinat (6.3)	1	200	Ultrasonic Flow meter
APARAN (7)	Pumping Station Aparan (7)	14		Transducer for Sensus Mechanical Flow meter
	Tank Qasakh (7.1)	1	300	Ultrasonic Flow meter for Two Channels in the Same Chamber
	Tank Davtashen verin (7.2)	1	400	Ultrasonic Flow meter for Three Channels in the Same Chamber
	Tank Fizaka (7.3)	1	200	Ultrasonic Flow meter
ARZAQAN-GYUMUSH (8)	Tank Jambul (8.3.5)	1	250	Ultrasonic Flow meter
		1	500	Ultrasonic Flow meter
ARZNI (9)	Pumping Station Arzni (9)	1	500	Ultrasonic Flow meter
	Tank Kovkasyan (9.2)	1	300	Ultrasonic Flow meter

1.2.2. PRESSURE SENSOR

Pressure sensors envisaged within the framework of the implementation of the remote processing system are listed in the board below.

Drinkable Water Distribution System	Installation Location	Quantity
GARNI (1)	Pumping Station Garni (1.1)	3
	Chlorination Station Garni (1.A)	2
	Main Line Noubarashen Petrol (1.2.A)	1
	Main Line Sari tax (1.7)	1
	Tank Arin-Berd (1.5)	1
	Tank Araratyan (1.6)	1
	Network Sector Kentron 2 (mosc-abov) (1.10)	1
	Network Sector Kentron 8 (Charentc) (1.14)	1
	Network Sector Kentron 8/1 (Charentc) (1.14)	1
	Network Erebuni hraprak (erebuni) (1.5.1)	1
	Network Erebuni hraprak (Ayvazovski) (1.5.1)	1
GARNI (1)	Sub-total	14

KATNAGHBYUR (2)	Main Line Borman (2.1.2)	3
	Main Line Katn-Arzak (2.4.2)	1
	Tank Marash (2.1.5)	1
	Tank Sari Tagh (2.1.6)	1
	Tank Zeytun Jramb (2.3.1)	1
	Network Narekaci (Ekexeci) (2.1.7)	1
	Network Duryan (Safaryan st) (2.1.11)	1
	Network 1 Masiv (Mersedes)(2.1.12)	1
	Network 2 Masiv (Gayi-Moldovakan) (2.1.15)	1
	Network 2 Masiv (Harkajini dimac) (2.1.16)	1
	Network 3 Masiv (Ojaxi dzor) (2.1.18)	1
	Network 4 Masiv (Sigaroni mot) (2.2.2)	1
	Network 5 Masiv (27 shenqi mot)(2.2.3)	1
	Network 6 Masiv (Ancumi mot)(2.1.18)	1
	Network 7 Masiv (Pioner palat)(2.1.20)	1
	Network 8 Masiv (Tevosyan PRV)(2.2.4)	1
	Network 9 Masiv (34 Shenqi mot)(2.1.22)	1
	Network Marash- 1 sektor (Ortopetiki hetevum)(2.1.23)	1
	Network Marash- 3 sektor (AHK-i mot)(2.1.25)	1
KATNAGHBYUR (2)	Sub-total	21
ARARATYAN (3)	Pumping Station Araratyan (3)	3
	Tank Kharberd (3.2)	1
	Network JEK (3.2.1)	1
ARARATYAN (3)	Sub-total	5

TSARAVAGHBYUR (5)	**Network Boiler (1.13)**	**1**
TSARAVAGHBYUR (5)	**Sub-total**	**1**
SHOR – SHOR (6)	**Pumping Station Shor-Shor (6)**	**2**
SHOR – SHOR (6)	**Sub-total**	**2**
APARAN (7)	**Tank Davtashen verin (7.2)**	**2**
	Tank Fizaka (7.3)	**1**
	Network Sector - Mashtoc 5 (Shiraz) (7.1.1)	**1**
	Network Sector - Mashtoc 7 bloc (Shiraz) (7.1.1)	**1**
	Network Sector - Mashtoc 15 (Fuchik-Margaryan)(7.2.1)	**1**
	Network Sector - Mashtoc 1 Davt-I (near the cemetery)(7.1.2)	**1**
	Network Sector - Mashtoc 2 (near theDavtII 9 building)(7.1.5)	**1**
	Network Sector - Mashtoc 4 (near Davt IV Arazen building)(7.1.9)	**1**
	Network Sector - Mashtoc 4 (near the Davt IV 45 building)(7.1.10)	**1**
	Network Fizika Cross (7.1.11)	**1**
APARAN (7)	**Sub-total**	**11**

ARZAQAN-GYUMUSH (8)	Pumping Station Gyumush (8.1)	3
	Main Line Nor hachn (8.2)	1
	Main Line Davtasheni Kamurj (8.3.1)	1
	Main Line Lamperi Lich (8.4.1)	1
	Network Sector Shahumyan 8 (Tichina) (8.3.7)	1
	Network Sector Shahumyan 8 (Sheram) (8.3.8)	1
	Network Sector Shahumyan 8 (Z.Andranik) (8.3.9)	1
	Network Sector Shahumyan 2 (Raffi) (8.3.10)	1
	Network Sector Shahumyan 1 (Babajanyan) (8.3.11)	1
	Network Sector Shahumyan (for v. Haxtanak tser) (8.3.14)	1
	Network Sector Shahumyan (near rob. Factory for Tairov)(8.3.15)	1
	Network Sector Shahumyan 5 (Shrjanajin)(8.3.16)	1
	Network Sector Shahumyan 6 (Kurxinyan)(8.3.17)	2
ARZAQAN-GYUMUSH (8)	Sub-total	16
ARZNI (9)	Pumping Station Arzni (9)	2
	Tank Dinamo (9.1.2)	1
	Network Sector 1 Qochar Kulpenk(9.2.1)	1
ARZNI (9)	Sub-total	4
TOTAL		74

1.2.3. CHLORINATION DOSIMETER

Chlorination dosimeter envisaged within the framework of the implementation of the remote processing system are listed in the board below.

Drinkable Water Distribution System	Installation Location	Quantity	Comments
GARNI (1)	**Pumping Station Garni (1.1)**	**1**	**For Residual Chlorine**
KATNAGHBYUR (2)	**Pumping Station Katnaghbyur (2.0)**	**3**	**For Residual Chlorine**
DZORAGHBYUR-YERGES (4)	**Spring DZORAGHBYUR-YERGES (4)**	**1**	**For Residual Chlorine**
TSARAVAGHBYUR (5)	**Spring Tsaravaghbyur (5)**	**1**	**For Residual Chlorine**
SHOR – SHOR (6)	**Pumping Station Shor-Shor (6)**	**1**	**For Residual Chlorine**
APARAN (7)	**Pumping Station Aparan (7)**	**1**	**For Residual Chlorine**
ARZAQAN-GYUMUSH (8)	**Pumping Station Arzaqan (8)**	**1**	**For Residual Chlorine**
	Pumping Station Gyumush (8.1)	**1**	**For Residual Chlorine**
ARZNI (9)	**Pumping Station Arzni (9)**	**1**	**For Residual Chlorine**
TOTAL		**11**	**For Residual Chlorine**

1.2.4. CHLORINE INJECTOR

Chlorine injectors envisaged within the framework of the implementation of the remote processing system are listed in the board below.

Drinkable Water Distribution System	Installation Location	Quantity
KATNAGHBYUR (2)	**Pumping Station Katnaghbyur (2.0)**	**3**
SHOR – SHOR (6)	**Pumping Station Shor-Shor (6)**	**1**
TOTAL		**4**

2. GENERAL SPECIFICATION

2.1. APPLICABILITY

The clauses in this section define the general requirements and standards of workmanship for the manufacture, supply, installation and commissioning of all instrumentation, monitoring and control equipment (excluding distribution switchgear and motor starter units), and shall be applicable to these works.

2.2. CONTRACTOR'S RESPONSIBILITY

The Contractor shall be responsible for:

1) All aspects of design, application and subsequent operation of the equipment, monitoring facilities and control circuits in accordance with all the operational requirements of this specification.

2) Liaison between subcontractors to ensure complete compatibility of all equipment at both component and system interface levels.

3) Overall systems engineering to ensure that all equipment, components and systems together form a consistent, rational and fully integrated monitoring and control installation.

4) Ensuring that each system is handed over complete in all detail and in perfect working order.

5) The supply and installation of all components, such as signal amplifiers, isolators, interference suppressors, line protection devices etc. which may be necessary to achieve the correct and specified function or to provide a safe and reliable installation, whether or not such components are specifically called for in the specifications.

6) Compatibility with existing monitoring, to ensure that all new and existing equipments will form a rational and integrated installation.

2.3. GENERAL DESIGN REQUIREMENTS

The Equipment shall be designed:

1) Such that routine and occasional maintenance through its life shall be a practical minimum, compatible with the preservation of maximum reliability.

2) To withstand the electrical, mechanical, thermal and atmospheric stresses to which it may be subjected under operational conditions, without deterioration or failure.

3) And constructed to the highest available standards of manufacture, reliability, accuracy and repeatability.

Where more than one component or item of equipment is supplied to perform a particular function, all such items shall be identical and interchangeable.

The degree of environmental protection for all equipment and enclosures shall be in accordance with BS 5490 or IEC 529 as follows:

1) IP54 for internal applications.

2) lP55 for equipment in pumping stations and similar locations.

3) IPW55 for external applications.

4) IP67 for transducers and equipment mounted within valve or meter chambers or similar locations.

All instrumentation, monitoring and control equipment shall be designed and guaranteed suitable for operation under the environmental conditions.

Equipment in air conditioned locations shall be rated for continuous operation in ambient temperatures up to 40°C. External equipment and internal equipment not in air conditioned locations shall be rated for continuous operation over the ambient temperature range 0°C to 45°C. The above temperatures make no allowance for local temperature rises due to operation of the equipment itself or by adjacent equipment.

External equipment shall be protected from direct sunlight by a well ventilated cabinet, canopy or other approved type of sunshade.

2.4. DRAWING APPROVAL

Where there is no detail in the Specification or associated drawings regarding the exact location or method of installation of measuring equipment, sensors or other site mounted equipment, the Contractor shall submit details of his proposed installation to the Engineer for approval and obtain this approval before starting any installation work.

The drawings, diagrams and schedules to be submitted for approval at an early stage in the contract shall include the following:

1) System block diagrams.

2) Fully detailed P & I diagrams.

3) Control schematic diagrams showing clearly the operation of each system.

4) Analogue loop diagrams showing all relevant detail including instrument reference and loop impedances.

5) Power distribution diagrams for all instrumentation and control supplies.

6) Certified drawings and technical data for all instruments.

7) Drawings showing the location and relevant installation details for all panels and enclosures.

8) Instrument installation and hook-up drawings.

9) General arrangement drawings (internal and front panel) showing finish and relevant construction details for all panels and enclosures.

10) Comprehensive instrument schedules covering all primary, secondary and panel instruments, giving all relevant data including reference (tag) No, input range and output ranges, input and output impedances, scale, supply voltage, manufacturer, type number and the like.

11) Complete alarm schedules including legends, initiating contacts or equipment, and alarm grouping.

12) Cable specifications, cable route drawings and comprehensive cable schedules.

13) Interconnecting cable termination details.

14) Earthing details.

2.5. INSTRUMENTATION AND CONTROL SUPPLIES

2.5.1. SUPPLIES - GENERAL

All instrumentation, monitoring and control circuits and equipment shall be supplied at a voltage not exceeding 55 volts to earth. These shall be from:

1) A battery/charger unit, typically of 24 volt nominal output, but under no circumstances exceeding 48 volts nominal output.

2) A double wound transformer having a fused primary, a 55-0-55 volt secondary with the centre point earthed and each secondary line fused.

3) A transformer/rectifier system, comprising a double wound transformer with a fused primary and a secondary having one end earthed, together with full wave rectifier unit incorporating voltage stabilisation if necessary. The mean voltage of the rectified output shall not exceed the nominal output from the instrumentation battery/charger units.

Equipment such as battery/chargers, uninterrupted power supplies, inverters etc. shall be supplied as necessary to maintain the required electrical supplies to essential instrumentation, monitoring and control systems which are to be kept in operation during a main power failure. The essential equipment to be maintained during a power failure shall include workstations, mimic panels, control panels, alarm systems and flow measuring/indicating/recording/integrating equipment or as otherwise detailed in the application clauses.

2.5.2. REMOTE CONTROL SUPPLIES

On remote control/indication circuits (such as occur with valves, penstocks etc). d.c. voltages and relays shall be used in all cases where the cable capacitance could be of sufficient magnitude to maintain a.c. relays in an energised state. The Contractor shall be responsible for establishing where such d.c. operation of control/indication circuits is required and for providing a suitable supply at locations where an instrumentation battery/charger supply is not available.

2.6. CONSTRUCTION OF PANELS

2.6.1. GENERAL

All panels, cubicles, cabinets, consoles, and desks together with any other types of enclosure (excluding motor control centres and switchgear) which form part of the instrumentation, monitoring and control installation shall comply with the requirements of this Clause, and of Clauses 7 and 8 covering panel wiring, equipment and terminals.

Removable earthed metal gland plates shall be provided to accommodate all incoming/outgoing cables, and shall be fitted not less than 250 mm above the floor level.

All equipment, other than front of panel items, shall be mounted on racks or fixing bars and not directly onto the panels.

Each enclosure shall be vermin proof and dust proof with the necessary provisions made for natural or forced ventilation.

All panel construction and arrangement details shall be approved before manufacture, and panels shall be subject to inspection.

2.6.2. PANELS FOR INTERNAL USE

All instrumentation, monitoring and control panels, designed for use within buildings shall be constructed of prime quality, cold rolled and annealed mild steel or zinc coated sheet steel, of adequate thickness, welded and braced to form a rigid structure. The minimum sheet steel thickness shall be 1.6 mm, with panel fronts and desk tops being thicker (2.00 mm min) to provide the necessary strength to prevent bowing. Panel fronts shall be flat and free of bow and ripple. External corners and edges shall be rounded to give a smooth overall appearance. No design involving the use of externally visible assembly bolts or screws will be accepted. All floor standing enclosures shall be constructed with a 60 mm deep plinth arranged to provide a recessed kicking strip at the front.

Equipment mounting panels shall be not less than 2 mm thick and shall be strengthened and/or braced to avoid any distortion or vibration. Equipment mounting plates and brackets shall, if necessary, be hinged to provide quick and easy access to equipment securing screws, terminals and wiring.

Doors and access panels shall be adequately braced or strengthened to avoid any buckling or twisting. Doors shall be of folded and welded construction mounted on lift-off hinges, with one hinge engaging before the other. Where necessary, removable access covers secured by quick release fasteners shall be provided. All doors and access panels shall close onto neoprene or soft rubber sealing strips which shall be held in place mechanically and not by adhesive. All doors shall be lockable. Where “Walk-in” panels or structure are provided, they shall be fitted with lockable car type handles operable from inside even when locked.

Surface preparation and finish shall be in accordance with the specification, with all internal surfaces finished in white. The external finish colour will be advised by the Engineer.

The design and construction shall be such as to provide an enclosure of superior quality which shall match all other panels in the same location in style, appearance and finish, and have environmental protection to IP54.

2.6.3. PANELS FOR EXTERNAL USE

All instrumentation and control cubicles, kiosks etc. designed for use outside shall be manufactured of double skinned, resin bonded fibreglass, with a totally encapsulated infill of rigid weather and “Boils” proof plywood or equivalent between the two skins.

The roof section shall have a totally encapsulated infill of end grain balsa instead of plywood.

Box section steel shall be encapsulated into door edges and door frames. Hinges shall be of high tensile, non-corroding alloy with stainless steel pins and through fixing bolts. Large plane surfaces shall have adequate reinforcing to ensure rigidity.

The doors shall be complete with latching handles and locks. All door catches and locks shall latch onto steel reinforced surfaces.

The laminate material shall have flame retardant characteristics and shall retain stability, integrity and insulation for 30 mins when tested.

Colour impregnated gel coats backed by coloured resin shall be used to ensure maintenance tree and “colour fast” finishes. The finish colour, both internal and external shall be white.

Door mounted meters and transparent windows shall be of glass. Cubicles and kiosks shall be provided with canopies to protect the top surface and any meter or window glass from direct sun light. There shall be an air gap of 100 mm between the top surface of the cubicle and the canopy.

All internal equipment shall be mounted on support built into the fibreglass structure. Fixing bolts through the skin will not be accepted.

Each cubicle shall be constructed to provide environmental protection to IP55.

2.7. PANEL WIRING AND EQUIPMENT

2.7.1. APPLICABILITY

The requirements of this Clause shall apply to all instrumentation and control cubicles, desks, cabinets, mimic panels etc., but not motor control centres or switchgear.

2.7.2. PANEL WIRING

Panel wiring shall be carried out using cable to the appropriate ISO or IEC Standards, installed in a neat, systematic manner, securely fixed and supported on insulated cleats or trunking, and arranged so as not to impede access to any internally mounted equipment.

Analogue signal cables and d.c. control cables at voltages not exceeding 48 volts (nominal) may be run together in the same cable bunch or trunking; but these cables shall be run separately from all other cables. In any cubicle, panel, or structure which is not fully enclosed (such as some mimic panel structures), all cabling which is or may be at a voltage in excess of 55 volts (nominal) to earth, shall be run in conduit.

For all cables, the sizing shall be fully adequate for the possible maximum loading, and de-rating shall be applied as appropriate for cable bunching and ambient temperature.

Identification ferrules shall be fitted to both ends of all wires, and shall be of the full circle type, threaded on to the cable such that all numerals are in line, and read outwards from the terminal.

Where stranded conductors are used, each end shall be fitted with a sleeved termination lug.

Terminations shall be restricted to one wire per terminal.

Cabling to door mounted equipment shall be bunched and cleated to form a loom with a loop of adequate length to allow easy door opening without causing strain to the components or cable.

Sharp edges of cubicles, trunking, components etc., which may be in contact with cables, shall be protected to avoid damage to cable insulation.

Requirements relating to terminals are covered in Chapter 2.8.

2.7.3. PANEL PROTECTION

All terminals and all live parts (on equipment) which are or may be at a voltage in excess of 55 volts (nominal) to earth, shall be enclosed by a protective cover, and carry a warning label stating the actual voltage.

For panels and enclosures covered under this section, the maximum potential between any two points within the panel or enclosure shall not exceed 250 volts.

Terminals and equipment which are supplied from other sources and which may remain live when the panel isolators are opened, shall be adequately protected and clearly labelled to this effect.

Adequate fuse protection for circuits and sub-circuits shall be provided and arranged such that any fuse failure causes the minimum disruption to controls and indications, and that any such fuse failure cannot create an unsafe operating condition. Fuses shall be of the HBC cartridge type with plastic moulded carriers and bases.

2.7.4. PANEL EARTHING

A copper earthing bar shall be provided and bonded electrically to the main frame. It shall be provided with suitable brass screw terminals for the connection of the metal cladding, instrument frames, gland plates, cable tray, the armouring of all incoming cables and the site earthing system.

2.7.5. PANEL/LIGHTING

Each enclosure shall be fitted with fluorescent lamp fittings to provide adequate and even illumination. Each lighting circuit shall be individually fused and switched.

2.7.6. PANEL HEATING

Each enclosure shall be fitted with one or more heaters to prevent condensation and assist ventilation. The heaters shall be so arranged and located that no deterioration can be caused to any equipment or wiring. The surface temperature of any part which may be accidentally contacted shall not exceed 65°C. The heating circuit shall be supplied via a fuse, an isolator and a Hand/Auto switch. In the “hand” position the heater shall run continuously and in the “auto” position the heater shall be controlled by a thermostat or humidistat. All switches and controls shall be mounted within the enclosure.

2.7.7. PANEL EQUIPMENT

A fuse and isolating switch shall be provided for each incoming a.c. and d.c. supply.

Where instrumentation, monitoring or control equipment is to be operated on ac. supplies derived from within the cubicle, a 110 volt (55-0-55) control transformer (or transformers) shall be provided for this duty. Each micro-processor and/or programmable logic controller shall have its own control supply transformer.

Each cubicle shall be complete with a distribution unit providing an adequate number of fused outlets at 110 volts (55-0-55) for possible future requirements.

For internal panels only, a minimum of two, three-pin switched socket outlets shall be provided. These shall be mounted within the enclosure, shall operate at the panel supply voltage and shall carry a label clearly stating the voltage and rating.

All items of equipment mounted within the enclosure such as relays, electrical transducers, indicators, recorders, switches fuses, terminals etc. shall be arranged so as to provide easy access, be securely fixed and clearly labelled as to their function, designation, and where applicable, the voltage.

Where meters and recorders are mounted on vertical fronted panels, the mounted height shall be based on the height of the centre line above finished floor level as follows:

- Indicating Meter: 1.35 m. min. to 1.90 m. max.
- Recorders: 1.45 m. min. to 1.85 m. max.

2.7.8. LABELS

All labels for panels and other items as specified shall be provided in accordance with corresponded Clause.

Panels with doors which are not interlocked with an isolator (or isolators) giving complete protection shall carry a warning label having white letters on a red background as follows:

"**DANGER LIVE TERMINALS" both in English and Armenian.**

The relevant voltage shall be stated.

2.8. CABLES

2.8.1. GENERAL

Cables shall be supplied by an approved manufacturer and where possible the same manufacturer shall be used for all cables.

All cables shall be delivered with cable ends effectively sealed. When a cable is cut from a drum both cable ends shall be immediately sealed to prevent ingress or moisture.

2.8.2. RATING

The Contractor shall ensure that each cable is adequately rated for its duty under normal and possible fault conditions.

The rated voltage of the cables shall not be less than the operating voltage and when assessing the rating and cross section of each cable the following factors shall be taken into account:

- Maximum voltage drop permissible.
- Type and magnitude of load.
- Fault level and duration related to circuit protection relays and fuse gear.
- Overcurrent setting of relays and circuit-breakers.
- Route length and disposition of cables.
- Ambient temperature.
- Method of laying.

2.8.3. CONDUCTORS

Conductors for all types of cable shall be of high conductivity copper. All cores shall be at least 2.5 sq.mm cross-section. With the exception of mineral insulated cables all conductors in excess of 2.5 sq.mm shall be stranded.

2.8.4. TYPES

Cables complying with BS or IEC approved equivalent standards will be accepted provided all cables which are supplied for a specified operating voltage are to the same national standard. Standards specified in the following clauses indicate the type of cables used in the design: if the Contractor wishes to use cables to an alternative standard then details of current carrying capacity, derating factors etc, shall be submitted to the Engineer for approval.

1) XLPE/SWA/PVC

Power cables specified as cross linked polyethylene insulated steel wire armoured and PVC sheathed are hereafter referred to as XLPE/SWA/PVC.

All such cables shall be terminated with mechanical glands which shall be of a type as to provide adequate mechanical support by positively locking on the armour and shall at the same time give a high level of earth continuity.

2) PVCSWAPVC

Power and control cables specified as PVC insulated and sheathed, galvanised single wire armoured cable with an overall PVC sheath are heinafter referred to as PVCSWAPVC.

All such cables shall be terminated with mechanical glands which shall be of a type as to provide adequate mechanical support by positively locking on the armour and shall at the same time give a high level of earth continuity.

3) PVCPVC

Power cables specified as single core insulated and sheathed are hereinafter referred to as PVCPVC cable. Such cables shall be terminated by mechanical glands similar to that specified for PVCWAPVC cable.

4) MICC/PVC

Certain control and miscellaneous circuits shall be carried out in mineral insulated copper clad cable with an overall extruded PVC sheath, hereinafter referred to as MICC/PVC cable.

All saddles, clips and accessories shall be of the type specially designed for MICC/PVC cable.

For the purposes of core phase identification coloured PVC core sleeves or coloured PVC extension sleeves shall be used. Core sleeves and extension sleeves shall only be used on the core sizes for which they are intended. Coloured adhesive tape shall not be used for this purpose.

The Contractor shall ensure that any special tools required for the installed MICC/PVC cable are made available to his operatives and they understand and are competent in their use.

The ends of all cables shall be at all times temporarily sealed to prevent the ingress of moisture.

When MICC/PVC cables are used in conjunction with equipment liable to vibrations, suitable terminal boxes shall be provided in the vicinity of such motors or equipment and the final interconnections shall be made by means of flexible cable or multi-strand wiring in flexible conduit.

Cable glands shall be protected by corrosion-resistant PVC hoods.

2.8.5. POLARITY

The polarity of all apparatus used for the works specified shall be arranged as follows:

1) For two pole apparatus the phase or "live" pole at the top (or left hand side) and the neutral or "earthed" pole at the bottom (or right hand side).

2) For three or four pole apparatus the phases in order, red, yellow, blue and neutral reading from top to bottom or left to right in the case of vertical and horizontal layouts, respectively, as viewed from the front.

All cables shall be so connected between main switchboards, distribution boards, plant and accessories so that the correct sequence or phase colours are preserved in the system.

All cable cores shall be identified with phase colours for three and four wire circuits and red and black for single phase circuits.

The neutral shall always be black. Where more than one phase is incorporated on a common system in one room then the live cores shall be red, yellow, blue as appropriate and fittings and switch accessories shall be permanently labelled and segregated.

2.9. CABLE IDENTIFICATION

Each and every cable shall be permanently identified at each end in accordance with an associated cable schedule. Approved type cable markers shall be used, fixed to the cable by corrosion resistant straps. Cable markers shall also be installed at entries of buildings and buried ducts and at other points as are necessary to identify the route of any cable.

Cables shall be so connected to items of plant that standard phase sequence and colour coding is maintained throughout the system. Cable cores shall be identified by phase colours on 4 wire and 3 wire systems and by red and black on 2 wire systems. Where it is impractical to connect cable cores to the identified terminals special markers shall be fitted as appropriate to individual cores.

In addition control cables shall have individual cores identified by approved type ferrules bearing the same numbers at both ends, the numbers reading from the terminal outwards.

Where the wiring system makes a change of number necessary at connecting points ferrules bearing both numbers shall be used. All numbering shall be in accordance with and shown on associated wiring diagrams.

2.10. TERMINAL AND TERMINATIONS

Terminals for the connection of all incoming/outgoing cables shall be provided and should comprise anti-tracking mouldings of melamine, phenolic or comparable material fitted on a purposed built mounting rail. The conductors shall be secured by screw clamps or bars, but not pinch screws.

All terminals used on circuits not exceeding 55 volts (nominal) to earth, excluding power supplies and auxiliary drives, shall be of the disconnecting link type.

Every terminal shall carry a clear identity number. Terminals at different voltages shall be grouped separately, and each group shall be clearly labelled with its respective voltage and function.

Transparent protective covers completed with voltage warning label shall be provided on all terminals which are, or may be, at a voltage in excess of 55 volts (nominal) to earth.

Sufficient terminals shall be provided to terminate all cores of all cables (including spares) associated with the particular enclosure. The number of terminals shall be sufficient to cater for all anticipated requirements plus 20% spare terminals and 30% spare terminal rail.

Terminals for connecting to incoming/outgoing cables shall be mounted vertically wherever possible and arranged to provide easy access and to enable ferrule numbers to be read without difficulty. Direct termination onto such equipment as distribution boards, fuses or miniature circuit breakers is not acceptable.

2.11. 24VDC SUPPLY FOR CONTROL

2.11.1. GENERAL

This Clause covers the requirements for 24 VDC supply, specified in the application clauses for the Operation of Control, Instrumentation, Alarm and Monitoring equipment, but not for switchgear tripping/closing batteries or other special function batteries.

220 VAC uninterruptible power supplies (UPS) must be provided for the supply of the equipment through control cabinets and panels. These UPS 220 VAC must be sized to enable the supply of the control components through a 220 VAC / 24 VDC convertor installed in the relevant control cabinets and panels to be installed in control rooms.

Where alternative a.c. supplies are available, provision shall be made for taking the supply to the UPS from either source (e.g. from either side of the bus-section switch) with facilities for changeover from one source to the other in the event of failure of the supply source.

The UPS unit shall form a composite unit and be housed in a single, sheet steel, floor standing cubicle having adequate ventilation and separate compartments for the batteries, chargers and inverter.

2.11.2. BATTERIES

The batteries shall be of the nickel cadmium type with a normal cell output of 1.4 volts, and shall be of adequate capacity to maintain full operation of the specific load equipment plus a further 10% for a period of 4 hours during mains failure, unless specified otherwise in the application clauses, and assuming a normal charge condition at the start of the mains failure.

The battery cases shall be made of translucent, high impact polystyrene so that the electrolyte level cans be seen through the battery casing.

All batteries shall be suitable for the intended service under the prevailing site conditions without excessive gassing or loss of electrolyte.

2.11.3. BATTERY CHARGERS

Duplicate chargers, one “duty” and one “standby” shall be provided and mounted on their own respective chassis in the upper cubicle compartment.

The controls for each charger shall be mounted on their own respective mounting plates, and these, together with all controls and indications projecting through the front of the upper compartment cabinet section shall be positioned at a height not exceeding 1 800 mm from floor level.

Each charger mounting plate shall contain:

- 1 “ON/OFF” Main switch.
- 1 Charger output Ammeter.
- 1 Charger output Voltmeter.
- 1 Lamp to indicate “Boost Charge” (Red).
- 1 Lamp to indicate “Float Charge” (Green).
- 1 Lamp to indicate “Charger Failed” (Red).
- 1 Lamp to indicate "High DL Voltage" (Red).
- 1 Lamp to indicate "Low DC Voltage" (Red).
- 1 Lamp "test button".

Each charger unit shall also be provided with:

- 1 “Float/Boost” elector switch, mounted internally.
- 1 set of a.c. supply fuses for each charger unit.
- A volt-free contact for charger failed alarm.
- A volt-free contact for low d.c. output voltage alarm.
- A volt-free contact for loss of d.c. output voltage alarm.

The above volt-free contacts shall open under fault conditions and be wired to a terminal block.

The battery charger unit shall also be provided with one set of full capacity rated output/d.c. terminals and fuses.

In the event of failure of the duty selected charger, the standby charger shall be connected automatically, and contacts for the remote alarm indication shall be provided. The alarm indications of the failed charger unit shall remain on until the duty charger has been repaired and returned to operation.

Reversion from "Standby" to "Duty" charger shall be a manual operation.

The chargers shall be of the solid state constant potential type, and shall be designed to regulate the charger output voltage to within +1 % for a mains input voltage variation.

The d.c. terminal voltage shall be further regulated such that under "Float" or "Boost" charge condition the d.c. voltage does not rise more than 10% of nominal.

The charger unit shall also be provided with both short circuit and reverse polarity protection.

All internal and external components shall be labelled in accordance with the Specification.

The cabinet shall be manufactured in accordance with Clauses 6.1 and 6.2 but with additional treatment to the interior surfaces to prevent any corrosion by battery chemicals and with environmental protection to IP52.

Internal wiring shall be in accordance with Clause 7.

Terminals and their positions shall be in accordance with Clause 8.

For each battery/charger unit, the Contractor shall supply a set of maintenance tools, spares and hydrometer; all of which shall be contained and secured within the charger cabinet.

The Contractor shall fix inside the cubicle a wiring diagram indicating and identifying all out-going terminals, components and fuses.

Special precautions shall be taken in the sizing of the battery and charger for tropical use, and all equipment shall be adequately rated for the prevailing site conditions.

2.11.4. INVERTER

Inverters shall be solid state type and shall provide a single phase output at 220 VAC.

Inverter mounting plate shall contain:

- 1 "ON/OFF" Main switch.
- 1 AC output Ammeter.
- 1 AC output Voltmeter.
- 1 AC output Frequency.
- 1 Lamp to indicate "Load on inverter" (Green).
- 1 Lamp to indicate "Load on reserve" (Yellow).
- 1 Lamp to indicate "Maintenance" (Red).
- 1 Lamp to indicate "Reserve fault" (Red).
- 1 Lamp to indicate "Inverter unsynchronized" (Red).
- 1 Lamp to indicate "Overload inverter built" (Red).
- 1 Lamp to indicate "Inverter fault" (Red).

- 1 Lamp to indicate “Inverter over voltage” (Red).
- 1 Lamp to indicate “Inverter bridge fault” (Red).
- 1 Lamp to indicate “Inverter over temperature” (Red).
- 1 Lamp to indicate “DC high voltage” (Red).
- 1 Lamp to indicate “Imminent shutdown” (Red).
- 1 Lamp to indicate “End of discharge” (Red).
- 1 Lamp to indicate “AC earth fault” (Red).
- 1 Lamp to indicate “General fault” (Red).
- 1 Lamp “test button”.
- 1 Lamp “reset button”.

Inverters shall have the following characteristics:

- Maintain an output frequency constant within ± 1% of nominal.
- An adjustable ac output voltage of ± 5% at nominal dc input voltage.
- A maximum deviation of ac output voltage of ± 2% over the entire ranges of load, dc voltage and power factor.
- Be capable of continuous operation under the ambient temperature specified.
- A limited overload capacity.
- An in-built current limiting circuit to provide short circuit protection.
- An ac output filter to limit the total harmonic voltage distortion across linear loads to 5%, over the entire range of load, voltage and power factor.
- A dc input filter to ensure that the r.m.s. value of ac voltage does not exceed 5% of the dc voltage.
- A totally enclosed floor mounting sheet steel enclosure with front access doors.
- The cabinet shall be manufactured in accordance with an environmental protection to IP52.

2.12. STATUS INDICATOR LAMPS

2.12.1. GENERAL

Where an instrumentation and control DC voltage supply is available, status indicator lamps shall be supplied from this source.

In applications where a DC voltage supply is not available, status indicator lamps shall operate on available a.c. supplies. For these applications, the indicator shall be a low voltage lamp supplied via a transformer incorporated within the light unit. The lamps shall have a voltage rating higher than the transformer secondary.

2.12.2. D.C. OPERATED LAMPS

On all mimics and elsewhere as practicable, indicators shall be by light boxes or illuminated LED incorporating two lamps. Multi-colour, single aspect indications on mimics may be single lamp units if twin lamp versions are not available.

All lamp status indications on control panels, mimics, instrumentation and control sections of MCC's shall be switched by relays located within the panel or enclosure incorporating the display, and powered by the local DC voltage supply. This is to ensure that all lamps in the display are of the same brightness.

Where resistor shall be connected in series with each lamp or pair of lamps, the circuit shall be arranged so that the relay contact shorts out the resistor to illuminate the lamp. The resistor value shall be such that, when in series with the lamp (or lamps), the filament shall start to glow when maximum DC voltage is applied.

The lamp relays shall be reed relays mounted with the lamp resistors on printed circuit boards. This requirement is to reduce space and DC power requirements. The relay contacts shall be adequately rated: for the duty of switching filament lamps.

All indicator lamps on instrumentation and control panels, mimics, etc., shall be incorporated within a lamp test facility.

2.13. ILLUMINATED PUSHBUTTONS AND OPEN/CLOSE INDICATORS

The illuminated pushbuttons shall have bezel dimension of not less than 24 x 36 mm, and shall be mounted in pairs to provide remote hand control of louvers, valves, penstocks and similar devices.

Each pair shall consist of one "open" (or "lower") pushbutton with red translucent screen, and one "close" (or "raise") pushbutton with green translucent screen. The screens shall be engraved and filled to show the action (open or close) and the device reference number.

Operation of the pushbutton shall initiate the appropriate action.

With the valve, penstock or louver fully closed, the green (close) lamp only shall be illuminated; and with the device fully open, the red (open) lamp only shall be illuminated. While the device is changing from one state to another, both lamps shall be illuminated.

The pushbutton contacts shall have a minimum rating of 5 amps at 240 volts 50 Hz.

The switch and associated circuits shall be arranged so as to provide the required operating characteristics for each device. All pushbutton circuits shall operate in the same manner. Circuit arrangements requiring the pushbuttons to be held down while the device is changing from one state to another, will not be accepted.

The open/close indicators shall be of the same type and appearance as the illuminated pushbuttons, with the same lamp colours and indicating sequence, but the screens shall be engraved "opened" and "closed".

All indicator lamps shall be included within a lamp test facility.

2.14. TRIP AMPLIFIERS

Trip amplifiers shall operate on various analogue signals and shall:

1) Operate from a 230 VAC or 24 VDC.

2) Have an input impedance in the order of 20 ohms.

Trip amplifiers or analogue alarm relays shall have single or dual set points as required and shall:

1. Have switched outputs with changeover contacts of suitable material and rating for the application.

3) Have set points which is infinitely variable over the whole input range by means of a lockable knob calibrated 0-100%.

4) Have a dead band of not less than 2.5% of input span.

5) Have a trip repeatability of ±0.25% of span.

2.15. CONTROL AND INTERPOSING RELAYS

All relays shall operate on a supply not exceeding 55 volts (nominal) to earth unless otherwise specified in the application clauses, and shall:

1) Operate reliably over the range +10% to -15% of the nominal supply voltage.

2) Be of the plug-in type complete with plastic cover and retaining clip.

3) Have vacuum impregnated coils and be suitably treated for operation under the specified environmental conditions.

4) Have contact material suitable for each application.

5) Have relay bases of the front connected, screw clamp type.

Mixed voltage shall not be connected to the contacts of any relay.

All relays and the associated wiring shall be protected by suitably rated fuses.

Relays having different contact arrangements or coil voltages shall not be interchangeable.

A permanent means of identification shall be fixed to each relay base and this identification shall be in accordance with the circuit diagram reference.

Where voltages from a remote source (i.e. voltages which cannot be isolated from within the cubicle) are connected to a relay or associated terminals, fuses etc., the Contractor shall ensure that all such live parts are fully shrouded and that appropriate warning notices are fitted.

The Contractor shall be responsible for ensuring that a.c. relays cannot be held in due to capacitance effects on long switching lines. Where such a possibility exists, a d.c. supply shall be provided.

3. PRODUCTS

3.1. FLOW MEASUREMENT

3.1.1. ULTRA SONIC FLOW METERS

Ultrasonic clamp-on flow measuring system for non-contact flow measurement of steel tubing without interrupting operation.

Ultra sonic flow meters shall be provided in accordance with the following:

1) Flow transmitter:
   - For installation in the Ex-free zone.
   - Double-spaced LCD display.
   - 1 adding counter.
   - Single channel design with three operating keys.
   - HART communication.
   - Accuracy of measurement can be validated internally.

2) Flow transmitter caracteristics:
   - Transmitter: IP67
   - Measuring range: ..... typically v = 0...15 m/s
   - Accuracy:..... typically +/- 2% v.M. plus +/- 0.05% v.E.
   - Inputs/outputs:.....analog: 0/4 to 20 mA with HART communication
     .....Pulse frequency 100 Hz: open collector
     .....Programmable as status output
   - Power supply:.....85-250 V, 50/60 Hz or 20-28 VAC / 11-40 VDC

3) Sensors (incl. sensor mounting and connector medium), sensor fastener and cable with the following features:
   - Design: .....sensing element with bayonet connection
   - Sensor mounting: .....strap retainer for nominal width between DN50 and DN2500
   - Medium temperature: .....-20°C to +80°C
   - Protection Sensors: IP67

3.2. PRESSURE TRANSDUCER LEVEL MEASURING EQUIPMENT

3.2.1. CONSTRUCTION

Pressure transducer level measuring equipment shall comprise a strain gauge or differential transformer type pressure transducer, a controller/transmitter and be complete with all necessary cable, conduits etc. as detailed below.

The pressure transducer shall be enclosed within an all welded, stainless steel case not less than 19.0 mm dia. and shall:

1) Have a single moulded cable which is securely bonded to the transducer case and comprise electrical connections, venting tube, strain wire or cord and an outer covering of material suitable for the application.

2) Be suitable for continuous immersion on all wastewater applications including raw sewage, primary sludge, secondary sludge and thickened sludge.

3) Be constructed so that the sensor diaphragm is protected against damage by shock, debris etc., without restricting the transference of pressure changes from the surrounding medium.

4) Incorporate automatic temperature compensation.

5) Withstand a continuous overpressure of up to 400% without sustaining permanent deformation or calibration change.

The controller/transmitter shall:

1) Be suitable for mounting within a control panel.

2) Accept the signal from the transducer and provide a 4-20 mA output proportional to level (gauge pressure), for indication and control.

3) Include independent zero and span adjustment.

The complete system shall:

1) Operate with up to 100 m of cable between transducer and controller/transmitter.

2) Provide an accuracy within ± 0.1% of the span with a linearity better than +0.1%.

3.2.2. PRESSURE TRANSDUCER INSTALLATION

For installations where the sump depth is in excess of 3 m or where the available headroom over the sump is limited, the pressure transducer shall be installed within a 100 mm dia. GRP tube to provide protection against mechanical damage to both the transducer and the cable. The GRP tubing shall have an adequate number of holes and/or slots to allow it to fill and drain as the level varies. The tubing shall be fixed to the sump wall at intervals not exceeding 2.5 m.

For installations where the sump depth does not exceed 3 m, the sensor shall be supplied and installed as a rigid assembly comprising a stainless steel tube, a tube holder (both as used for control electrodes) and the transducer, with the cable passing through the tube. The transducer shall be a close fit located completely within the tube at the lower end. The assembly shall be fixed at not less than two places to the sump wall and installed with the bottom of the tube clear of the sump invert.

For all installations, the cable between the transducer and the controller/transmitter shall be a continuous length, and kept as short as is reasonably possible. This cable shall be run in conduit and installed well clear of all a.c. mains and power cables.

All fixings, brackets etc. as required for the complete installation shall be provided.

3.3. RESIDUAL CHLORINE ANALYZER

1) Type and Design:

- The residuel chlorine analyzer shall be of the type using amperometrics cells to provide continuous measurement of the concentration of total residual chlorine in treated water. Total residual chlorine in this application is defined as either free residual chlorine or chlorine.
- The unit shall comprise the sensor assembly and a signal transmitter for DCS and remote indication at an instrument panel.
- The sampling flow to the sensor shall be kept constant by means of a constant head weir (header tank) or any oyher arrangement and shall produce a low-level signal for the transmitter.
- The signal shall be proportional to the total residual chlorine concentration of the water. The total residual chlorine measurement shall be read directly without any calculated or inferred values.
- The electrodes shall be of corrosion resistant material well protected from fouling to minimize maintenance and output signal drift.
- The tenderer shall provide full details of the features provided to prevent fouling of the electrodes in the residual chlorine analyzer offered.
- Residual chlorine analyzers of other types may be offered, but these must be equal or superior in performance to the type specified above.
- The sensor assembly shall be insensitive to variations in hydraulic head an pH (within the range of pH 4 to pH6) expected during normal process operation. It shall be provided with facilities to compensate for the effects of changes in the sampled water temperature within a 0 to 50°C range.
- A carbon filter shall be provided for calibration purposes.
- The sample flow to the sensor shall pass through a constant pressure regulator and removable fiber filter.

2) Type of Signal and Transmitter:

- The residual chlorine analyzer shall have an integrated signal transmitter.
- The tanderer shall provide full details of its construction circuitry.
- The transmitter shall be suitable for providing a 4-20 mA-wire signals to the DCS.
- One indicator shall be integrated with the residual chlorine analyses module.
- The residual analyzer shall be fitted with high, low and failure alarm contacts.

3) Measuring Range, Sensitivity, Repeatability and Accuracy:

- The residual chlorine analyzer shall have an operating range of 0 to 5 mg/l with a sensitivity of not less than 0.04 mg/l.
- Response time to changes in residual chlorine shall not be greater than a few seconds after the water sample enters the residual chlorine analyzer.
- The overall accuracy of the analyzer shall be within +/- 5% of the actual total residual chlorine throughout the entire measuring range.
- The overall repeatability shall be within 0.05 mg/l.
- The residual chlorine analyzer shall be designed for reliable long-term service and properly manufactured to resit corrosion.

4) Installation and Operation:

- The chemical reagents for the measurement of total residual chlorine (within conditioned range of pH 4 and pH 6) shall be an acid buffer and KI solution
- Each refill of these chemical reagents shall last at least four (4) weeks.
- All necessary feed pumps for the dosage of these chemicals shall be included.

3.4. CHLORINE GAS DOSING SYSTEMS

The Chlorine Gas Dosing Systems shall be realized by the vacuum principle for successfully avoids gas leakage.

Vacuum chlorine gas dosing systems are composed of three principal components:

1) Vacuum regulator

The vacuum regulator is a pressure reducing valve, wich reduces the overpressure from the chlorine tank side to the negative pressure on the vacuum site.

The valve opens, when a sufficient vacuum is present on the outlet side.

Vacuum regulators with pressure gauge and a liquid trap shall be available for more safety.

2) Dosing regulator

The chlorine gas volume flow shall be adjusted with the dosing regulator.

This can be effected manually or automatically via motor control.

3) Injector

Injectors have the task to bring chlorine gas into the water flow. They should operate according to the principle of water jet pumps

The injector body shall comprise a nozzle with a successional diffusor.

Between the nozzle and the diffusor, there shall be a narrow annular gap, where chlorine gas shall be sucked out of the dosing line through the injector head.

A diaphragm check valve at the gas supply line shall prevent the ingress of water into the vacuum line.oOo