# Volume 2

# Technical Specifications

# Division 1

# General Specifications

# Part 4

# Electrical Works

# TABLE OF CONTENTS

**Page No.**

**401. GENERAL ELECTRICAL SPECIFICATION REQUIREMENTS 8**

401.1 ABBREVIATIONS 8

401.2 APPLICABILITY 9

401.3 INSTALLATION STANDARDS 9

401.4 MATERIALS 10

401.5 WORKMANSHIP 10

401.6 SAFETY INTERLOCKS 11

401.7 PLANT OPERATION 11

401.8 POLARITY 12

401.9 FAULT LEVEL 12

401.10 SUPPLY INTERRUPTION 13

401.11 ELECTRICITY SUPPLY SECURITY 13

401.12 VOLTAGE DROP 13

401.13 EQUIPMENT AND CABLE RATINGS 13

**402. EQUIPMENT 14**

402.1 ELECTRICAL PANELS 14
402.1.1 Switchboard Motor Control Centres 14
402.1.2 Panel Construction 15
402.1.3 Doors and Covers 16
402.1.4 Switchboard and Busbars Rating 16
402.1.5 Alarms and Indications 17
402.1.6 Panel Wiring 17
402.1.7 Earthing 19
402.1.8 Panel Preparation and Finishing 19
402.1.9 Paint Colours 20
402.1.10 Labels 20
402.1.11 Warning Signs 21
402.1.12 Equipment for Potentially Explosive Atmospheres 22
402.1.13 Field Mounted Equipment 22
402.1.14 Cabling Facilities 23
402.1.15 Terminals 24

402.1.16 Insulating Mats 24

402.2 TRANSFORMERS 24
402.2.1 Current Transformers 24
402.2.2 Voltage Transformers 25
402.2.3 Control Transformers 25
402.2.4 Low and Extra Low Voltage Supplies 25
402.2.5 LV Outlet Transformer 25
402.2.6 High Voltage Transformers 26

402.3 SWITCHES 31
402.3.1 Switches 31
402.3.2 Push Buttons 31
402.3.3 Selector Switches 31
402.3.4 Emergency Stops 32
402.3.5 Auxiliary Switches 32
402.3.6 Low Voltage Fuse Switches 32

402.4 RELAYS 33
402.4.1 Control Relays 33
402.4.2 Protection Relays 33

402.5 FUSES 35
402.5.1 Fuse Links and Holders 35
402.5.2 Distribution Fuseboards 35

402.6 MOTOR STARTERS 36
402.6.1 General 36
402.6.2 Isolation 37
402.6.3 Contactors 37
402.6.4 Protection 38
402.6.5 Control Circuit 39
402.6.6 Control and Monitoring 39
402.6.7 Heaters 40
402.6.8 Star Delta Starters 40
402.6.9 Auto-Transformer Starters 40
402.6.10 Stator/Rotor Starters 41
402.6.11 Electronic Assisted Starting 41
402.6.12 Frequency Converters 42

402.7 ELECTRIC ACTUATORS 44
402.7.1 General 44
402.7.2 Motors 45
402.7.3 Manual Operation Interlock 46
402.7.4 Position Monitoring 46
402.7.5 Position Control 47
402.7.6 Torque and Limit Switches 48
402.7.7 Auxiliary Switches 48
402.7.8 Terminal Facilities 48
402.7.9 Starters and Control Gear 49
402.7.10 Painting and Corrosion Protection 52
402.7.11 Name Plates 52
402.7.12 Actuator Isolators 53

402.8 ROTATING ELECTRIC MACHINERY 53
402.8.1 General 53
402.8.2 Rating 54
402.8.3 Electric Motors 55
402.8.4 Terminal Boxes and Connections 62

402.8.5 Heaters 62
402.8.6 Maintenance Facilities 63
402.8.7 Bearings 63
402.8.8 Slip Rings 63
402.8.9 Noise Level 63
402.8.10 Protection of Motors 63
402.8.11 Motor Manager 64

402.9 CIRCUIT BREAKERS 66
402.9.1 Low Voltage Air Break Circuit Breakers 66
402.9.2 Moulded Case Circuit Breakers 67
402.9.3 Thermal-magnetic motor circuit breakers 69
402.9.4 Miniature Circuit Breakers 69
402.9.5 Distribution MCB Boards 69
402.9.6 Residual Current Circuit Breakers 69
402.9.7 High Voltage Circuit Breakers And Disconnectors 70

402.10 ELECTRIC GENERATORS 73
402.10.1 Alternators 73
402.10.2 Generator Panels 74
402.10.3 Mains/Standby Supply Changeover 74

402.11 ELECTRODES 77
402.11.1 Electrode Mounting 77
402.11.2 Heavy Duty Electrodes 77
402.11.3 Light Duty Electrodes 77
402.11.4 Electrode Circuits 78

402.12 LOCKS & KEYS 78
402.12.1 General 78
402.12.2 Padlocks 78
402.12.3 Key Cabinets 79

402.13 LIGHTNING PROTECTION AND GROUNDING SYSTEMS 79
402.13.1 General 79
402.13.2 Lightning Protection Systems 80
402.13.3 System using air termination network 81
402.13.4 Systems using rod lightning conductor 82
402.13.5 Overvoltage protection 83
402.13.6 Grounding system 85

402.14 HEATERS & THERMOSTATS 86
402.14.1 Water Heater 86
402.14.2 Space Heaters 86
402.14.3 Space Heater Thermostat 86
402.14.4 Electric Trace Heating 87
402.14.5 Trace Heating Thermostat 87

402.15 UNINTERRUPTIBLE POWER SUPPLY (UPS) 87

402.16 BATTERIES & CHARGERS 90
402.16.1 Battery Charger 90
402.16.2 Starter Battery 90
402.16.3 Battery Supplies 90

402.17 POWER FACTOR CORRECTION 91

**403. CABLING & WIRING 92**

403.1 ELECTRICAL CABLES INSTALLATION 92
403.1.1 General 92
403.1.2 Installation of visible Cables 94
403.1.3 Insulated Wires 94
403.1.4 Other Conditions 94
403.1.5 Segregation of Duties and Services 95
403.1.6 Intrinsically Safe Circuits 96
403.1.7 Galvanising and Fastenings 96
403.1.8 Protection of Exposed Cables 97
403.1.9 Cutting Away and Making Good 97
403.1.10 Termination of Glanded Cables 97
403.1.11 Lead Sheath Cable Terminations 98
403.1.12 Jointing 99
403.1.13 Earthing and Bonding 99
403.1.14 Main Earth Connections 101

403.2 SELECTION OF CABLE RUNS AND SIZES 101
403.2.1 General 101
403.2.2 Cables in Concrete Trenches 102
403.2.3 Cables on Trays or Ladders 102
403.2.4 Cables in Ducts 103
403.2.5 Cable Laid in Ground 104
403.2.6 Cables in trunks 107
403.2.7 Cables in Conduits 108

403.3 CABLE MATERIALS 111
403.3.1 General 111
403.3.2 Mineral Insulated Cables 113
403.3.3 Single Core Cables 113

403.4 CABLE ACCESSORIES 114
403.4.1 Compression Glands for Cables 114
403.4.2 Wiring Ferrules 114
403.4.3 Cable Cleats 115
403.4.4 Cable Racks 115
403.4.5 Cable Ladders 116
403.4.6 Cable Channels 116
403.4.7 Cable Trays & Covers 116
403.4.8 Sealing Boxes for Lead Sheathed Cables 117
403.4.9 Sealing Compound 117
403.4.10 Busducts 118

**404. CIVIL WORKS FOR CABLE INSTALLATIONS 119**

404.1 GENERAL 119

404.2 TRENCHING MEASUREMENTS 119

404.3 COVERAGE FOR BURIED CABLES OR DUCTS 119

404.4 CLEARANCES BETWEEN OTHER SERVICES 119

404.5 EXCAVATIONS AND PRECAUTIONS 120

404.6 BEDDING FOR CABLES 120

404.7 DUCTS AND COUPLINGS 120

404.8 BEDDING OF DUCTS 121

404.9 DUCT ALIGNMENT AND CLEANING 122

404.10 CABLE DRAW PITS 122

404.11 BACKFILLING AND REINSTATEMENT 122

404.12 CABLE TRENCHES 124

404.13 CABLE TROUGHS 124

404.14 TRANSFORMER BAYS 124

404.15 EARTHING CONNECTIONS 125

**405. ROAD LIGHTING 126**

405.1 LUMINAIRES 126

405.2 CONTROL GEAR 126

405.3 CONNECTION COMPARTMENT 126

405.4 COLUMNS 126

405.5 LOCATION OF LUMINAIRES 127

405.6 EXCAVATIONS 127

405.7 ERECTION OF COLUMNS 128

405.8 ALIGNMENT 128

405.9 BACKFILLING 128

405.10 TEMPORARY REINSTATEMENT 129

405.11 TREATMENT OF COLUMNS AFTER ERECTION 130

405.12 MARKING 130

405.13 ELECTRICAL EQUIPMENT 130

405.14 WALL AND BRACKET MOUNTING 132

405.15 FOLDING COLUMNS 132

405.16 FEEDER PILLARS 132

405.17 HIGH MASTS 134

405.18 WINCHING ARRANGEMENTS 134

**406. ELECTRICAL INSTALLATION FOR BUILDINGS 135**

406.1 GENERAL 135

406.2 ELECTRICITY SUPPLY 135

406.3 NATURE AND ORIGIN OF MATERIALS 137
406.3.1 General 137
406.3.2 Electrical Distribution Boards 137
406.3.3 Circuit Breakers 138
406.3.4 Contactors 140
406.3.5 Electric cables 140
406.3.6 Insulated Conductors 141
406.3.7 Conduits 142
406.3.8 Boxes 143
406.3.9 Switches 144
406.3.10 Power Outlets Sockets 144
406.3.11 Grounding Systems 145
406.3.12 Lighting Fixtures 147
406.3.13 Characteristics of Materials 148
406.3.14 Fluorescent Luminaires 148
406.3.15 Incandescent Luminaires 149
406.3.16 Lamps 149
406.3.17 Emergency lighting 150

406.4 EXECUTION OF THE WORKS 151
406.4.1 Locations for Installation of Equipment 151

406.5 CABLE INSTALLATION 153
406.5.1 General Conditions 153
406.5.2 Installation of visible Cables 153
406.5.3 Other Conditions 153
406.5.4 Insulated Wires 153

**407. TELEPHONE INSTALLATION 155**

407.1 GENERAL 155

407.2 CIRCUITS DISTRIBUTION 155

407.3 TELEPHONE PLUGS 155

# 401. GENERAL ELECTRICAL SPECIFICATION REQUIREMENTS

## 401.1 ABBREVIATIONS

The following abbreviations are used in these documents :

| | |
|---|---|
| 1/head/day | liters per head per day |
| AC | Asbestos Cement |
| AGMA | American Gear Manufacturer's Association |
| AOD | Above ordnance datum |
| BS | British Standard |
| CDR | Council for Development and Reconstruction. |
| CFM | cubic feet per minute |
| Ch | Chainage |
| CMR | Continuos Maximum Rating |
| CP | Code of Practice |
| CPU | Central Processing Unit |
| DI | Ductile Iron |
| DIN | Deutsch Industrie Normen |
| DOV | Double Orifice Valve |
| DPSK | Differential Phase Shift Keying |
| DTU | Documents Techniques Unifiés |
| EDL | Electricity of Lebanon |
| EMC | Electromagnetic Compatibility |
| EOH | End of hole. |
| FDS | Functional Design Specification |
| FIDIC | Federation Internationale des Ingénieurs- Conseils |
| FSK | Frequency Shift Keying |
| g | acceleration due to gravity ($9.807 m/s^2$) |
| GL | Ground level |
| gpm | gallons per minute |
| gr | gram |
| GRP | Glass Reinforced Plastic |
| GTSD | General Technical Specification Document |
| hr | hour |
| I/O | Input / Output |
| IEE | Institute of Electrical Engineer |
| ISO | International Standards Organization |
| ITS | Institute of Technical Studies |
| kgf | kilogram force |
| kPa | kilo Pascal |
| kVA | kilovolt-ampere |
| kW | kilowatts |
| kWh | kilowatt hour |

| | |
|---|---|
| LED | Light Emanating Diode |
| m | meters |
| $m/s^2$ | meters per second per second |
| $m^3$ | cubic meters |
| $m^3$/day | cubic meters per day |
| MDPE | Medium Density Polyethylene |
| mgd | million gallons per day |
| mhd | meters head |
| mm | millimeters |
| NFE | Normes Françaises - (Electrical) |
| NLQ | Near Letter Quality |
| NPSH | Net Positive Suction Head |
| PS | Particular Specification |
| PTT | Poste de Téléphone et de Télégraphe |
| PVC | Polyvinyl Chloride PWL |
| | Pumping Water Level |
| RAM | Random Access Memory |
| RBC | Rotating Biological Contractor |
| RTR | Reinforced Thermoplastic Resin |
| RTU | Remote Terminal Unit |
| SCADA | System Control And Data Acquisition |
| SOV | Single Orifice Valve |
| SPTD | Signal Pole Double Throw |
| SSU | System Supervisory Unit |
| SWL | Static Water Level |
| TDH | Total Dynamic Head TDM |
| | Time Division Multiplex |
| TEFC | Totally Enclosed Fan Cooled |
| UHF | Ultra High Frequency |
| UPS | Uninterrupted Power Supply |
| UPVE | Unsaturated Polyvinyl Chloride |
| VDU | Video Display Unit |
| VGA | Video Graphics Array |
| VHF | Very High Frequency |
| VHS | Video Home System |

## 401.2 APPLICABILITY

The following clauses specify general electrical requirements and standards of workmanship for the equipment and installations. General specification clauses shall apply where appropriate except where particularly redefined in the individual specification clauses.

## 401.3 INSTALLATION STANDARDS

All electrical work must be carried out by a contractor in possession of a current license acceptable to the client which will permit the contractor to carry out work on high voltage and low voltage equipment and cabling.

All works shall be carried out in accordance with the requirements of:

i. ISO, DIN, AFNOR - Mechanical equipment

ii. The institution of Electrical Engineers (I.E.E.) regulations for the electrical equipment CEI, UTE, VDE, AFNOR, BS.

iii. British Standards Institution (B.S.I.) and code of practice (C.P.) or equivalent international electro-technical commission (I.E.C.).

## 401.4 MATERIALS

All materials incorporated in the works shall be the most suitable for the duty concerned and shall be new and of first class commercial quality free from imperfection and selected for long life and minimum maintenance.

The use of dissimilar materials in contact shall be avoided, but where unavoidable these materials shall be selected so that the natural potential difference between them does not exceed 250 million volts. Electro-plating or other treatment of contacting surfaces shall be employed as necessary to reduce the potential difference to the desired limit.

All materials and material finished shall be selected for long life under the site conditions detailed in the specification and shall be derated by the approved factors given in the British Standard Specifications.

## 401.5 WORKMANSHIP

Particular attention shall be paid to the appearance of the electrical installation, arrangements of which shall be agreed by the Engineer's representative before the commencement of installation. The Contractor shall ensure that the installation is completed to the highest standard of neatness with respect to the visible cable runs and the arrangement and alignment of apparatus and fittings.

Conduit shall be surface run with the exception of personnel, administration and control room where, generally, fittings shall be suitable for flush installation.

The positions of all equipment should be detailed on arrangement drawings, indicating the exact position of all equipment and conduit runs.

The Contractor shall be responsible for the fixing of all switches, fuseboards switchboards switchgear, cables, fitting, cable trays, accessories and all other items comprising the electrical

installation. No work shall commence until approval of the electrical general arrangement drawings has been given by the coordinating Engineer, the Engineer and were appropriate, the relevant authority.

No structural steel, timber work or concrete shall be drilled for the support of cables or fittings without the prior approval of the Engineer's representative.

Should the Contractor propose to use junction boxes in auxiliary control cable circuits for the

purpose of marshalling a number of cables feeding to a common item of equipment full details shall be given to the Engineer, and the Contractor shall only proceed after the receipt of the Engineer's written approval. Any such junction box shall be of the wall mounting weatherproof pattern (IP55) with double terminals. All cores shall be ferruled and identified in accordance with the system schematic and cable diagrams.

The Contractor shall arrange for the switchgear and panel manufacturers to provide skilled labour for the supervision of off-loading, placing in position on prepared foundations, erection and commissioning of all switchgear and control panels.

## 401.6 SAFETY INTERLOCKS

A complete system of interlocks and safety devices shall be provided as necessary for the safe and continuous operation of the plant in order to provide for:

i- Safety of personnel engaged on operational and maintenance work on the plant.

ii- Correct sequence of operation of the plant during start up and shut down.

iii- Safety of the plant when operating under normal or emergency conditions.

interlocks shall be preventive and not corrective in operation.

The Contractor shall be responsible for the preparation of interlocking schemes for the approval of the Engineer.

## 401.7 PLANT OPERATION

The plant will be unattended and all constituent units shall be arranged to be fully automatic and maintained ready for service at all times.

In order to simplify operation and maintenance, all control schemes shall, as far as possible, follow the same operating pattern, have similar control cubicle layouts, and employ similar items to minimise spares holdings.

Electrical system design shall reflect the hydraulic system design as far as possible and shall be directed to making each major item of plant capable of running substantially independent of

others. Where common equipment is employed then every effort shall be made to ensure that no single fault can affect the entire plant and particular care must be taken to protect the overall integrity of the system.

Provided that the principle of segregation is not infringed, solid state or microprocessor based equipment may be incorporated within the various control panels in lieu of electromagnetic relays, timers, etc., in order to perform the necessary control functions. In this event, full details of the proposal to achieve segregation shall be submitted for approval with the Tender. All costs for programming, setting-up, proving and training of purchasers staff in the operation and maintenance of such equipment shall be separately identified in the Schedule of Prices.

## 401.8 POLARITY

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

i. For two poles 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). On plug and socket outlets, the polarity shall conform to BS 196, BS 546, and BS 1363 as appropriate.

ii. For three or four pole apparatus, the phases in the order L1, L2, L3, and neutral reading from top to bottom or left to right in the case of vertical and horizontal layouts respectively. These layouts are when viewing the apparatus from the front.

All cables shall be connected between main switchboards, distribution board plant and accessories so that the correct sequence of phase identification is preserved throughout the system.

All cables cores shall be identified with phase references. Where more than one phase is incorporated on a common system in one room, then the live cores shall be identified as appropriate and fittings and switch accessories shall permanently labeled and segregated in accordance with the relevant clauses of the I.E.E. regulations.

## 401.9 FAULT LEVEL

Where a switchboard is directly connected to the low voltage side of a transformer or transformer without any distribution cut-out, then the complete switchboard shall be manufactured to comply in total, with a short circuit rating of 44 (K.A.) for a duration of 1 second minimum.

All small wiring for controls, voltmeter supplies, etc., that originate from the main and sub-main busbars shall be protected by means of busbar mounted H.R.C. cartridge fuses suitably rated for the purpose intended. The maximum size of fuse used shall not exceed 20 amps.

## 401.10 SUPPLY INTERRUPTION

To ensure that the effects of incoming electricity supply disruptions have minimal effects on pumping capacity, main switchgear shall be fitted with overload, overcurrent and earth fault protection. The switchgear shall not require manual resetting or closing after a supply interruption. Where contactor controls are used for main and auxiliary transformer circuits, these shall be latched so that they are re-energised when the supply is restored.

Re-starting of main motor circuits under automatic control shall be staggered to reduce system disturbance. (See Pump Duty Control.)

## 401.11 ELECTRICITY SUPPLY SECURITY

Works or pumping stations shall be provided with single or duplicate electricity supplies to a level of security determined by the Purchaser's operating principles and practices, as specified herein.

Duplicate supplies shall be derived from different sections of the supply system network.

Alternative or additional security may be specified by the provision of on-site stand-by generating capacity.

### 401.12 VOLTAGE DROP

The volt drop within the installation shall not exceed a value suitable for the safe functioning of any fixed current-using equipment.

### 401.13 EQUIPMENT AND CABLE RATINGS

All busbars, cables, switchgear, fuses, motor starters, relays, instruments, panel wiring, etc. shall be sized and rated in accordance with normal operational requirements of the associated plant and equipment, taking into account maximum load currents, voltage drop, frequency of motor starting, maximum ambient temperature, etc.

Where specific voltage or current ratings have been included on the Drawings and in the description of individual items of equipment in the Specification and/or Bill of Quantities the values stated shall be deemed to be minimum values. It shall however be the responsibility of the Contractor to ensure that all equipment supplied is properly insulated and adequately rated to handle operational loads and, in the case of fuse gear and circuit breakers, to deal with prospective fault currents.

## 402. EQUIPMENT

### 402.1 ELECTRICAL PANELS

#### 402.1.1 Switchboard Motor Control Centres

All L.V. and H.V. switchboards and motor control centres shall conform to the relevant British standards and consist of cubicles of equal height and depth mounted side by side to form a composite board of uniform and pleasing appearance.

All L.V. switchboards and motor control centres shall be manufactured by a single, approved, supplier and the construction of each individual panel shall be such that all components shall be selected for standardisation.

L.V. motor control centres shall comply with the requirements on BS5486 (I.E.C. 439) Class 3 of the National Appendix in order to provide fully segregated self-contained compartments. Fully type tested designs only shall by considered.

Switchboards shall be so positioned that access thereto is not obstructed by the structure or contents of the building. A distance of not less than 900 mm shall be provided and maintained in front and at the rear of every switchboard/panel for the purpose of safety and effective operation and adjustment of all equipment mounted thereon, and space and access behind switchboard/panels shall be sufficient for adequate service, but in no case less than 900 mm.

Where a switchboard incorporates rack-out switchgear, doors or hinged panels, there shall be a clearance of not less than 1200 mm. between any wall or immovable structure and the switchgear, doors or hinged panels when it is in the racked-out or open position.

Rear access switchboards and panels shall be provided with unhinged lift-off panels only. Hinged panels will not be permitted.

All apparatus shall be positioned on a switchboard so that there is ample room for its safe and effective operation and handling.

Each individual switchboard, motor control centre shall be provided with 3 no. socket outlets. They shall be installed to facilitate connection of test equipment (220 V) portable tools and inspection load (110 V). Each socket shall be provided with a colour coded cover and matching colour coded plug.

Each section shall be fitted with a demountable undrilled metal gland plate positioned at low level but with adequate space for termination of cables, conduits, etc. The gland plates shall be efficiently earthed to the panel earthing system by a separate earthing conductor. The base of the panel shall be provided with removable plates of the split type to seal the cable/conduit entry cut-outs. The plates shall be positioned directly below the gland and base plate shall be of non-ferrous material.

Switchboard and motor control centres shall be suitable for mounting on concrete plinths.

All foundation holes shall be at least 75 mm from any outside edge of the panel and at least 75 mm from any concrete edge to avoid break-out when tightening bolts.
All lifting eyes supplied with the boards shall be removable and replaced, at site, with chrome plated screws.

Each panel shall be treated in accordance with the metal protection requirements. The colour finish of the outside shall be as advised by the Engineer. Cubicle interiors shall be painted white. Colour shades shall be to BS. 4800.

### 402.1.2 Panel Construction

Panels shall be constructed of sheet steel having a minimum thickness of 2.0mm (14 SWG) or other approved material, and similar equipment shall be of the same manufacture and units of the same type and rating are to be interchangeable. The use of toxic, hygroscopic or flammable materials shall be avoided.

LV Panels shall be damp and dust protected (IP44 for indoor dry or IP55 for indoor humid/wet) situations and hoseproof (IP65) for outdoor or wet situations, or as otherwise specified under the Particular Specifications.

Switchboards shall incorporate a rigid steel frame and be suitable for ready extension at each end without further cutting or drilling. Composite switchboards shall be assembled by the principal electrical manufacturer and shall be sectionalised as necessary to facilitate handling.

Switchboards shall include barriers between each of their units to ensure safe maintenance on any circuit during normal operation with the remainder of the board live. When a functional unit is isolated and open, the degree of protection to any remaining live part shall be at least IP20. Barriers or covers to live components shall have warning labels attached.

If any compartments are provided within a section of outgoing units which are not fully equipped, they shall be arranged so that they can be fully equipped without de-energising that section of the switchboard.

Cubicle type switchboards shall be totally enclosed, flush-front and rear pattern, arranged in a multi-tiered formation if practicable, with at least 300mm clearance between floor level and any operational item of fuse gear or control gear. Kicking strip protection shall be provided by a 100mm high plinth forming the base of the switchboard.

The overall height of control panels, including plinths, shall not exceed 2300mm. Isolator handles, control switches, push buttons shall be centered not more than 1800mm above finished floor level. Indicator lamps and instruments shall be centered not more than 2000 mm above finished floor level.

All components mounted on the front of the panel shall be of matching uniform appearance, orientation and colour, with all bezels and escutcheons finished black. The layout and grouping of components shall be as approved or specified.

Within each control cubicle a reduced size schematic diagram of the control circuit, printed on durable material, shall be permanently fixed.

All cubicles shall be provided with anti-condensation heaters mounted at low level and, with the exception of starter cubicles, they shall be provided with internal thermostats (adjustable type) and externally operated ON/OFF control switches mounted on respective doors. The thermostat range is to be compatible with the location and climate.

### 402.1.3 Doors and Covers

Each section or compartment shall be provided with full width access doors or covers, with individual doors or covers not exceeding 750mm width.

All doors and covers shall have returned edges for rigidity and incorporate dust seals of flexible material secured in channel rebates. Covers exceeding 0.5m² in area shall be provided with a supporting lip within the lower edge or have lift-off hinges. All doors shall be supported on strong hinges of non-corrodible material and shall be secured by adjustable quarter turn cams, operated by small TEE handles incorporating key operated barrel locking facilities or flush locks with drive key inserts. Covers shall be secured by similar fastenings or captive bolts.

All additional fittings such as handles, hinge brackets and locks shall be a black finish, polyamide moulding or epoxy coated metal.

Doors shall open at least 90° with the opening positively limited such that doors and their appurtenances are prevented from fouling adjacent panels when opened.

All doors shall be fitted with a restrainer, so positioned that each door shall be prevented from swinging more than 120°. Earth leads connected to doors will not be acceptable as restrainers.

### 402.1.4 Switchboard and Busbars Rating

Switchboard busbars, droppers, switchgear and its associated cable boxes shall be mechanically and electrically designed to withstand the fault level and duration specified herein and (except for LV switchboards rated less than 800A) shall be an ASTA certificated design rated at not less than 80 kA RMS for 1 sec. or 50 kA for 3 sec. LV switchgear and motor control gear shall comply with BS 5486 Form 4 segregation of busbars, functional units and terminal chambers, unless otherwise specified.

Busbars and droppers shall each be air insulated and formed from solid drawn, high conductivity copper bars, having a constant current rating with a uniform cross sectional area

throughout their length. Each shall be clearly marked with the appropriate colours to indicate each phase, neutral and earth. Droppers shall be as short and as straight as possible. Busbar compartments shall be fully segregated and shrouded from all other sections of the switchboard.

All busbar connections shall have at least two bolt fixings. Where flexible busbar connections are used these shall be secured by high tensile steel bolts and nuts with anti-vibration locking devices.

### 402.1.5 Alarms and Indications

Separate indication of the following conditions shall be provided by means of annunciators grouped as indicated on the front of the panel. All indications shall have a lamp test facility.

Alarm annunciators shall be provided with accept and reset facilities together with an audible alarm and an audible/mute selector switch.

Each of the alarm conditions specified shall initiate its individual annunciator with a flashing indication which shall become steady when the "Accept" button is pressed and be extinguished by the "Reset" button once the alarm condition is removed.

In specified unattended locations, self reset facilities shall be provided to enable the system to restore itself to normal operation after the fault has passed.

With the audible/mute switch set to "Audible", the audible alarm shall sound when the indication is flashing and be silenced when the "Accept" button is pressed. In the "Mute" position the audible alarm shall be muted and any alarm initiation shall give a steady lamp indication only.

To prevent false alarms occurring during mains failures or on restoration of mains supply, the common alarms specified shall be supported by a battery backed supply, either directly or via an inverter.

### 402.1.6 Panel Wiring

Panel wiring shall be run neatly within the cubicle in suitable cable looms or panel trunking, and in the case of instrument, intrinsically safe or safety extra-low voltage circuits, run in separate groups accommodated within the cubicles. The looms or trunking shall be adequately secured without the use of adhesive material. Wiring carried across door hinges shall be neatly loomed and rolled in torsion in the plane of the hinges to minimise flexing of the wiring, thus

wiring shall enter and leave at different levels as widely spaced as practicable. Bushings or grommets shall be used where wiring passes through sheet metal or plastic.

All components and auxiliaries in repetitive units shall be wired in an identical pattern to match the arrangement of each component.

Wiring cables shall be adequately rated, tinned copper stranded conductors of not less than 1.0mm² (32/0.20) PVC insulated 600V grade, except wiring to PLC or other light current equipment which shall be not less than 0.5mm² (16/0.20).

Wiring insulation shall be coloured as follows:

AC Circuits
Mains supply (LV) - Black
Uninterruptible power supply (LV) - White
ELV supplies (up to 50V AC) - Yellow
Intrinsically safe circuits - Blue

DC Circuits
Battery supply (ELV, not exceeding 120V DC) - Grey

Where various voltages exist within the above definitions, the colour coding shall be subject to agreement with the Engineer.

Each wire shall be terminated with suitable ring or spade crimps or bootlace ferrules and identified at both ends by means of white or resistor colour-coded ferrules imprinted to correspond with the diagram of connections. Wires linking common points in the circuit shall bear the same reference at each termination. Alternative identification methods require prior approval of the Engineer.

All switchboard and instrument panel wiring shall be carried out in P.V.C. insulated cable, in a neat and systematic way and securely fixed and arranged so that access to the apparatus is not impeded.

Auxiliary wiring shall be run neatly within the cubicle and in the case of instrument circuits, run in separate groups accommodated within the cubicles. The minimum size shall be submitted for the Engineer's approval. Wiring shall be supported in insulated cleats or cable trunking.

All terminal blocks for the connection of small wiring shall comprise shrouded anti-tracking mouldings of melamine phenolic or comparable material within provision for securing conductors either by high tensile screws and clamps or alternatively, in the case of the small telephone type conductor, by solder tag connection.

Terminal blocks shall be arranged to facilitate easy access to both terminals and wiring ends. Connections for outgoing circuits to auxiliary pilot cables shall be provided with test links.

Identification ferrules or reference numbers shall be fitted on the wires at both ends and letters and numbers shall correspond to the appropriate wiring diagram and coded in accordance with I.E.C. 446.

### 402.1.7 Earthing

All metal cases of meters, relays, instruments, starters, and control switches shall be connected to the switchgear frame earth terminal by means of green and yellow PVC insulated cable, not less than 2.5mm² cross section.
An earthing terminal or group of terminals shall be provided in the panel for termination of panel earthing connections and incoming cable earth or connection to a main earth bar.

A main earth bar of copper shall be provided to run the full length of each board so that all cable sheaths and armouring may be bonded to it. Where the fault level at the switchgear is 33kA or less the minimum size shall be 31.5mm x 6.3mm. For short circuit duty in excess of 33kA the size shall not be less than 50mm x 6.3mm.

All live terminals of equipment mounted on cubicle doors and/or enclosure covers shall be adequately screened unless protected by an interlocked isolator. All doors and hinged covers shall be efficiently earthed by a separate conductor.

### 402.1.8 Panel Preparation and Finishing

The whole preparation and paint system shall be suitable for the operating environment specified and a painting schedule giving details of preparatory treatments, types of paint, number of coats and method of application shall be submitted with the Tender. Proprietary items may be used in their standard finish subject to the approval of the Engineer.

The system proposed shall conform to the following minimum requirements.

After all machining and forming has been completed all steelworks surfaces shall be thoroughly cleaned of rust, scale, welding slag or spatter and other contaminations prior to any painting.

Panels for indoor location shall, immediately after cleaning, have all surfaces protected by an approved zinc-based corrosion resistant primer, followed immediately by one intermediate and two finishing coats of paint to give a minimum total dry film thickness of 50 microns (0.002").

Panels for damp situations or outdoors shall have the surfaces grit blasted and zinc sprayed within 4 hours to BS 2569 Part 1 to a thickness of 125 microns (0.005") at the works. The final paint finish shall be one of two pack epoxy primer and two coats of epoxy paint to give a minimum total dry film thickness of 75 microns (0.003").

Steel fixings and fastenings shall be treated to prevent corrosion by hot dip galvanising to BS 729 or sherardised to BS 4921 Class 1 before painting. Chromed fittings shall not be used.

Any damage occurring to any part of a painting scheme shall be made good to the same standard of corrosion protection and appearance as originally employed. Any finish coat applied on-site shall be considered for decorative purposes only.

### 402.1.9 Paint Colours

The colours of the primer, intermediate and finishing coats of a paint system shall be easily distinguishable from each other and the materials used shall be suitable for the application employed and preferably be supplied by one manufacturer who shall ensure that all coatings

are compatible.

Electrical control panels shall be gloss finished in the following final colours:

| DETAILS | COLOUR | BS 4800 Ref: | BS 381C Ref: |
|---|---|---|---|
| Panel Exterior | as advised by the Engineer | | |
| Interior Equipment | White | 10 B 15 | - |
| Trays | White | 10 B 15 | - |
| Busbar Shutters | Signal Red | 04 E 53 | 537 |
| Circuit Shutters | Lemon Yellow | 10E 53 | 309 |

**402.1.10 Labels**

Individual items not subject to switchboard requirements shall have labels of non-corrodible, Traffolyte sandwich type white/black/white, or yellow/black/yellow for danger labels or as approved by the Engineer. They shall be fixed square to the equipment by means of screws or rivets of nylon or non-corrodible material. Labels affixed with adhesive will not be accepted.

Inscriptions on labels and circuit lists shall be in English and Arabic and be submitted for the approval of the Engineer. The abbreviation `No.` shall not be used.

A list of circuits in approved form shall be supplied and fixed behind a "Perspex" sheet on the inside of all distribution boards which are provided or rewired under this Contract.

Each switchboard shall be provided with a title label and have circuit designation labels fixed to the front and rear cover of each circuit compartment. Rear covers for more than one sub-section shall have labels for each sub-section. In all cases, the label shall be positioned so as to leave no doubt as to which item it refers.

All indicators, instruments, relays, control switches, push-buttons, fuses and other ancillary apparatus shall be provided with labels clearly stating their function.

Character sizes for main title and circuit designation labels shall be at least twice those for ancillary items.

All label inscriptions shall be to the approval of the Engineer and the abbreviation `No.' shall not be used.

Labels fitted to the front of the switchboards/control panels/starters shall be of transparent perspex with radiussed or chamfered front edges, reverse engraved with white infill then sprayed on the rear to match the colour of the board. Other labels shall be sandwich type white/black/white, or yellow/black/yellow for Danger labels, or as approved by the Engineer.

All labels shall be fixed square to the equipment by means of screws or rivets of nylon or non-corrodible material. Labels affixed with adhesive will not be accepted.

All external labels supplied to H.V. and L.V. switchboards and motor control centres and other items where specified, shall be clear perspex, back engraved, filled black and back painted the same colour as the switchboard. All labels shall have chamfered edges and shall be affixed with chrome plated screws. Adhesive labels will not be accepted.

All internal labels shall be engraved multi-layered plastic (Traffolite or similar) affixed with chrome plated screws, adhesive labels will not be accepted.

Each switchboard, control panel, distribution board, compartment door etc. shall have a label and each door mounted component or control shall have a function label.

Every internal component shall be identified and each fuse shall be labelled with identification, fuse type, fuse current.

Compartments with doors not interlocked to an isolator or removable covers having access to live parts shall have an external label affixed thereto : - "DANGER LIVE TERMINALS" black letters on a yellow background.

All other labels shall be in English but space shall be left for additional labels in Arabic to be mounted alongside or directly above unless otherwise instructed.

### 402.1.11 Warning Signs

`Automatic Plant' warning signs shall be provided and erected by the Contractor in the building or on the plant in a prominent position to be agreed. The 500mm x 300mm x 0.7mm (22SWG) signs shall be located approximately 1.6m above the adjacent floor level to the sign centre.

The sign shall be of 22 swg, vitreous enamelled aluminium sheet or plastic, having black letters on a yellow background, inscribed as follows:

**CAUTION**

PLANT UNDER AUTOMATIC CONTROL
AND LIABLE TO START WITHOUT WARNING

ISOLATE AT SOURCE BEFORE ATTEMPTING ANY
MAINTENANCE OF MECHANICAL AND ELECTRICAL PLANT

### 402.1.12 Equipment for Potentially Explosive Atmospheres

Equipment for use in potentially explosive atmospheres shall be selected and installed in accordance with BS 5345, subject to the temperature classification of the specified gas, vapour or liquid. Ex(d) and Ex(i) classified equipment shall be certified for Apparatus Groups IIA and IIB.

In such areas, aluminium and other light metal alloys shall only be used for enclosure of electrical apparatus and fittings where such enclosures conform to the material requirements of BS 5501
Part 1.

Aluminium and light metal alloy fans on motors may be used if adequately protected, or if plastic fans or cowls are used they shall be of anti-static material.
Where no British Standard is applicable, equipment to an equivalent European standard may be submitted, subject to the approval of the Engineer.

### 402.1.13 Field Mounted Equipment

Individual starters, fuse-switches, distribution boards and other equipment shall be housed in robust, heavy gauge, rustproof, metal-clad enclosures having external fixing lugs except where otherwise specified.

Components, fittings and housings shall be as specified elsewhere in this specification.

Equipment housings shall be mounted such that the terminal and covers are readily and safely accessible and are not obstructed or affected by the adjustment or mounting arrangement.

i) Push button stations shall be single or composite units suitable for accommodating the required buttons in the above enclosures. Each button top shall be fitted with a durable protective flexible boot.

ii) Junction boxes shall be equipped with rail-mounted, feed-through terminals adequately sized to accommodate the cables to be terminated. An earth connection facility shall be provided for each box.
Surface junction boxes used to connect power cables for submersible pumps shall be equipped with busbars of adequate rating as specified in the "Switch board & Busbars rating" paragraph. The busbars shall be drilled to accommodate all necessary terminal lugs. Adequate glands and gaskets shall be used to maintain the junction box with an index of protection of IP67.

iii) Auxiliary switches shall be mechanically and electrically suitable for the duty and circuit operations specified herein and intended by the switch manufacturer. Roller-lever operated switches shall be of the snap action type.

Where employed for crane or gantry duty, spring failure within a limit switch shall not render it inoperative.

Hand-gear interlocks shall be fitted to any driven equipment which has provision for manual operation to ensure that it is not possible for drives to start with the hand-gear in position.

### 402.1.14 Cabling Facilities

Cable boxes and glands shall be accommodated within the cubicles except where otherwise approved and all removable access, sealing and gland plates are to be provided with gaskets to form an adequate seal against the external atmosphere.

Adequate space within each compartment shall be allowed for external cable tails to be connected without stress on the terminations, bearing in mind the type and size of such conductors. Where multicores in excess of 95mm² or any single core cables are to be terminated, a minimum distance of 450mm free space shall be allowed between the gland plate

and the terminal connection point.

In multi-tier compartments, individual terminal covers and gland plates shall be provided for each circuit such that additional circuits may be terminated safely whilst the switchboard is energised.

For paper insulated cables, a suitable cable end sealing box shall be provided for each circuit as specified. Where the cable enters from beneath the panel, the bottom of the wiping gland shall be at least 150mm above the panel floor level. Removable split sealing plates are to be provided for subsequent fitting around such cables.
Un-drilled removable gland plates shall be provided for cables requiring compression glands entering from beneath the panel. The plate shall be located at least 300mm above the panel floor level and shall form part of a compartment constructed within the panel to seal the interior from the exterior of the panel. Access for glanding-off shall be provided by removable covers fitted to the available vertical sides which may extend the full width of the panel as necessary.

Where single core cables are to be accommodated, a non-magnetic or slotted gland plate shall be provided.

Terminals, studs or drilled holes shall be provided to accommodate all necessary cable terminal lugs and, prior to manufacture, the Contractor shall confirm cabling termination requirements with the Engineer.

### 402.1.15 Terminals

All terminal blocks for the connection of small wiring shall comprise shrouded anti-tracking mouldings of melamine phenolic or comparable material with provision for securing conductors either by high tensile screws and clamps or by solder tag connection.

Terminal blocks shall be arranged so that both terminals and wiring ends are readily accessible and have separate terminals provided for incoming and outgoing wires, together with insulated barriers between adjacent connections and transparent insulated covers. Blocks accommodated on common mounting rails shall have a foot designed to ensure a secure fit to the rail. Foot springs shall be of stainless steel and have a locking device fitted to prevent accidental release of the block.

Each terminal shall be labelled to correspond with the diagram of connections and terminal identification labels shall be attached to the fixed portion of the terminal blocks only. Terminals for intrinsically safe circuits shall be clearly segregated and coloured blue.

Terminals which may be `live' when the equipment is isolated from the main supply shall be adequately shielded from accidental contact and be clearly identified and inscribed accordingly.

All terminal boards and terminal blocks shall provide a positive mechanical clamp type connection. Pinch screw type terminals shall not be used. Terminals for the connection of all external cabling shall be situated at least 100mm from their respective gland plate or further if the cable size requires a greater distance for dressing.

All main phase terminals shall be suitably marked to ensure correct phase identification

### 402.1.16 Insulating Mats

Black rubber matting shall be supplied complying with BS 921 shall be supplied for all indoor control or switch gear panel. It shall extend the complete length of the control panel and the minimum width shall be one metre.

## 402.2 TRANSFORMERS

### 402.2.1 Current Transformers

Each current transformer shall bear a label showing the ratio, class, short time factor and accuracy limit factor. The inscription must be readable when the transformers are installed within the gear without the necessity of dismantling any equipment other than removing cover panels.

Bar type current transformers shall be supplied in preference to those with wound primaries. Short time current factors shall relate to the full fault level specified. For over-current

protection, the product of VA rated burden and rated accuracy limit factor shall be 150 unless otherwise agreed with the Engineer.

One secondary terminal of each current transformer shall be earthed at the switch-gear.

### 402.2.2 Voltage Transformers

Voltage transformers shall be vacuum impregnated or encapsulated resin insulated type. Each transformer being fully isolatable and accessible for maintenance purposes and fitted with primary and secondary fuses.

### 402.2.3 Control Transformers

Each motor starter shall be provided with a single phase low voltage transformer to supply the operating control circuit.

Primary windings shall be suitable for 220 volts single phase supply and be complete with control fuse and neutral link. Secondary windings shall be suitable for 110 or 220 volt supply, centre tapped earth (55-055 volts) and protected by a suitably rated fuse fitted to each pole.

Transformers shall be adequately rated for each starter control circuit and generally comply with BS. 3535.

### 402.2.4 Low and Extra Low Voltage Supplies

Where low and extra low voltage supplies are required for illumination and power supplies (hand lamps, installations liable to flooding portable hand tools, etc.) they shall be obtained from suitable transformers mounted within each switch-gear control panel or distribution cubicle.

These units shall be of the non-inherently short circuit proof type and shall have primary and secondary fuses mounted in an accessible position. All fuses shall comply with the Fuses requirements.

### 402.2.5 LV Outlet Transformer

Isolating transformers shall be of air cooled, double wound construction in accordance with BS 3535, fitted with an earthed metallic screen between primary and secondary windings and suitable for operation from a 220V 50HZ single phase supply.

The secondary winding shall have a rated output of 100VA continuous (1500VA intermittent tool rating) at 110V and have a centre tapping connected to earth.

The transformer shall be enclosed in a wall mounting sheet steel or moulded casing with external fixings lugs and separate cabling connections. The secondary output shall be via fuses incorporated in the enclosures.

### 402.2.6 High Voltage Transformers

#### 402.2.6.1 General

The transformers will be used for distribution purposes on electrical power and lighting installations as specified.

Each transformer shall comply with the requirements of BS 171 for outdoor, naturally cooled types, having an insulation level in accordance with Part 3, Table II List 2.

They shall be mineral/silicone oil cooled or dry type/cast resin as specified and shall operate satisfactorily at any supply voltage between ± 15% of the rated voltage as specified herin, and within ± 2.5% of 50Hz. Simultaneous variations in voltage and frequency will not be in opposite directions.

All connections between the transformer coils and the items mounted on the enclosure shall be provided, adequately braced and supported to withstand the specified fault conditions.

#### 402.2.6.2 Tappings

Tappings at ± 7% and ± 15% nominal voltage shall be provided on the HV windings as specified herein, preferably arranged at positions in the coils to preserve the electro-magnetic balance of the windings at all voltage ratios, and the transformer shall give its full rated output on any tapping.

In any dual voltage units, the changeover facilities shall be by means of internally mounted, off-load links within the enclosure.

#### 402.2.6.3 Tapping Switch

An externally operated, off-circuit tapping switch of robust construction shall be provided, especially designed against risk of damage from short circuits and having all contact surfaces of ample area for satisfactory operation during overloads.

The mechanism shall be hand-operated and shall come to rest only when the switch is making full contact, giving clear indication of the ratio at which the transformer is operating. The switch shall operate simultaneously on all three phases.

Approved means shall be provided for locking the tapping switch mechanism in the positions corresponding to each voltage ratio.

402.2.6.4 Rating and Identification Plates

Each transformer shall be provided with a terminal marking and rating plate, together with a distinguishing number plate of approved type bearing a specified designation reference in raised characters not less than 75mm in height.

402.2.6.5 Construction

The core shall be built up of interleaved laminations, stepped to give optimum magnetic contours and insulated on one side, of cold reduced, grain oriented silicon steel working at a flux density not exceeding 16,500 lines/sq.cm (1.65 Tesla). Corner and yoke joints shall have minimum gaps for quiet and efficient operation and shall be securely clamped and braced with channel section frames to reduce vibration.

Oil filled enclosures shall comprise a tank of sheet steel construction incorporating facilities for lifting and jacking the complete units and have a channel section skid base fitted with rollers. Holes shall also be provided in the skid base at each end for haulage purposes such that, after installation, the rollers may be re-located therein and the transformer will stand on its base.

Cooling shall be by means of flange mounted radiators. Top cover plates shall be weld sealed for ratings up to 800kVA. Ratings of 1000kVA and above shall have gasketted removable top cover plates.

All flanged joints shall have gaskets of suitable non-absorbent material to prevent entry of water or leakage of coolant.

Each tank shall be provided with a flanged drain valve (minimum 1" BSP) fitted with a blanking plate. All valves shall be of gunmetal and the sluice type with internal screw, unless otherwise approved.

402.2.6.6 Painting

All associated enclosure steel work to be shot blasted on completion to ensure freedom from welding slag, rust or grease prior to spraying.

Oil filled tank interiors shall be given a high quality coolant-resisting, anti-corrosion finish coating.

The outside of the tank shall be covered with a minimum of 3 coats of paint, consisting of primer, intermediate and final high gloss, weather resistant finish, applied by the flooding process to ensure complete coverage of tubes and areas inaccessible to brush and spray.

#### 402.2.6.7 Earthing

The core and any conductive parts of any protective enclosure shall be earthed by means of substantial connections to a common terminal provided for this purpose. An earthing terminal stud not less than 12mm diameter, complete with brass nuts and washers, shall be provided at the base of each transformer for connection to the external earthing system.

#### 402.2.6.8 Cable Terminations

Terminal boxes shall be provided suitable for connecting the external cables specified herein and terminal assemblies shall be capable of withstand and the specified prospective fault rating. Where single core cables are to be accommodated, a non-magnetic or slotted gland plate shall be provided.

#### 402.2.6.9 Link Boxes

Where PILC cables are terminated in compound filled boxes, disconnecting link boxes shall be provided to enable tails to be pressure tested without the need to remove cables. Links shall be of the bolted type and should be readily accessible without disturbing the cable connections or the transformer enclosure.

#### 402.2.6.10 Oil Gauge

A gauge of adequate size shall be fitted to indicate the oil level at 15°C and when the temperature has risen to the limit permitted by BS 171. The level in the gauge shall be clearly visible from the ground and the gauge shall be protected against accidental damage.

#### 402.2.6.11 Thermometers

A dial type indicating thermometer shall be provided and mounted on the side of the enclosure for ease of reading arranged to measure the temperature in the hottest areas of the transformer coolant or winding. This may incorporate the temperature protection requirements specified below.

Oil cooled transformers shall be provided with a thermometer pocket in the tank and a thermometer to register the coolant temperature. The pocket shall be fitted with a protective thimble when not in use.

402.2.6.12 Protection

The following protective facilities shall be provided as specified for each transformer. All switches contacts shall be rated at least 125V 0.5A DC.

Restricted earth fault protection shall be arranged such that the star connection of the secondary windings shall be earthed via an air insulated, removable link which will accommodate a current transformer provided by the switch-gear manufacturer. The CT shall be provided with adequate supports and terminating facilities and both the link and CT shall be housed in a box with a removable cover. The box shall have a 20mm ET threaded entry for the CT cable.

i) Sealed type transformers shall be fitted with a spring-loaded self resetting pressure relief device actuated by excess pressure within the transformer tank. The setting shall be suitable for application with the coolant used and actuate a manually resettable switch to initiate a remote trip.

   Over-temperature protection shall be provided by means of a scaled dial indicating thermometer fitted with two adjustable contacts arranged to initiate a remote alarm and trip circuit respectively.

ii) Aspirated type transformers shall be fitted with an oil sealed de-hydrating breather of the visible indicating pattern.

   Over-temperature protection shall be provided by means of a scaled dial indicating thermometer fitted with two adjustable contacts arranged to initiate remote alarm and trip circuits.

Transformers having a conservator shall be fitted with a Buchholz gas and oil actuated protective device of approved make. The protector shall be of the double float pattern with both alarm and trip contacts, an inspection window and a terminal box suitable for conduit entry. A petcock shall be provided at the top for the release of gas and a second petcock fitted at a lower level for testing the operation of the relay by compressed air.

402.2.6.13 Conservators

Oil filled, aspirated transformers rated in excess of 2MVA shall be provided with a conservator vessel fitted with a sump and suitable means of drainage. The oil connection to the transformer tank shall project at least 50 mm vertically inside the conservator and the oil sight gauge fitted to conservators shall be arranged to indicate oil in the conservator tank only when the oil connection to the transformer tank is submerged.

The transformer top plate shall be removable without disturbing the conservator mountings or connections.

402.2.6.14 Drying out and Filling

Each transformer shall be dried out and filled to normal working level with coolant at the

manufacturer's works. It shall be transported, installed and put into service without the necessity for further drying out on site.

402.2.6.15 Dry Type Transformers

For indoor use only and where specified, dry type transformers shall comply with all the proceeding clauses except that:-

i) **Coils:** The windings and impregnation shall be designed to minimise stresses induced under normal and abnormal circuit conditions. Assembled coils shall be impregnated under high vacuum with epoxy resin and cured to relieve stress, prevent voids and be non-hygroscopic.

The coils shall be located concentrically and firmly on their formers with allowance for axial movement due to temperature changes. All air ways shall be smooth and un-obstructed.

The core frame shall incorporate lifting lugs and be mounted on a base frame having towing holes and cross members for stability.

ii) **Enclosures:** They shall be ventilated housings formed of fire resistant building materials, glass fibre moulded panels with steel mesh

reinforcing or sheet steel panels, providing a minimum protection to IP 21 against water and accidental contact. Access doors for maintenance shall be provided and interlocked with the controlling HV and LV switch-gear to prevent access when either switch is closed.

The construction, preparation and painting details for sheet steel panels and doors shall be as specified under the switch-gear requirements.

iii) **Protection**: Over temperature protection shall be provided by thermistors located in the three phases of the LV coils. These shall be set to suit the operating characteristics of the transformer, one set to provide a high temperature alarm and a second set to provide a higher temperature trip.

Where enhanced cooling by fans is specified, additional thermistors shall be provided for switching control of such fans.

All thermistors shall be wired to relays housed in a box mounted externally on the enclosure. The box shall include suitable terminals for external cabling, a 20mm ET threaded entry and a removable cover.

## 402.3 SWITCHES

### 402.3.1 Switches

Switches shall be of the air break pattern, enclosed in zinc sprayed heavy duty, cast metal or sheet steel cases providing enclosure protection to at least IP55 unless otherwise specified, suitable for industrial surface mounting or flush cubicle mounting as specified.

They shall be rated in accordance with BS 5419 or equivalent and be fitted with solid or HRC fuse links as appropriate in each phase and a neutral link, all contained within the switch case, with the terminals accessible from the front of the switch. Phase barriers and contact shrouds shall be provided with an interlock to prevent withdrawal or access when the fuse switch is in the `ON' position.

Each switch shall have a free handle control mechanism to prevent inching and damage to contacts, be fitted with `ON' and `OFF' position indicators and have provision for locking in the `OFF' position. When padlocked in the `OFF' position, interlocks shall prevent the unit door being opened.

The moving contacts of fuse switches shall be readily withdrawable as a complete unit for maintenance when the remainder of the board is live.

The compartment isolating switch shall interrupt all supplies into the compartment to enable safe maintenance to be undertaken. Isolators shall have robust handles and means shall be provided to enable the isolator to be padlocked in the OFF position only. One padlock with 4 keys shall be supplied for each isolator on the board.

### 402.3.2 Push Buttons

Push buttons shall be heavy duty, double break pattern with fully shrouded moulded buttons having a spring return action through a flexible oil-tight seal. Each button shall be coloured in relation to its function in accordance with Appendix 2 or as otherwise specified herein and bezels shall be coloured black.

Emergency stop buttons shall be arranged to de-energise without delay the drive motors for the whole of the associated plant whatever control mode of operation may be selected. They shall be of the `stay-put' type having a large red mushroom head with twist-to-release manual reset, suitably labelled and have at least two poles, 1 N/O and 1 N/C with contacts suitable for the circuit operation.

Where key reset heads are required, the key shall be common for all buttons.

### 402.3.3 Selector Switches

Selector switch shall be mounted on the front of the panel; The switch shall be lockable in each position by means of a barrel locking device incorporated in the handle and the switch handle shall clearly indicate the switch setting.

### 402.3.4 Emergency Stops

Where means of stopping are required adjacent to a motor or the driven plant to prevent danger, emergency stop push buttons, trip switches or interlocks shall be provided, arranged to immediately isolate the supply, so long as a greater risk is not thereby introduced.

In automatic control schemes, emergency stop buttons shall have a stay-put lock off feature,

with "twist to release" manually operated reset facility. Such a button shall be located on the motor starter panel. A key operated reset facility shall be provided where emergency button is located at the plant.

Where plant is normally enclosed or has fixed guards to prevent accidental contact from moving parts, stop buttons are not normally required adjacent to such parts.

Stop buttons shall be hard wired direct to all motor control circuits and not by way of any semi-conductor logic control circuitry.

Means of equipment isolation for maintenance purposes shall be provided. This may be either by use of key operated emergency stop buttons or lockable isolators, which may be at the control panel or local to the plant.

### 402.3.5 Auxiliary Switches

Auxiliary switches for indicator, protection, interlocking and supervision purposes shall be readily accessible and enclosed in a transparent dust proof cover.

Adequate secondary disconnection shall be included between the fixed portion of a circuit breaker and the moving portion.

Spare auxiliary contacts, two normally open and two normally closed, shall be provided on each unit and wired to suitable spare terminals.

### 402.3.6 Low Voltage Fuse Switches

Fuse switches shall comprise flush mounted, heavy duty, composite air break switches with fuse units complying with BS. 5419 and fitted with fuses to BS.88 and shall be rated for the design load.

Composite units shall be contained within an enclosure of metal and shall be fitted with an earthing terminal or equivalent to enable the enclosures to be earthed irrespective of any means of connection, such as is provide for attaching armouring or other metallic covering of the cable supplying the composite unit.

The enclosure shall be so constructed that the cover cannot be opened until the switch is fully opened and that when the cover is opened, a competent examiner can override the interlock and operate the switch. After such operation, the cover shall be prevented from closing with the switch position indicator in a false position.

Switches shall be provided with mechanical ON/OFF indicators and operating handles. Means shall be provided for locking the switch in the OFF position only.

The fuse shall either include a suitable fuse carrier or it shall be capable of isolation. If the fuse carrier is included, it shall be such that when it is being withdrawn normally or when it is completely withdrawn, the operator is completely protected from accidental contact with any live metal of its fuse link, fuse contacts and fixed contacts.

If the fuse is capable of isolation, it shall be so interlocked with the switch that isolation is complete before the fuse enclosure can be opened; further the switch shall be prevented from

closing while the fuse cover is open.

## 402.4 RELAYS

### 402.4.1 Control Relays

Control circuit relays for switching 5A/250V or less shall be of the multi-pin plug-in type having the following features:

- Neon or LED indication of relay energisation;
- mechanical ON/OFF indication;
- manual test button with provision for retention of the button in the operated condition for test purposes;
- legend plates on relay and base;
- relay retaining clip;
- be mounted on moulded bases having recessed screw terminals.

If sufficient contacts are not available in one relay, not more than two relays may be connected in parallel.

Any relay used to switch an external alarm circuit shall have a volt-free contact for the purpose.

### 402.4.2 Protection Relays

Protective relays shall be provided, for fault and overload protection, to operate L.V. circuit breakers.

All protective relays shall conform to the latest edition of BS. 142 and be manufactured by an approved international manufacturer. They shall be suitable for climate and site conditions and fully sealed against the ingress of moisture and dirt.

Each relay shall be complete with panel mounting facilities and terminals for external circuit connection.

Electro-mechanical protection relays and associated devices shall be provided as specified, suitable for flush mounting in dust proof cases; withdrawable types being provided where they are fitted in fixed panels.

## 402.5 FUSES

### 402.5.1 Fuse Links and Holders

Suitably rated fuses shall be provided at all points necessary for circuit protection and isolation, separate fuses being provided for instruments, indication, alarm, heater and coil circuits. Fuse ratings shall be rationalised as far as possible to limit spares.

i) LV fuses in circuits exceeding 50V shall, where practicable, be housed in all-insulated carriers with fully shrouded bases of matching colour, which shall not be interchangeable with carriers and bases provided for removable solid links which shall be coloured white.

LV fuse links shall be HRC cartridge type to BS 88, Class Q1, having provision for screw fixings for attachment to the carrier.

ii) Control and Instrument fuses may be accommodated in moulded terminal blocks suitable for DIN rail mounting. Fuses rated up to 6.3A 250V shall be 20x5mm (G type DIN 41660) having a hinged fuse carrier housing.

Fuses rated up to 13A 250V shall be 25 x 6.3mm cartridge type to BS 1362, secured by a screw cap. The live connection being made to the lower terminal.

A complete schedule of all fuses in the panel shall be affixed in a convenient position in the panel, control heater and pilot lamp circuits shall each be protected by a separate fuse. All fuse carriers shall be fully insulated and shrouded type, withdrawable units the design of which shall prevent contact with "live" parts while the fuse carrier is being, or has been withdrawn. Fuse holders and bases shall be manufactured as moulded plastic. Ceramic material will not be accepted. Neutral links shall not be arranged in fuse holders but shall be separately bolted copper links with one link per fuse circuit.

Fuses and links in the same circuit shall be mounted fuse above link in separate rows and not alternate in the same row.

Where incorporated in distribution boards fuse fittings shall have basic sizes of 16, 32, 63, 100 and 200 amp. and holders shall accept fuse links of that rating or any other down to the next basic size.

H.R.C. fuses where used in distribution and light circuits should have a fusing factor of 15 giving "close" protection as defined in I.E.E. regulations.

### 402.5.2 Distribution Fuseboards

Fuseboard cases shall be of rust proofed, zinc sprayed, heavy gauge sheet steel, having a flush fronted door with concealed hinges and a resilient sealing gasket, providing enclosure protection to at least IP55 unless otherwise specified.

The interior shall be assembled from all-insulated shrouded fuse carriers and bases of the 380V pattern, fitted with phase dividing barriers and all live parts being fully shrouded, all in accordance with BS 5486 or equivalent.

Circuit identification charts shall be fitted to the inside of all fuseboard doors.

All fuse carriers shall be fitted with fuse-links rated to suit the circuit duty. Spare ways shall have fuse links of the same current rating as the carrier, unless different current ratings are called for under the Particular Specifications. The Contractor shall however confirm fuse ratings with the Engineer before fitting fuses to the carriers. Fuse-links shall be of the HRC cartridge type to BS 88, Class Q1, having screw fixings to the carriers

## 402.6 MOTOR STARTERS

### 402.6.1 General

Starters shall be housed in damp and dust proof cubicles.

Each starter shall contain all the necessary equipment to control the circuit load and isolate it from the supply in the event of a fault and shall be equipped to comply with the following general requirements unless otherwise specified under the relevant starter duties.

For starting LV Motors direct on line, the starter shall be rated for intermittent duty class 0.3 (up to 30 operating cycles/hour) and utilisation category AC-3 in accordance with BS EN 60947, or as otherwise specified.

The starter cubicles are required to form part of a motor control centre and as such circuit connections, protection devices, etc., shall comply with BS.5486. The starters shall comply with BS.4941 (Motor starters for voltages up to and including 1000 V. A.C.). The motor starter shall be of a rating to carry the full load current of its rated duty at its most severe load conditions. All starters shall be capable of carrying out at least the number of starts per hour at 100 per cent full load torque as detailed in the appropriate clause.

Motor starter control circuitry shall be generally arranged to suit the motor drive and to comply with the relevant clauses in this specification.

Unless otherwise specified, 3-phase, 380V motors shall be provided with Direct-ON-Line starters up to and including 5 kw rating.

For any form the Contractor shall ensure adequate rating for operating under the relevant climatic conditions.

Heat dissipation shall be considered when designing Air Conditioning Plants where relevant.

The tenderer shall also ensure that the equipment he offers can be within the building as

designed and that adequate space for service, maintenance and access is retained.

The motor starter shall be of sufficient rating to carry the full load current of its rated duty at its most severe load conditions. Panel control circuits shall operate at 110/220 Vac single phase.

### 402.6.2 Isolation

Each unit shall be housed in a separate compartment or enclosure and be completely isolated by means of an isolating switch interlocked with the door or cover to allow access only when the switch is open. The isolating switch shall be operated by means of an external handle and shall have provision for padlocking in the "OFF" position. When in the "ON" position, interlocks shall prevent the unit door being opened. Any components still live after this switch has been opened shall be adequately shrouded and have warning labels attached thereto.

The switch shall be capable of carrying continuously the full rated current of the conductor and shall be rated for making and breaking stalled motor current duty as specified in BS 5419. Off-load isolators shall be suitably interlocked to ensure that they do not make or break load currents and be provided with locking facilities in the "ON" position.

Additional physical isolation by means of withdrawable units for ease of maintenance may be offered but is not a Particular Specification. For such an arrangement the live poles shall be automatically shuttered when the unit is withdrawn and the shutters shall have provision for padlocking in the closed position.

### 402.6.3 Contactors

Power contactors shall be to BS 5424 (IEC 158-1, 947-4) and shall have the following characteristics:

- Rated insulation voltage: ≥ 1000 V
- Rated Operational Voltage : 1000 V
- Rated breaking capacity : 10 times the rated current.
- Electrical life at rated current and 380V
  ≥ 1 million cycles up to 400A utilization category AC3
  ≥ 600 Kcycles above 400A utilization category AC3.

All contactors shall be of the air-break electromagnetically held-on type. All contact pieces shall be readily replaceable and the necessary auxiliary contacts for control, indication and alarm shall be mounted in accessible positions and arranged in the same sequence on each contactor.

### 402.6.4 Protection

Each starter shall be provided with an adjustable motor over-load and single phase protection device suitable for the motor load and have adjustable trip and reset delays provided, together with manual local and remote resetting facilities. Ambient temperature compensation shall be provided where relevant. Other protection features shall be as specified relevant to the particular drive.

Protection devices shall be arranged to trip the load and initiate the fault indications specified and accept normal switching of load.

Where starters are fed directly from busbars or other systems having a high prospective fault level, suitably rated fuses or other means shall be provided within the starter to limit the fault let through to a value within the rating of the starter components. Protective overload devices shall be arranged to ensure that any such fault is cleared by such fuses and provide Type `2' coordinated protection to BS EN 60947.

### 402.6.5 Control Circuit

All control circuits shall operate at not more than 110V and be derived from a double wound, screen earthed isolation transformer with one side of the secondary winding connected to neutral/earth. The primary supply shall normally be from one phase to neutral if available.

Individual transformers shall be provided for each starter but sequenced groups of starters having a common isolator shall use a common control transformer.

Fuses shall be provided on each primary and secondary supply and be clearly labelled and segregated. A link shall be fitted in the neutral/earth connection.

The control circuit and the main supply must be isolated before opening the cubicle door but provision shall be made to re-energise the control circuit when the main supply to the cubicle is isolated, so that the operation of the control gear may be inspected without energising the motor. The necessary control circuit Normal/Test switch shall be mounted within the cubicle and so arranged that it is not possible to close the door with this switch in the `Test' position.

The motors in some applications will be required to operate in a predetermined sequence and starters should include suitable auxiliary relays and contacts.

Each plant control panel shall contain a multiple cam contact timer housed in a separate clearly labelled compartment. The timer shall have sufficient contacts to provide as minimum one per starter plus 25 percent spare.

The timer shall allow drives to restart in a predetermined staggered sequence under both automatic and manual (hand) control following a failure of power supply and its restoration.

Each contact shall be fully adjustable between 0 and 30 minutes.

### 402.6.6 Control and Monitoring

The method of control and operation shall be as called for under the Particular Specifications for the starter.

Control selector switches fitted to the front of starters shall have matching operating handles which are clearly shaped to show the selected position. Specified function switches shall have a key operated barrel locking device in the handle, or be key operated alone, with the key removable in each lockable position.

All fault conditions relevant to each mode of operation shall stop the drive and prevent it re-starting until the particular fault is cleared and individually reset; lock-out relays and a reset button being provided for any self-resetting devices such as excess torque switches etc.

Specified fault conditions shall be identified by separate indications on the starter. Volt-free contacts shall be provided and wired to terminals in each starter unit for remote signalling of all status indications specified. Minimum status indications shall be Auto Available/Un-available and Running/Fault.

Where the starter is to be remotely controlled by a remote terminal unit (RTU), interposing relays with 24 volt DC coils complete with back EMF suppression diodes shall be provided in each starter unit to facilitate remote control and watchdog capability (See Instrumentation Specification).

"Hours-run" meters shall be of the non-resettable cyclometer type indicator having a flush fascia and driven by a synchronous motor connected to show the hours (up to 99,999.9) run by the main motor. They shall incorporate visible indication of operation but need not necessarily be of the same bezel size as the instruments.

All starters for motors of 3 kW and above shall have ammeters, local 'running' indicator lamps being provided for loads less than 3 kW.

### 402.6.7 Heaters

Anti-condensation heaters shall be fitted in each starter (and motor, where specified), fed from a separate fuse through the starter isolating switch and an auxiliary contact on the motor contactor, arranged so that the heaters are disconnected when the motor is running.

In multi-tiered starter panels, the heater shall be located at low level within each tier and fed from a clearly identified common distribution supply with local isolating links in each tier.

### 402.6.8 Star Delta Starters

Star/Delta starters shall be of the closed transition "Wauchope" type, having starting resistors, mechanically and electrically interlocked Star and Delta contactors plus a timing relay in addition to DOL starter requirements, all rated for up to 10 starts per hour.

### 402.6.9 Auto-Transformer Starters

Auto transformer starters shall be of the closed transition “Korndorffer” type, having suitably rated mechanically and electrically interlocked "start" and "run" contactors plus a timing relay in addition to DOL starter requirements.

The auto transformer shall be oversized, Class H, air cooled with tappings provided at 50%, 65% and 80% of line voltage and unless otherwise specified, be suitably rated for up to 10 starts per hour. The transformer shall be contained within the starter panel or may be installed in a separate enclosure.

Contactors of one Starter shall be of the same type and rating. The current rating of the contactors shall be 10% higher than required by the driving motor at continuous maximum rating in utilisation category AC3.

### 402.6.10 Stator/Rotor Starters

Where separate stator and rotor cubicles are provided, a key interlock shall be fitted to prevent access to the rotor cubicle unless the stator isolating switch is in the `Open' or `Earth' position.

Rotor resistances shall have suitable interlocking facilities to prevent operation of the starter switch until all sections of rotor resistance are in the starting condition.

The resistor enclosure shall be ventilated to IP41 and a thermostat shall be incorporated to trip the starter if the resistance overheats due to excessive use or mal-operation.

Rotor resistances may be metal or liquid material as specified to suit the drive characteristics. Metal resistors shall consist of rustless unbreakable resistor grids which may be readily replaced. Where tiered banks of resistors are provided, it must be possible to readily remove from the front any section without disturbing any other section of the resistance bank.

Liquid or derived vapour resistors shall have the electrolyte contained in leakproof containers and incorporate means of restricting evaporation and detecting loss of electrolyte.

### 402.6.11 Electronic Assisted Starting

Starters for specified squirrel-cage induction motors shall incorporate a solid state device designed to provide a smooth acceleration up to the motor's rated speed.

The acceleration time shall be adjustable by means of control settings provided to enable optimum maximum starting current and torque as well as initial threshold starting current and torque to be selected.

The starting current of the largest motor shall be limited as specified.

Where specified to reduce system shocks, provision shall also be made for motor stopping under controlled deceleration.

a) Protection

The electronic power device shall be protected by high speed semi-conductor fuses and heat sink thermal cut-outs.

The device shall shut down in the event of single phase loss or open circuited the electronic power device.

In the event of short circuited the electronic power device, the drive shall continue to run at full voltage by automatically transferring to an override condition.

b) Indications

Alarm indications shall be provided for each of the above faults.

An auxiliary relay shall be used to control the function of the main contactor.

c) Energy Saving Facility

For continuous running drives, an energy saving control shall be provided where the voltage applied to the motor is automatically matched to the actual power demand. The control shall be effective after run-up and a dwell time at full voltage has been allowed to enable the motor load to stabilise.

The device shall respond immediately to any sudden load changes to prevent a potential stall condition.

### 402.6.12 Frequency Converters

The motor speed control shall be a frequency converter of an approved type and manufacture, providing a variable frequency output of adequate capacity to drive the specified motor over the specified speed range and suitably matched to the starting torque and the speed torque characteristics of the driven plant. (Details to be determined by the Contractor from the driven plant/motor manufacturer during the Contract.)

The converter unit with the associated control electronics shall be housed in a steel, free standing, drip protected (IP21) panel, mounted in the position specified. The unit shall be suitably air-cooled by means of an integral fan and all the components within the unit shall be readily accessible for easy servicing and removal without disturbing other components. Chassis units shall be suitable for rack mounting.

The incoming supply shall be via an isolator interlocked with the panel door and have suitable fuse protection.
The drive unit shall be capable of operating with the motor disconnected for test purposes.

A current limiting circuit shall be incorporated to give short circuit and overcurrent protection in the output circuit, and undervoltage detection shall be incorporated to protect the drive against fan failure. A thermostat shall be fitted for protection against fan failure and overheating.

a) Harmonics

The unit shall be protected from any harmonic distortion or switching surges in the power supply system and incorporate contactors to automatically isolate the input and output and to

protect the unit from component damage arising from a power supply interruption which shall, if necessary, include automatic shutdown. If the converter will not perform correctly when running from a specified Standby generator an interlock shall be provided to prevent such operation.

To prevent distortion of the supply system wave form (and dependent instrumentation), harmonic voltage and current distortion introduced into the mains supply by the drive unit shall be within the limits specified in Electricity Council Engineering Recommendation G5/3. The

point of common coupling shall be regarded as the output connections of the first upstream transformer.

The supplier shall list with the offer the expected harmonics generated by the drive under running conditions (worst case).

Where an input filter is used to limit the harmonic currents, the design shall minimise the possibility of resonance with any power factor correction capacitors fitted.

The supplier shall include any shielding necessary in accordance with BS 800, to prevent any interference that may affect other surrounding instruments.

b) Monitoring and Control

The control of each variable drive unit shall normally be from a PLC outstation which will provide a start/stop facility and a 4-20mA speed control signal. Where the distance between the drive unit and PLC exceeds 20m, special care shall be taken to ensure radio frequency interference and distortion are kept to a minimum.

The following signals will be required from the drive unit and wired to clearly marked terminals:

(a) Common fault (motor overload, emergency stop operated etc)
(b) Control status indicating Hand/Off/Auto
(c) Control 'on'
(d) Motor available
(e) Motor running
(f) RS 232 Serial Interface (where required by the specification).

The following items shall be included along with other control devices and instrumentation:

a - Control potentiometer for speed setting on hand control, (scaled with linear graduations over the range and arrows indicating clockwise rotation to `INCREASE SPEED' and anti-clockwise rotation to `DECREASE SPEED');
b - Output ammeter;
c - Frequency/speed meter;
d - Test and fault diagnostic card for circuit checking, having a front of panel display and facility for serial link remote indication.
e - Isolated inputs for 0-10/4-20mA auto control, start/stop, external reset, etc.
f - Adjustments for ramp up/down, duration, frequency range, base/maximum speed, current limiting facility and economy mode.

The following items shall be monitored for fault conditions:

- Phase failure
- Earth fault
- Overcurrent
- Over voltage
- High temperature/fan failure
- DC link fuse failure

## 402.7 ELECTRIC ACTUATORS

### 402.7.1 General

Electric actuators shall be suitable for outside installation and all components shall be housed in waterproof enclosures to IP67 or better, which shall incorporate an anti-condensation heater.

Actuators shall be designed in such a way, that exposure to environment will not interfere with the safe operation. All joints shall be sealed by radial seals or O-rings. In order to prevent loss

of screws, all covers which can be opened for setting and service shall be fixed with captive screws.

The whole actuator shall be of easily maintained design. Electrical connection shall be by means of plug and socket to enable easy and quick disconnection during commissioning and maintenance works. The actuators shall be of robust construction. The design must provide simple setting, testing, maintenance and repair. Torque and limit switching shall be of the mechanical type to allow settings without special tools or instruments (e.g. battery backed setting tools). Actuator shall be sized to guarantee the penstock or valve opening or closing at the maximum differential pressure specified herein. The operating speed shall be approximately 300mm/minute unless otherwise specified.

All actuator component items shall be coupled via flanged mating faces secured by stainless steel bolts, except valve mounting fixings subject to thrust forces which shall be by means of suitably sized, high tensile steel bolts.

The gearbox shall be of the worm gear totally enclosed, with lubricant, having a cast iron housing suitable for operating at any angle and provided with the appropriate filling and drain plugs. Housings made out of aluminium shall not be allowed. The actuator drive bushing shall be easily detachable for machining to suit the valve stem or gearbox input shaft and the length of the drive nut shall not be less than 1.25 x the spindle diameter.

In case quarter-turn-gearboxes are required in combination with multi-turn actuators to operate the valve, the gear housing shall be made out of cast iron (GG) or ductile iron (GGG). End stops in both directions, located at the input shaft (not the gear housing) shall be available by means of a travelling nut to protect the valve against excessive torque. The gearbox shall be designed as per valve and actuator requirements. The worm wheel shall be made out of bronze. Segment type worm wheels or spindle type shall not be used. Enclosure for gearbox shall be IP67.

The output shaft shall be hollow to accept a rising spindle where appropriate, and incorporate thrust bearings of the ball or roller type. The design shall preferably permit the gear case to be opened for inspection without releasing the spindle thrust or taking the penstock/valve out of service.

### 402.7.2 Motors

All motors fitted to actuators shall be specially designed for the application and of the squirrel cage induction type for operation from the single phase Power supply system of 220 Vac ± 5%, 50 Hz.

All motors shall be specifically designed for valve-actuator operation which is characterized by high starting torque, low stall torque and low inertia.

Motors shall be of the non ventilated totally enclosed type (TENV).

Motors must be totally separated from the lubricant-filled gearing of the actuator, allowing to replace a motor without loosing any lubricant regardless of mounting position.

Motor-insulation must be in accordance with IEC 85 Class F (155° C).

The rated output of the motors shall be determined by the tenderer in relation to the requirements of the mechanical plant described elsewhere in this specification, and starting torque shall be at least 10% in excess of maximum service requirements. The intermittent running load factor shall be 25% in accordance with VDE 530.

The motors shall preferably be 4 pole 1440 revs/minute machines designed with adequate thermal capacity to ensure that the actuator and starter can adequately perform, without overheating, the number of successive opening and closing operations, in no case shall this number be less than three.

Each motor shall be fitted with a thermostat or thermistor per phase arranged to stop the motor in the event of dangerously high temperature in the motor windings due to overcurrent or an abnormally high number of starts per hour.

### 402.7.3 Manual Operation Interlock

The actuator shall have a side mounted handwheel for manual operation which will be at standstill during motor operation. A lever shall be provided for engaging the handwheel drive, and this shall be interlocked so that when starting the motor the handwheel is automatically uncoupled without danger to the operator. Provision shall be made for the lever to be padlocked in either position to prevent hand or motor operation as required.

Clockwise operation of the handwheel shall cause the valve to close. The face of the handwheel shall be clearly marked with an arrow and the word ‘CLOSE’.

The handwheel must be sized in such a way, that one man can generate the rated actuator output-torque. The torque switches shall be active in manual operation mode as well, thus allowing to provide a signal when the set-torque has been reached.

Under manual operation, the handwheel shall drive the worm shaft. Self locking shall be maintained in hand operation. The motor must be disengaged during manual operation. The handwheel shall automatically disengage when the electric motor is energised.

### 402.7.4 Position Monitoring

A mechanical position indicator, showing the open, closed or intermediate positions of the valve on a visible dial, shall be incorporated in the actuator housing. Alternatively, where specified, a continuous position indicator shall be provided.

Remote position indicators, where specified, shall be controlled from a suitable potentiometric drive arranged to provide a continuous proportional signal from `Open' to `Closed' positions.

### 402.7.5 Position Control

Where specified for control purposes, a current position transmitter shall be provided to give a positive 4-20mA signal proportional to the valve position, and shall incorporate zero and span adjustments to suit the actual valve travel.

### 402.7.6 Torque and Limit Switches

All switches shall be accommodated within the actuator housing and all contacts and mechanism shall be of sealed, rustproof and robust construction. All switches (limit and toque) shall be of the snap-action micro switch type, totally enclosed acc. IP66, each with one set of NO contacts and one set of NC contacts. The connecting wires shall be sealed in the switch-housing. Torque switch signalisation must be active in manual operation (by handwheel) as well. Adjustable torque limiting devices and switches shall be provided to trip the starter in the event of mechanism overload due to obstructions or jamming etc. Limit and torque switches must be operated by counter gear-driven cams, which are mechanically linked to the driving devices, without slip-clutches. No battery backed limit sensing shall be used to avoid malfunction of the actuator in case of power failure or dead battery.

Adjustable limit switches shall be arranged to trip the starters when the `fully open' or `fully closed' positions are reached. Should the manufacturer consider it desirable (to ensure proper seating) the travel may be stopped in the `fully closed' position by the torque limit switches, but in this case the `fully closed' limit switches shall still be provided, although they will be adjusted to be inoperative.

The actuator shall be equipped with two independent torque limit switches operating in both rotational directions.

### 402.7.7 Auxiliary Switches

Two adjustable auxiliary switches shall be provided. They may be used for remote controls or indications monitoring the `Open' and `Closed' positions.

### 402.7.8 Terminal Facilities

All electrical components shall be wired out to a plug/ socket connector, to allow quick disconnection in case of maintenance or repair in a common terminal plug incorporated in the actuator housing.

Each terminal shall be labelled to correspond with the diagram of connections and shall be capable of accommodating not less than 2.5mm² copper conductors.

Terminal blocks shall comprise shrouded anti-tracking mouldings of melamine phenolic or comparable material with provision for securing conductors by screw connector or other approved vibration-proof devices.

The terminal compartment shall provide sufficient space to accommodate the possible maximum number of incoming wires. Separate cable entries (2XPG21, 1XPG13,5) must be

provided for motor power cables and controls, *connection for redundant bus cabling and the required final resistors for bus termination.

*For two wire communication only

Each cable entry shall be properly sealed by cable glands during site installation. The cable glands size shall be chosen by contractor responsible for wiring during commissioning phase.

Any conduit entries not used after cabling is completed shall be plugged with threaded aluminium blanks and the threaded joints made watertight by using suitable tape or jointing compound.

### 402.7.9 Starters and Control Gear

The actuator motor shall be controlled through integrally mounted electrically and mechanically interlocked contactors, rated for switching the motor direct on-line, adequate for the duty requirements and complete with all necessary auxiliary contacts for the functions specified herein.

The control circuit shall operate at 24V DC derived from a suitably rated transformer/rectifier with one side of the secondary winding connected to earth or as otherwise specified. Primary and secondary windings shall be protected by cartridge type fuses.

The method of control and operation shall be one of the following options as called for in the Particular Specifications and the actuator shall be provided with any facilities called for therein to suit the method of control, whether this be automatic or by hand. Local controls integrally mounted on the actuator shall consist of push buttons for `Open', `Close' and `Stop' functions, together with a Remote/Off/Local selector, lockable in all positions. The "Emergency Stop" button shall be effective in both local and remote settings and operate directly in the contactor control circuit.

Option A) Standard controls and signalisation

The following features shall be in the integral motor controls:

- Reversing contactors (mechanically and electrically interlocked). An electronic reversing unit (thyristor) shall be available as an option up to 1,5kW.
- Programmable control logic in CMOS SMD-technique

**Remote Commands**

- Remote commands ‘OPEN - STOP - CLOSE’, potential separation by opto-isolators
- Control voltage for remote commands, 24V DC, internally or externally supplied.

**Output Signals**

- Signal from selector switch, position ‘LOCAL - REMOTE’, with potential-free contacts
- Signals for end positions ‘OPEN - CLOSED’ with potential-free contacts
- Monitor relay for collective fault signal (power failure, phase failure, wrong phase sequence, thermoswitch tripped and torque switch tripped in mid travel)

- Control voltage 24V DC, externally supplied.

Option B) Communication via bus system

The following features shall be in the integral motor controls:

- Reversing contactors (mechanically and electrically interlocked). An electronic reversing unit (thyristor) shall be available as an option up to 1,5kW
- Programmable control logic in CMOS SMD-technique

- An interface board for digital two wire control communication shall be available, preferably supporting the PROFIBUS FMS protocol according to EN 50 170. The protocol shall be based on the ISO / OSI layer model (ISO 7498, 1994). FMS communication according to DIN 19245 parts 1 and 2. Physical interface RS 485.
- It shall be possible to have direct communication between actuators and higher level DCS systems, without using additional master stations as protocol translators.

The two wire communication shall include:

- Multimaster function: the actuator shall be able to communicate with several masters
- Master redundancy: the actuator shall be able to support several designs of master redundancy
- Slave initiative: the actuator shall be able to generate messages for the master which results in shorter reaction times
- Data transmission speed shall be 9,6 kbit/sec. To 187,5 kbit/sec.

**Commands:**
- Run OPEN / run CLOSE / STOP
- Run to an intermediate position
- Perform alarm operation

**Signals:**
- Ready for service (OK)
- Valve positions OPEN / CLOSED
- Actuator in pre defined intermediate position (option)
- Mode of operation - position of selector switch OFF / LOCAL / REMOTE
- Fault Signal, including:
  - Phase sequence and phase failure
  - thermoswitch tripped
  - torque switch in 'OPEN' direction tripped in mid travel
  - torque switch in 'CLOSE' direction tripped in mid travel
- Status:
  - actuator stands still
  - actuator runs
  - actuator performs an operation after an adjustable delay time
  - actuator performs an emergency operation
  - actuator stands still, alarm status active

The following options shall be made available:

- Positioner:

A positioner can be provided within the equipment. The nominal position value shall be sent as reference input from an external controller to the actuator. The integral positioner generates the signal for the motor controls, depending on the difference between input command signal and position feedback signal. Position feedback is provided within the actuator.

- Analogue sensor connection:

The actuator shall be additionally equipped with an interface enabling the connection of an

external analogue sensor (0/4 to 20mA).

- A digital input signals:

The actuator shall be additionally equipped with four digital input signals.

- Repeaters:

The actuator supplier shall also provide repeaters if required by plant set-up.

Wherever motorised penstocks and valves are specified, they shall be provided with adequately rated starters. The starters shall be electrically attached to the actuator via a plug and socket connection to the actuator in a robust constructed housing and shall form a totally enclosed weatherproof unit with the actuator. The design shall allow to alter the position of the local controls at site (without special tools) in such a way, that the switch lever and push-buttons face the operator. Depending on the application, it shall be possible to separate the actuator from the local controls and to install the local controls (including motor controls) at a pillar or for mounting at a wall. A wall bracket shall be available as an option. The IP67 enclosure shall not be effected from this. The motor starter shall be capable of starting the motor under the most severe conditions.

The starter housing shall be fitted with contacts and terminals for power supply, remote control and positional indication, and shall also be fitted with internal heaters to provide protection against damage due to condensation. Heaters shall be suitable for single phase operation. The heaters shall be switched to "ON" when the starters are "OFF" and shall be switched "OFF" when the starters are "ON".

### 402.7.10 Painting and Corrosion Protection

Corrosion protection shall fulfill the requirements of salt spray tests in accordance with DIN 50021.

Actuator painting must be performed in such a way, that no corrosion takes place under the ambient conditions as specified. All outside screws or bolts shall be made out of stainless steel (A2).

Surface preparation for cast iron parts shall be sand blasted, equivalent to Sa 2½ according to SIS 0559 000-1967 / DIN 55 928, part 4. Surface treatment for external parts which need to be removed during commissioning or maintenance shall be electro dip coated or metallic surface protected. Primer coating shall be a 2-component primer based on epoxy resin with micaceous iron oxide. Finish coating shall be a 2-component coating based on polyurethane micaceous iron oxide. Colour shall be silver grey (DB 701), similar to RAL 9007). Entire film thickness shall be app. 140 µm.

### 402.7.11 Name Plates

Two nameplates, made out of stainless steel, shall be attached to each actuator; one on the motor housing, showing all relevant motor data, one on the actuator housing showing all relevant actuator data. Special information, like the valve tag no., shall be shown if required.

The nameplates shall be securely fixed to the actuator and motor, so that they cannot be removed or scratched off during shipment, installation, operation or maintenance.

### 402.7.12 Actuator Isolators

Unless otherwise specified, motorised actuators shall have an isolator switch. The switch shall have a slow make and break mechanism of the two position rotary pattern arranged to isolate the 3 phase supply and all other control circuit supplies to the actuator. The isolator rating shall be based on the actuator average load current being switched normally off-load, but emergency on-load.

Each switch shall be incorporated in a heavy duty, hoseproof, cast aluminium enclosure to IP65, having external fixing lugs and adequate seals and drip shields on the operating shaft and cover. Austinlite rotary type EXO 190 or equal.

Switch positions shall be 90° apart, clearly and permanently inscribed or embossed as `OFF' and `ON' on the cover, and the switch handle shall incorporate provision for the switch to be padlocked in both the `OFF' and `ON' position. The `OFF' position to be to the left of centre or vertical, the `ON' position to the right or horizontal.

It shall be possible to remove the switch cover for access to the terminal without disturbing the switch or its mounting base. The enclosure shall be suitable for mounting on, or adjacent to, the penstock pedestal. If mounted on the penstock pedestal, cabling between the isolator and the actuator above may be arranged through conduit connections, suitable for disconnection should it be necessary to remove the actuator assembly complete.

(This item preferably to be provided by the contractor who is responsible for the cabling.)

## 402.8 ROTATING ELECTRIC MACHINERY

### 402.8.1 General

Machine type and starting or driving arrangements together with type of enclosure protection shall be as specified herein. Vertically mounted machines shall be fitted with a drip-proof top end cowl and those fitted with skirts shall have a skirt depth in excess of the shaft extension.

Each machine shall comply with the current BS 4999 and the relevant parts of BS 5000 and shall be designed to run at a high power factor and efficiency at the prescribed plant duty.

### 402.8.2 Rating

The output of each machine shall be a continuous maximum rating (Duty type S1) determined by the Tenderer in relation to the power requirements and the normal working environmental conditions for the plant offered in accordance with this Specification. The maximum temperature rise of any machine winding shall not exceed 80°C above a 40°C ambient when operating at the above rating. Where the insulation is rated up to 120°C only, the maximum plant loading shall not exceed 95% of the rated output of the machine.

### 402.8.3 Electric Motors

Motors shall be suitable for operation from a standard supply voltage of 380 Vac ± 5%, 50 Hz, 3 phase having the star point earthed and the phase sequence running R-Y-B anticlockwise. Motors rated less than 0.5kW may be arranged for single phase operation.

The direct starting current ($I_S$) of electric motors shall not exceed 7 times the nominal rated current ($I_N$). The rotational speed shall not exceed 3000 rpm unless otherwise specified in PS.

The torque available during starting of each motor shall be at least 20% in excess of the maximum required at any speed to satisfactorily start and accelerate the mechanical plant load under all service conditions.

All motors shall be of the asynchronous squirrel cage induction type, single or multi cage versions. Other types will not be considered unless the tenderer can show at the time of submitting his tender that such motors cannot be obtained from any source or that in view of size the starting current is prohibitive in terms of either plant compatibility or loading acceptability. In the event of starting current being the problem the tenderer must put forward alternative offers, the first and main offer using squirrel cage motors of either type and the second using alternative motors.

The alternative will not be considered without the main offer.

All motors shall be suitable for operation within the specified environment, and consideration shall be given to the effects of the corrosive atmosphere. Motors for exhaust fans of dangerous fume, gas or explosive atmosphere shall be only of 3 phase type.

All motors intended for outdoor and indoor use shall meet or exceed the requirements of IP55 with regard to protecting from harmful ingress of sand and dust and harmful effects of water projected from a nozzle.

All motors shall be suitable for operation in the climatic conditions detailed in the Specification and in ambient temperature up to 40°C.

The site rating, if derating applies, and normal ratings of all motors together with all performance data be provided with the offer.

All outdoor motors shall be provided with suitable covers to protect them from direct sunlight. Motor cowls shall not be fabricated in fibreglass or plastic.

The efficiency and power factor of the motors shall be high over a wide range of load conditions and the motors shall be designed, manufactured and tested in accordance with BS.4999 and BS.5000 or BS.2048 and BS.5000 in the case of small power motors up to and including 0.75 kW in rating.

For insulation class of electric motors, refer to Particular Specification.

A winding connection diagram shall be supplied permanently affixed to the inside of the terminal box or cover for classification of windings insulation and classification of temperature rise limitation (refer to PS)

Motors shall be of a duty type to suite the driven machine and suitable for the minimum number of starts per hour stated in PS.

The continuous maximum rating (C.M.R.) of each motor shall be in accordance with the following requirements : -

| Application | Up to 75 kW Drives | Above 75 kW Drives |
|---|---|---|
| All pump motors (excluding positive displacement type) | 10% above the calculated maximum power requirements under all conditions of operation | 5% above the calculated maximum power requirements under all conditions of operation |
| Positive displacement pumps & accessories | 25% above the calculated power requirements for normal duty or 5% above the power required for maximum duty whichever is the greater | 12 1/2% above the calculated requirements for normal duty or 5% above the power required for maximum duty whichever is the greater. |
| All other drives, including screens, tank scrapers, etc and process plant. | 50% above normal duty requirements | 25% above normal duty requirements. |

The above percentages shall be added to the calculated power requirements for motors, prior to making the necessary adjustments (increased ratings) for high ambient temperature at site. A higher percentage shall be added to the calculated power requirements for motors, if specified in the appropriate machinery section of the specification.

All motors shall be capable of developing a minimum starting torque of 150 per cent of the full load torque. It may, however, be necessary to limit the starting torque on some drives and this shall be achieved by the form of starter and method of starting.

The site rating and normal ratings of all motors together with all performance data shall be provided at the time of tender.

All guaranteed and technical data shall be that for an ambient temperature of 40°C, although all proving tests at the manufacturer's works shall be carried out at ambient temperature. The declared site rating at 50°C shall be estimated by means of approved recognised method and the manufacturer shall provide derating curves for each motor and these shall be included in the maintenance instructions. Where identical type and size motors are being supplied one motor only shall be subjected to full tests and the remaining units to abbreviated tests.

All motors shall have terminal boxes arranged to accept both the main cable and a separate anti-condensation heater cable.

Termination boxes and terminals shall be of suitable dimension to accept appropriate oversized cables to suit site required derating factors.

All motors drivers shall be labelled to correspond with their respective starters.

Arrangements shall be made with the manufacturer so that the Engineer may witness motor tests if so desired Triplicate copies of motor Test certificates shall be provided for approval. Additional copies shall be provided and included in the operating and maintenance instructions.

i) Overspeed and Reverse Rotation

Each motor shall be capable of satisfactory performance during a period of 2 minutes whilst it is run at 1.2 times its rated speed and subsequently at normal speed continuously.

Where specified (to cater for backflow consequent upon delivery valve failure), pump motors shall be capable of reverse rotation up to these speeds without damage.

ii) Electromagnetic Brakes

Where an electromagnetic brake is fitted to a drive, the brake shall be continuously rated. It shall be suitable for direct connection across the associated motor terminals or for individual supply and interlinked control, depending on the method of operation and control specified herein.

The brake shall be arranged to fail-safe by holding on under spring return passage when the coil is de-energised and have provision for hand easing for maintenance purposes. All control circuits for brakes shall be arranged to fail-safe.

Coil and terminals shall be totally enclosed in a fully weatherproof housing.

iii) Water Supply Submersible Pump Motor

Submersible pump motors shall be heavy duty, designed for long running period without maintenance and shall operate at any immersion depth.

Motor frames for submersible pumps liable (even by accident) to submersion shall conform to a degree of protection of not less than IP68.

The pump and its associated motor shall form a compact integral pumping unit suitable for installation within the area specified. The motor shall be of squirrel-cage construction suitable for starting method as called for in the PS, and rated for continuous submerged operation in water having a maximum temperature of 25°C. unless otherwise specified in PS.

The motors shall have a flanged connection at the shaft end in accordance with NEMA Standard.

Unless otherwise specified, the motors shall have an efficiency of at least 80% when operating between 75% and 100% of nominal power output and shall operate at a power factor of at least 0.8 in the same output range.

Motors shall be continuously rated at least 20% above the maximum power absorbed by the pump within the specified operating range. Motors shall be designed to allow a # of starts per hour. (Refer to the PS)

Unless otherwise specified, the motor housing shall be constructed from chromium stainless steel not welded, and shall be designed for easy dismantling and re-assembly to facilitate replacement of motor guide and thrust bearings.

The motor windings shall be insulated with an approved heat resistant material of high insulation resistance and impervious to water. All connections on the motor windings shall be made watertight. The temperature rise of motor windings shall be limited to 45°C above ambient water temperature. The class of insulation shall be "Y" type and the motor stator shall be rewindable unless otherwise specified.

The motor shall be equipped, in factory with a minimum of three (3) Pt100 thermoprobes for readout, control, signalling, etc...

The motor shaft shall be machined from high tensile chromium stainless steel of sufficient diameter to prevent distortion from the dynamic and electro-magnetic stresses imposed on it. Critical shaft speed shall be well above the maximum running speed.

The motor shall be provided with a heavy duty multi-pad thrust bearing at the base of the motor (MITCHELL Type) to absorb the shaft down thrust developed by the pump. The bearing design shall incorporate tilting thrust pads with replaceable segments arranged to self adjust according to the thrust load. The thrust disc shall be of a suitable segments carbon based or similar approved material. The minimum downward thrust capacity shall be 40 KN.

The thrust bearing design shall also be suitable for reverse rotation of the shaft in the event of backflow of water through the pump.

Motor guide bearings shall utilise either leaded bronze, copper impregnated carbon or similar approved material. Rubber, nylon, Tufnell and similar materials will not be accepted for the motor guide bearings.

Motor guide and thrust bearings shall be lubricated by the motor coolant water, containing non-toxic antifreeze added in the factory and protecting the motor down to -8°C, which shall be effectively isolated from the water to be pumped. A compensating device shall be incorporated in the motor design to allow for expansion of the coolant when its temperature rises.

Submersible pump motor shall have a mechanical seal with silicon sides and a sand slinger.

A length of butyl rubber insulated, CSP sheathed flexible cable shall be provided and connected to the motor. Unless otherwise specified, the cable length shall be at least 20 metres without joints. The cable cores shall be phase coloured and be suitable for carrying the motor full local current under the specified operating conditions. The cable sealing gland shall be a watertight design and, where included within the pressurised

pipework, shall be capable of withstanding a water pressure of 1.5 times the closed valve head generated by the pumping plant.

iv) Motors for submersible pumps for sewage and river water applications

Motors shall be heavy duty, designed for long running period without maintenance and shall be suitable for wet and dry installation unless otherwise specified in the PS.

Motor frames shall conform to a degree of protection not less than IP68.

The motor shall be of squirrel-cage construction suitable for starting method as called for in the PS, and rated for continuous submerged operation in water having a maximum temperature of 40°C unless otherwise specified in PS.

Unless otherwise specified, the motors shall have an efficiency of at least 80% when operating between 75% and 100% of nominal power output and shall operate at a power factor of at least 0.8 in the same output range.

Motors shall be continuously rated at least 20% above the maximum power absorbed by the pump within the specified operating range. Motors shall be designed to allow a # of starts per hour. (Refer to the PS)

Unless otherwise specified, the motor housing shall be constructed from chromium stainless steel not welded, and shall be designed for easy dismantling and re-assembly to facilitate replacement of motor guide and thrust bearings.

The motor windings shall be insulated with an approved heat resistant material of high insulation resistance and impervious to water. They shall be suitable for class S1 duty even when not submerged. All connections on the motor windings shall be made watertight. The temperature rise of motor windings shall be limited to 45ºC above ambient water temperature. The class of insulation shall be “F” type and the motor stator shall be rewindable unless otherwise specified.

The motor shall be equipped, in factory with a minimum of three (3) Pt100 thermoprobes for readout, control, signalling, etc...

The motor shaft shall be machined from high tensile chromium stainless steel of sufficient diameter to prevent distortion from the dynamic and electro-magnetic stresses imposed on it. Critical shaft speed shall be well above the maximum running speed.

The thrust bearing design shall also be suitable for reverse rotation of the shaft in the event of backflow of water through the pump.

Motor guides and bearings shall utilise either leaded bronze, copper impregnated carbon or similar approved material. Rubber, nylon, Tufnell and similar materials will not be accepted for the motor guides and bearings. Motor guides and bearings shall be maintenance free, lubricated for life.

Motor cooling shall be ensured by blockage free jacket cooling system with heat transfer by continuous medium circulation by means of pumped liquid. For motors up to 10 kW,

the stator casing shall be equipped with extended surfaces to obtain maximum heat dissipation with the surroundings.

Motors shall have two independent mechanical face seals mounted in tandem with an interposing oil chamber which is used to lubricate the seals and to act as an additional leakage barrier. The seals shall be silicon carbide on the medium side and carbon chrome on the motor side. The oil chamber shall be equipped with a sensor to give a timely indication for regular inspection and shall act as a detector for oil leaks and water in oil. The oil chamber shall be filled with physiologically harmless paraffin oil. The oil shall be free from aromatic hydrocarbons, medically clean and be approved according to FDA 172.878

The stator housing shall be equipped with a humidity sensor installed at the bottom of the housing. This sensor monitors the humidity level in the stator housing.

The supporting bearings shall be equipped with a temperature sensor monitoring the temperature of the bearings.

The motor connection chamber shall be separate , water-pressure tight ( at depths up to 20m) encapsulated, with two stage cable inlet with strain relief and anti-kink protection.

### 402.8.4 Terminal Boxes and Connections

Terminal boxes shall be provided, suitable for PVC/SWA/PVC cables for all external cabling connections.

All boxes shall be bonded to the main frame earth and the frame of each machine shall be provided with means of connecting an earth protective conductor.

Each machine rated 10kW or above shall have the six ends of the stator winding extended to the terminal block with the necessary linking effected there, adequate clearance being provided between phase terminations to permit the use of cable sockets.

For high voltage machines the terminal assembly shall be capable of satisfactorily withstanding the full fault capacity specified herein for 1 second.

### 402.8.5 Heaters

The motors shall be fitted with anti-condensation heaters of a size to maintain the temperature of the windings 5$^{o}$C above ambient. Each heater shall be provided with a switch and also an automatic control, within the respective starters, to disconnect it when its motor is in operation.

Anti-condensation heaters shall be provided in all non-submersible machines as an integral part of the machines and wired with butyl rubber insulated tails to a terminal box adjacent to the main terminal box, the cover being clearly labelled `Heater Supply - 220V'.

Heaters shall be of the embedded element type having a low surface temperature and be

impervious to moisture. They shall be arranged to operate on a 220V supply from the associated control unit when the motor winding is de-energised.

### 402.8.6 Maintenance Facilities

Machines rated over 50kW shall have lifting ears or eyes forming part of the main frame of the machine and both ends of the rotor shaft shall be drilled and tapped for maintenance lifting and pulling facilities with a single tapped hole in accordance with the tables given in BS 4999 (Part 10). Depth of tapped hole shall be 1.5 times the diameter.

### 402.8.7 Bearings

Bearings shall be of the heavy duty ball or roller type greased for life enclosed in a substantial housing designed so that lubricant cannot escape on to the windings and fitted with adequate seals to prevent contamination or escape of lubricant down the rotor shafts. Means of lubrication shall be made available from outside the machine carcass or enclosure. The shaft shall be suitably located to prevent the rotor from moving out of magnetic centre while starting or running.

The rotor of any vertical spindle machine shall be provided with a suitable thrust bearing to support the weight of the rotor and its half coupling only.

The bearings caps on the non-drive end covers of the motors shall be arranged so as to allow a speed check to be taken.

### 402.8.8 Slip Rings

All machines which incorporate slip rings shall be so designed that the slip rings and associated slip ring mountings shall form a single unit which can be readily detached from the shaft for repairs and replacements. The slip rings shall be continuously rated and of the totally enclosed type.

### 402.8.9 Noise Level

The motors shall be commercially silent in operation and run free from vibration. The rotors shall be balanced both statically and dynamically and shall be tested and adjusted, in an approved manner.

### 402.8.10 Protection of Motors

For motors rated less than 2 KW, a three pole, thermal overloads with single phasing protection, shall be provided.

All motors above 2 KW shall be fitted with three Pt 100 internal thermal devices. They shall be arranged such that in the event of device operation, a lock out function shall operate to prevent automatic re-start upon temperature reduction. The tripped indication shall operate.

For motors rated above 2 KW and up to and including 75 KW shall be protected by three pole adjustable thermal magnetic overloads and single phasing protection.

Motors above 75 KW, unless otherwise specified, should be protected by an electronic protection relay which shall incorporate a thermal equivalent circuit taking into account both the copper and iron losses in the motor, thereby producing characteristic that closely follows the overall temperature of the motor during starting, running and cooling. The unit must follow the cooling characteristic during a loss of supply and must pick up at the correct point on the curve when supply is restored.

The trip characteristic shall be adjustable, so that it can protect motors having differing maximum locked rotor times and currents therefore shall protect motors with long run-up times.

### 402.8.11 Motor Manager

The device shall be a self monitoring unit with the following operating features : -

- select and change operating parameters.
- select and modify setting values.
- display values and modifications.
- indicate faults.
- test, e.g. verify the unit operation.
- reset: Enable the unit after a trip.

Technical data

- Operating temperature : -5$^{o}$C to 60$^{o}$C
- Storage temperature: -40$^{o}$C to 60$^{o}$C
- Climatic sensitivity: as per IEC 68-2-3 and IEC 68-2-30.
- Degree of protection: IP65
- Resistance to vibration: as per IEC 68-2-6.
- Resistance to shock: as per IEC 68-2-27.
- Noise emission and noise proof as per EMC standard.
- Power supply module shall be self-protected against short circuits.
- Data shall be retained in case of voltage supply failure.
- Fail-safe operation.
- Output relays (contacts) galvanically separated.

Protective functions

- Thermal overload.
- Asymmetry.
- Overload.
- Rotor stalling during running and starting period.
- Underload
- Earth fault.

- Long starting (Monitoring of starting time).
- Limited starts per hour.
- short circuit.
- Thermistor (PTC) input.
- Phase sequence.
- Phase failure.
- Pt 100 input (up to six No.)

This unit shall be equipped as well with a communication interface to enable data exchange with logic controllers or PLCs.

## 402.9 CIRCUIT BREAKERS

### 402.9.1 Low Voltage Air Break Circuit Breakers

The air break circuit breakers shall be suitable for control loads as for maximum operation, and shall comply with BSEN 60947 for 380V, 3 Phase, 50 Hz. 4-Wire operation for use on 31MVA fault level for 1 second for climatic conditions.

All low voltage circuit breakers shall be housed in control boards which comply with the requirements of Electrical Panels.

The circuit breakers should be horizontally isolated, horizontal draw-out pattern, air break type. The closing and tripping mechanism shall be in accordance with manufacturer's recommendation. The circuit breaker closing mechanism shall be a HAND spring charging or solenoid type.

The operating mechanisms shall have a mechanical ON/OFF indicator and a manual trip device fitted with means for locking, test terminal blocks, healthy trip lamp (coloured white) and associated push buttons, set of auxiliary switches, supply available lamps (on incoming units only) cable boxes complete with glands of suitable size for the accommodation of the incoming and outgoing cables entering from below.

Closing solenoids shall be suitable for operation at 80 per cent of the nominal solenoid supply voltage.

Closing and tripping batteries shall comply with the Safety Interlocks requirements. Auxiliary

contacts for the indication of breaker state for use at 30V. D.C. shall be provided. Slow closing

of the circuit breakers to facilitate maintenance and contact adjustment shall be provided. This operation shall be possible only with a circuit breaker in the fully withdrawn position. Any necessary handle or lever shall be included in the schedule of spare parts.

Individual shutters which automatically operate as the truck is racked in and out, shall be provided for busbar and circuit spouts. When closed the shutters shall effectively prevent any contact with either the busbar or the circuit connections and also seal the spouts against the ingress of dust. The shutters are to be coloured and painted in bold characters with "BUSBARS" (red) or "CIRCUIT" (yellow) as appropriate in Arabic and English. Provision shall be made to lock each shutter in the closed position.

Facilities shall be provided for testing the circuit breaker operation when in the isolated and

withdrawn positions.

There shall be a purpose designed, separate earthing device. The device shall be arranged to earth either the cable box or the busbar side of the circuit breaker, and shall be stored in a

suitable robust container which shall include a permanently fixed instruction label in Arabic and English giving details of assembly and use.

Auxiliary jumper connection, as necessary, shall be included.

The height of any controls shall not exceed 1800 mm, above finish floor level.
All circuit breakers shall be provided with interlocks to ensure that : -

i- Circuit breaker cannot be plugged in or isolated when it closed.

ii- The circuit breaker cannot be closed until it is fully plugged in or completely isolated.

iii- The circuit breaker cannot be closed in the service position without completing the auxiliary circuits between the fixed and moving position.

iv- The circuit breaker cannot be slow closed except in the fully withdrawn position.

v- The circuit breaker can only be operated manually in the withdrawn position.

The incoming circuit breakers shall be fitted with a voltmeter (0-600V) with selector switch to read voltage of the line to line and line neutral.

Ammeters shall be fitted on the busbar side, voltmeters on the line side of the incoming circuit breakers.

To facilitate the removal of circuit breakers for maintenance, there shall be supplied if necessary, a purpose designed hand operated trolley.

### 402.9.2 Moulded Case Circuit Breakers

Moulded case circuit breakers shall be of the quick make, quick break, trip-free type complying with BSEN 60947 and shall be complete with the following:

402.9.2.1 Type “A” circuit breakers

With an Electronic Trip Unit for protection as follows:

Long time protection against overload with adjustable threshold:
Ir = 0,4 to 1*In and adjustable time delay.
Short time protection against short-circuits with adjustable threshold:
Im = 2 to 10 In and adjustable time delay: 0.05 s to 0,30 s.
Instantaneous protection against short circuit with adjustable threshold:
I = 1,5 to 11 In
Earth fault protection with adjustable residual current threshold:
0.2 to 1xIr and time delay threshold: 0,2 s to 0,40 s.

- A minimum of 4 Auxiliary changeover switches that indicate pole position and a minimum of one auxiliary switch for tripping.

- A shunt trip release for remote tripping.

- A motor mechanism for remote control closing with the following main characteristics and auxiliaries:
  a) Remote spring charging after an opening by a shunt trip release.
  b) Toggle extension for manual spring charging.

- Terminal shields and Phase barriers.

- A counter that indicates normal Open/Close or tripping of the circuit breaker shall be installed for maintenance operation.

- One calibration test kit shall be supplied with connecting cables used to check the operation of the trip units of all circuit breakers.
-
- Visual indication of Open, Close and Trip conditions shall be provided. Circuit breakers shall be padlockable in the "OFF" position.

**N.B.** All circuit breakers shall normally operate at no-load.

402.9.2.2 Type "B" circuit breakers:

- All characteristics of type "A" circuit breakers.

- Each circuit breaker shall be mounted on a withdrawable chassis with the following functions:

  a) Operations on disconnected position: the power circuits are disconnected, the circuit breaker is simply "withdrawn" and may still be operated and controlled (on, off, push-to-trip etc...)

  b) A safety trip shall be installed on the circuit breaker, that causes automatic tripping if the circuit breaker is ON before engaging or withdrawing it.

  c) Auxiliary switches shall be supplied for remote position indication (connected and disconnected positions).

Multiple breakers shall have a common trip bar and trip elements on each pole to ensure that any abnormal condition on any one pole will cause all poles to open simultaneously.

Visual indication of open, close and trip conditions shall be provided. Circuit breakers shall be padlockable in the "OFF" or "Withdrawable" positions.

### 402.9.3 Thermal-magnetic motor circuit breakers

Thermal-magnetic circuit breakers shall be of the quick make, quick break trip type complying with BSEN 60934 and 60947 standards and shall be complete with the following:

- An adjustable thermal overload protection with automatic temperature compensation between -20° C and +60° C for open mounting and -20° C and +40° C for closed mounting.
- An instantaneous protection against short-circuit with fixed threshold 13 times the rated current.
- A minimum of three auxiliary switches that indicate pole position and a minimum of one auxiliary switch for tripping.
- A shunt trip release for remote tripping.
- A counter that indicates the number of Open/Close or Tripping operations of the circuit breaker for maintenance purposes.
- A visual indication of Open/Close/Tripped condition.
- Circuit breakers shall be padlockable in the "OFF" position.

### 402.9.4 Miniature Circuit Breakers

Miniature circuit breakers shall be of the quick make, quick break, trip-free type complying with BS 3781 Part 1. Circuit breakers shall be complete with thermal/magnetic or magnetic/hydraulic releases. Multi-pole breakers shall have a common trip bar and trip elements on each pole to ensure that any abnormal condition on any pole will cause all poles to open simultaneously.

Visual indication of open, close and trip conditions shall be provided. Circuit breakers shall be padlockable in the "OFF" position where specified.

### 402.9.5 Distribution MCB Boards

Miniature circuit breaker distribution boards shall be totally enclosed, metal clad, flush fronted units, with a hinged front door, all in accordance with BS 5486 Pt 12. The interior shall be assembled from all-insulated miniature circuit breakers with bolted connections and with switch dollies arranged for vertical operation. Phase dividing barriers shall be provided and all live parts shall be screened from the front. Circuit identification charts shall be fitted to the inside of all distribution boards.

### 402.9.6 Residual Current Circuit Breakers

The circuit breaker shall be arranged to isolate each live conductor simultaneously within 30ms if the residual leakage current through the device exceeds 30mA.

It shall be housed separately or incorporated into other composite enclosures, include provision for testing the tripping operation under earth leakage conditions by means of a built-in resistor and push button, and require manual resetting.

### 402.9.7 High Voltage Circuit Breakers And Disconnectors

402.9.7.1 Breakers

For AC circuits, circuit breakers shall be triple pole of the vacuum interrupter, SF6 or air break type as specified, suitable for the short circuit fault duty specified herein. Low voltage breakers shall incorporate a neutral link, unless in special cases a neutral pole is called for on the breaker under the specific requirements. Air or oil break circuit breakers shall be `trip-free' and the whole of the operating mechanism shall be suitable for such conditions of operation.

The whole equipment shall be robust and capable of withstanding repeated closing and opening impacts satisfactorily.

Each breaker shall be provided with the following:

a) Mechanical `Flag' indicator giving reliable indication that it is either "Off" (open) or "On" (closed).

b) Means of isolation so that the breaker may be maintained with busbars alive.

c) An operating handle that can be concealed when not required, to ensure a flush fronted appearance.

d) An adequate number of auxiliary switches with the addition of one normally open and one normally closed spare switches, all to be wired to a terminal board of approved design in the fixed portion of the switch-gear and arranged in the same sequence on all equipment.

e) Protection relays and tripping devices as specified.

f) Facilities for connection of appropriate auxiliary circuits when the circuit breaker is in the isolated position to permit operation of the breaker for test and indication purposes.

g) Key operated interlocks between breakers as specified.

402.9.7.2 Disconnectors

HV disconnectors shall be triple pole, oil free switch-disconnectors rated for fault making/load breaking duty to IEC 265, mounted on a non withdrawable chassis and enclosed in a metal clad enclosure in accordance with BS 5227 or equivalent.

The contact breaking mechanism shall incorporate expulsion quenching techniques to ensure positive arc extinction and high closing speeds to enable the switches to close onto existing short circuits without harming the equipment or the operator.

The switches shall be either manually or electrically closed and manually or electrically tripped as detailed in the Specific Requirements. All operations shall be effected with the panel door closed and include an ON/OFF indicator. Contact separation shall be clearly visible through a viewing window on the cover.

### 402.9.7.3 Safety Shutters

Where withdrawable circuit breaker units are used, the housing shall be arranged to accurately locate the movable portion prior to engagement and accommodate automatic safety shutters.

Each group of busbar and circuit spout orifices shall be fitted with an individual automatically operated safety shutter, the appropriate shutters being positively opened or closed when the circuit breaker is racked in or out.

When closed, the shutters shall effectively prevent any contact with either the busbar or circuit connections and seal the spouts against the ingress of dust. The shutters shall be painted in bold characters `BUSBARS' or `CIRCUITS' as appropriate, the busbar shutter being coloured red and the circuit shutter being coloured yellow (see Appendix 8).

For testing and inspection, each shutter shall be separately hand operated from the front of the unit and latched in the open position. Any movement of the circuit breakers either in or out of the housing shall automatically restore the automatic feature.

Provision shall be made for each shutter to be locked only in the closed position.

Non-withdrawable HV switch-gear shall have a three phase test access point incorporated in the design such that cable and injection tests may be carried out on each circuit. The test access point shall be fitted with a lockable cover and interlocked to prevent access to live circuits.

### 402.9.7.4 Provisions for Earthing

Provision shall be made for earthing the busbars and each circuit outlet through the circuit breaker, either integrally or by means of a portable device as specified; such an arrangement being suitable to withstand the full short circuit rating of the switch-gear.

Where integral earthing facilities are included, selection of the locating mechanism shall prevent the breaker being engaged into any position other than that selected. Visual indication of such circuit breaker locations shall be clearly marked, eg. "CIRCUIT EARTH", "BUSBAR EARTH", "SERVICE/ON" and "ISOLATED/OFF".

Facilities shall be provided so that padlocks can be fitted to prevent the selection of either "EARTH" positions.

Facilities shall be provided for padlocking the circuit breaker while it is closed on to an earthed circuit to prevent unauthorised tripping electrically or mechanically.

The circuit breaker truck (or carriage) and oil tank if applicable, shall be effectively earthed when in the "SERVICE/ON" position.

HV switches shall have facilities for earthing the circuit by means of a selector and the ON, OFF and EARTH positions shall be visibly indicated, appropriately labelled and provided with locking facilities in each position. Inspection windows shall be provided so that the position and condition of the selector contacts and insulators can be observed.

### 402.9.7.5 Interlocks

Each circuit breaker unit shall be provided with mechanical interlocks to prevent incorrect operation or accidental contact with live metal, and to protect the equipment and operator from the dangers of mal-operation and designed to prevent the following where relevant:

The circuit breaker being closed unless it is in the fully- engaged or fully-withdrawn position.

The circuit breaker being engaged and plugged into the busbar and circuit spouts unless the tank is bolted to the top-plate.

The circuit breaker being engaged or withdrawn unless the main contacts are open.

The circuit breaker unit being withdrawn from or pushed into the unit housing unless the breaker is in the fully-withdrawn position.

The circuit breaker being positioned in the unit in any position other than that indicated on the locator.

Access to voltage transformers unless they are in the isolated position.

### 402.9.7.6 Handling Track

For each switchboard and different type of breaker supplied, one purpose designed, manually operated lifting and handling track shall be provided to enable safe removal of a circuit breaker from its compartment.

### 402.9.7.7 Switch Oil

The first change of switch oil shall be provided for each oil circuit breaker or switch. An oil level indicator shall be provided on each tank with maximum and minimum limits marked.

## 402.10 ELECTRIC GENERATORS

### 402.10.1 Alternators

Alternators shall be star connected machines producing a 3 phase, 4 wire, 50 Hz supply at the specified rated voltage within a standard waveform deviation, when being driven at the rated speed and connected to the plant load specified herein.

The alternator shall be continuously rated and generate at 380 volts, 3 phase, 50 Hz, with the neutral point connected to an individual earth bed.

The alternator enclosures shall be protected to IP22 Bs.4999 part 20. They shall be suitable in all respects for operating in the climate conditions specified in the tender document.

The insulation of the stator and rotor shall be in accordance with British standard class "H", but the alternator shall be designed for a class "E" temperature rise. The efficiencies of the alternator shall be stated in the tender and shall be determined in conformity with the procedure laid down in BS.4999 Part 33 and shall be manufactured in accordance with BS.5000 Part 99.

Each alternator shall be capable of satisfactorily providing an output 10% percent in excess of the BS rating for one hour in any period of 12 hours consecutive running.

The rotating parts shall be statically and dynamically balance to close limits.

Each alternator shall be fitted with anti-condensation heaters of a size to maintain the temperature of the windings 5°C above ambient. Each heater, shall be provided with a switch and automatic control to disconnect the heater when the alternator is running.

Terminal boxes shall be provided and arranged with sealing chambers for the reception of the cables detailed in the relevant sections of the specification. Terminals shall be clearly marked to give phase identification.

i) <u>Regulation</u>

The generator automatic voltage regulation system for single set running shall be capable of maintaining the voltage for all loads between no load and rated load at rated power factor.

Due allowance shall be made for the current peaks associated with starting the motor loads connected to the alternator, and the regulation system shall be designed such that the transient voltage reduction following the load application does not exceed 15% of the rated voltage and shall be restored to within 97% of rated voltage in less that 1.5 seconds. The transient voltage rise when the rated load is thrown off shall not exceed 25%.

Where voltage regulation equipment is mounted on the alternators, the components shall be readily accessible and detachable for servicing, having terminations separate from the main terminals.

ii) <u>Excitation</u>

The alternator shall be the brushless self-excitation type with rotating armature and verifier assembly mounted on the alternator shaft, electrically interconnected with the field winding. Radio noise suppression shall be in accordance with BS 800 and the exciter field shall be safely discharged when the alternator is tripped.

### 402.10.2 Generator Panels

The panel shall be easily accessible, protected against fluid projections and fixed on shock absorbers near the engine.
It shall include :

- 3 ammeters
- 1 voltmeter
- 1 frequency meter
- 1 oil pressure gauge
- 1 water thermometer
- 1 oil thermometer
- Push-buttons : on, off, and emergency stop
- 1 hour meter
- 1 contact key

### 402.10.3 Mains/Standby Supply Changeover

The changeover section shall monitor the three phase voltages and Neutral of each of the two incoming supplies and automatically close the 4 pole contactor to the healthy supply. The two incoming supply contactors shall be healthy supplies.

Where a bus-section switch is provided for manual switching arrangements to allow both supplies to be utilised without paralleling, the contactors must be electrically interlocked between each other and the bus-section switch. The bus-section switch will normally be closed so that all plant is fed from the healthy supply. If however the bus-section switch is opened, the anti-paralleling interlock will be defeated and it shall be possible to close both incoming contactors for exercise purposes.

Voltage monitoring settings shall be adjustable and nominally set to operate on a rising voltage of 90% nominal, with low/high voltage settings at ±15% nominal on each of the three phases.

**a) <u>Automatic Operation</u>**

<u>Mains Supply</u> - Closing the incoming isolator or restoring a healthy supply will initiate the closing of the Mains contactor via the monitoring relays, subject to the generator operating condition.

Momentary supply drop-outs up to 5 secs. shall allow the plant to resume without further action. Breaks of supply greater than 5 secs. shall initiate the generator supply. Delayed start timer setting to be adjustable 0-3 min.

On restoration of mains supply a minimum period of 10 sec. shall elapse before a signal is given to stop the generator. Delayed stop timer setting to be adjustable 0 - 3 min.

Generator Supply - After the generator has been initiated, the monitor relays shall control the closing of the generator supply contactor to the load. The generator shall continue to run until signalled to stop by the restored Mains supply. A timer provided by others in the generator control panel shall ensure that the generator shall run for a minimum time on-load of not less than 30 mins, (adjustable 0 - 60 min). All timers shall be set to suit operational requirements.

**b) Manual Operation**

If the generator is to be connected to both halves of the switchboard (bus-section closed) whilst the Mains supply is still available, the Mains supply switch shall be opened and the generator will receive its automatic start signal due to apparent loss of Mains supply. The generator will start and take on load automatically as if for a normal mains failure. The generator will continue to run until the Mains switch is closed, generator shutdown will then occur as defined for automatic mode.

If the generator is to be connected to its own half of the switchboard only, with the other half still fed form a healthy Mains supply, opening the bus-section switch will allow both contactors to be closed. The generator must then be manually started from the 'Generator Run-Up' button as mains failure will not be detected. When the generator is running and ready to take load, the generator supply contactor will close automatically and the drives may be started in sequence

as required. The generator will continue to run until the 'Generator Run-Down' button is operated, this will immediately stop the generator and de-energise its supply contactor, allowing the Mains supply contactor to be restored after the bus-section switch has been closed. The generator minimum run timer being over-ridden for the manual facility.

If the generator is to be run off-load only, then its incoming supply switch may be opened, alternatively the bus-section may be left closed, thus preventing the generator contactor from closing whilst the Mains supply is in use. The 'Generator Run-Up/Run-Down' buttons or the Start/Stop buttons on the local generator control panel shall be used.

**c) Restoration of Loads**

After any changeover of supplies, automatic or manual, the pump motor loads may be restored automatically or manually (remotely or locally) as specified but with sequential 20 sec. re-start delay timers incorporated in each pump starter circuit to prevent Co-incident starting surges.

## 402.11 ELECTRODES

### 402.11.1 Electrode Mounting

The electrode heads shall be mounted on a suitable support bracket at a height well above the expected maximum water level.

Intermediate steady brackets shall be provided and fitted for every 2m of electrode length, insulated lengths of electrode being fitted where these are used.

Support brackets and steady brackets shall be hot dipped galvanised to BS 729 or otherwise protected to prevent corrosion.

### 402.11.2 Heavy Duty Electrodes

Each electrode shall comprise a single element mounted in an insulating high impact phenolic moulding, impervious to corrosion and having separate fixings for the flange mounting base and for the cover.

The base shall have a 20mm screwed conduit entry and be suitable for accommodating the electrodes, and incorporate provision for adjusting the electrode length by means of a substantial clamping collar which shall also have a provision for terminating the cable conductor.

A sealing gasket shall be fitted between the base and cap and the whole head shall be sealed to prevent the ingress of water after installation is completed.

The electrodes shall be formed of 3/4" BSP galvanised steel tubes (approximately 27mm diameter) sealed at one end and cut to suite the specified length, cut ends being dipped or coated with galvanising paint or similar. Where intermediate steady brackets are required or when otherwise specified, the electrodes shall be sheathed with an insulating material to within 150mm of the electrode tip.

Spacing between electrodes and to the adjacent wall shall be not less than 150mm.

### 402.11.3 Light Duty Electrodes

Each electrode shall be mounted in an insulating moulded body having a 20mm screwed conduit entry and a screwed cover such that the whole head may be sealed to prevent the ingress of water after installation is completed.

The electrodes shall be formed from not less than 6mm diameter stainless steel rod and should not exceed 1.5m in length for light duty applications. Spacing between electrodes and to the adjacent walls shall be not less than 100mm.

### 402.11.4 Electrode Circuits

All electrode circuits and components shall comply with BS 5345 and the BASEEFA requirements for an intrinsically safe system for Apparatus Groups IIA and IIB.

The system shall operate by the circulation of an AC current when the circuit is completed by the liquid coming into contact with the electrode, this current operating a relay to initiate the events specified herein. The relay operation shall incorporate a five second time delay 'On' and 'Off' to allow for spurious initiation.

Intrinsically safe electrode circuits shall be completed by a separate return electrode for each circuit.

## 402.12 LOCKS & KEYS

### 402.12.1 General

Lockable selector switches or panel doors in a multi-unit installation shall employ a common interchangeable operating key but keys for each function may be non-interchangeable, subject to the approval of the Engineer.

For each key pattern employed, three keys shall be provided; each having a permanently attached brass identification label, embossed with the following:

a) key number
b) location of lock/item of equipment ref.

Loose padlocks and keys for security locking switchgear, isolators, shutters etc. shall not be included but will be provided by the Client to suit their master key suite for permit locking. Hasps shall have not less than 9mm diameter holes suitable for 6mm diameter shackles.

### 402.12.2 Padlocks

Padlocks shall be provided for independently securing busbars and circuit shutters in the closed position and also for locking each circuit breaker or switch in the open position. A padlock and key, or similar device, shall be provided to lock each circuit breaker closed when in the earth

position. Padlocks and keys shall also be provided to lock any isolator and earthing device handles in either the open or closed position, such that the mechanism is inoperative unless the locks have been removed. All padlocks in any station shall take the same key.

Glass fronted lockable key boxes, with labelled hooks, shall be provided for each switchboard.

### 402.12.3 Key Cabinets

Key cabinets shall be provided to accommodate, on suitably numbered/coloured, adjustable hook bars, one set of all the above keys and padlocks. The keys shall be fitted with corresponding number/colour coded tabs. The cabinets shall be of stove enamelled sheet steel material, suitable for surface wall mounting and be fitted with lockable hinged cover doors.

## 402.13 LIGHTNING PROTECTION AND GROUNDING SYSTEMS

### 402.13.1 General

Lightning protection systems shall be designed to withstand direct and indirect lightning strikes.

Lightning protection systems shall consist of the following:

- Air termination network or rod-type lightning conductor.
- Down conductors.
- Ground termination network.

Ground termination shall be acheived by installing electrode rods (in pits) connected to the bottom of the down conductors using tape tails.

#### 402.13.1.1 Joints

Any joint other than welded represents a discontinuity in the current conducting system. The lightning protection system must have as few joints as possible.

Joints should be mechanically and electrically effective, e.g. clamped, screwed, bolted, riveted or welded with overlapping joints, the overlap should not be less than 60 mm for all types of conductors. Contact surfaces should first be cleaned and then inhibited from oxidation with a suitable non-corrosive compound. Bi-metallic joints should be thouroughly cleaned using a separate abrasive for each type of material.

All joints should be protected against corrosion or erosion from the elements of the environment.

402.13.1.2 Bonds

Bonding shall be used to prevent side-flashing.

Careful attention shall be given to the metals and items being bonded.

A bond should be mechanically and electrically effective and protected from corrosion and erosion either by selection of material or by protective measures.

## 402.13.2 Lightning Protection Systems

402.13.2.1 General Requirements

**Down conductors**

Down conductors shall be copper flat strip and have a minimum 25x3 mm² c.s.a. They shall be fixed with leaded gunmetal clamps, secured by phosphor bronze screws or bolts. Each down conductor shall take the most direct route from the air termination network to the earth termination and be provided with a bolted test joint in such a position that, whilst not inviting unauthorized interference, it is convenient for testing purposes.

Plates indicating the position, number and type of earth electrodes should be fitted above each test point.

Down conductors shall be protected with galvanised steel covers between the control junction and the ground up to 2 m above ground.

**Equipotential bonding system**

Buildings with a lightning protection system must be included into the main equipotential equalisation by means of the main earthing bar or equipotential bonding bar. Lightning protection equipotential bonding for the conductors of the energy network must be accomplished as close as possible to the point of entry of the mains into the building.

**Ground termination network**

Earth electrodes of 16 mm² copper bonded, steel cored rods shall be deep driven into the ground as close as practical to the structure. The rods shall be installed in sections connected by screwed couplers and driven to a sufficient depth to acheive a combined resistance to earth not greater than 3 ohms.

The screwed couplers shall be long length aluminium bronze material, counterbored to protect the threaded ends from damage and corrosion.

The ground termination network shall be able to carry high currents repeatedly.

Electrodes may be one of the following types:

– Deep driven rods

- Radial strip
- Solid plate or mat.

Step and touch voltages on the surface of the ground in the vicinity of earth electrodes must be restricted to a maximum value of 5% the voltage gradient.

### 402.13.3 System using air termination network

The protection system shall be designed and installed in accordance with BS 6651. No part of the roof should be more than 5 m from the nearest horizontal conductor. For large flat roofs, this will be achieved typically by an air termination network mesh which dimensions are adequately chosen. On a reinforced concrete structure, the air termination network should be connected to the reinforcing bars in all positions required for down conductors.

All metalwork on or very close to the structure shall be bonded to the lightning protection system. Where connection between dissimilar metals are made, precautions shall be taken to prevent corrosion.

If portions of a structure vary considerably in height, any necessary air termination networks for the lower portions, should be joined to the down conductors of the taller portions in addition to being joined to their own down conductors.

It must be noted that at all times adequate conductor fixings must be used in conjunction with the recommended fixing centres.

#### 402.13.3.1 Lightning protection zones

The zone concept of integrating external and internal lightning protection systems through equipotential equalisation shall be followed to ensure an effective and complete protection system of all sensitive equipment susceptible to damage and failure from switching operations in power networks, or from the effects of lightning, together with overvoltage hazards due to electrostatic discharges.

All the cables entering the building must be incorporated into the protective equipotential bonding system at the interfaces between lightning protection zones.

The active conductors of power supply and computer networks shall be integrated into the protective equipotential bonding system via special lightning arresters.

Local equipotential bonding must additionally be ensured at every other interface between zones within the building. Equipotential bonding of active conductors is realized with the aid of overvoltage arresters at these points.

The local equipotential bonding bars are to be connected to each other and to the main lightning protection equipotential bonding bar.

### 402.13.4 Systems using rod lightning conductor

#### 402.13.4.1 Franklin type

This type of protection consists of a lightning conductor inert rod mounted on a mast and connected to a ground post by down conductors.

Location and height shall be determined by the Contractor and approved by the Engineer to ensure that the protection of the entire plant is in accordance with NF C 17-100.

The lightning conductor shall be tied with galvanized steel clamps on the mast to withstand vibrations and mechanical stresses.

402.13.4.2 Early streamer emission type

The same installation rules of the Franklin type apply for the early streamer emission type with the following additions:

- No radioactive sources shall be used.
- The high voltage/frequency emission components shall be inaccessible.
- No external electrical or mechanical energy supply shall be needed: The system shall be self-contained, drawing its energy from the ambient electric field existing at the time of the storm (5 to 20 KV/m).
- The radius of protection and installation height shall be determined in accordance with NF C 17-102.
- A test report from a high voltage laboratory shall be submitted to the approval of the Engineer as well, confirming the initiation advance $\Delta T$ of the lightning conductor and the efficiency of the self-contained electronics in the lightning conductor.

**402.13.5 Overvoltage protection**

Electrical and electronic equipment shall be protected against surges or transients generated by switching operations, electrostatic discharges and induction, etc... by the use of graded lightning and overvoltage arresters.

Other grounding systems such as that for building, plumbing, power supplies, information processing etc... shall be taken into consideration upon designing the complete protection system.

Compatible overvoltage devices for 'line-side' protection, that includes basic, medium level and detailed protection, shall be installed and shall be of the same brand.

These overvoltage devices shall be installed according to BS EN 60099 and to the manufacturer's recommendations and shall have the following characteristics:

- Modular design
- Visual fault indication
- Remote signalling module
- Replacement of active module (varistor) without interrupting the power supply
- Negligeable leakage current

- High discharge capacity
- No follow current when the surge voltage has died down
- Short response time

Telecommunication systems, data interfaces, electronic networks, etc... shall be protected with adequate overvoltage protection devices.

### 402.13.6 Grounding system

Grounding system shall consist of the following:

- Earth points and underground connections (main grounding network)
- Electrode inspection pits
- Collector pits
- Protective conductors

402.13.6.1 Main grounding network

The main grounding network shall be of the mesh type, therefore the rupture of an underground conductor in a given point of the installation shall not lead to the isolation of this point from the ground.

The main grounding network shall consist of rings made by a cable laid within the structure's foundations and surrounding each part of it. These rings are connected to one another by at least two separate connections. No cut-off or isolating device shall be inserted between these conductors.

Where the execution of rings is not possible, the contractor may adopt other standard alternatives:

- Crows foot earth configuration
- Solid plates
- Radial strip electrodes
- Matrix arrangement of deep driven parallel earth rod electrodes.

The resistance of the main grounding network compared to a reference zone located outside the influence zone of the mesh network shall not exceed five ohms.

Rings, and ground networks in general shall be buried in trenches at least 1 m below ground level.

402.13.6.2 Electrode inspection pits

Connections with rings, links and other auxiliary grounding systems shall be done exclusively inside standard inspection pits.

These inspection pits shall allow location of main ground points, verification of electrical continuity and measurement of resistivities.

402.13.6.3 Collector pits

Collector pits shall be erected as required in the grounding system. They shall contain a grounding collector made of a tinplated copper frame of appropriate c.s.a allowing the connection of all protective cable ends.

The grounding collector shall ensure at least a double connection with the grounding network.

402.13.6.4 Protective conductors

They shall be of appropriate c.s.a and constitute with the grounding collectors a radial network. Hence, series grounding connections are strictly prohibited.

Protective conductors shall be laid exposed in gutters or in a sleeve built-in in masonry or concrete works.

Radius of curvature of the protective conductors shall not exceed 8 times its overall outside diameter.

Protective conductors rising from the floor, shall be protected by a sleeve protruding 50 cm above ground level.

## 402.14 HEATERS & THERMOSTATS

### 402.14.1 Water Heater

Single point water heaters shall be thermostatically controlled free outlet 'single point' heater suitable for wall mounting. The water inlet shall be 0.5" BSP fitted with a control tap and the outlet swivel spout shall have a reach of approximately 300mm. The heater shall have a capacity of approximately 1.5 gallons (7.0 litres) and an electrical loading of approximately 3kW.

### 402.14.2 Space Heaters

Wall mounted single tier tubular heaters rated at 250 watts/metre and suitable for 220V operation shall be provided.

The heaters shall be mounted approximately 300mm above floor level. They shall be directly connected to heater circuits controlled by the room thermostat, the final connection to the heaters being made by means of flexible conduit and a protective conductor. The flexible conduit shall enter from below the heater.

### 402.14.3 Space Heater Thermostat

The thermostat shall be a surface mounting 14 Amp bi-metallic strip type, adjustable over the range 0-30°C and lockable to prevent unauthorised adjustment of the setting.

The room thermostat shall be mounted approximately 2.0m above the floor level.

### 402.14.4 Electric Trace Heating

Heating cables shall comprise a self-regulating, conductive polymer core or double insulated heating elements within a waterproof outer PVC sheath having sealed ends with a cold lead at one end. The cable shall have a flat section to provide efficient heat transfer.

The cable shall be straight laced along the underside of pipes and secured with cable ties at 300mm spacing or be spiralled around the pipe and secured at each end. All heating cable must be in intimate contact with the pipe and must not be overlapped on itself, additional ties being positioned on either side and close to all flange joints. To avoid mechanical or leakage damage, the cable shall be run over the sides of flanges at 90° to the invert on horizontal pipe runs.

After any thermal insulation has been fitted, wiring labels shall be fitted in prominent positions on the pipework to indicate the presence of trace heating.

### 402.14.5 Trace Heating Thermostat

A wall mounting, air sensing thermostat set at 5°C shall be provided and arranged to switch on the heater for frost protection. If non-self-regulating heating tapes are used and where lagging is applied, or on PVC pipework, a thermostat shall be located on the pipework and arranged to switch off the heater if the temperature exceeds 60°C. Liquid filled sensing bulbs and capillary tube connections to the thermostat shall be of stainless steel with a stainless steel flexible sleeve fitted over the capillary tube for mechanical protection.

The air measuring thermostat shall be mounted on the outside wall, 600mm above ground level and adjacent to but not above the protected pipework.

Enclosure and terminal arrangements to be as specified for field mounted equipment.

## 402.15 UNINTERRUPTIBLE POWER SUPPLY (UPS)

A rectifier/battery/inverter system shall be rated and arranged to provide a 'no-break' supply to the specified loads.

The UPS shall incorporate maintenance free, lead acid, sealed batteries and operate in a continuous mode to protect the connected loads from AC supply interruptions and irregularities. The general technical characteristics of the UPS are as follows unless otherwise specified:

- Output : 110 V / 220 V ± 5%, 50 Hz ± 0.001 (crystal control), sinusoidal

- Efficiency : inverter ≥ 85% - Total ≥ 80%
- Autonomy : 3 hours at optimum power output
- Total distortion : maximum 3% at full load
- Power supply : 110 V / 220 V ± 10%, 47-53 Hz

- Power factor : inductive load 0.6 to 1
  capacitive load 0.85 to 1
- Overload : 125% for 3 seconds
  150% for 1 second
  200% for 50 ms
- Protection : Circuit breaker for: battery low voltage - overloads
- Signalling : - Inverter : 'ON'
  - Power supply voltage : 'ON'
  - Battery voltage
  - Overload indicator
  - Ammeters, voltmeters
  - Audible alarm

The unit shall incorporate a static by-pass switch arrangement such that in the event of failure of the inverter, it shall automatically transfer the load to the by-pass supply with no loss of continuity in supply. This unit shall monitor the mains and output frequencies to maintain synchronisation within $\pm$0.5 Hz and $\pm$5% voltage. Where these tolerances are not maintained, the static by-pass shall be inhibited to prevent out of sync switching. Where generator sets are to be connected, a frequency tracking inhibit switch shall be included.

A manual by-pass switch shall also be provided to enable the UPS to be taken out of service for maintenance. No feedback shall be possible and any live parts shall be fully shrouded.

The transformers of remote control, signalling..., circuits shall be class I, insulation class E and according to standards. They shall be installed in the control panel, non insulated, with terminals protected by an adequate screen.

The UPS shall be selected according to the required maximum power, taking into consideration voltage drops, climatic conditions and necessary derating.

During mains failure, the battery will take over the supply via the inverter. On re-connection of the mains supply, the system shall automatically revert to its normal operating mode and the battery be recharged to its full operating capacity.

The unit shall be protected at the upstream by a thermo-magnetic circuit breaker, and at the downstream by a differential thermo-magnetic circuit breaker 30 mA.

A galvanic isolation of inputs-outputs shall be ensured. Circuit breakers shall be equipped with a fault signalling device.

Distribution towards the different parts shall be carried out by means of distributors.

The set of relays shall be of low in-rush current.

Controls, metering and indications shall be provided on the panel front and arranged in an approved manner.

a) Start, Stop and Reset push buttons.

b) Metering shall be provided for:

1) battery voltage
2) battery amps (centre zero)
3) output voltmeter
4) load ammeter

c) Status indications shall be provided for:

| **Normal conditions - White** | **Fault conditions - Amber** |
|---|---|
| Mains on | Battery volts low |
| Boost charge | Charge failure |
| Inverter on | Inverter failure |
| By-pass supply available | Static by-pass inhibited |
| By-pass supply to load. | |

All fault indications shall provide 'volt-free' contacts for remote indication.
On/Off control switches shall be provided within the panel for:

Mains input
Battery isolator
By-pass supply
Boost charge

When isolating the UPS for maintenance, separate mains input and battery supply isolators shall be provided, interlocked such that the battery isolator cannot be closed before the mains switch is closed (to limit stress on the storage capacitors).

The UPS output shall be protected against under/over voltages and overcurrent during load transfers. The UPS shall be capable of satisfactorily withstanding an overload of 125% for 10 minutes and maintain output frequency stability of $\pm$5% for 100% load changes.

Current limiting and over-voltage protection shall be included in the charger circuit together with charge rate adjustment to suit the battery manufacturer's recommendations, with automatic initiation of a timed boost charge as required.

The harmonics generated shall be restricted by suitable filters to be within the tolerances defined in Engineering Recommendations G5/3 "Limits for Harmonics in the UK Electricity Supply System".

The charger (rectifier) shall be sized to suite the maximum total power requirements of circuits. The rectifier output shall also include filters to reduce DC ripple to the batteries to maximise battery life.

The UPS shall preferably be located within the Control & Monitoring Panel but where the panel is a separately mounted, free-standing unit, all construction, component and finish details shall comply with those specified for the switchboard panels.

## 402.16 BATTERIES & CHARGERS

### 402.16.1 Battery Charger

The battery charger shall operate from the mains supply and be suitable for the battery provided and shall include overcurrent protection and automatic voltage regulation irrespective of the load on the battery. Where permanent loads are connected, the charger shall be capable of supplying a normal float charge designed to meet the standing loads and maintain the battery in a fully charged condition. Provision shall be made for a boost charge, selected by means of a Normal/Boost switch mounted within the panel with a label adjacent giving instructions on the use of the boost control.

The charger shall incorporate a provision for adjustment of the charging voltage and have protective devices to initiate the "Battery Fault" indication on the specified panel in the event of charge failure and low battery voltage. Mounted on the front panel shall be a mains supply indication lamp and meters showing the charging voltage and current.

When associated with engine starting duties, the charger shall be automatically isolated during the engine starting procedure. During engine operations, battery charging shall be automatically maintained by an engine driven generator working through a regulator and cut-out.

### 402.16.2 Starter Battery

The battery shall be a 24V lead acid, stationary, high performance, low maintenance Plant type suitable for Standby engine starting duty and continuous normal charging.

Its capacity shall be sufficient to provide at least three successive 10 second attempts to start within a period of 2 minutes at 0°C.

The battery shall be accommodated securely in a wooden stand supporting a protecting cover, all finished with 2 coats of black chlorinated rubber paint.

### 402.16.3 Battery Supplies

Batteries for switchgear, control and alarm duties shall be of pocket plate nickel cadmium structure with an alkaline electrolyte and shall be suitable for constant trickle charging.

Each trip battery shall be rated for performing three successive tripping duties and for alarm relay circuits required for the associated circuit breakers. The trip battery shall not be used for other than these purposes.

## 402.17 POWER FACTOR CORRECTION

Unless otherwise specified, a power factor correction capacitor complying with BS 1650 and suitable for operation over the temperature range -10°C/+40°C shall be connected to improve the overall power factor of each machine to not less than 0.9 when running at full load.

Each capacitor bank shall be fitted with HRC fuse protection enclosed within a sheet steel housing having a terminal box with separate bolted access cover and an external earthing terminal.

Means shall be provided for monitoring fuse failure visually. Striker pin fuses shall be provided

and arranged to operate a trip bar which shall initiate an alarm contact for remote indication. Resistors shall be fitted to provide a controlled discharge on de-energisation except where such discharge is effected by the machine windings.

The terminal boxes of motors and capacitors shall be labelled with “Traffolite” type labels, black letters on yellow background, to read in Arabic and English.

"WARNING LIVE TERMINALS- ISOLATE BEFORE REMOVING COVER".

"WARNING - EQUIPMENT CONNECTED TO STORED ELECTRICAL CHARGE. ISOLATE AND EARTH ALL TERMINALS BEFORE HANDLING".

# 403. CABLING & WIRING

## 403.1 ELECTRICAL CABLES INSTALLATION

### 403.1.1 General

The electrical installation shall comply with the current edition of the Regulations for Electrical Installations published by the Institution of Electrical Engineers (IEE Wiring Regulations) and the requirements specified herein where these differ from the IEE Wiring Regulations.

The installation shall be arranged in a neat and orderly manner which may involve running out of direct lines in order to conform to building outlines etc. and to utilise any holes provided for cabling purposes in the structure. Unnecessary crossing of cables will not be accepted and due care should be given to this when selecting runs. Each cable shall be in one continuous length and no straight through joints will be permitted except as agreed with the Engineer.

It shall be the entire responsibility of the Contractor to program the whole of his work and Co-operate with other contractors to ensure that the various parts of the electrical installation are executed at the proper stages of the construction, special care being taken with concealed work.

Care should be taken that servings and sheathings of cables are not damaged during installation. Should any part be damaged, the damage shall be made good to the entire satisfaction of the Engineer. Cables shall only be installed when the ambient and cable temperature is above 0°C and has been so for the previous 24 hours.

Cables shall, wherever possible, be arranged to enter equipment from below, particularly equipment located externally or in damp situations. Cables entering cubicles provided with sealed covers of timber or sheet steel shall be accommodated by drilling or dividing the covers with clearance holes as necessary to allow the cable to pass through and be terminated at glands or gland plates provided within such cubicles, so that the covers when replaced prevent entry of dust and vermin.

All cables shall be of suitable voltage grade, with stranded copper conductors, selected for the climatic conditions specified:-

i- Ground Temperature 30°C

ii- Cables above ground, not exposed to direct sunlight Air Temperature 40°C

iii- Cables above ground and exposed to direct sunlight Air Temperature 70°C

Each cable shall be of sufficient rating for its duty under normal, fault and site installation conditions. To assess the rating and cross-section required for each cable, the following factors must be considered as a minimum.

i- Fault level.
ii- Conditions of ambient temperature relevant to method of laying.

iii- Voltage drop.
iv- Voltage drop in motor circuits due to the starting method.

v- Over current settings of circuit breakers.

vi- Disposition of cabling, whether in air, ducts or soil.

Derating factors shall be applied for all cables at the following conditions : -

a- Cable depth 0.6 metres minimum

b- Cable grouping to be in accordance with the relevant IEE regulations.

c- Cable in air to be in accordance with the relevant IEE regulations.

Where cables are run in conduit or trunking, any requirements or I.E.E. Regulations must be complied with.

Where a neutral conductor is required, its cross-sectional area shall not be less than that of the phase conductors, unless otherwise specified. Each and every mains supply cable shall be provided with an individual earth continuity conductor, which shall be of sufficient cross section area being either one core of a multicore cable or a separately run, P.V.C. insulated (green, or green/yellow) stranded single core cable sized in accordance with the regulations. The use of cable armouring, conduits, water or other service pipes as the only means of an earth continuity path is strictly prohibited.

Prior to dispatch to site the supplier shall pass to the Engineer, in triplicate, copies of the cable manufacturers test certificates for approval.

Each cable shall have its individual cores identified along their entire length by permanently printed numerals or letters. At every point of termination, core identification shall be carried out using an approved system of ferrule markers. At points of interconnection of wiring at which a change of numbering is unavoidable double ferrules shall be provided on each wire.

Any change of numbering shall be recorded on the wiring diagrams of the equipment at which the change is made.

When more than one cable is to be terminated at an item of equipment, particular care should be taken to ensure that all cables to the equipment are routed from a common direction and each is terminated in an orderly and symmetrical fashion. Each and every cable shall be

permanently identified at each end by its cable number, as noted within the schedules. The identification label shall be of adequate size and style to a pattern approved by the Engineer and shall be securely fixed to its relative cable.

In the event of any armouring or serving fault being made it will be the responsibility of the Contractor to repair or make good any such faults to the satisfaction of the Engineer. Where any such fault occur, these shall be made known to the Engineer and subsequently recorded on the final record drawings.

All L.V. and H.V. cables shall be delivered on robust cable drums which shall bear the full details of manufacturer, size, length and insulation and shall be offered to the Engineer for inspection prior to installation.

### 403.1.2 Installation of visible Cables

All visible cables shall be mounted as follows:

a) Cables shall be installed on cable tray in one layer and shall in no case be superimposed. Each cable tray, shall have a 25% reserve in order to allow for the installation of future cables. Vertical sections shall be fitted with cable fixing devices.
b) Cables shall be fixed on masonry along walls by means of galvanised steel brackets or other means proposed by the Contractor and approved by the Engineer.
c) Beneath ceilings, cables shall be held by substantial supports. The supports shall be

sufficiently close to avoid droop of the cables.

### 403.1.3 Insulated Wires

All wires and connection devices shall be accessible for inspection and replacement as required. They shall be so set out and installed as to allow handling without causing any mechanical deterioration.

All wires shall be installed entirely inside conduits.

The pulling of wires in conduits shall be carried out carefully in order not to damage the insulator. It is forbidden to use oils, grease or any other fluid for facilitating the pulling of wires, the contractor can however use powder of an approved type.

### 403.1.4 Other Conditions

Lengths of cables mounted between ground and a height of 2.50m and those crossing masonry shall be installed inside galvanised steel tube.

### 403.1.5 Segregation of Duties and Services

Cables of different circuit categories shall be segregated as defined in the IEE Regulations. Instrument control cabling shall as far as possible be routed separate from electrical power cables and long parallel runs to these or pipework should be avoided. Where parallel routes and crossovers are necessary, a minimum separation of 250mm shall be maintained. Power cables shall not occupy the same ducts as instrument cables.

Similarly, separation between the three categories of instrument cables shall also be maintained as scheduled below:

| | | **Separation** | |
|---|---|---|---|
| **Categories to BS 6739** | **Cat 1** | **Cat 2** | **Cat3** |
| **CATEGORY 1**<br>Instrument power & Control<br>(over 50V, under 10A, AC or DC | ---- | 200 mm | 300 mm |
| **CATEGORY 2**<br>High level signals<br>(5V to 50V DC) | 200 mm | ---- | 300 mm |
| **CATEGORY 3**<br>Low level signals<br>(Less than 5V DC | 300 mm | 300 mm | ---- |

Only conductors carrying signals of the same category shall be contained within any one multicore cable. Similarly, conductors forming part of intrinsically safe circuits shall be

contained within multicore cables reserved solely for such circuits.

All screens for instrument cables shall be earthed at one point only, preferably at the main control centre.

### 403.1.6 Intrinsically Safe Circuits

Circuits complying with the requirements of BS 5345 for intrinsically safe circuits shall be arranged such that all cables are identified and segregated as detailed in BS 6739.

Conductors forming part of an intrinsically safe circuit shall only be contained within multicore cables reserved solely for such circuits and must be terminated separately.

Intrinsically safe circuits shall be connected to a separate earthing system as detailed in BS 6739 and any shunt diode barriers shall be installed in accordance with the certification requirements.

### 403.1.7 Galvanising and Fastenings

Where manufactured or purpose-made steelworks, ladder, racking, tray supports and all fixings nuts, bolts and washers are specified as galvanised, this shall mean hot dipped galvanised finish to BS 729 as far as practicable. Bolts and nuts shall be in matched condition.

Fixings screws for boxes, saddles, clips and other accessories shall be of brass or other non-corrodible type eg. cadmium plated steel.

### 403.1.8 Protection of Exposed Cables

Where cables emerge through steel platforms or concrete floors, the Contractor shall provide and position protective curbing or sleeves made from galvanised material extending 75mm above finished floor level. Sleeves shall be finished flush with the underside of the floor. Final details shall be agreed with the Engineer on site in respect of all situations.

Cables rising into or against floor mounted equipment shall be secured to the equipment in a neat manner to ensure that the cables are properly supported and that no undue strain is put on the cable termination or the plant. Where vibration or expansion is a consideration, adequate precautions and vibration loops shall be made at the appropriate position.

Where cables emerge in an area exposed to vehicular traffic and no overhanging projection exists up to one metre above ground level, a galvanised steel pipe or protection cover fabricated from 3.0mm (10 SWG) galvanised mild steel (or heavier as appropriate) shall be provided and fixed to the associated structure for a minimum height of 1.5 metres above the local finished ground level.

### 403.1.9 Cutting Away and Making Good

The Contractor shall be responsible for marking out the agreed positions of all chases, holes

and fixings required for the passage of cables and conduit, and shall arrange with the Main Contractor for making good with a weak mix of concrete.

The Contractor shall carry out all the necessary drilling for fixing up to 25mm diameter in the building fabric for the support and fixings of all items supplied or specified herein. Such work shall be carried out in a neat and workmanlike manner without unduly defacing concrete or brick surfaces. The use of stud fixings employing cartridge guns will not normally be permitted.

Where indicated on the Specification drawings, holes have been incorporated in the structures for the passage of cables and any additional cutting away and making good necessary to such structures will be done by the Main Contractor with the agreement of the Engineer.

### 403.1.10 Termination of Glanded Cables

All cable compression glands shall be fitted by the Contractor, with the insulated conductors and sheathing being carried through the gland. The sheathing shall be preserved where required within the equipment and the insulated conductors properly connected to the terminals of the equipment concerned.

The armouring shall not be cut off short of the gland but shall be properly laid up and secured under the clamping ring provided. The gland shall be fitted finally with an overall PVC sealing sleeve.

All cable tails shall be of sufficient length to connect up to the equipment terminal boards, and in addition to making off the gland the Contractor shall strip, insulate, ring through and identify the individual cores, fit suitable termination lugs, ring or spade crimps or bootlace ferrules as appropriate, and fit numbered reference ferrules, lace the tails in a workmanlike manner and finally connect up.

All spare conductors within multi-core cables shall be terminated as shown on the connection diagram or be folded back with sufficient surplus to allow them to be connected if required in the future.

### 403.1.11 Lead Sheath Cable Terminations

The Contractor shall submit to the Engineer for approval the proposed method for terminating lead sheathed cables. Terminations must ensure that moisture cannot creep along the cores of the cable nor in between cores.

Where cable tails are to be brought out, cores shall be cut back below the level of the sealing compound and connected to the tails using a brass ferrule sweated to provide a solid damp and oil migration barrier between tail and core.

Paper insulated tails shall be double half lapped with an approved non-hygroscopic insulating tape. Alternatively for LV cables, instead of an approved tape, a length of temperature sensitive, PVC sleeving may be heat shrunk over the tail, joint and cores.

The continuity of armoured cables shall be maintained by an efficient bond between the cable armour, the gland and the metalwork of the equipment at which the cable terminates, in order

that a reliable path is provided for fault currents.

When the lead sheath has been wiped on to the cable gland, the steel armouring shall be brought over the wiped joint and clamped to the top of the gland to provide additional earth continuity and mechanical strength to the plumbed joint. The armour clamp shall sandwich a copper braid between the clamp and the armouring to ensure a bedded connection.

Compression glands shall be to an approved pattern providing adequate bonding and armour clamping facilities.

Cable cores shall be fitted with suitable termination lugs and be phase coloured as appropriate and marked with an approved label to correspond with the diagram of connections.

Glands exposed to weathering shall be totally wrapped in impregnated tape to exclude all moisture from the gland connection and have an outer wrapping of PVC tape.

### 403.1.12 Jointing

Personnel employed for jointing power cables including all types of terminations for aluminium conductors shall have received specialised training. Joints in all buried or stranded cables shall be sweated, but compression joints will be permitted for stranded copper or solid aluminium conductors at terminations only.

Joints shall be completed without pause or unnecessary delay. Reduction in the number of strands is not approved but limited reduction in the cross sectional area of solid conductors by an approved method is permitted. Cable cores shall be cut with due regard to fanned out terminations, leaving a neatly arranged minimum of slack core between cable and terminal. As far as practicable all H.V. joints shall be made to avoid crossed or twisted cores, final phasing out being arranged in the cable box termination.

Where a crossed joint is approved, a sleeve at least 30% longer than standard shall be used to minimise the distortion of cores. The Engineer shall witness the final termination in order that the Contractor may prove the phasing before the last joint in a cable run is made.

Cables shall be jointed colour to colour or number to number. Where numbered cores are to be jointed to existing coloured cores etc. the Engineer will direct the system to be used.

A reliable continuity path shall be provided for fault currents flowing via the lead sheath and/or armouring by means of an efficient earth bond between the cable armouring and sheath on each side of the joint.

Any semi-conducting screens incorporated in H.V. cables (i.e. XLPE rated at 6350/11000V) are to be thoroughly removed before the application of any stress control components supplied with the necessary cable jointing kits.

Where dissimilar cables are to be jointed eg. armoured cable to flexible cable of submersible pump, a junction box shall be employed.

Such box shall be arranged with suitable cable glands for incoming and outgoing cables and of a complete water and gas tight construction (IP67) using either cast iron or steel not less than 4 mm thick finished in accordance with Appendix A.

Internally a fixed two bolt termination block with termination for all cores and a removable link connection shall be provided.

A separate junction box shall be used for each through connection and shall be securely fixed to the structure in an accessible position.

### 403.1.13 Earthing and Bonding

All non-current-carrying metal parts of the electrical installation and other services shall be properly bonded together and connected by means of a protective conductor to an efficient earth in accordance with IEE Wiring Regulations.

All connections shall be by means of an approved mechanical joint or adjustable clamp which shall be accessible and made secure with brass nuts and bolts. On no account shall plain or spring washers of ferrous metal be used.

Protective conductors shall provide earth continuity either through the conduit, armouring, lead sheathing, copper sheathing, steel trunking or by independent earth tapes or PVC sheathed wires, according to the system of wiring employed. Where PVC conduits or trunking systems are employed the protective conductor shall be routed within the conduit or trunking.

Wherever cable armouring is used as a protective conductor, care must be taken to ensure an adequate earth bond and additional bonds to the metalwork shall be provided as required.

### 403.1.14 Main Earth Connections

Where a main earth bar is to be installed it shall be connected in a ring with the earth bar provided on the switchgear and any existing main earth ring in the building. The glands and wire armour of cables shall be connected to the switchgear earth bar or directly to the earth ring.

The main earth bar shall be formed from high conductivity, hard drawn copper bar Grade C101 to BS 1433 of not less than 31.5mm x 6.3mm cross-section. Any joints in the earth bar are to be brazed together using brazing alloy type CP1 to BS 1845 or pan head riveted and sweated. The bar overlap/thickness ratio shall be not less than 5.

The earth bar shall be secured to an inside wall in an accessible position. Connections to the metalwork of electrical plant shall be made in soft drawn copper tape or equivalent sized cables. Where plant is subject to vibration, connections shall be made using flexible conductors. All earthing conductors and equipotential bonding cables shall have a green and yellow PVC sheath, and earth bars shall have a green/yellow marker tape or sheathing applied.

Reinforced concrete or sheet steel piling shall be connected to the earthing system as directed by the Engineer. Structures of steel framed buildings shall be bonded to the main earth bars.

Earth rods are to be 16mm (5/8") diameter driven by an automatic hammer to a depth of approximately 4 metres. Spacing between rods is not to be less than the depth of the rod. Inspection pits shall be provided for each electrode to allow subsequent access for testing.

Where copper earth tape is buried below ground level it is to be served with PVC or double half lap wrapped with an approved grease-impregnated tape for a distance of at least 300mm above and below ground level.

The routing, dimensioning and arrangement of all main earth bars and connections shall be detailed on the schedules and drawings forming part of this Specification as called for in the Particular Specifications. Disconnecting links for testing purposes shall be provided as shown therein.

## 403.2 SELECTION OF CABLE RUNS AND SIZES

### 403.2.1 General

The route, arrangement and method of installation of all cables and the position of equipment and wiring points shall be marked out on site by the Contractor and agreed by the Engineer before any work is put in hand. Where cable routes and method of installation have been agreed, the Contractor shall be entirely responsible for measuring the lengths and cross section calculation of cables to be ordered and ensuring that the cables are supplied in the correct length and cross section. Cross section and length of cables shown on electrical schematics are only an approximation.

Straight through joints will not be permitted except where the route run is in excess of the maximum drum length, in which case the Engineer is to be notified.

Where necessary, protection shall be provided against mechanical damage.

Cables shall be free from kinks and the whole installation shall present a neat appearance.

Service installations for administration buildings, office, amenity buildings, etc. shall be carried out in full compliance with all local regulations.

When a cable is cut from a length on a drum the drum length shall be immediately sealed. All cables once cast and laid shall be terminated in their final position or effectively sealed. All cables shall be drawn from the top of its drum which shall be jacked and positioned from easy draw off in relation to its final position of installation. Where it is required for a long length of cable to be drawn from its drum, cable rollers or skid boards shall be used.

The general routing of cables shall be designed by the Contractor but the final routes shall be those agreed with the Engineer prior to any cable installation work being carried out. All cables shall be installed in strict accordance with the requirements of this specification.

### 403.2.2 Cables in Concrete Trenches

Where cables are run in concrete troughs or trenches, they shall be run on the floor of trenches less than 300mm deep. In trenches deeper than 300mm, cables shall be supported along the side of the trench on galvanised mild steel hangers, racking, cleats or on a suitable tray run supported from the side of the trench, whichever is specified. The spacing cleats or hangers shall be as specified under `Cable Cleats'.

Where use is made of existing trenches with existing cables installed, it may be necessary to reposition certain existing cables so that the new cables can be laid in a proper manner and the whole of the cables (new and old) left in an arrangement which is tidy and fulfils engineering requirements. Such repositioning work shall be carried out to the directions of the Engineer.

### 403.2.3 Cables on Trays or Ladders

Cables shall be laid flat and straight, properly dressed into position and fastened by cable ties or straps of metal reinforced PVC strip material, secured at intervals not greater than 1m for horizontal and vertical runs. Where the run is horizontal but arranged in the vertical plane, support spacing shall be as specified under `Cable Cleats'. Care shall be taken to space the cables to allow adequate cooling. Not more than seven cables shall be embraced by one group tie and not more than two layers of cables shall be run on one tray.

### 403.2.4 Cables in Ducts

403.2.4.1 General

Before drawing any cables in ducts, the Contractor shall ensure that they are clean and free from obstructions.

Adequately spaced temporary supports and cable rollers shall be provided for the drawing in of cables such that abnormal strains and damage to the cable is prevented; approved lubricants shall be used as necessary. Cable stockings shall be used for general drawing work, core pulling eyes being specially fitted for heavy hauls.

Stresses shall not exceed: 10MN/m² (1500 lb/sq in) on the lead sheath

70MN/m² (10,000 lb/sq in) on the core

Maximum pulling tension shall not exceed 20 kN (4500 lb).

403.2.4.2 Duct Seals and Cable Transits

After the cables are drawn in, the Contractor shall seal the ends of all ducts, pipes or trenches leading into buildings, passing through walls or floors within buildings or underground chambers containing equipment for cabling associated with this Contract, whether occupied or not.

All cables, conduits or pipes shall be sealed into the ducts by means of a secure and effective water, gas, vermin and fire-proof material which will accommodate settlement and vibration. This may be a self-supporting non-setting mastic packed into the annulus to a depth at least equal to the sleeve diameter, or approved multi-cable transit units with appropriate fillers and insert blocks. All steelworks on such transit assemblies and frames shall be hot dip galvanised.

Where shown on the Specification drawings, transit frames will be incorporated in the construction by the Civil Works contractor.

### 403.2.5 Cable Laid in Ground

403.2.5.1 General

Where cables are laid direct in the ground, they shall be well bedded in fine soil or sand and shall be covered with protective tiles. A minimum of 60mm thickness of fine soil or sand shall be supplied around the cables. All cables running along any one portion of route shall be laid at the same time and no extra payment will be made for re-excavation should any cable be overlooked at the time of laying. The Contractor shall be responsible for all excavation, for the supply of fine soil or sand for bedding, and for the backfilling and reinstatement of cable trenches along previously agreed runs. Trenches shall not be back-filled until the installed cables have been inspected by the Engineer.

403.2.5.2 Clearance and Coverage for Buried Services

Where possible, electric cables and their ducts shall be routed so that subsequent excavation to expose another service will not disturb cables and electrical ducts. Where separated routes are not practicable then the following clearance shall be ensured.

**Minimum Coverage**

| **Type of Service** | **Vehicular Roadways** | **Open Ground or Footpaths** |
|---|---|---|
| HV | 1000mm | 750mm |
| Others | 750mm | 500mm |

**Minimum Clearances**

| **Type of Cable** | **To HV Cable** | **To LV Cable** | **To Other Cable** | **To Gas/Water etc Pipes** |
|---|---|---|---|---|
| HV | 150mm | 300mm | 300mm | 300mm |
| LV | 300mm | 150mm | 250mm | 300mm |
| Others | 300mm | 250mm | 150mm | 300mm |

The spacing of cables installed at the same time shall be generally in accordance with the above table, but where circumstances permit a more economical arrangement may be specified by the Engineer.

As far as possible electric cables shall avoid the same route as other services except where otherwise directed. Where such segregation is not possible then 50mm thick concrete or stone slabs may be used as separators with the Engineer's approval. Electric cables shall be at least 50 mm clear of the side of trench excavation. Adequate slack shall be left at each bend for cables laid direct.

403.2.5.3 Protective Cover Tiles

These shall be of the concrete apex pattern engraved `Danger -Electricity' or similar, of dimensions appropriate to protect the number of cables along a particular route.

Following the installation and compaction of the bedding soil or sand over the cable, covers shall be laid by the Contractor so that they overlap by approximately 30mm each side of the cable run. Where cables are displaced by no more than 300mm vertically, covers shall be installed only over the upper cable run.

403.2.5.4 Route Markers

These shall be of reinforced concrete with the words 'ELECTRIC CABLES' cast in one face. They shall either be of the flush block type approximately 300mm x 300mm x 150mm or the pillar type approximately 600mm high erected with 300mm projecting above the ground, as directed by the Engineer.

As soon as site conditions allow, the location of each group of buried cables and every joint shall be accurately marked. Concrete marker posts or blocks shall be set at the origin, changes of direction, joints and otherwise at intervals of 20 metres or as directed by the Engineer.

403.2.5.5 Cable Identification

Identification labels of durable corrosion resistant material shall be provided suitable for permanently affixing to the cable sheath by means of buckle type straps and shall carry the

cable reference in PVC channel strip. The reference character sizes shall be not less than 4mm (5/32") high (Critchley Unilabel or similar).

Cable identification labels shall be fitted to each cable end below its respective cable gland, also where the cable passes through ducts or trenches and at each entry and exit to a room or building.

**403.2.6 Cables in trunks**

403.2.6.1 General

All trunking, bends, cover plates, tees, flanges, supports, fixings, etc. shall comprise an approved complete system capable of adaptation and erection without size modification and with compatible manufactured bends and accessories being used as far as practicable. The trunking access covers shall comprise easily removable convenient sized lengths retained over the entire length by clip-on features or suitable fastenings which shall not obstruct cable entries. Overlapping covers and internal flanges or coupling sleeves shall be provided at all trunking junctions. All cable supports, edges, sharp internal angles etc. shall be protected with PVC or formed to present a smooth edge.

403.2.6.2 Trunking Materials

i) Metal trunkings and fittings shall be zinc coated or galvanised mild steel not less than 1.2mm thick (18 SWG). Copper earth bonding straps shall be fitted at the junction of adjacent lengths of trunking and fittings.

ii) PVC trunkings and fittings shall be of high impact heavy duty rigid PVC.

403.2.6.3 Trunking Installation

As far as practicable, trunking shall be installed clear of other services and positioned so that future access is not restricted. Drawings detailing supports, terminations, sizes and centre lines of trunking shall be submitted to the Engineer for approval prior to commencement of the installation. Provision for expansion of the trunking materials shall be made in accordance with the manufacturer's instructions. Trunking shall include fire barriers of fibreglass wadding fitted at each point where the run passes through fire walls and floor levels. All cable and conduit exits shall be fitted with bushes without decreasing the effective cross-sectional area of the trunking.

When connecting adjacent sections of trunking or when fixing trunking to a wall or supports, round or mushroom headed bolts or screws shall be used such that no sharp edges project into the inside surface. When installed in damp situations the trunking shall be spaced from the wall by means of short tube collars.

All trunking shall be protected against damp and corrosion and where entries, joints and/or bends have been installed, cut and/or sawn edges exist, all damaged galvanising shall be made good by a minimum of two coats of primer (zinc based galvanised or similar approved equivalent) and two top coats of aluminium paint of an approved quality. For extensively damaged galvanised coatings the items shall be re-galvanised or replaced with acceptable components.

Conduit shall be connected to the trunking by means of couplings and male bushes to obtain a good earth connection.

To assist identification within trunking, final circuit wiring shall be formed into groups held by buckle clips or PVC straps. Each group shall be labelled where wiring enters or leaves the trunking and at intervals of approximately 15 metres in long trunking runs. In vertical runs the trunking shall be fitted with PVC coated pins at approximately 600mm centres to be used as cable supports.

Separate conductors comprising the same circuit shall be run enclosed together throughout their length.

### 403.2.7 Cables in Conduits

403.2.7.1 General

For wiring installations carried out with PVC insulated cables in conduit, the wiring throughout is to be on the "looping in" system and no "Tee" or other intermediate joint between fittings will be permitted, and in no case must the cable be drawn into the conduits until all such conduits, bends, boxes or other fittings have been fixed permanently in position and approved by the Engineer.

Any water which may accumulate in the conduit during erection shall be removed before any cables are drawn in. Sufficient slack shall be allowed at each point to ensure that all conductors are under no physical strain or tightness.

Separate conductors of the same circuit shall always be drawn into one conduit, but cables forming final circuits connected to different distribution boards shall not be drawn into the same conduit or box.
The cables shall be coloured RED or BLACK as required to distinguish opposite poles, a BLACK conductor shall be used throughout for neutrals and connected to the neutral pole of the supply system.

No reduction of the strands forming the conductors will be allowed at switch or other terminals; all the strands shall be efficiently secured by screws, nuts and washers or other approved means and all conductors shall be so proportioned that the drop of potential does not exceed that indicated by the IEE Wiring Regulations.

After the Contract award a Table (in duplicate) showing the proposed arrangement of wiring circuits and the size of cables to be used shall be submitted to the Engineer for his approval before any work is put in hand.

403.2.7.2 Conduit Materials

i) Metal All conduits and fittings shall be Class 4, galvanised steel, heavy gauge welded and screwed smooth bore tube employing threaded couplings and complying with BS 31 and BS 4568. As an exception, lengths of conduit completely encased in structural concrete may be finished with black enamel.

   Conduit boxes shall be of malleable cast iron. For surface work the lid shall be of cast iron machined or ground to make good contact with the boxes. Adaptable boxes for surface work shall be of malleable iron.

ii) PVC All conduits and fittings shall be heavy duty gauge PVC in accordance with BS 4607.

iii) Flexible Flexible conduits shall be waterproof metallic type PVC sheathed and adaptors

to rigid conduit shall be of the internally rifled split brass type.

Flexible conduit shall only be used for bridging expansion joints in a building or for final connections from the rigid conduit system to the terminal boxes of equipment subject to vibration or adjustment. All such conduit shall have an earth continuity conductor connected through the flexible adaptor at each end. Individual lengths of flexible conduit should not exceed 400mm.

403.2.7.3 Conduit Installations

The conduit system shall be continuous throughout so that the cables are fully protected. No conduit smaller than 20mm shall be used. Provision shall be made for draining condensed moisture where directed by the Engineer. The conduit throughout shall be of adequate capacity in accordance with the IEE Wiring Regulations, and shall be arranged with draw-in boxes to allow for easy draw in or out of any one or all of the cables in the conduit. For multiple parallel conduit runs, draw boxes may be combined by an appropriately sized adaptable box provided segregation of services is maintained.

Wherever possible, conduits shall be installed either horizontally or vertically and changes in direction shall be effected by easy bends or well formed sets without altering the section or opening joints; solid or inspection tees or elbows shall not be installed.

The inside surfaces of the conduit ends and all fittings shall be smooth and free from burrs and all other defects.

For surface work the conduits shall be fixed by means of spacer bar saddles or substantial distance saddles. Where conduits pass directly through concrete or similar floors and where washing down is likely to occur, the conduits shall be sleeved. The sleeve shall be grouted flush with the underside of the floor and extend 75mm above the top surface of the floor. Where conduits are run on steel work, they shall be fixed by means of purpose-made clips. If the Contractor requires to drill any steel work, permission in writing must be obtained from the Engineer.

In exterior situations, all joint box lids etc. shall be made waterproof with compound or gaskets as appropriate.

i) Metal conduit installations shall be electrically continuous throughout, and at all terminations conduits shall either be screwed into approved spigot boxes or coupled by means of screwed couplings and smooth bore hexagon bushes. In no case shall the length of the thread into which the conduit is screwed be less than the outside diameter of the conduit. Where tapped entries are provided and where internal space permits, a ring bush shall be used as a lock nut.

All exposed threads and damaged galvanising shall be cleaned and thoroughly coated with zinc rich paint. If black enamel conduit has been approved for use, then where the black enamel is damaged the conduit shall be satisfactorily repainted to the approval of the Engineer.

Contact between conduit and gas pipes shall be prevented wherever possible by adequate spacing, or by means of insulating distance pieces. Where the conduit is or

may be in contact with any other pipes or metal work an efficient metallic connection shall be made between the conduit and the pipes or metal work and the incoming gas, water and electricity services shall also be bonded together, all as required by the IEE Wiring Regulations.

Metal conduits shall be adequately grounnoud to BS7430.

ii) PVC conduit installations shall have couplers and spouted fittings joined with a permanent solvent adhesive, and provision shall be made in surface conduit installations for expansion by using a semi-permanent mastic jointing seal in expansion couplings as necessary.

Conduits shall be fixed by means of spacer bar saddles spaced as defined in the IEE Wiring Regulations.

These figures apply to surface runs at normal room temperature. Where high ambient temperatures or rapid fluctuations are likely these spacings shall be reduced as agreed with the Engineer. Conduit shall also be secured 150mm either side of a bend.

The bending radius of PVC conduit shall be not less than 4 times the diameter of the conduit and bending shall be achieved by the use of the correct size bending spring. If

bending is to be carried out in temperatures below normal room temperature, frictional heat shall be applied to the conduit before bending commences.

iii) Potentially Explosive Area conduit installations shall employ metal conduit and comply with the relevant Parts of BS 5345 for the specified zone classification; Ex(d) protection for Zone 1 and Ex(n) protection for Zone 2 applications.
All screwed joints whether entering into switchgear, junction boxes or couplings, must be secured by a standard lockout to ensure a tight and vibration-proof joint which will not slacken during the life of the installation and thus impair continuity and flameproofness. The length of thread on the conduit must be the same as the fitting plus sufficient for the locknut. Due to the exposed threads, the use of running joints is not permitted and specially designed flameproof unions shall be used for securing conduit to an internally screwed entry. All unwanted outlets shall be plugged with approved blanking plugs.

When a conduit passes from a hazardous to a safe area, the flameproof section must be terminated by a stopper box or sealing device mounted in the safe area.

All conduits entering directly into a flameproof enclosure where exposed terminals are fitted shall be sealed at the point of entry by means of stopper boxes which must be entirely filled with a non-oxidising compound. Conduit boxes or indirect entry compartments not containing exposed terminals do not require sealing.

Conduit stopper boxes of certified design must be used, having splayed, plugged filling spouts in the cover to facilitate the entire filling of the interior with compound.

## 403.3 CABLE MATERIALS

### 403.3.1 General

Cables shall be of approved design from a BASEC approved manufacturer having a certificate of Assessed Quality Management. They shall be manufactured within the 12 months prior to delivery and be delivered to site on cable drums or with protective wrappings.

The overall sheath of the cables shall be coloured as follows:

| | |
|---|---|
| High Voltage | - Red |
| Low Voltage | - Black |
| Earth continuity conductor | - Green/Yellow or Green |
| Instrument | - Grey |
| Intrinsically safe | - Blue |

Cables shall be of the voltage grade, conductor size and type detailed in the Particular Specifications. General specification of the cable type to be used are detailed hereunder.

Paper insulated mains cables shall be stranded plain annealed copper conductors, insulated with helically wound paper tape, mass-impregnated with non-draining insulating compound.

i) Multi-core cables shall be laid up in a belted construction having a lead sheathing applied overall, protected by a single wire armouring and having an extruded PVC sheathing overall (PLSW/PVC type).

Single core cables shall have a lead alloy sheath without armouring but with an extruded PVC sheathing overall (PLY/PVC type).

ii) Cross-linked polyethylene cables shall have stranded, copper conductors with cross-linked polyethylene insulation. Multi-core cables shall be laid up in an extruded bedding, single wire armoured and sheathed overall with PVC, to BS 5467 (XLPE/SWA/PVC type).

Single core cables shall have aluminium wire armour. Cables rated over 6350V shall incorporate graded semi-conducting tapes and core screens in accordance with IEC 502.

Low smoke and fume emission cables shall be as above except that the bedding and sheathing shall be of low smoke and fume emission material, all in accordance with BS 6724 (XLPE/SWA/LSF type).

iii) PVC armoured cables shall have stranded copper conductors with extruded PVC insulation, PVC sheathed, single wire armoured and sheathed overall with PVC (PVC/SWA/PVC type). Cables shall be in accordance with BS 6346. Conductors of 1.5mm² and 2.5mm² shall have stranded conductors (7/0.50 and 7/0.67 respectively).

iv) PVC insulated wiring cables shall be 450/750 volt grade single core stranded copper conductors PVC insulated to BS 6004 (PVC wiring type).

v) Mineral insulated cables conductors and sheaths shall be solid annealed high conductivity copper separated by highly compressed mineral insulating powder. The cable shall be sheathed overall with PVC.
Light duty rated up to 600V, heavy duty up to 1000V, all as BS٦٢٠٧ (MICS/PVC type).

vi) Telephone cables shall be thermoplastic insulated multipair cables having twisted pairs of copper conductors (telephone type).

vii) Instrumentation cables shall be polyethylene insulated copper conductors with twisted individual pairs screened, polyethylene bedded, steel wire armoured and PVC sheathed overall, all in accordance with BS 5308 Part 1 Type 2. Conductors shall be 0.5mm² stranded 16/0.2mm (PE/IS/SWA/PVC type).

viii) Earth and bonding cables shall have stranded copper conductors PVC insulated and sheathed (PVC/PVC type).

ix) Flexible cables shall have stranded, tinned copper, flexible conductors, EP rubber insulated and CSP sheathed all in accordance with BS 6007 (flexible type).

x) Flame retardant cables shall be EP rubber insulated, tinned copper conductors in a CSP sheath, braided with galvanised steel wire (single cores having phosphor bronze wire) and protected with a CSP sheath overall, generally in accordance with BS 6883.

The sheathing shall have heat and oil resisting characteristics to BS 6899 with an oxygen index value not less than 35 (HOFR type).

### 403.3.2 Mineral Insulated Cables

Cables shall be installed saddled to trays, run on the surface or as otherwise specified. The spacing of saddles shall be in accordance with the IEE Regulations. Cable termination accessories and saddles shall be brass or copper and shall be supplied by a particular cable manufacturer. All cables shall have a temporary mastic seal applied during installation. Once cut to length, each cable shall be permanently terminated without delay by using an approved seal. Termination seals shall be anchored in approved glands and locked into screwed conduit entries or gland plates forming part of accessories or equipment. Wherever possible, glands shall be locked in position with locknuts. Shrouds shall be fitted over glands except where they are encased in the structure of the building.

In cables where dampness may be present or where dissimilar metals are present, corrosion inhibiting paste shall be interposed in all voids between surfaces in contact.

Where MICS cable serves an inductive circuit liable to voltage surges or circuits subject to lightning surges, appropriate surge diverters shall be connected across the inductive sources (coil etc.) or between lines and earth at the point of entry in the case of lightning protection.

### 403.3.3 Single Core Cables

Circuits utilising single core cables shall be installed under IEE 'Defined Conditions' but to minimise mutually induced voltages, three phase circuits shall be run for as long as possible throughout the route in close trefoil formation. Where a circuit employs more than one cable per phase, each trefoil group shall contain one cable of each phase, allowing at least 50mm clearance between adjacent groups. Cleat spacing shall not exceed 1.2 metres.

Ferrous screens or armour shall not be used on such cables and associated terminations or enclosures must avoid the use of magnetic material which would provide a flux path in service.

To control induced voltages, single core cables shall have their metallic sheathing and/or aluminium armouring bonded together at both ends of the run, the bonding being connected directly to the system earth bar or other approved points. Cables having no insulating oversheath shall have their metallic sheaths or armouring bonded together by the use of normally spaced, well fitting, non-magnetic metallic trefoil cleats.

In all cases the bond shall be sized to carry the prospective fault current and have a conductivity not less than that of the cable sheath and/or armouring. Bonds for cables laid in a flat formation shall also allow for the unequal sheath currents.

To prevent circulating currents, bonding and earthing at the supply end only of short runs of single core cables will be permitted where it can be shown to the satisfaction of the Engineer that the induced voltages are safe under fault conditions.

## 403.4 CABLE ACCESSORIES

### 403.4.1 Compression Glands for Cables

All the glands shall be supplied by the Contractor and shall be of the brass compression pattern, so designed that any strain on the cable is taken by the steel wire armouring. The glands shall incorporate watertight seals on both inner and outer sheaths and have a separate armour clamping ring to ensure a good mechanical connection for the earth continuity path. The glands shall be secured with heavy duty locknuts and the whole assembly is to be protected by an overall plastic sleeve, suitably sealed to prevent atmospheric attack.

Glands fitted to unthreaded gland or adaptor plates, non-metallic equipment, or where specified for circuits likely to pass high fault currents, shall include a brass earthing tag and connections arranged to effectively bond the gland body via a protective conductor to an effective earth point. Where instrument cable screen terminations need to be isolated, insulated gland adaptors or non-metallic plates shall be used.

Glands and earthing tags shall be compatible with the gland plate and cable armouring materials to prevent electrolyte corrosion; eg. brass for steel wire armouring/gland plate and aluminium for aluminium wire armouring/gland plates.

Glands fitted in Zone 0 and 1 potentially explosive atmospheres shall be similar to those described above, but shall be classified Ex (d) in accordance with BS 5501 Pt 5 and be suitable for use with Apparatus Groups IIA and IIB.

Where cables to BS 6346, BS 6116 or BS 5467 having an extruded or taped bedding are used for direct entry into such apparatus Groups, a sealing stopper box or compound sealed barrier gland shall be used in accordance with BS 5345 Part 3.

### 403.4.2 Wiring Ferrules

These shall be of durable materials suitable for permanently affixing to the cable cores and be of the interlocking slide-on type, such that the interpretation of the reference is unambiguous.

All control circuits consisting of more than two wires shall be identified by means of wiring ferrules attached to the individual cores at each end of the conductor where it is connected to any apparatus or junction box.

Unless otherwise specified, it shall be the responsibility of the cabling contractor to obtain interconnection terminal data and references from the equipment manufacturer to enable proper connections to be made.

### 403.4.3 Cable Cleats

Cleats for fixing cables to walls, structures, etc. shall be of the non-corrodible hook and clamp type made of high impact plastic or cast aluminium comprising two halves fixed by means of galvanised rawlbolts or on to galvanised backstraps where the number of cleats makes this more economic.

All assemblies to be complete with necessary galvanised bolt, nut and washers.
The spacings of supports or cleats for cables shall in any case be not greater than shown in the following table but, where circumstances merit, closer spacing arrangements may be required by the Engineer.

The vertical spacings shall be applied to runs sloping up to 30° from the vertical. For greater deviations, the spacing for horizontal runs shall apply.

For outdoor and damp situations, fixing bolts or studs for cleats shall not be less than 13mm overall diameter unless otherwise agreed by the Engineer.

Cable Support Spacing (mm)

| Cable Type | XLPE/SWA/PVC or PVC/SWA/PVC with stranded copper conductors | |
|---|---|---|
| Overall dia (mm) | Horizontal | Vertical |
| up to 15 | 350 | 450 |
| 15 - 20 | 400 | 550 |
| 21 - 40 | 450 | 600 |
| 41 - 60 | 700 | 900 |
| over 60 | 1100 | 1300 |

### 403.4.4 Cable Racks

Cable racks shall be robustly constructed of mild steel, not less than 2.5mm (12 SWG) in thickness and galvanised after manufacture. Where cleats are not used, the rack shall be provided with a toe at the outer end. Racks of proprietary construction may be used subject to approval.

Main rack supports, where fixed to brickwork or concrete, shall be secured with bolts of not less than 13mm diameter. The fixing bolts shall be of the self-securing type with expanding sockets and shall not require grout to hold them in position.

Where fixed to walls in places subject to dampness and in cable subways, the racks shall be set off from the walls by 35mm x 18mm thick galvanised packers placed at the bolt fixing positions.

In cable basements, the lower tier of any row of racks etc. shall be not less than 100mm above finished floor level.

### 403.4.5 Cable Ladders

Cable ladder shall be heavy duty type, fabricated from mild steel not less than 2mm thick and galvanised after manufacture. The side rails shall be at least 120mm deep with rungs set towards one edge, spaced at regular intervals of approximately 300mm and having elongated slots to accommodate the cable fixings.

Lengths of ladder shall be coupled and changes in direction, level and width shall be achieved by means of standard accessories designed for the system, such as radiussed risers and

gusseted intersections. Cable tray shall be accommodated on the ladder system for cables less than 15mm overall diameter.

### 403.4.6 Cable Channels

Cables requiring mechanical support across voids may be accommodated in not less than 40mm square galvanised channel sections fitted with plastic closure strips and suitable end caps in preference to tray, and subject to the Engineer's approval.

### 403.4.7 Cable Trays & Covers

The Supplier shall supply and erect all required cable traywork.

The following points are to be taken into account selecting routes for cable trays : -

i- Number of drive, power and control cables to be located on each cable tray.

ii- The avoidance of pipework and pipework required for future extensions.

iii- The avoidance of maintenance areas of machinery, pipes, etc.

iv- The avoidance of installation areas for the future extensions to the plant.

v- The avoidance of unnecessarily long runs of cable.

Cable tray shall be heavy duty pattern formed from galvanised sheet steel, perforated with elongated holes for cable fastenings and shall have suitable covers made of identical material and thickness. The tray shall have side flanges not less than 25mm deep with returned edges and be galvanised after fabrication. Material gauge shall be 1.5mm (16 SWG) minimum, except that for tray widths less than 400mm the gauge may be reduced subject to the flange depth and the approval of the Engineer. Factory made tee sections and bends shall be used where possible.

The cutting of trays shall be kept to a minimum but where unavoidable, all cut edges shall be rounded or folded over and protected with zinc rich cold galvanising paint, holes for cables shall be bushed with nylon/PVC strip edging material. Mushroom headed bolts and nuts shall be used to join sections of tray and accessories and arranged not to present any obstruction on the tray. Capacity amounting to 25% usable tray area shall be left spare.

Where specified herein for damp or corrosive conditions, the trays shall be of unplasticised PVC with non-corrodible nuts and bolts.

Metal cable trays shall be adequately grounded to BS 7430.

### 403.4.8 Sealing Boxes for Lead Sheathed Cables

For terminations at plant items, these will be provided by others except as specified herein and

will be of cast iron, compound filling type, provided with filling plugs in the appropriate position for filling with compound when mounted on the associated equipment. Each will be complete with wiping cone armour clamp. For through joints or tee joints, the Contractor shall provide suitable boxes as detailed herein.

All necessary jointing materials, filling compounds and earthing requirements shall be included for all joints to be made under this Specification.

### 403.4.9 Sealing Compound

The outer protection boxes for joints or terminations shall be filled with compound of the hot or cold pouring variety of a type compatible with the cable materials to be agreed by the Engineer.

Compounds which require heating shall be evenly heated, well stirred and the temperature maintained within the recommended pouring ranges. Cable accessories shall be thoroughly dried before filling and pre-warmed where possible.

Where cable sealing boxes are fitted beneath oil-filled compartments or where inverted cable sealing boxes are used due to cables entering from overhead, the compound shall be of the oil resisting type to prevent any risk of softening due to contamination from the insulating oil.

Cold pouring resin encapsulation materials shall be carefully mixed to avoid entrapped voids or uncured filler materials.

### 403.4.10 Busducts

Connections between major electrical items shall (where specified) employ a fully integrated, totally enclosed, busduct system to BS 5486 (IEC 439-2), comprising HDHC copper conductors embedded in a non-flammable, self extinguishing, cast epoxy resin insulation.

The complete assembly including junctions shall be completely free of condensation and watertight to IP68. Fire resistance shall be Class M1 (F) and Class B1 (D) to IEC 332.

All parts of the system shall be from the same manufacturer and comprise factory made lengths, bends, tees and terminating pieces to suit the physical application and layout of the installation.

The voltage and prospective fault ratings of the system shall be suitable for the application and the current rating shall be based on the most onerous method of installation for the circuit. The cross sectional area of the conductors shall not be reduced throughout a given circuit.

The installation shall allow for any necessary expansion, be properly supported and connected in accordance with the manufacturer's instructions. Fire and damp-proof barriers shall be provided when passing through walls, floors/ceilings etc.

Conductors shall be jointed by means of double junction plates, one on each side to ensure low joint resistance. The junction shall be compressed by means of high tensile steel nuts and bolts. After assembly, all junctions shall be overcast with the same materials mixed under vacuum, as used for the busduct elements, thus maintaining a homogenous and weatherproof enclosure

throughout.

Provision for conductor shifting, transfers and paralleling, shall be made within the terminal elements.

## 404. CIVIL WORKS FOR CABLE INSTALLATIONS

### 404.1 GENERAL

The works involved are associated with the cable installation and comprise trenching, excavation, supply, laying and jointing of cable ducts; building of jointing and draw-in pits; application of bedding sand or soil; temporary reinstatement of ground. The installation of cables, supply and laying of cable covers and preparation of route record drawings will be carried out by the contractor appointed to undertake the cable installation. Excavation, duct and cable laying and backfilling shall proceed in accordance with an agreed program ensuring that all cables and ducts are satisfactorily covered immediately following laying and after approval from the Engineer.

### 404.2 TRENCHING MEASUREMENTS

The depths and widths of individual trenches for cables or ducts and the clearances from other services shall be determined by reference to the clauses in this part. For contracts let with scheduled rates it will be assumed upon re-measuring that excavations have been in accordance with this specification unless the Engineer has been sent an advice to the contrary.

### 404.3 COVERAGE FOR BURIED CABLES OR DUCTS

Trenches shall be excavated or ducts laid at such a depth that the minimum coverage to the top of the duct or the cable shall comply with the following:

| Type of Service | Vehicular Roadways | Open Ground or Footpaths |
|---|---|---|
| HV | 1000mm | 750mm |
| Others | 750mm | 500mm |

### 404.4 CLEARANCES BETWEEN OTHER SERVICES

Where possible electric cables and their ducts shall be routed such that subsequent excavation to expose another service will not disturb cables and electrical ducts. Where separate routes are not practicable then the following clearances shall be ensured:

| Type of Cable | To HV Cable | To LV Cable | To Other Cable | To Gas/Water etc Pipes |
|---|---|---|---|---|
| HV | 150mm | 300mm | 300mm | 300mm |
| LV | 300mm | 150mm | 250mm | 300mm |
| Others | 300mm | 250mm | 150mm | 300mm |

Where such spacings are not possible then 50mm thick concrete or stone slabs may be used as separators with the Engineer's approval. Each cable shall be at least 50mm clear of the side of the trench excavation.

## 404.5 EXCAVATIONS AND PRECAUTIONS

Turf and topsoil shall be carefully removed and positioned where indicated on the drawings or as directed by the Engineer for subsequent reinstatement in their original position.

Broken land drains and damage to other services shall be reported to the Engineer and marked on site.

Excavations shall be kept free of water and properly shored up. Other services uncovered shall be adequately supported by slings or other means and protected.

## 404.6 BEDDING FOR CABLES

Prior to laying the bedding for the cable, the bottom of the trench shall be cleared of loose and projecting rubble etc. and evenly graded.

A sand bedding shall be applied below and around the cables and shall be thoroughly compacted. Thickness of bedding around the cable shall be 60mm except where soil contains coke, ash or other corrosive matter where the thickness shall be 200mm. Bedding shall be well graded sand, free of clay with minimum particle size of approximately 0.08mm (BS sieve No. 200) and maximum particle size of approximately 2mm (BS sieve No. 7). 60% of the material shall pass through BS sieve No. 72. Where the Engineer directs, local soil may be used for bedding after passing through a 10mm mesh sieve provided the material is evenly graded.

## 404.7 DUCTS AND COUPLINGS

Buried cable ducting shall be smooth bore UPVC pipe to BS 4660 (or medium density polyethylene, where greater flexibility is required) jointed by spigotted ends or couplings of compatible, non-deteriorating material. These couplings shall be a self-aligning, push fit and incorporate seals to prevent the ingress of water and other fluids as far as possible and the joint so formed shall be equal in internal diameter to the duct itself.

Ducts entering below ground level into a building or structure shall emerge inside the building either directly into an accessible trench or void, or the duct shall have an upturned bend to emerge adjacent to an inside wall face, or as otherwise specified.

All exposed upturned duct ends shall project at least 75 mm clear of the finished floor or ground level to prevent unwanted collection of water or debris and protect the cable exit.

## 404.8 BEDDING OF DUCTS

Prior to laying ducts in trenches, the trench bottom shall be evenly graded, cleaned of loose

rubble etc. and compacted to form a solid foundation. In rocky soil a layer of loose, rock-free earth shall be used for this foundation.

Where ducts are laid beneath vehicular access roads, the ducts shall be haunched in C20 concrete for the full width of the road and extend each side beyond the curbside by at least 300mm.

## 404.9 DUCT ALIGNMENT AND CLEANING

Ducts shall be laid in a straight line as far as possible with minimum deviation. Where bends are required, these may be manufactured, pre-formed bends with a radius of not less than 10 times the bore diameter. No continuous duct run shall incorporate more than two bends nor turn through a total of more than 135° in any plane. No single bend shall exceed 90°.

Where greater changes of direction are necessary, cable draw pits shall be incorporated in the run as required or defined by the Engineer.

A non-corrodible draw wire or rope shall be left in each duct and plugs shall be inserted at the ends of each section of duct to prevent entry of soil or stones. On completion of the ducts and prior to drawing in cables, a circular wire brush 6mm greater in diameter than the duct shall be pulled through each duct.

## 404.10 CABLE DRAW PITS

Cable draw pits shall be of reinforced concrete construction fitted with suitable removable access covers and have bellmouthed duct entries into the pit interior. The interior dimensions shall be determined by the Engineer but shall be not less than 750 x 600mm for power cables and not less than 600x600mm for telemetry cables in plan, the depth shall be determined by the invert level of the lowest duct with a minimum of 150mm clearance to the base of the pit.

Where specified, a pulling eye for the use of a 2000kg pulley block shall be provided opposite each group of ducts in the wall of the pits, and positioned to facilitate as straight a pull as possible on the cables with the use of a pulley block. The base of the pit shall be formed with a fall towards a sump, suitably placed for pumping dry.

## 404.11 BACKFILLING AND REINSTATEMENT

Reinstatement of soil following laying of cable or duct shall be effected by backfilling in 100mm layers. Hand ramming shall be employed for the first two layers and power ramming for subsequent layers. Backfilling shall only proceed in the presence of the contractor responsible for laying cables.

After hand ramming to a depth of 200mm, a yellow coloured plastic tape approximately 150mm wide with the words `CAUTION ELECTRIC CABLE BELOW' shall be provided and run over the centre of the route of each cable run.

Top soil is to be replaced and the level of the finished reinstatement shall not protrude more than 50mm above ground level. All surplus spoil is to be removed from the site, and areas surrounding the excavation shall be restored to their original condition. Where tarmac surfaces

have been excavated, the final 200 mm backfilling after allowing the settlement shall consist of 120 nun of compacted graded hardcore, followed by 60 mm concrete screed and a 20 mm top dressing of tarmacadam.

## 404.12 CABLE TRENCHES

Trenches cast in floors or ground shall be of specified internal dimensions to suit the specific installation. They shall have smooth vertical sides and bottom with provision for cover plates to finish flush with the finished floor surface.

Inside bends shall be either radiussed (150mm min) or chamfered at least 100mm back, equally angled from each direction. Such radiussing or chamfers shall extend the full height of the trench, however the top 100mm may be corbelled out to simplify the cover plate arrangement.

Trench covers shall be of aluminium or galvanised mild steel chequer plate (min 8mm thick) supported to prevent undue flexing and having suitable holes to allow removal by standard lifting keys. Support shall be by means of steel curbing rebates cast into the trench top edges, providing a landing width of at least 30mm.

Additional or alternative support for switchboards etc shall be from at least 75 x 35 mm channel section cross bearers and transverse trimmers, fixed or cast into the floor and located to suit equipment fixings, access requirements and floor cover spans.

To prevent differential deflection, butt straps shall be fitted to the underside of floor plates which have no other support.

Edging curbs suitable for mild steel chequer plate shall be painted in red oxide primer, the curbing may be tapped to accept cover securing screws. Where aluminium plates are used in contact with any mild steel supports, a bitumen coating on the points of contact shall be used.

## 404.13 CABLE TROUGHS

Pre-cast concrete trough sections shall be laid either flush or upon the finished ground level as specified.

The sections shall be sized and provided with rebated covers to suit the span and any imposed load conditions specified, eg. at road crossings. Provision shall be allowed for handling/removal of such covers. Pre-formed junctions and turn-outs shall be provided with suitable chamfers on inside bends.

## 404.14 TRANSFORMER BAYS

The dimensions and weight of the transformers are specified herein in order that access clearances and loadings may be determined. The transformer bases shall be located at ground level, accessible from a made up road or hard standing to the bays.

Each transformer bay shall be separately enclosed to prevent unauthorised access and be partitioned by plain brick blast walls up to a height of 2.2m, with one side being fitted with full

width, lockable open-mesh gates or louvred doors for access and ventilation. Where roof covering is necessary, it shall be of non-flammable construction and allow 800mm clearance at least for natural ventilation of the transformer.

The bay shall be sized at least 1.5m greater than the transformer width (across terminal boxes) and at least 1.0m greater than the transformer depth. A level concrete mounting ramp shall be located within the bay area suitable for rolling the transformer into position, and a pulling eye shall be fitted centrally in the rear wall at ground level.

The area surrounding the plinth within the bay, and enclosed after transformer installation by a low bund wall if required, shall be excavated sufficient to accommodate 10% in excess of the transformer oil capacity when filled with fire quenching 50mm graded pebbles having 30% voids. Provision shall be made for drainage of accumulated rainwater.

Cable ducts shall be arranged to suit the cable routes and have up-turned spouts projecting clear of the designed oil/pebble level for the bund.

Alternatively, provision shall be made for the oil to be conducted to underground drainage tanks having access for pumping out, separate tanks being provided for each transformer.

For silicon cooled transformers of sealed construction, quenching pebbles will not be required, but an oil catchment area shall be provided where specified.

## 404.15 EARTHING CONNECTIONS

Two earthing connection tabs shall be welded to the concrete reinforcing bars in the positions shown on the specification drawings and be incorporated in the concrete encased, reinforcing steel network of the building foundations. The network shall be not less than 30m in length, buried at least 1m below ground level. The total length may comprise more than one bar, welded together to form the required minimum length.

Each earthing tab shall be of hot dip galvanised flat bar steel 50mm wide x 6mm thick, attached by welding to at least two parallel reinforcing bars (9mm diameter minimum) and of sufficient length to project beyond the finished concrete surface by at least 100mm in an accessible position.

The welding shall be of good mechanical strength over the full 50mm tab width and shall be located in an area of the rebar not required to provide structural strength, such as a trimmer or surplus length of the bar.

The reinforcing steel of existing buildings may be used to provide the electrode for a new installation or to replace a damaged or deficient conventional earthing system. A substantial rebar of a main beam or column shall be exposed by chipping away its concrete cover. The earthing terminal plate shall be welded to the rebar and the removed concrete replaced by mortar.

## 405. ROAD LIGHTING

### 405.1 LUMINAIRES

The Luminaires shall be weatherproof to at least IP 55 or as otherwise specified. The output and spectral distribution characteristics shall be as detailed in the Particular Specifications.

### 405.2 CONTROL GEAR

The Control gear for the lamps shall be mounted in the lantern head or base of the column as appropriate. The circuit components shall be suitable for the range of temperatures and humidity as defined in BS 4533. Power factor correction capacitors shall be included to give an overall improvement to at least 0.85.

### 405.3 CONNECTION COMPARTMENT

A connection compartment shall be provided and have a flush fitting, vandal proof door with a weather skirted cover to IP 55, secured by two key headed non-corrodible latches. A non-corrodible earth terminal and non-hygroscopic back board shall be provided within the compartment.

The column shall be set such that the compartment door is fully accessible and faced away from the adjacent traffic stream.

The connection compartment shall also incorporate a bekable disconnect switch for power isolation.

## 405.4 COLUMNS

Columns shall be suitable for the specified duty and be manufactured and installed in accordance with requirements of BS 5649 (EN 40). They shall be made of hot dipped galvanised mild steel, aluminium or pre-stressed spun concrete with tubular tapering or multi-sectional construction without the use of welds or swaging and having an internal cable way throughout the length.

The head of the column shall have a 76mm dia spigot extension or other means of accepting the lantern head or bracket. The head shall also incorporate an anti-rotation device to fix the arm at 90° increments to the door.

The column base shall be either a substantial surface mounting plate to BS 5649 or rooted for securely supporting the whole column on/in the ground in a vertical position. Rooted columns

shall have a side exit port 500mm below ground level for cable access and be planted at depths related to column height as specified in BS 5649.

The base and root section of steel columns shall have a minimum nominal material thickness of 5mm.

The columns shall be installed in accordance with the manufacturers recommendations and concrete foundations shall be to grade C20 with a maximum aggregate size of 30mm.

## 405.5 LOCATION OF LUMINAIRES

The position of all luminaire/columns shall be as indicated on the Engineers drawings and as agreed with the Engineer. These positions shall be clearly marked on site to prevent obliteration before the work is started.

## 405.6 EXCAVATIONS

Holes shall be excavated to the appropriate column-planting depth, unless the excavations are in hard material or loose sand, when any necessary alterations in planting depth shall be the subject of agreement with the Engineer. The width of the holes shall be kept to a minimum compatible with the conditions encountered under the surface and the surrounding soil shall be disturbed as little as possible. The width of holes in loose soil or sand may require to be greater to allow for heavier foundations and the dimensions should be agreed with the Engineer. In normal well-consolidated soil, the width of the holes should not greatly exceed the width of the base plates or flags where these are used. The maximum width of flags placed under the base of concrete columns should normally be limited to about twice the width of the column base.

During excavation, every care shall be taken to avoid damage to underground services or other property and any paving flags shall be lifted carefully and preserved for disposal as directed by the Engineer.

Agreement shall be reached with the Engineer on the method to be used for excavating rock or other hard material. Explosives shall not be used except with the express approval of the Engineer.

Excavations shall be lighted and guarded in accordance with local bye-laws, safety codes and regulations including CDR Safety Requirements, as applicable to the site.

Where underground obstructions are likely to necessitate the use of columns with special roots or re-sitting of the column positions, trial holes should be taken out at each position or at selected positions as decided by the Engineer.

## 405.7 ERECTION OF COLUMNS

Before erecting columns in position the excavation shall be examined to see that it is clear of obstructions and the foot firm and free from water, rubble or loose soil; the roots of steel columns shall be examined to ensure that the priming coats are complete. Any bare or corroded patches shall be cleaned and treated with black bituminous paint, unless it is specified that these should be left untreated for earthing purposes.

Base plates, where provided, shall be fitted securely, and where used for earthing purposes shall be electrically bonded and base stones or flags shall be placed in position where appropriate.

Any precautions necessary for the warning of traffic during erection shall be taken and any rope slings shall be visually examined before and after each lift to ensure that no deterioration has taken place.

## 405.8 ALIGNMENT

Columns shall be correctly aligned in the vertical position or at the rake agreed by the Engineer. The cable hole for the bracket shall be in the correct position relative to the road so that the bracket, when fixed in its correct position, will align correctly with the cable hole. Unless otherwise specified, the door opening shall face away from oncoming traffic.

## 405.9 BACKFILLING

When the columns have been placed in position, the holes shall be filled in and well consolidated.

(a) **Group A Installations**.

Excavations for Group A installations shall be filled in with enough concrete to hold the columns firmly in their true position. Unless otherwise specified, the concrete shall be brought up to within 450mm of the ground surface. The concrete shall be efficiently mixed so that there is a uniform distribution of material and the mass is uniform in colour. Concrete shall normally be placed in position before the initial set has taken place ie. 1½ hours after mixing has been completed, but in any event within such a time that it can be consolidated effectively without the addition of further water. The concrete shall then be thoroughly tamped and compacted by hand or by other satisfactory means, at intervals of not more than 150mm, at the same time ensuring that the column does not depart from its correct setting or alignment.

(b) **Group B Installations**.

Excavations for Group B installations shall be filled in with selected excavated materials, concrete or other materials to the satisfaction of the Engineer.

Adequate provision shall be made for the entry of underground services to the columns.

## 405.10 TEMPORARY REINSTATEMENT

The remainder of the hole shall be filled with soil which shall be well rammed at regular intervals. The finished level shall be substantially the same as that of the surrounding level.

The earth around the column shall not be disturbed for at least seven days after temporary reinstatement.

## 405.11 TREATMENT OF COLUMNS AFTER ERECTION

(a) **Concrete Columns**.
The joints between parts of concrete columns shall be pointed in accordance with the manufacturer's instructions. The colour of the material used shall match the colour of the columns.

(b) **Steel Columns**.
The exterior surface and external metal attachments of metal columns shall be painted after erection in accordance with the specification.

## 405.12 MARKING

After erection, columns shall be clearly marked with painted numerals, number plates or separate characters firmly secured to the columns, as specified by the Engineer.

## 405.13 ELECTRICAL EQUIPMENT

Lanterns, switches, control gear and accessories shall be fitted, wired and connected in accordance with the IEE Wiring Regulations for Electrical Installations and the work shall be done by a qualified electrician.

Fuse cut out boxes shall be made of flame retardant, resin moulded materials incorporating fuseways, looping terminals and earthing connections to suit the application. Fuse covers and other access to live parts shall be accessible only by the use of tools.

Metal columns, lanterns and the external metal work of switches and control equipment shall be electrically bonded, to the satisfaction of the Local Electricity Authority, and unless otherwise specified, connected to earth by one of the following methods:-

(i) In installations served by an underground supply, by a conductor connected to the metal sheath of the supply cable (the bonding of this connection to the cable sheath is normally

the responsibility of the Local Electricity Authority).

(ii) In any section of an installation served by an overhead wiring system, if a continuous earth wire is available along the entire length of the system, by a conductor suitable for connection to this wire; if no continuous earth wire is available, by individual earthing to each column in a manner to be specified by the Engineer.

Lanterns shall be attached to the columns only after the columns have been securely fixed in their agreed vertical and horizontal alignment. Together with any optical components, they shall be correctly orientated with the road in accordance with the manufacturer's instructions. Leveling devices shall be used as supplied and as recommended by the manufacturer.

The lamps shall be carefully inserted in the lanterns without subjecting them to undue mechanical shock or vibration. Care shall be taken to ensure that lamps operate in the correct burning position, in accordance with the lamp manufacturer's instructions. Lamps, reflectors, bowls and refractors shall be clean and free from dust or obscuring films after assembly.

## 405.14 WALL AND BRACKET MOUNTING

In the absence of detailed instructions, the erector shall ensure that wall brackets and wall-mounted lanterns are securely fixed to structurally-sound parts of the wall. The dimensions of fixing screws and wall plugs should be adequate for the loads to be carried. Where lanterns are mounted on long outreach brackets or where large surface areas are involved, the lanterns or brackets should be fixed to solid brick or stone walls by means of thoroughly caulked or grouted rag-bolts of adequate dimensions. The method of attachment to timbered buildings or other forms of construction should be the subject of agreement with the Engineer.

Control gear not located inside the lantern should be housed in robust waterproof and tamperproof containers, securely fixed to the wall if appropriate. Surface wiring between the lantern and control gear compartments should be protected mechanically by means of heavy gauge welded steel conduit or steel wire armoured cables.

The requirements of the statutory authority should be complied with where street lighting lanterns and accessories are mounted on poles owned by statutory authorities.

## 405.15 FOLDING COLUMNS

Where folding columns are specified for maintenance access, the two sections shall be positively seated and hinged to prevent unauthorised interference. The extended skirt shall totally enclose the gear compartment to provide protection to IP33. The upper section may only be lowered by use of a specially designed device to assist the operation. At least one lowering device shall be provided together with one additional device for every multiple of one hundred such columns installed.

## 405.16 FEEDER PILLARS

Feeder pillars to accommodate electrical distribution components shall be made of cast iron, sheet steel, aluminium or glass resin bonded polyester material as specified in the Particular Specifications.

They shall be free standing assemblies, designed for base mounting either direct to concrete plinths or for attachment to separate root extensions suitable for direct burial. The shell shall be partially removable to allow access for cable jointing and termination.

Doors shall be hinged with stainless steel pins in nylon bushes and allow 180° opening. They shall sealed all round with a watertight gasket and be secured by wedge type locks, protected by brass cover plugs requiring special keys to prevent unauthorised access.

The housing shall incorporate baffled ventilation apertures to provide overall enclosure protection to IP 34. Equipment mounting boards within the pillar shall be of non-hygroscopic material.

## 405.17 HIGH MASTS

The masts shall be manufactured from mild steel to a tapered profile using the minimum number of horizontal joints. The base flange shall be adequately welded and gusseted and the base compartment opening shall be reinforced to maintain the strength of the mast.

The mast head frame and lantern carriage shall be a welded steel construction, hot dip galvanised after assembly. The head frame shall be protected overall by an aluminium canopy and the lantern carriage shall be designed to enable it to be assembled or removed from the column after erection. Guides shall be provided to ensure the carriage engages securely into the head frame.

The carriage mounted junction box shall house the connections to the lanterns and the electrical supply cable. The cable shall be a flexible multicore with EPR insulation and sheathed with heavy duty PCP. Electrical disconnection by means of a plug and socket with a threaded coupling facility shall be provided in the base of the mast. A similar electrical coupling shall be provided at the lantern carriage to enable the supply to be directly connected to the lantern when the carriage is at ground level.

### 405.18 WINCHING ARRANGEMENTS

Manually operated or power driven winches shall be provided where specified for raising and lowering Luminaires or lantern assemblies. They shall incorporate an automatic gravity latch and a disc brake on the drive shaft to prevent creepage when the winch is stationary. Lifting ropes shall be formed of flexible stainless steel strands and sized to operate within their rates safe working load with a safety factor of 5 : 1.

Winches shall be driven through a worm reduction gearbox, totally enclosed in a cast iron gear case filled with lubricant for life. Power drives for the gearboxes shall be transferable and coupled through a mobile mounting jig as required.

On high masts, multiple ropes shall be used and arranged to maintain a level rise and fall. The pulleys for the hoist ropes and the electrical supply cable shall be of cast aluminium and shall have close fitting guides to ensure correct location of the ropes and cables during operation. The electrical cable shall also have guide rollers to assist centring.

The fixed and moving elements of Luminaires designed for raising and lowering by means of winching shall incorporate guidance channels and latching mechanisms to ensure secure engagement and release in conjunction with the winching device.

## 406. ELECTRICAL INSTALLATION FOR BUILDINGS

### 406.1 GENERAL

Electrical installations for buildings shall comply with the French Standards as normally applicable in Lebanon.

Materials and works for building electrical installations shall comply with:

- D.T.U. (Unified Technical Document) No. 70.1 published in December 1971 and completed by erratum July 1981
- D.T.U. published in April 1973
- N.F.C. 15-100: Electrical installations
- N.F.C. 71-800: Security blocks
- N.F.C. 13-200: High voltage electrical installations - Regulations
- N.F.C. 14-100: Sub-circuits installations - Regulations
- N.F.C. 15-150: High voltage gas discharge lamps installations

The works which are the subject of this specification are for the installation of the electrical power supply network in the pumping stations and related buildings.

All equipment shall be to class of protection IP55 as a minimum.

The works include:

a) Distribution boards
b) Secondary distribution boards if specified
c) Cabling and wiring

d) Installation of wiring in conduits for lighting, socket-outlets and outlet boxes starting from main and secondary boards, as well as the lighting points, socket outlets, and outlet boxes.
e) Internal and external lighting Luminaires.
f) Grounding systems.

## 406.2 ELECTRICITY SUPPLY

The electrical supply has the following features:

– Three-phase.

– 380 V between phases

– 220 V between phase and neutral

– Frequency 50 Hz

Note: voltage may vary in Lebanon +15%, -15% from the nominal value.

## 406.3 NATURE AND ORIGIN OF MATERIALS

### 406.3.1 General

All materials intended for incorporation in the works shall comply with the D.T.U. in force and the regulations for construction, and the recommendations of the International Electrotechnical Commission.

Any approval of the Engineer on the origin of materials does not release the Contractor from his responsibility in respect of the quality and the reliability of the materials supplied to site, which must always be consistent with the relevant specifications. Any change of the origin of materials previously approved shall be submitted for approval.

### 406.3.2 Electrical Distribution Boards

A main distribution board to be installed near the entrance to the building.

i) A cable shall supply the power to this panel from the pumping station main panel or as otherwise stated in the Particular Specification

All distribution boards shall be metallic or polyester construction, they shall be monocellular, rectangular and have a plane front face, designed for built in or surface mounting as specified. They shall have a lockable door and a key.

They shall have class of protection IP55 and be finished with textured paint RAL 7032 or RAL 7035.

Secondary distribution boards shall be installed according to the specification and the electrical installation drawings. These boards shall comprise:

Distribution boards shall be supplied with all wiring, bus-bars, equipment such as circuit breakers, ammeters, voltmeter selector switch etc..., accessories, cables, junction boxes, and installation material ready for installation directly on arrival at site.

The boards shall be designed to facilitate inspection, maintenance and repair and all articles having the same characteristics and dimensions shall be entirely interchangeable.

Distribution boards must not show any deformation or welding effect. They shall be rigid enough to support the equipment without deformation both during normal operation and under short circuit condition. They shall be fitted with reinforcement especially against the effect of short-circuits.

All bus-bars, equipment and connections shall withstand the nominal rated current continuously without heating beyond admissible values.

The design of distribution boards shall take into consideration every change of rating of the equipment to suit the climatic conditions specific to the site. All live terminals and parts shall be adequately insulated from the frame of the panel board. Metallic boards frame shall be grounded.

Bus-bars shall be so protected as to exclude the possibility of contact with them or any live part when closing or releasing circuit breakers.
Boards comprising several cells, shall be protected with an earthing bar covering the entire length of the board.

Frames and the metallic enclosures of equipment shall be connected to the earthing bar by means of approved accessories.

Each single phase distribution board shall have one bus-bar and one neutral bar. The section of the bars shall be sufficient to allow the passage of the nominal current without leading to excessive heating, the rating shall be equivalent to at least the total nominal current of incoming circuit breakers in the board.

Bus-bars shall be made of electrolytic copper. The Contractor may offer variants made of another material, but in this case, he shall submit for the Engineer’s approval all the details concerning the accessories required for the connection of cables and equipment to bus-bars.

The frames of metallic distribution boards shall be treated against corrosion. They shall be painted internally and externally with one coat of primer and two grey finishing coats.

All circuits fed from the panel board shall be labelled.

Distribution boards shall have at each feeder, a chart or diagram describing, according to the distribution scheme, the circuits connected to this feeder. The boards shall be of fixed, non removable type. Circuit breakers shall be of miniature type.

Connections to all equipment shall be easily reached and made from the front without having to dismantle the board.

Ammeters shall be fitted at each incoming feeder.

### 406.3.3 Circuit Breakers

406.3.3.1 General Specifications

All circuit breakers shall meet the following conditions:

- They shall be designed to function under the electrical current supplied to the station.

- Each phase pole shall be fitted with an instantaneous action thermo-magnetic type over current trip. The trip shall act on a common tripping bar and provoke the simultaneous tripping of all poles.
- Circuit breakers shall be of automatic trip type.
- Each pole shall be fitted with an arc extinguishing mechanism.
- Circuit breakers shall be compensated for ambient temperature. All thermal relays shall be compensated in order to function correctly in the ambient temperature of the site.
- Circuit breakers shall be fitted

Three-phase circuit breakers shall also meet the following conditions:

- Incoming circuit breakers from the main panel board, connected directly to the transformer station shall be four pole. All other circuit breakers shall be three pole.
- All the poles of three-phase circuit breakers should trip simultaneously with one control mechanism.

Circuit breakers installed in the general panel board may be of miniature type.

Circuit breakers installed in secondary panel boards may be moulded case miniature type.

406.3.3.2 Rupturing Capacity

- All circuit breakers shall have sufficient rupturing capacity to switch off the highest short-circuit currents.

- Circuit breakers shall have the rating indicated on the drawings.

The minimum rupturing capacities shall be as tabulated hereunder and consistent with the D.T.U.

| Rating (A) | Voltage (V) | Rupturing Capacity (A) |
|---|---|---|

| | | |
|---|---|---|
| 32 | 240-380 | 6000 |
| 70 | 240-380 | 6000 |
| 100 | 380 | 14000 |
| 125 | 380 | 14000 |
| 150 | 380 | 22000 |
| 500 | 380 | 30000 |

### 406.3.4 Contactors

Contactors used in the installation shall be three-pole, mounted in screened boxes, protected to class IP55. They shall be designed to function under the nominal working voltage and current corresponding to the circuit breakers protecting the circuits they control.

The mechanical and electrical resistance of the contactors shall be high and they shall be protected against dust or any other factor that might harm their proper functioning.

"On" and "Off" push-buttons shall be mounted on the cover of the box.

### 406.3.5 Electric cables

The cables to be installed include the following:

- Main distribution board power supply cables.
- Connection cables between the main and secondary distribution boards.
- Power supply cables to metering.
- Connection cables between meters and secondary boards.
- Cables used for the power supply of low power motors.

Multicore cables shall be protected with an external sheath made of thermoplastic material of NYA type consistent with the most recent VDE standards or of an equivalent type consistent with other recognised standards.

All cables shall be of 1000 volts rating.

Cores shall be made of pure electrolytic copper; resistivity = 0.01724 Ohm/mm$^2$/m at a temperature of 20$^o$C. They shall be multi stranded for sections exceeding 6mm$^2$.

The insulation of the cores shall be colour coded as specified.

### 406.3.6 Insulated Conductors

Conductors laid in polyethylene tube shall be made of copper insulated with thermoplastic materials. They shall be of NYA type consistent with the most recent VDE standards or of an equivalent type consistent with other recognised standards. They shall be of 600 volts rating.

Conductors shall be made of pure electrolytic copper; resistivity = 0.01724 Ohm/mm$^2$/m.

The minimum section of conductors shall not be less than 1.5mm$^2$. Conductors having sections

exceeding 2.5 $mm^2$ shall be multi-stranded.

In single-phase circuits, the section of neutral conductors shall always be equal to that of the phase conductor. Each circuit shall have an independent neutral from the secondary panel board.

All phase-conductors of single-phase circuits shall be linked to the same phase in the distribution board.

Each phase conductor, neutral conductor and earth conductor in the installation shall be differentiated, one from the other, by the colour of the insulation.

- Each phase conductor shall have a colour different from those of the others, changing the colour for a phase conductor along the same circuit is absolutely forbidden.
- The neutral conductor shall be grey throughout the installation.
- Earthing conductors shall be yellow-green or green throughout the installation.

The Connection of conductors shall be carried out exclusively inside enclosures, by means of clamping screws in order to prevent the scattering of strands.

The use of an insulating adhesive tape is forbidden.

Maximum voltage drop in comparison with the available voltage in the main panel board: 3%

Maximum density of current: 3A/$mm^2$ for 2.5$mm^2$ cables and 2A/$mm^2$ for larger cables.

### 406.3.7 Conduits

Where electrical wires and cables, including very low voltage wiring, are installed in plastic conduit, the conduit shall be consistent with the DTU and its addenda (class of protection IP55)

The connection of conduits shall be carried out by means of accessories of the same type, using the materials specified in the catalogues of the conduit manufacturer (class of protection IP55) Adequate flexible accessories shall be used for electric lines crossing expansion joints or fixed to different structure units.

Generally, all accessories used with electrical networks shall be of the same type and shall have the same characteristics.

Conduits shall be so installed that the junction, sub circuit, and wiring draw boxes are always accessible for maintenance and repair.

The connection of conduits or of conduits and other accessories shall be carried out according to the instructions of the conduit manufacturer.

Surface mounted conduits shall be fixed by means of galvanised steel brackets, sufficiently close to each other to ensure a solid fixing. Screws and nuts shall also be galvanised.

After laying the conduits, they shall be fixed in cement mortar.

The Contractor shall make grooves in the walls for built in conduits; in all cases he shall fix the conduits in such a way as not to damage the finish of the structure.

The use of wooden pegs for sealing is strictly forbidden.

No more than two 90° bends shall be permitted throughout the run of a conduit between two junction boxes. Should more than two bends be required, the Contractor shall install additional junction boxes in order to facilitate the laying and removal of wires.

In the event of the electrical conduits crossing other pipes, electrical conduits shall be so installed as to keep a free space between conduits and pipes.

A minimum clearance of 200mm shall be maintained between electrical conduits and heating or steam pipes. If this 200mm clearance cannot be achieved electrical conduits shall be externally insulated.

Conduits embedded in walls shall be vertical or horizontal. Installation of diagonal conduits inside walls is not permitted.

Surface mounted conduits shall run parallel or perpendicular to walls.

Note: All low voltage cables shall be installed in separate conduits.

The internal diameters of various sizes of conduit are tabulated hereunder together with the number and section of conductors that may be installed therein. The numbers stated in the table represent in millimetres the minimum internal diameters. The Contractor shall supply conduits having a diameter equal to at least that specified.

| Section of Conductors ($mm^2$) | Number of Conductors in Conduit | | | |
|---|---|---|---|---|
| | 3 | 4 | 5 | 6 |
| 2.5 | 16 | 16 | 16 | 16 |
| 4 | 16 | 16 | 16 | 16 |
| 6 | 16 | 16 | 16 | 23 |
| 10 | 21 | 21 | 21 | 29 |
| 16 | 21 | 29 | 36 | 36 |
| 25 | 36 | 36 | 36 | 48 |
| 35 | 36 | 48 | 48 | 48 |

No more than 6 conductors may be installed in one conduit unless the seventh is an earthing conductor.

### 406.3.8 Boxes

Boxes used for connections and sub circuits, as well as those installed at each feeder, shall be supplied with appropriate covers (class of protection IP55)

They shall have knockouts for conduit connections.

Switch and socket boxes shall be provided for the switches and sockets to be installed, in conformity with the recommendations of the supplier of these items.

Surface mounted boxes shall be watertight to IP55, of moulded construction with inlets fitted with glands.

Junction boxes installed outdoors or inside humid locations shall be watertight weatherproof type (class of protection IP55)

Power supply circuits of low power equipment such as fans and air convectors shall be linked to junction boxes with fixed connections for the corresponding equipment.

Junction boxes shall be either single-phase or three-phase.

### 406.3.9 Switches

Lighting circuit switches shall be single two, or three way rated for 16 Amp, 250V. They shall be silent toggle switches.

The switch and cover plate shall be fixed to the box with stainless steel or chromium-plated screws. Hook fixings are forbidden.

Flush switches shall have their covers made of an insulating material (class of protection IP55)

Switches shall be flush or surface mounted according to the type of installation.

Surface mounted switches shall have the same mechanism as flush switches, but shall be installed inside dust proof boxes, having inlets fitted with glands (class of protection IP55)

Switches shall be installed on phase wires and in no case on neutral wires.

Switches shall, in general, be installed 1100mm above the finished level of the floor, except in particular cases where their installation shall be submitted for the Engineer's approval.

Switches intended for the same duty in different locations shall be installed at the same heights. Switches shall always be installed in the most suitable places for their operation.

### 406.3.10 Power Outlets Sockets

406.3.10.1 General

The exact locations of power-outlet sockets shall be determined according to the construction details of the building. These locations shall be submitted for the Engineer's approval.

Power outlet sockets shall be flush or surface mounted according to the type of the installation.

Flush mounted socket outlets shall be installed in their boxes with screws.

All single-phase power-outlet sockets and plugs shall have ground contacts or terminals to be connected to the grounding system.

Three-phase power-outlet sockets shall be installed at heights which suit the equipment they supply with power.

Power-outlet sockets intended for the same duty in different locations shall be installed at the same heights.

Three-phase power outlet sockets shall be supplied with corresponding plugs.

406.3.10.2 Single Phase Power-Outlets (1-Ph P.O.)

Each single-phase power-outlet socketsand plug shall have 2 terminals and one ground contact. They shall be rated for 10/16 Amp and 20Amp-250V.

Fixing the switch and cover plate to the box shall be done with stainless steel or chromium plated screws. Hook fixings are forbidden.

Switches used with built-in installations shall be of flush type and fitted with square or rectangular covers made of an insulating material.

Surface mounted switches shall be installed inside waterproof boxes (class of protection IP55). These boxes shall have inlets fitted with glands and shall be provided with knockouts.

It shall not be possible to insert telephone plus into power outlet sockets.

406.3.10.3 Three-phase Power-Outlet Sockets (3-Ph P.O.)

Three-phase socket-power and socketsplugs shall be rated for 32 Amp, 380V and shall have ground terminals.

Surface mounted power-outlet sockets shall be installed inside water-proof boxes (class of protection IP55) or better. These boxes shall have inlets fitted with glands and shall be provided with knockouts.

It shall not be possible to insert telephone plugs into sockets.

### 406.3.11 Grounding Systems

406.3.11.1 General

The following independent grounding systems may be utilised.

Grounding system of the neutral point of the Standby generating set alternator.

Grounding system of the metallic frame of the main panel board.

Grounding system of the building or metering system.

These systems shall have a resistance of less than 5 Ohms.

406.3.11.2 Installation

Each grounding system, shall be achieved by one or several rods.

The resistance of the grounding shall not exceed the value stated in the previous paragraph.

The Contractor shall install a sufficient number of rods to achieve this resistance value.

Grounding rods shall consist of a steel core covered with a copper coat.

The heads of the grounding rods shall be buried 500mm deep in the ground. A concrete manhole having a 500mm side shall be prepared for each earth terminal in order to facilitate maintenance operations and later reinforcement works utilising additional elements if required to increase the earthing installation.

The manhole shall have a cast iron or concrete cover allowing permanent access.

The head of each grounding terminal shall be fitted with a sectioning bar allowing the isolation of this grounding element from the installation and, hence, the measurement of the ground resistance.

The connection of grounding cables to the earthing system shall be carried out by means of sockets ensuring very good contact.

406.3.11.3 Grounding Conductors

The sections of grounding conductors of the various terminal circuits or power supply circuits of a panel shall be the same as those of the neutral conductor of the corresponding circuit, in such a way that they are not less than 2.5mm$^2$ nor more than 70mm$^2$.

Connections shall be carried out by permanent weld or by screw clamping.

Connections between the grounding network and equipment subject to movement shall be carried out by means of copper braids having the same sections as grounding conductors.

Series grounding is prohibited.

All insulated grounding conductors shall be yellow-green (external colour). This colour shall not be used for any other part of the installation.

**406.3.12 Lighting Fixtures**

406.3.12.1 General Conditions

The installation of the lighting system shall be consistent with the technical specifications

generally, and particular attention shall be given to those related to humid and corrosive situations (chlorine).

Lighting installations shall be complete and shall include all necessary accessories, whether the accessories are described hereunder with the description of the lighting installation or not.

The body of the lighting fixture, its base, or support shall entirely cover the corresponding box.

External devices shall be mounted with non-ferrous accessories.

The frame of lighting devices inserted in a false-ceiling shall not allow light to infiltrate between the frame and the false-ceiling.

Lighting devices fixed directly to a centre box shall be solidly held by a peg and a cramping block.

### 406.3.13 Characteristics of Materials

406.3.13.1 General

- Unless otherwise stated on the drawings lighting devices shall, wherever applicable, comply with all conditions stated below.

- The name of a supplier and catalogue number are stated for reference only as a description of type and standard. The equipment supplied shall be consistent with the specifications and, if necessary, standard equipment shall be modified accordingly.

406.3.13.2 Wiring

Wiring inside lighting devices shall have a section equal to or exceeding $2mm^2$, and shall be insulated for a nominal voltage of 500V.

406.3.13.3 Sheets

The minimum thickness of sheet used in lighting devices shall be 1mm.

Metallic parts of lighting devices shall be free from any scratch.

406.3.13.4 Treatment and Painting of Sheets

- All sheets shall receive the following treatment:
  Prewashing, grease removal, rinsing, passivating, drying.

- Unless otherwise specified, all non reflecting surfaces, such as the frames of lighting devices, bases, etc.. shall be coated with an enamel finish. The colour of the paint shall comply with the specifications unless specified otherwise by the Engineer.

– All reflecting surfaces shall be coated with a white enamel having a minimum reflection coefficient of 80%.

### 406.3.14 Fluorescent Luminaires

406.3.14.1 General

Flush Luminaires shall be so dimensioned as to allow the replacement of one or more sections of the false-ceiling without requiring any cutting.

406.3.14.2 Bushes

Lighting devices shall be equipped with white clip-on bushes.

406.3.14.3 Ballasts

Ballasts shall be consistent with the standards of the D.T.U. and designed for 45°C ambient temperature. Only one or two-lamp ballasts shall be used.

Ballasts shall be completely enclosed inside a metallic casing and shall have a corrosion-resistant finish.

Windings shall be impregnated with a polyester resin suppressing every risk of softening and melting and ensuring excellent heat dissipation.

Ballasts shall be corrected to give a power factor better than 0.9.

Ballasts shall be of silent-type operation and unless otherwise provided for, shall be rapid start type.

Two series-lamp ballasts shall be lead-lag type or equivalent.

### 406.3.15 Incandescent Luminaires

a) Incandescent Luminaires shall be fitted with porcelain-base bushes having an Edison screw E27 for lamps up to 200W, and Goliath screw E40 for lamps of 300W or more.

b) It shall be possible to place and remove lamps without dismantling the system.

c) The various types of incandescent Luminaires shall comply with the detailed description given by the manufacturer.

### 406.3.16 Lamps

406.3.16.1 General

Lamps shall be supplied and placed in all the lighting fixtures as specified.

Prior to the final commissioning of electrical installations, lamps used throughout the works shall be replaced by new ones.

406.3.16.2 Incandescent Lamps

Incandescent lamps shall be of the internal satin type with screw bases.

Lamps shall be designed to work at 220V (or 24V) voltage, they shall have a lifetime of a minimum 1000 hours.

406.3.16.3 Fluorescent Lamps

Unless otherwise specified, fluorescent lamps shall be rapid start type. They shall have a high luminous efficiency.

406.3.16.4 Halogen lamps

Halogen lamps shall be tubular type, having a lifetime of at least 4000 hours and operating in all directions and positions.

The colour temperature shall be 2850°C, the fuse shall be incorporated and the flux value is 5000 lumen.

Particular Cases: Lighting of Humid Buildings

Given the humid atmosphere inside pumping, treatment and other similar areas, 200 Volts should not be used for the lighting system without a security mechanism.

The Contractor shall install a special security mechanism in the following manner:

The outgoing supply cable shall be equipped with an isolating transformer and a power circuit breaker fitted with differential protecting devices of adjustable sensitivity and delays: 03A, 1A, 3A up to one second.

The rupturing capacity shall be 20KA in accordance with D.T.U.

NB All equipment used in the buildings shall be standard (Class of protection IP55 minimum) and shall comply with international technical regulations.

**406.3.17 Emergency lighting**

Emergency lighting shall be provided to maintain sufficient illumination in accordance with BS 5266 for escape routes within the building during mains supply failures.

Luminaires shall comprise at least a single 8w fluorescent tube with a solid state changeover

circuit and high efficiency, high frequency inverter all contained within a die-cast aluminium bulkhead body, having a corrosion resistant, stove enamel finish. The diffuser shall be of

unbreakable opal polycarbonate material, secured by an oil and water proof sealing gasket to result in a luminaire rated to IP65.

Luminaires shall be self-contained and shall incorporate a maintenance free, nickel cadmium battery, capable of preserving the light output for a period of at least 3 hours without mains supply, together with an automatic recharging circuit to restore the charge within 24 hours of total discharge. Each luminaire shall incorporate an indicator to show that the charger circuit is healthy and have a removable gear tray and fused terminal blocks for ease of maintenance and installation.

Unless otherwise specified, luminaires shall be either of the following forms:

a) maintained form, normally lit from the mains and automatically switched from mains to battery during mains failure;

b) non-maintained form, energised automatically from the battery supply only when the mains fails and the associated local lighting circuit is switched on;

c) sustained form, having two lamps, one of which is mains fed only, the other operating from the battery supply during mains failure

## 406.4 EXECUTION OF THE WORKS

### 406.4.1 Locations for Installation of Equipment

The general locations for the installation of materials shall be as shown on the drawings. These locations shall be agreed on site between the Contractor and the Engineer or his representative.

406.4.1.1 Distribution Panel Boards

Unless otherwise directed, Panel boards shall be centered 1.50m above finished floor level.

Distribution boards shall be totally protected and fitted with circuit breakers. In three-phase panel boards, the numbering of circuits indicated on the drawings is based on a three-phase separation where circuits are connected respectively to the red, yellow and blue phase.

Internal equipment of panel boards (bus bars, circuit breakers,...) shall only be installed in the enclosure after installation, fixing and connecting conduits.

All openings left in the panel shall be properly sealed.

Distribution panels shall be installed vertically; under no circumstances shall the conduits serve as supports to the panel.

The sides of panels to be embedded shall be covered before installation with a thick coat of emulsified tar.

The frames of built-in panel boards shall be installed squarely and in alignment with the walls.

Each distribution panel shall have at the front side an engraved plate stating the name and reference letters of the panel board. On the inside of each panel board door, there shall be a list stating the reference number for each circuit connected to the panel board and the reference number of the locations supplied with power by the circuit.

## 406.5 CABLE INSTALLATION

### 406.5.1 General Conditions

Cable installations shall conform to the following.

a) The methods used for the installation of cables shall not damage the conductors and the insulators.
b) The pull utilised for installation of cable shall be kept to the minimum necessary for installation and shall not permanently strain the conductors.
c) The connection of wires to equipment shall not be subject to any strain.
d) The radius of curvature of cables shall, at no point, be less than 10 times the outside diameter.
e) Between any two sub circuit boxes, cables shall be continuous, no junctions shall be allowed.
f) The use of wooden pins for sealing is forbidden.
g) Cables shall be marked every 10 metres in order to facilitate identification.

### 406.5.2 Installation of visible Cables

All visible cables shall be mounted as follows:

a) Cables shall be installed on cable tray in one layer and shall in no case be superimposed. Each cable tray, shall have a 25% reserve in order to allow for the installation of future cables. Vertical sections shall be fitted with cable fixing devices.
b) Cables shall be fixed on masonry along walls by means of galvanised steel brackets or other means proposed by the Contractor and approved by the Engineer.
c) Beneath ceilings, cables shall be held by substantial supports. The supports shall be sufficiently close to avoid droop of the cables.

### 406.5.3 Other Conditions

Lengths of cables mounted between ground and a height of 2.50m and those crossing masonry shall be installed inside galvanised steel tube.

### 406.5.4 Insulated Wires

All wires and connection devices shall be accessible for inspection and replacement as required. They shall be so set out and installed as to allow handling without causing any mechanical deterioration.

All wires shall be installed entirely inside conduits.

The pulling of wires in conduits shall be carried out carefully in order not to damage the insulator. It is forbidden to use oils, grease or any other fluid for facilitating the pulling of wires, the contractor can however use powder of an approved type.

# 407. TELEPHONE INSTALLATION

## 407.1 GENERAL

The required installation shall comprise:

a) Main distribution boxes
b) Secondary distribution boxes for each office unit.
c) Distribution circuits
d) Telephone plugs

## 407.2 CIRCUITS DISTRIBUTION

a) Cables required for this installation shall have copper conductors of 0.5mm in diameter, except for the earthing conductor which shall have a sufficient diameter according to the number of socket-outlets and plugs it connects. All cables shall be insulated with PVC sheathing.

   Cables shall be divided into three categories:

   - Multicore cables between main distribution and main distribution boxes of various floors and locations. The capacity of these cables shall be equal to the number of conductors required for each distribution box, in the 25% spare capacity.

   - Two-core cables between secondary distribution boxes or main distribution boxes and telephone plugs. An appropriate main circuit shall be installed for each telephone plug.

b) All cables shall be laid in conduits identical to those used in electrical installations. The section of the conduit shall be, as a minimum, two times larger than the total section of cables (including insulation) it is designed to house.

## 407.3 TELEPHONE PLUGS

Telephone plugs shall be built in or surface mounted. They shall have the same brand name as socket-outlets and plugs.

# Volume 2

# Technical Specifications

# Division 1

# General Specifications

# Part 5

# Instrumentation & Control

# TABLE OF CONTENTS

**Page No.**

**501. GENERAL REQUIREMENTS FOR INSTRUMENTATION & CONTROL 7**

501.1 ABBREVIATIONS 7

501.2 DESIGN AND ELECTROMAGNETIC COMPATIBILITY 8

501.3 INTERRELATION WITH OTHER SECTIONS 10

501.4 INTERRELATION WITH OTHER CONTRACTS 10

501.5 TEMPERATURE AND HUMIDITY 10

501.6 ENCLOSURE PROTECTION 10

501.7 VOLTAGE AND FREQUENCY TOLERANCE 10

501.8 INSTRUMENTS 10

501.9 INPUTS, OUTPUTS AND SIGNAL LOOPS 11

501.10 TERMINALS 11

501.11 PROGRAMMING AND MONITORING UNIT 11

501.12 DISCRETE COMPONENTS 13

501.13 INTEGRATED CIRCUITS 13

501.14 SUB-MINIATURE SWITCHES 13

501.15 PRINTED CIRCUIT BOARDS 13

501.16 SOCKETS AND CONNECTORS 13

501.17 TEST FACILITIES 14

501.18 SURGE PROTECTION 14

**502. INSTRUMENTATION 15**

502.1 INDICATING INSTRUMENTS 15
502.1.1 General Requirements 15
502.1.2 Analogue Instruments 16
502.1.3 Digital Instruments 16
502.1.4 Strip Indicators 16
502.1.5 Indication Lights 16

502.1.6 Indicator/Recorders 17
502.1.7 Time Indicator 18
502.1.8 Indicator Gauges 18

502.2 CURRENT AND VOLTAGE TRANSDUCERS 19

502.3 CAPACITIVE DEVICES 19

502.4 PRESSURE TRANSDUCERS 20

502.5 ULTRASONIC DEVICES 21

502.6 LEVEL CONTROL 21

502.7 FLOW SWITCH 22

502.8 DIFFERENTIAL PRESSURE SWITCHES 22

502.9 FLOWMETERS 22
502.9.1 Electro-magnetic Flow Meters 22
502.9.2 Differential Pressure Flowmeters 25
502.9.3 Variable Area Flowmeters 26
502.9.4 Ultrasonic In-line Flowmeters 26
502.9.5 Mechanical Flowmeters 27

**503. PROGRAMMABLE LOGIC CONTROLLER (PLC) 29**

503.1 DESIGN 29

503.2 POWER SUPPLIES 29

503.3 PLC SOFTWARE PROGRAMMING 29

503.4 MEMORIES 29

503.5 COMMUNICATION PORTS 30

503.6 WATCHDOG 30

503.7 INSTALLATION 30

503.8 HAND-HELD PROGRAMMING UNIT 31

**504. REMOTE TERMINAL UNITS 32**

504.1 DESIGN 32

504.2 POWER SUPPLIES 32

504.3 MEMORY 32

**505. CONTROL SYSTEMS** **33**

505.1 OVERVIEW 33

505.2 DATA ACQUISITION AND RESTITUTION OF COMMANDS 34
505.2.1 Data acquisition 34
505.2.2 Faults and Alarms Detection 34
505.2.3 Data Restitution 34

505.3 SYSTEM PERFORMANCE 34

505.4 POWER FAILURES/BACK-UP/RESTART 36

505.5 OPERATIONAL CONSIDERATIONS 36

505.6 EXPANSION 36

505.7 RELIABILITY 36

505.8 OPERATING PARAMETERS 37

505.9 PROCESS AREAS 37

505.10 ORGANIZATION 37
505.10.1 Network 38
505.10.2 Front end processor 38
505.10.3 Station 38
505.10.4 Channel 38

505.11 MANAGEMENT REPORTS 38

505.12 COMPLIANCE WITH SPECIFICATION AND STANDARDS 38

505.13 TRAINING 40

**506. SYSTEM HARDWARE** **41**

506.1 DESIGN 41

506.2 VISUAL DISPLAY UNITS 41

506.3 KEYBOARDS 41

506.4 PRINTERS 41

506.5 MODEMS 42

506.6 MIMIC PANEL 43
506.6.1 Engraved Panel 43
506.6.2 Panel with a front side or relief panel 43
506.6.3 Panel with a painted front side 44

**507. SCADA SYSTEM** **45**

507.1 MODES AND FUNCTIONS 45

507.2 ENVIRONMENT 45

507.3 SYSTEM SECURITY 47

507.4 DATA PROCESSING 47
507.4.1 Measurements 47
507.4.2 Setpoints 49
507.4.3 Signalling 51
507.4.4 Counters 51
507.4.5 Calculation 53

507.5 DATA STORAGE 53
507.5.1 Values storage 54
507.5.2 Events storage 54
507.5.3 Saving/Retrieval 55

507.6 USER INTERFACE 55
507.6.1 Administrator (functions accessible at the ″configuration″ level) 56
507.6.2 Supervisor (functions accessible at the ″remote control″ level) 57
507.6.3 Duty-staff (functions accessible at the ″consultation″ level) 59

507.7 DUTY STAFF 59
507.7.1 Duty staff management 59
507.7.2 Remote consultation 60

507.8 CONFIGURATION FUNCTIONS 60
507.8.1 Creation of a library of labels 61
507.8.2 System parameter setting 61
507.8.3 Creation of pages 61
507.8.4 Creation of stations 62
507.8.5 Configuration of the variables of a station 62

507.9 COPYRIGHT AND PRODUCT SUPPORT 63

507.10 PROGRAMMING 63

507.11 PROGRAM DOCUMENTATION 63

507.12 DIAGNOSTIC ROUTINES 63

**508. INFORMATION PRESENTATION** **65**

508.1 DISPLAY 65

508.2 COLOURS 65

508.3 CURVES 68

508.4 POKE POINTS 70

508.5 OPERATING PARAMETERS AND SAMPLE RATES 70

508.6 LAYOUT AND STRUCTURE 70

508.7 MENU HIERARCHY 71

508.8 MIMICS (VDU) 71
508.8.1 Mimic Design and Approval 73

508.9 ALARMS 74

508.10 ALARM LOGGING 75

508.11 EVENT LOGGING 75

508.12 MANAGEMENT REPORTS 76

508.13 MAINTENANCE ASSISTANCE 78

508.14 MENUS AND LOGS 79

**509. FUNCTIONAL DESIGN SPECIFICATION 80**

509.1 PURPOSE 80

509.2 STRUCTURE 80

509.3 DOCUMENTATION 81

509.4 POST-INSTALLATION DOCUMENT 81

**510. COMMUNICATIONS 83**

510.1 CONTROL AND COMMUNICATIONS 83

510.2 TRANSMISSION MODES 83

510.3 PRIVATE LINES/DEDICATED LINES 83

510.4 RADIO LINKS 84

510.5 LOW POWER RADIO 84

510.6 FIBRE OPTIC LINKS 86

**511. COMPUTER ROOMS 87**

511.1 GENERAL 87

511.2 LIGHTING 87

511.3 AIR CONDITIONING 88

511.4 FIRE DETECTION AND EXTINGUISHING EQUIPMENT 88

511.5 ELECTRICAL POWER OUTLETS 89

511.6 DUST CONTROL MAT 89

511.7 BLINDS 89

511.8 FURNITURE 89

511.9 DECORATION 90

# 501. GENERAL REQUIREMENTS FOR INSTRUMENTATION & CONTROL

## 501.1 ABBREVIATIONS

The following abbreviations are used in these documents :

| | |
|---|---|
| 1/head/day | liters per head per day |
| AC | Asbestos Cement |
| AGMA | American Gear Manufacturer's Association |
| AOD | Above ordnance datum |
| BS | British Standard |
| CDR | Council for Development and Reconstruction. |
| CFM | cubic feet per minute |
| Ch | Chainage |
| CMR | Continuos Maximum Rating |
| CP | Code of Practice |
| CPU | Central Processing Unit |
| DI | Ductile Iron |
| DIN | Deutsch Industrie Normen |
| DOV | Double Orifice Valve |
| DPSK | Differential Phase Shift Keying |
| DTU | Documents Techniques Unifiés |
| EDL | Electricity of Lebanon |
| EMC | Electromagnetic Compatibility |
| EOH | End of hole. |
| FDS | Functional Design Specification |
| FIDIC | Federation Internationale des Ingénieurs- Conseils |
| FSK | Frequency Shift Keying |
| g | acceleration due to gravity ($9.807 m/s^2$) |
| GL | Ground level |
| gpm | gallons per minute |
| gr | gram |
| GRP | Glass Reinforced Plastic |
| GTSD | General Technical Specification Document |
| hr | hour |

| | |
|---|---|
| I/O | Input / Output |
| IEE | Institute of Electrical Engineer |
| ISO | International Standards Organization |
| ITS | Institute of Technical Studies |
| kgf | kilogram force |
| kPa | kilo Pascal |
| kVA | kilovolt-ampere |
| kW | kilowatts |
| kWh | kilowatt hour |
| LED | Light Emitting Diode |
| m | meters |
| $m/s^2$ | meters per second per second |
| $m^3$ | cubic meters |
| $m^3$/day | cubic meters per day |
| MDPE | Medium Density Polyethylene |
| mgd | million gallons per day |
| mhd | meters head |
| mm | millimeters |
| NFE | Normes Françaises - (Electrical) |
| NLQ | Near Letter Quality |
| NPSH | Net Positive Suction Head |
| PS | Particular Specification |
| PTT | Poste de Téléphone et de Télégraphe |
| PVC | Polyvinyl Chloride PWL |
| | Pumping Water Level |
| RAM | Random Access Memory |
| RBC | Rotating Biological Contactor |
| RTR | Reinforced Thermoplastic Resin |
| RTU | Remote Terminal Unit |
| SCADA | Supervisory Control And Data Acquisition |
| SPDT | Signal Pole Double Throw |
| SSU | System Supervisory Unit |
| SWL | Static Water Level |
| TDM | Time Division Multiplex |
| TDH | Total Dynamic Head |
| TEFC | Totally Enclosed Fan Cooled |
| UHF | Ultra High Frequency |
| UPS | Uninterrupted Power Supply |
| UPVE | Unsaturated Polyvinyl Chloride |
| VDU | Video Display Unit |
| VGA | Video Graphics Array |
| VHF | Very High Frequency |
| VHS | Video Home System |

## 501.2 DESIGN AND ELECTROMAGNETIC COMPATIBILITY

All circuits and equipment shall be designed in accordance with good engineering practice and particular care shall be taken to ensure that no component shall exceed its maximum voltage/current/power ratings at any time, including during transient surges.

All instrumentation equipment shall be protected from interference emanating from radio frequency transmissions, either radiated or cable borne, such that it shall not cause malfunction of the system or damage to the components.

All equipment supplied shall not radiate any form of electromagnetic energy in amounts that might interfere with external equipment or instrumentation.
The latest standards on interference and the principles of electromagnetic compatibility (EMC) IEC 801-2 to IEC 801-5 shall be followed. The electrostatic discharge (ESD) and surge immunity shall be applied to the design of the plant and applications.

## 501.3 INTERRELATION WITH OTHER SECTIONS

Requirements given in other sections shall be applicable wherever relevant to equipment or materials specified in this Section.

Thus indicator gauges, meters, enclosures, panel construction, finish, components, wiring, terminations, cabling requirements and environmental operating conditions shall be in accordance with the relevant clauses of the Mechanical and Electrical Sections unless specifically amended in this Section.

## 501.4 INTERRELATION WITH OTHER CONTRACTS

Where the location, installation or connection of any components of instrumentation are arranged by the Engineer under other contracts, it shall be the responsibility of the Instrumentation Contractor to advise and provide all relevant information on such matters to the Engineer in order that the correct and proper performance of the Contractors instrumentation is not prevented or impaired.

## 501.5 TEMPERATURE AND HUMIDITY

All supplied equipment shall function without error and shall be constructed of such materials or so treated as to prevent the formation of mould, fungus or any corrosion over the ranges of temperature and relative humidity specified in the specific clauses for this site.

## 501.6 ENCLOSURE PROTECTION

Instrumentation and hardware mounted in the field shall be contained in suitable enclosures to provide ingress protection to BS EN 60529 rating indoors dry and wet locations IP55 and IP65 outdoors as a minimum. Sensors installed below water level or liable to submersion shall be rated to IP 68. Where items are fitted in a panel or other enclosure, they shall preserve the design IP rating of that enclosure.

## 501.7 VOLTAGE AND FREQUENCY TOLERANCE

Equipment shall be capable of working from a supply whose voltage may vary ± 15%, and tolerate any transients that could be experienced in such an environment without programme corruption or system failure.

## 501.8 INSTRUMENTS

Each instrument and sensor shall be selected considering all the relevant performance parameters for the principle of measurement adopted, its intended use and the particular process in question.

All instrument output signals shall be volt-free, clean contacts rated at 220v AC 2A for digital and 4-20mA continuous proportional linear signal for analogue. Pulsed outputs suitable for integration counter drives shall be 24V DC.

## 501.9 INPUTS, OUTPUTS AND SIGNAL LOOPS

Opto-isolation shall be provided on all input and output interfaces to cards.

Digital signals shall be 24V DC with the power supply from either the associated power pack or the external instrument. Relays shall be used where more than one instrument including I/O are fed from a single signal.

Analogue signals shall be continuous linear scaled signals with a 4-20 mA operating range. Loops with instruments wired in series (e.g. panel mounted indicator and RTU input) shall have zener diodes fitted across each subsequent instrument leg to ensure loop integrity.

## 501.10 TERMINALS

Signal terminals shall be the disconnect type. Power supply terminals shall be shrouded and clearly marked with the appropriate warning tags. LED's shall be provided for fault tracing, if not supplied on the I/O cards. LED's in either case must be clearly visible from the front, with only the enclosure door open.

For each incoming screened cable, a separate earth terminal shall be provided for screen termination to earth.

All equipment, isolators, terminals and cables shall be clearly marked. 20% spare terminals shall be provided.

## 501.11 PROGRAMMING AND MONITORING UNIT

If computers, PLC’s and specialised systems, such as Control & Monitoring systems, SCADA, Data logging or systems with embedded microchips, are date-sensitive, these systems operation shall not be affected upon the change of Century.

Hand-held portable devices shall be provided for each item allowing user configurable

operation and to enable the downloading or uploading of data or software and the local running of diagnostic software. For RTU plc's the device shall be fully compatible with the RTU and shall be supplied with:

a) Software to enable the development of programmes and the subsequent downloading to the RTU.

b) Software to enable full communications with the RTU and to:

   i. upload data or alter data in the RTU;
   ii. access communications ports and I/O.

c) Full page process mimic display capability.

## 501.12 DISCRETE COMPONENTS

All discrete resistors, capacitors, switches, relays, diodes, transistors and other electronic devices shall comply with the BS 9000 series specification for components of assessed quality.

The Engineer's agreement must be sought before using components that are not certified, but it will remain the Contractor's responsibility to ensure that all components are suitable for the application.

Similar types of components shall be of the same manufacture and design wherever possible.

## 501.13 INTEGRATED CIRCUITS

All integrated circuits shall be of a proven design and shall be clearly marked with the original manufacturer's identity and device number.

## 501.14 SUB-MINIATURE SWITCHES

Where DIP or other sub-miniature switches are used they shall be provided with a cover, or other means of protection, to prevent accidental switching during handling.

## 501.15 PRINTED CIRCUIT BOARDS

Printed circuit boards shall be made of glass fibre with copper trackwork, all exposed copper being tinned prior to assembly, and the board and components cleared of flux before a thin layer of clear varnish is applied for environmental protection.

The board and its components shall be identified by references relating to the corresponding circuit diagram which shall be printed on the component side of each board. Where a number of boards are mounted in a rack system, the rack and boards shall be clearly marked to identify each board to its particular position.

## 501.16 SOCKETS AND CONNECTORS

The use of plug-in connectors for electronic equipment shall be kept to a minimum, and all circuit components including integrated circuit chips shall have soldered connections where this is permitted by the chip manufacturer.

Where sockets and connectors are incorporated in the design, they shall have self-cleaning, hard gold alloy plated, wiping action contact faces, and incorporate polarising keys or similar means to prevent incorrect mating. Insulation displacement type connectors shall not be used.

All light current wiring having a cross-section of 1.0mm² or less shall have tinned copper conductors.

## 501.17 TEST FACILITIES

The electronic equipment is to include built-in test facilities to permit the detection and replacement of faulty modules without the use of oscilloscopes, signal generators, or other sophisticated test equipment.

## 501.18 SURGE PROTECTION

All telecommunication lines, data and signal cables and other items of equipment external to the building environment prone to damage resulting from induced surges due to lightning discharges, shall be fitted with lightning surge protection barrier devices at each end of the line to suppress and divert any transients likely to cause damage to the connected equipment.

All surge diverters/lightning arresters fitted to telecommunication lines shall be of a design approved by the telecommunications authority.

Surge protection units shall be un-fused, solid state devices, designed to limit the transient over-voltages to not more than twice the normal working voltage of the line. They shall have low in-line resistance and automatically return to normal operation after diverting a surge.

The units shall have provision for either DIN rail or individual panel mounting or direct bolted connection to a suitable copper earth bar.

The location of the units shall be arranged such that the earth connection shall be routed clear of the protected signal cables and have short, straight connections without sharp bends to the main earth points, using copper conductors not less than 16mm² csa and not greater than 5 metres in length to provide a low impedance path.

Surge suppression devices to provide protection from mains switching or other supply network disturbances shall be incorporated or fitted to all sensitive monitoring or control devices. They shall be designed to filter un-wanted transients and limit the 'let-through' voltage to less than twice the working mains voltage, between all conductors and each conductor and earth. Protection monitoring status indication shall be fitted.

# 502. INSTRUMENTATION

## 502.1 INDICATING INSTRUMENTS

### 502.1.1 General Requirements

Indicating instruments shall conform to the following standards:

| | | |
|---|---|---|
| BS 5458 | IEC 51 | VDE 0410 |
| BS 7194 | IEC 414 | VDE 0411 |
| BS 5164 | | |
| BS 89 | | |

Indicating instruments shall show the specified measured values in either electro-mechanical or electronic and analogue or digital form, as defined in the Particular Specifications.

Instrument cases shall be made of magnetic sheet metal providing further protection against external magnetic fields. The instruments shall be termite and fungus resistant and shall be self extinguishing.

All indicating instruments shall withstand a minimum of 20% current and/or voltage overload.

All instruments and their accessories shall be suitable to operate between -25°C and 50°C at 85% maximum humidity for 60 days without condensation.

All instruments shall be shock proof and they shall not be affected by vibration. They shall have an insulation of 2 KV at 50 Hz.

Wherever possible, panel mounting indicating instruments shall be of matching size, appearance and orientation and suitably scaled, all in accordance with the general requirements for electrical panels.

All indicating instruments shall be of a similar flush vertical mounting, rectangular pattern, enclosed in black coloured, dust and damp-proof cases, one side being not less than 90mm (3.5") long or as specified. Scaling shall be in approved metric units normally ranged from zero to 20% - 40% above the system designed operating value, except where finite limits exist (e.g. p.f. indicators, synchroscopes) or where restricted ranges are specified. Adjustable set points within the instrument ranges shall be incorporated as specified.

Instruments having a mechanical movement shall provide at least a 90° scaled arc. 240° arc scales shall be employed on principal specified indicators.

Ammeters for motor circuits shall have an extended scale to cater for the starting current. These shall have adjustable red pointers or red markings on the scale to indicate the normal circuit current for the associated plant and shall be connected to each of the three phases of a three phase motor circuit.

### 502.1.2 Analogue Instruments

Analogue indicating instrument shall be of the moving iron or moving coil and fixed magnet type.

They shall have a class 1.5 accuracy.

### 502.1.3 Digital Instruments

Digital indicating instruments shall have the following characteristics:

- A seven (7) segment, LED display
- Polarity indication
- Protection against incorrect polarity
- Minimum digit height of 14 mm.
- 1 to 5 reading update per second
- Automatic zero adjustment
- Class 1 + 1 digit accuracy
- Minimum insulation resistance of 10 M Ω

### 502.1.4 Strip Indicators

Strip indicators shall be provided for the specified functions and arranged as shown on the proposed panel layout.

The indicators shall be solid state electronic type employing a column of neon gas plasma bars, illuminated consecutively in proportion to the input signal. The scale length shall be at least 100mm and allow on-line span and zero adjustment.

All indications shall be driven from transducers or inputs giving analogue signals of 4-20 mA.

### 502.1.5 Indication Lights

Signalling and alarm lamps, shall have standard drilling diameters ∅ 22 or modular sizes.

Indication lights shall be flush panel-mounted types with bodies fastened and keyed so that the lamps shall be capable of replacement from the front of the apparatus without disturbance to the lamp holder or panel wiring. Lens colours shall be as specified below. Bezels shall be coloured black.

signalling lamp (white) : main power supply ON

signalling lamp (red) : fault
signalling lamp (white) : RUN
signalling lamp (green) : standby ready to start
signalling lamp (blue) : level of tank
fixed or flickering signalling lamp (yellow or orange) : minor defect

All light sources shall be operated at Extra Low Voltage. Single units shall be fitted with MES

caps and be illuminated by LED clusters where colours permit, otherwise filament lamps shall be used.
To extend lamp life, filament lamps shall be arranged to operate at approximately 20% below their rated voltage and details of voltage and type of indication lamp shall be submitted for the Engineers approval. Particular consideration shall be given to circuits operated from a battery supply permanently floating across a charging circuit, where the terminal voltage may be higher than the nominal voltage.

When annunciator style indicators are used they shall incorporate two lamps wired in parallel for each fascia which shall have a window area of not less than 48mm x 24mm. The engraved characters shall be not less than 3mm in height and shall be filled black on a translucent background coloured as specified.

Alternatively where specified (particularly for unattended situations) self-contained LED annunciator display modules shall be used and configured for panel mounting. Legend plates shall be provided adjacent to each indicator. Where message display indicators are used, they shall have programmable legends and adjustable pulse rates.

### 502.1.6 Indicator/Recorders

Electro-mechanical indicator/recorder shall be a flush, panel mounting, single/multi pen indicator/recorder, scaled and labelled as specified herein. The initiating signals for each pen and the trace colour(s), together with any event markers and/or alarm settings, shall be as specified.

Continuously running recorders shall run at a speed of 20mm/hour with date and time annotation at 4 hourly intervals. For intermittent running, as in storm pumping applications, the recorder chart speed shall be 60mm/hour and shall only be initiated when the level approaches the first pump start level and be stopped 30 minutes after the final pump cuts out. Starting and stopping times and dates shall be printed on the chart and each pump operation shall be individually annotated by means of a single trace for each pump showing its running time.

To provide minimum time lags between other channels on the recorder, dot printouts may be used where required.

The Z folded chart paper shall be 250/100mm wide, linearly scaled in half hourly divisions and the width shall be calibrated 0-50 divisions linearly or logarithmically scaled as specified, to adequately show the normal range of operation and include the maximum possible signal. The

chart shall run for a minimum period of 30 days and 24 spare charts shall be provided. Circular charts shall be 105mm wide, 7 day graduated.-

Each channel shall provide a continuous ribbon strip visible indication over a calibrated scale (left hand zero) and an individually different coloured trace on the chart by means of either fibre tipped pens fed from disposable ink cartridges or electrical writing or sensitised paper.

Each input shall be separate and isolated from the conditioning amplifiers and all necessary computing modules shall be included in the unit to provide the required indications.

The following features shall be provided for the operator control, accessible from the front without withdrawing the unit during operation:

(a) Pen renewal (if relevant).

(b) Power on/off switch.

(c) Chart drive on/off switch.

(d) Chart replacement and adjustment.

Adjustable high and low, volt free alarm contacts shall be provided on each channel and incorporated into the control scheme as required to initiate the alarms as specified.

### 502.1.7 Time Indicator

A mains driven synchronous type clock shall be suitable for front of panel mounting and resetting.

The display shall be either digital or analogue as specified and based on a 24 hr notation. The digital display shall be of white figures (not less than 55mm high), on a black background. The analogue display shall be dual scaled showing 0-12 hr black figures and 13-24 hr red figures on a white faced dial of not less than 220mm diameter.

The mains supply for the clock shall be via a suitably fused clock connector mounted in the panel, connected such that the clock is energised from the live side of the panel isolator.

### 502.1.8 Indicator Gauges

All gauges shall be constructed with non-corrodible metal cases and stainless steel bezels. They shall be located to enable easy reading by the plant operator and mounted to preclude damage due to vibration. The cases shall be at least 50mm dia. unless otherwise specified, scaled in metric units and normally ranged over a 240° arc from zero to 20% - 40% above the system designed operating value for full load conditions; except where finite limits exist, eg. level/contents gauges which shall be ranged 0-100%, or where restricted ranges are specified.

A schedule of gauges shall be provided for approval, detailing arrangements, scale ranges, designation label inscriptions and any alarm contacts.

Labels shall be securely attached on or adjacent to each gauge and groups of any such instruments shall be of matching appearance and approved layout.

Pressure gauges shall be of the Bourdon tube or diaphragm type. Each gauge shall incorporate a surge damping device and be fitted with its own stainless steel isolating cock.

Pressure gauges incorporating transducers for remote monitoring shall be damped to provide a steady output. The pressure at the tapping point shall give a direct indication on the gauge as

well as driving the transducer. Any alarm contact settings shall be independent of the transducer function and neither shall interfere with the direct gauge indication.

Temperature gauges shall be of a type suitable for the application with the sensing element mounted within a thermal well. Where specified, the maximum working temperature under full load conditions shall be marked by means of a preset red pointer.

Pumping station water pressure gauges shall have a dial diameter of not less than 100mm and be calibrated in metres head. The gauges shall be uncorrected for datum and show actual pressure at the tapping point. The label bearing the designation given in the gauge schedule shall include the Ordnance Datum level of the tapping point.

Pump delivery and station delivery pressure gauges shall be mounted at a convenient height for reading. Suction and delivery gauges and their isolating cocks may be mounted direct on the tapping bosses and shall be adequately supported.

## 502.2 CURRENT AND VOLTAGE TRANSDUCERS

Current and voltage transducers shall have the following characteristics:

- Class 0.5 accuracy
- 100 ms minimum response time
- Three (3) times nominal current (In) continuous overload for current transducers
- 20% overload for voltage transducers
- Incorrect polarity protection

## 502.3 CAPACITIVE DEVICES

Level monitoring shall be by means of a capacitance electrode suitable for the medium and environmental conditions specified such that the electrode capacitance varies in proportion to the immersed electrode length and be arranged to provide a 4 - 20 mA output proportional to the specified level range on a scaled indicator giving a continuous read out.

Auxiliary switches shall be provided for high level alarm, low level alarm and control of external equipment. The position of all switches being adjustable over the level range.

Any fault in the electrode connection and in the electronic circuits shall provide an electrically isolated alarm signal for remote monitoring.

The electrode housing shall be a heavy duty pattern to IP 68 suitable for 2" flange mounting and incorporate a 20mm ET cable entry. The head shall be removable for cabling and servicing without disturbing the electrode mounting.

## 502.4 PRESSURE TRANSDUCERS

Pressure monitoring shall be by a transducer suitable for the medium and pressure/level range specified herein.

Each transducer shall be ranged to provide adequate sensitivity over the working range and be capable of sustaining a 400% overpressure without damage. They shall be of rugged and waterproof design, employing a pressure sensitive element within a stainless steel enclosure having an isolation diaphragm, suitable for either free wire suspension in the medium or fitted with a BSP thread for external connection to the relevant pipe tapping.

Suspended sensors shall be mounted in accordance with the manufacturer's instructions within a UPVC or HDPPE 'stilling tube' of sufficient nominal bore to enable easy withdrawal of the sensor.

Sensors shall be enclosed to IP 68, offer a long life and shall be supplied complete with a suitable signal cable to reach the approved point of termination transmitter-converter without intermediate joints.

The position of the equipment shall be such that withdrawal and installation can be achieved easily.

Cable entry shall be by integral sealed assembly or by 20mm conduit entry into a sealed watertight terminal enclosure with provision for transducer venting.

A transmitter shall be provided either integral with the transducer or separately mounted as specified, suitable for operation from the mains or battery supply or UPS specified (not greater than 24V) and converting the signals received from the transducer to a 4 - 20 mA signal proportional to the range specified which shall be used as follows:

(i) To drive an indicator/recorder to give a continuous readout;

(ii) To operate separate on/off pre-set adjustable points.

The transmitter shall have provision for range and zero adjustment.

For use in hazardous areas as specified, the units shall be certified intrinsically safe Ex (I).

## 502.5 ULTRASONIC DEVICES

Flow or level monitoring by non-contact ultrasonic measuring devices shall incorporate ambient temperature compensation and adjustable datum setting facilities. Where specified, the output shall be computed to give a flow reading for the given parameters and/or control of pumps.

i. **Transducer** The sensor head shall be protected to IP 68, mounted to provide an unhindered beam path, prevent unwanted reflections, within easy reach of maintenance personnel and, where possible, be clear of flood conditions. For sewer or foul pumping sumps, the units shall be certified intrinsically safe Ex(i) for use in hazardous areas.

ii. **Signal Converter** The converter shall be suitable for operation from the specified power supply and convert the signals received from the sensor head to a 4-20 mA signal proportional to the range specified, to be used as detailed in the Particular Specifications.

The converter shall comprise a base unit and a programming device, all in a polycarbonate enclosure to IP 65. Communication between the programmer and the signal converter shall be in such a manner that the IP rate is not prejudiced.

A minimum of 3½ digit liquid crystal display shall be used to indicate key programming features, settings and output conditions, including flow calculations to BS 3680 for flumes and weirs.

Accuracy of the signal converter shall be better than $\pm$ 1% of reading and shall have the following programmable outputs:

(a) mA proportional to user definable engineering units;
(b) SPDT relay contact output closing upon failure of the signal converter, lost echo or multiple echoes.
(c) off SPDT contact outputs with independently set trip points. These outputs shall be programmed to energise upon high/low level, rate of change or to allow a number of pump sequencing operations. Contacts rated at 5A 240V ac, non-inductive.
(d) Serial port RS 232 for down-loading data.

## 502.6 LEVEL CONTROL

The water level shall be monitored by a system providing the necessary duty set points, each being adjustable over the full range of control required.

To achieve performance stability under all environmental conditions and variations, all necessary signal compensation devices shall be included.

The monitoring system shall be dampened to prevent spurious switching due to transient wave motion but shall respond sufficiently to allow adequate time for plant reaction to stabilize in order to prevent hunting.

The system shall include a duplicate back-up monitoring device or have built-in self monitoring circuitry with alarm facilities.

Any high level settings which may be provided as part of a level control system may be linked with the independent high level alarm sensors specified.

## 502.7 FLOW SWITCH

This flow control device shall have the following characteristics:

- Body in Stainless Steel 316L
- IP65 class of protection according to DIN
- 1/2" and NPT pipe fitting
- 85°C maximum ambient temperature
- 120°C maximum fluid temperature
- Stainless Steel paddle sensing element
- 8A, 250Vac microswitch with switching contacts
- Galvanized steel base plate with ABS cover
- Mounting in all directions

The device shall be supplied with "T" connection to fit the required pipe size.

## 502.8 DIFFERENTIAL PRESSURE SWITCHES

Differential pressure switches shall have contacts with differing "cut-in" and "cut-out" values. The nominal values at which differential pressure switches operate shall be fully adjustable over the whole range of the instrument and the set value shall be clearly indicated by means of a scale and pointer. Contacts of differential pressure switches shall be hermetically sealed.

## 502.9 FLOWMETERS

All meters shall be in accordance with ISO 4064/1.
A flow stabilizing section shall be installed directly upstream all flowmeters.

### 502.9.1 Electro-magnetic Flow Meters

The flowmeters shall be of electro-magnetic inductive type having a DC pulsed field with automatic zero error averaging and low power consumption. They shall have no moving or protruding parts nor cause any restriction in the flow path and be capable of setting adjustments without the need to stop the flow.

Each metering system shall comply with BS 5792 and comprise a flow sensor mounted in the pipework line and a transmitter which degree of protection is IP67, either integrally mounted or remotely located preferably within the main control panel.

The system accuracy shall be a maximum at normal operating flow with an error not more than 0.2% of the reading. When operating in the lower 30% of the meter range, the accuracy shall be within $\pm$0.5%.

a) **Flow sensors** These shall comprise electrodes located in a meter tube which shall be of watertight construction, suitable for operation without loss of accuracy when totally submerged to a depth of 3 metres or even burried into the ground together with the water pipe. Its degree of protection shall be IP68. They will not contain any active components such as amplifiers or memory modules.

The meter tubes shall be made from a non-magnetic material lined with an inert material suitable for the medium. The flow-meter may be flanged or welded ends type. On flanged type the lining shall cover the external parts of both flanges.

The measuring electrodes shall be continuously cleaned by means which do not interrupt the process flow or the measurement. A sensing electrode shall also be provided to detect when the flow meter is not fully charged with liquid.

The flowmeter body shall be effectively bonded by non-corrodible, tinned copper braid links at each end, to the adjacent pipework to ensure a good connection between the body and the metered liquid, an earthing flange being inserted where non-conducting pipework is employed.

**b) Transmitter**

The transmitter shall provide the following minimum functions:

- Conversion of its supply voltage (85 to 260 VAC or 11 to 40 V DC) with galvanic separation up to 500 V in a pulsed signal which feeds the coils in the flow sensor. This method allows the transmitter to compensate for a zero drift of the flowmeter and shall give the flowmeter a perfect zero stability.

- Supervision of the flow sensor: the transmitter shall be able to generate an alarm signal when the following conditions occur:

  - water conductivity below a preset level
  - flow meter empty
  - reverse flow direction

- Output signals to inform the control/display equipment. Thus, the transmitter shall have as a minimum the following independent output signals:

  - Standard analogue current signal 4-20 mA fully isolated from input and other outputs, and where the zero and full scale mA -

value are configurable as well as the measuring range. The range adjustment shall be continuous, and the units shall be configurable in flow engineering units.

This analogue signal shall represent forward and reverse flows.

An output digital signal shall be provided to indicate flow direction.

Moreover, the transmitter shall provide the possibility to switch automatically to a second selected range where the flow is heavily variable; in this case an output contact shall be provided as well to indicate the selected measuring range.

- Serial port for down - loading data.

- Two pulse signals, fully configurable in volume and length. The pulse signals shall be open collector transistors or voltage free contacts.

- Two alarm signals, fully configurable and representing the following error signals (each error signal can be assigned through configuration to the first, the second or none of the two alarm contacts):

  * empty pipe
  * conductivity out of range
  * no signal from electrodes
  * coils broken (open circuit)
  * flow above or below selected alarm level
  * reverse flow direction
  * output pulse frequency above maximum selected rate.

The alarm signals shall be open collector transistors or voltage free contacts.

- One contact input signal, used to reset the built-in flow totaliser, configurable as being enabled or disabled.

- Local, user-friendly indicator, used to inform the operator about the measurement. The indicator shall provide at least the following information and functions:

  - actual flow with direction, in selected units
  - alarm indication with full description
  - selection of total positive, negative and net flow as well as velocity in the pipe and actual flow in percentage of full scale.

- Configuration tool: It consists of a password protected menu from which the operator shall be able to access and set all configurable parameters grouped by function:

  measuring range, totalisers, alarms,..... A test function shall be available as well to test the wiring and the complete configuration.

- Where specified, removable data storage memory, non volatile memory module (EEPROM) chip for instruments data and process data in case of replacement of the

instrument.

**c) Flowmeter Cabling**

Where remote mounted converters are specified, cables shall be provided, installed and terminated between the sensor and converter/ pulse power unit for the following purposes:

flow signal;

reference signal;

coil supply;

Such cables and sealing glands shall be suitable for submersible operation (IP68) of the sensor to the depth specified. The length of each cable shall be as specified.

**d) Spool Piece**

A flanged steel pipe spool piece shall be provided of the same diameter and length as the respective flowmeter and flanged for insertion in the pipe should it be necessary to remove the flowmeter.

Isolating gate valves shall be provided on either side of the flow meter.

**e) Accuracy**

The accuracy of the flowmeter shall be independent of the range which has been selected for the analogue signal and shall be better than 0.2% of the actual measurement. Thus the flowmeter shall be supplied with a calibration certificate mentioning also the pressure at which the meter has been factory tested.

**Note** : the flow test shall be made on a recognised test bench which is traceable to international standards.

### 502.9.2 Differential Pressure Flowmeters

Flowmeters of the differential pressure type shall be designed and installed in compliance with an Approved Standard. Primary devices shall be carrier-ring type orifice assemblies with stainless steel orifice plate, or venturi tubes and shall include two sets of gaskets and fixing

bolts for each primary device. Gasket materials shall be appropriate to the metered fluid and service conditions. Full details of orifice or venturi tube calculations shall be supplied.

An adequate filter unit shall be installed upstream the meter.

Orifices shall be square-edged and concentric. The upstream edges of orifices shall be sufficiently sharp that the reflection of a beam of light from the edge cannot be seen without magnification. Drain holes shall be provided. The diameter ratio shall be between 0.20 and 0.70. Orifice assemblies shall have identification tags showing the direction of flow, orifice

diameter and position of drain hole. The identification tag shall be welded to the plate before the orifice is machined.

Insertion probe type installations shall follow equipment manufacturers recommendations. The probe shall be mounted to a standard sired ferrule or flange plate and include appropriate 3-way valve block.

Differential pressure transmitters and switches shall have over-range protection up to 1.5 times the maximum line pressure.

Location of these devices should be such that no tubulence shall interfere with the measurement of pressure either side of the device.

Signal converter - The sensor shall be of the inductive type giving an output of 4-20m a proportional and the flowrate and a totaliser. The sensor shall be protected to IP66 and having the following characteristics:

- Accuracy: <±0,25% of FSD between 25 & 100% of the flow measured.
- Stability: 6 months period: ±0,25% of FDS
- Voltage supply: 220 V AC
- Sensitivity: < 0,005%/V at 50% flow and more

### 502.9.3 Variable Area Flowmeters

Variable area flowmeters shall have glass or metallic tubes according to the particular application.

An adequate filter unit shall be installed upstream the meter.

Metering tubes shall be removable for range change or cleaning without disassembling the meter or removing it from the line. Metering tubes shall have ends of equal cross-sectional area and if 0 ring seals are used, tube retainer springs shall be outside the fluid stream. End fittings shall be rotatable to any angle. Connections shall be horizontal and plugged vertical openings shall be provided for cleaning purposes.

### 502.9.4 Ultrasonic In-line Flowmeters

The flowmeters shall have flanged steel bodies and be without probes or pressure tappings which can foul or create a disturbance to the flow. The meter performance shall not be affected by emptying of the pipeline, and servicing shall be possible without the need to remove the meter from the pipeline.

The sensor tube and associated equipment shall be capable of withstanding occasional submergence in the flowmetering chambers. The contract shall include for the provision of a 230 V 50 Hz power supply from the nearest distribution panel, and a power pack unit if required for flowmeter operation.

The converter/transmitter unit and the power pack unit shall be housed in a G.R.P. lockable cabinet which may be either pedestal or wall mounted as appropriate to the meter location. The cabinets shall have heaters and thermostats if required to prevent condensation.

The contract shall include for all internal wiring, and for cabling between the flowmeter and cabinet. Where necessary cabling shall be screened to prevent interference.
The transmitter shall give an output signal of 4-20 mA.

The span of the instrument shall be adjustable and the range of each instrument shall be chosen to unit the particular flow range. Meters shall be able to withstand surge flows above the normal operating range. Means shall be provided for check calibrating the meter on site.

The output signals from the flowmeters shall be wired back for indication, integration and recording of flows with provision for future wiring to a telemetry outstation.

Meters on gravity lines will normally have flow, and although this could be low at some times of the day, in practice flow is unlikely to drop below approximately 20% of maximum. The meters on the pumping mains will have flow dependent on the operation of the pumps.

### 502.9.5 Mechanical Flowmeters

Mechanical flowmeters shall be of the helix type and incorporated into a flanged section of pipe.

Tapers shall be provided, or non-standard bearings and propellers, if required, to obtain the specified degree of accuracy at the specified flow rates.

The meters shall be suitable for working pressures up to 16 bar unless otherwise stated.

An extension drive and extended head shall be fitted to meters as required. The drive shaft bearings and gears shall be designed for long life under continuous operation, and normal wear shall not significantly affect the accuracy of the meter.

Meters shall have a circular dial and rate of flow indicator registering flow in units as specified in PTSD. A flow totalizer having at least six digits shall be incorporated in the head. The totalizer shall have a capacity of at least one years flow at maximum flow rate. A multiplying

factor in multiples of 10 may be used in conjunction with the totalizer if required, however if this is the case, the factor shall be clearly marked alongside the register.

The meter bodies shall be in cast iron with a high quality epoxy coatings minimum 150 microns, inside and outside.

An adequate filter unit shall be installed upstream the meter.

Meters shall be individually flow calibrated at the manufacturers works and shall be guaranteed to within ±2% of true flow within the rated range of the meter. Each meter shall be supplied with a calibration certificate.

The coupling between the wet and the dry part (totaliser mechanism) shall be magnetic, fully tamperproof against any external non destructive actions. The totaliser mechanism shall be located in a non plastic housing, preferably copper, and with a solid glass window. It shall be

totally condensation free and waterproof if submersed under 2m of water.

It shall be possible to remove all moving parts from the meter without the necessity to remove the meter body from the pipeline. A blanking plate shall be provided for each meter, if necessary, to allow flow to pass through the meter body when the operating mechanism has been removed.

The spare parts shall include as a minimum spare gearing and bearings for each size of flowmeter used.

Where specified meters shall incorporate a pulsed output unit and data logger connection to enable flow rates to be monitored and transferred for plotting at a remote data port, microcomputer and printer for analysis. However, the totaliser mechanism of all meters shall be pre-equipped to receive a pulse output unit in the future which can be added on site without destroying the seal and without removing the meter or the measuring mechanism. The pulse unit and data module shall be self supporting using dry batteries.

## 503. PROGRAMMABLE LOGIC CONTROLLER (PLC)

### 503.1 DESIGN

These are microprocessor based controllers designed to suit various application needs such as controlling, regulating, monitoring, etc...

They shall be of a proven technology, shall have robust enclosures and shall provide reliable functioning even in locations near sources of electromagnetic interference.

The PLC units could be of an expandable compact or a modular type. PLCs shall cater for analogue and digital inputs/outputs and have serial ports for connection to computer equipment. They shall be capable to accommodate special modules such as intelligent peripheral cards or functional units that operate autonomously.

The PLC units shall be capable of processing complex data at high speed. For large programs, CPUs shall be added to maintain a high processing speed.

PLC shall support hierarchical configurations of control system networks with central operator station.

### 503.2 POWER SUPPLIES

Instrument signals shall operate at 24 VDC, derived from a suitably rated power supply to each PLC or instrument panel section and connected to the I/O terminals as necessary. The power supply units shall be sized such that the total demand does not exceed 75% of the power supply's maximum rating.

### 503.3 PLC SOFTWARE PROGRAMMING

The programming language shall conform to IEC 1131 part III and it could be one of the

following types:

Ladder diagram
Function Chart
Instruction Set

The software development shall be done by the use of a PC for easy programming.

## 503.4 MEMORIES

The PLC memory management system shall include the following memory functions:

a) System memory: for basic software already programmed by the manufacturer to compile the user programs.

b) User memory: It contains the user program, the capacity of this memory shall be determined according to the application.

c) Card memory: to retain information for a specific period in case of communication failure.

## 503.5 COMMUNICATION PORTS

The unit (PLC) supplied shall have at least two communication ports for:

a) Connection of hand-held or portable programming and monitoring unit.

b) Connection to a data highway, telemetry system or other processors.

Item b) shall, unless for reasons of compatibility with existing systems, conform to either RS232 or RS422/RS485 standards.

The contractor shall be responsible for verifying compatibility of communication interfaces and shall provide full details of the protocols used by this system or other systems needing to communicate with it.

## 503.6 WATCHDOG

All PLCs shall be self monitoring and any system failure (or instrumentation failure where appropriate), whether hardware or software derived, shall cause the watchdog relay(s) to de-energise/fail-safe and uninhibit back-up control operation and/or carry out any function as detailed in the functional design specification.

Watchdog status shall be indicated visually on the panel sections and the SSU mimics.

Failure of PLCs shall not leave the associated plant in an unsafe condition or allow a process failure.

### 503.7 INSTALLATION

The installation of PLC units and accessories (communication couplers, modems,etc...) shall be to the manufacturer recommendations.

PLC equipment shall be mounted in secure lockable panels, which may be housed within an instrument panel.

Cables used for PLC unit supply, I/O connections and data communication bus shall be routed in a separate conduit away from any power cables.

### 503.8 HAND-HELD PROGRAMMING UNIT

It shall be supplied where specified in particular specifications. It shall connect to the PLC units through a communication port and shall be able of monitoring and field tuning of operational parameters as well as modifying user programs.

## 504. REMOTE TERMINAL UNITS

### 504.1 DESIGN

Remote Terminal Units (RTU) consist of a number of PLCs as described in the PLC section of the general specification.

The RTU shall transmit a digital report whenever a nominated alarm or analogue change-of-state condition occurs except when periodic interrogation/polling is taking place - then the alarm will report at end of session. The RTU receiver will support acknowledgement messages and periodic interrogation/polling from the SSU. The transceiver equipment shall be specifically designed for use in digital networks and incorporate the following features:

i) Ultra low power consumption.
ii) Sleep and Standby modes.
iii) Hardware and bit synchronisation.

Intercommunication between RTU's will be necessary if they are used as signal repeaters, or if the message handling of the radio network requires the RTU transmissions to be synchronised.

All RTU equipment shall be mounted in secure lockable panels, which may be housed within an instrument panel.

A watchdog system is required at each RTU/process area or group.

### 504.2 POWER SUPPLIES

RTU equipment shall operate from the specified site U.P.S., however, at locations where power is not available, then batteries charged from solar panels may be designated as the electrical

supply source.

90 minutes full function battery backup including continuous battery charging equipment shall be provided for each RTU unit and the signals required for monitoring and control at 24V DC, 110V AC and any other voltage used for instrumentation.

### 504.3 MEMORY

The RTU unit shall have sufficient memory capacity such that in the event of a communications failure, information shall be retained for a minimum of two weeks with normal digital event/alarm density and all analogues at 15 minutes sample rate.

## 505. CONTROL SYSTEMS

### 505.1 OVERVIEW

A fully instrumented control scheme utilising distributed control systems, where particularly specified, shall be provided for monitoring, controlling and retrieving data from the plant. Sufficient instrumentation and hardware interfaces shall be installed to enable the control system to automatically control the process and provide sufficient information for the plant performance to be monitored.

The control system shall consist of a PC based, System Supervisory Unit (SSU) at a specified location (control center) and a number of remote terminal units (RTU's).

Each RTU shall be capable of autonomous operation without reference to the central computer, but shall collect and transfer plant and process data and accept control or programming information from the central computer, (ON/OFF commands, analog set points, counter index setting). Data is collected by sensors connected to the RTUs, and commands are dispatched to controlling elements also connected to the RTUs.

User facilities provided at the System Supervisory Unit shall include but are not restricted to:

- presentation of current data via VDU mimic diagrams and hard copy;
- display and acceptance of alarms;
- presentation of historical data via VDU graphics and hard copy;
- manual input of information/data (eg. operator's log, chemical analysis, etc);
- management summary reports.

Access to such facilities shall be presented in a manner which requires no programming experience.

All processes shall be Software controlled through microprocessor based controllers (PLC, ...). All plant shall be monitored through local telemetry units to display status/alarms at the SSU.

Safety, emergency and high priority signals must be independent of the software based control system. The Contractor shall review the control system at each stage of the design and provide all required inhibits.

All inhibit status shall be indicated visually, on the panel sections and SSU database/mimics and all alarm signals shall be hard-wired to annunciators.

The control system shall be designed for automatic and manual operation.

## 505.2 DATA ACQUISITION AND RESTITUTION OF COMMANDS

### 505.2.1 Data acquisition

Data acquisition depends mainly on the adopted communication protocol and the type of network (permanent links or public switched telephone network).

The computer system allows the data acquisition in real time (without time logging) or deferred time (with time logging) in a user-transparent way.

Data acquired by the Center are logic states, analog measurements, counter values, events (alarms, change-of-state), measurements or counters recording.

### 505.2.2 Faults and Alarms Detection

The Center detects any change-of-state which generates an alarm and the reversion to the normal state.

The Center verifies that it receives from each station significant information at a sufficient frequency. The maximum response time is configurable for each station. Should the period be exceeded an alarm shall be initiated. With query / response protocols, transmission faults could be managed as alarm triggering events.

The Center monitors the execution time of remote commands (remote On/Off commands, remote setpoints, counter index setting) where specified in the configuration : it compares the issued command to the expected result and initiates an alarm, should the discrepancy last more than the maximum specified execution time.

### 505.2.3 Data Restitution

The user can intervene on the process from the Center, by sending information to the local units which modify the actuators operation. These information are as follows:

- remote controls, logic type information, which allow the modification of equipment status, such as, fixed speed pumps.

- remote setpoints, analog type information, which allow the adjustment of an equipment operation variables, such as the valve position or the speed of a variable speed pump.

- remote values, digital type information, which allow the modification of the counter index setting or the transmission of any value used by the local unit during its operation (e.g. a coefficient).

## 505.3 SYSTEM PERFORMANCE

The system must be capable of accommodating the full Input/Output configuration including all options with spare I/O per outstation of 20%. In this fully expanded mode the following performance figures shall apply:

a) VDU mimic update and regeneration - 10 secs max.

b) Maximum time from field alarm or status event (eg. contact closing) to report on printer/VDU shall be 20 seconds.

c) Maximum time from completing a request to change an output to the output activating shall be 20 seconds.

## 505.4 POWER FAILURES/BACK-UP/RESTART

In the event of power failure, the entire system of control centre and distributed outstations shall restart automatically upon resumption of the supply. By a series of interrogative commands, the outstations shall determine the position in the cycle which the process had reached at the instant of interruption and shall resume control at an agreed point.

The central computer shall have an uninterruptible power supply to enable the components defined in the Particular Specifications to function properly during a power supply failure of 30 minutes unless otherwise specified.

Memories for outstation plcs shall be provided with battery back-up facilities for the same duration or as otherwise specified.

## 505.5 OPERATIONAL CONSIDERATIONS

System users and control room operators must not be expected, or need, to have other than a superficial knowledge of computer usage.

The main methods of operator access will be via qwerty-based keyboard(s) and cursor control device (mouse) with which to point and select commands.

Operator facilities shall be available to the user in menu format. The need for the normal operational user to access the host computer's operating system shall be avoided in day to day operation.

## 505.6 EXPANSION

The system shall be designed to allow for expansion. The ultimate capability of the system shall not be constrained by the initially installed hardware and software.

As a minimum, expansion should be allowed for in the following areas:

a) Number of RTU's to be addressed and polled
b) Number and type of points to be defined, addressed and polled
c) Range of functions to be processed
d) Number and type of peripherals to be driven
e) Amount of memory to be addressed
f) Ability to expand the control output functions of the system as a whole without reference to the Vendor for sophisticated equipment, licences, etc.

## 505.7 RELIABILITY

The system hardware and software shall demonstrate a high level of reliability.

The application software shall prevent the input of illegal or undefined commands, prevent system lock up and have a constantly available recovery mechanism for the user.

A key design principle must be that of graceful degradation, with the ability to maintain the maximum degree of control for the maximum time under fault conditions. The loss of facilities should, as far as possible, be isolated on the principle of damage containment and shall fail in the safe mode at all times.

## 505.8 OPERATING PARAMETERS

Initially the system will be operated with the operating parameters being fixed on a first estimate basis, but as information is accumulated these operating parameters will be fine tuned. All operating parameters shall be software controlled and are identified in the text by 'OP'.

## 505.9 PROCESS AREAS

For control purposes, the works shall be sub-divided into process areas by the Contractor, typically as indicated in the Particular Specifications.

These areas shall not necessarily be the locations of the RTU's. It may be possible to use a single outstation to control and monitor a number of areas; alternatively, more than one RTU may be required for a particular area.

Instrumentation, motor starters, actuators and electrically operated items of equipment shall be connected to each RTU as appropriate, which shall control and monitor its process area without reference to the SSU. Therefore the system software shall reside for each area in the RTU's but changes of control operating parameters shall be possible only from the SSU (under normal conditions). All plant data shall be routed to the SSU through the RTU's via either a radial or loop configuration depending upon the relative suitability of the equipment being offered. This data highway may be hardwired, fibre optic or radio based.

Process data between area RTU's shall continue uninterrupted in the event of an SSU failure. Should the SSU fail or the RTU/SSU link break, the RTU shall be able to continue to control the plant area using the last operating parameters settings/process data until the link is restored or the OP's are changed with a portable unit.

In the event of the RTU failing the watchdog systems under each process area shall operate.

## 505.10 ORGANIZATION

The operator shall locate each datum geographically through a hierarchical structure consisting of a ″network″, a ″front end processor″, a ″station″, and a ″channel″.

### 505.10.1 Network

A network is constituted by the local units communicating with the center via one same asynchronous serial line. Local units in one network have the same communication protocol.

However, different networks may support different protocols. The computer system shall support, as a minimum, the number of networks specified in the Particular Technical Specifications Document.

### 505.10.2 Front end processor

A front end processor manages communications with PLC's or transmitters, is compatible with and can support all communication links.

Data exchange between the front end processor or the station and the Center is governed by a communication protocol. The software shall be designed to allow for the installation of new protocols.

### 505.10.3 Station

The available data block in a front end processor may be sub-divided into ″stations″ representing either a functional unit or a particular local unit (RTU). This subdivision allows the system query with selection criteria.

### 505.10.4 Channel

A channel is a logic, analog or digital input or output. There are six types of channels.

- a signalling : logic input
- a command : logic output
- a measurement : analog input
- a counter value : digital input
- a setting : digital output.

## 505.11 MANAGEMENT REPORTS

An essential part of the monitoring mode shall be the production of management reports, for which data processing will be carried out at the SSU. The logging interval and signal value, instantaneous or average over the logging period, will be determined by the management report

requirements.

## 505.12 COMPLIANCE WITH SPECIFICATION AND STANDARDS

The following documents shall be used and complied within the design and installation of the control system and instrumentation:

a) IEE - Guidelines for the documentation of computer software,

b) BS 6739 - Instrumentation in process control systems,

c) The relevant European or International Standard shall be used for any item, installation or application.

d) ISO 9000 standards.

Where a particular specification has been identified in a detailed clause it shall be complied with in conjunction with the above. Any contradictions found should be notified to the Engineer.

### 505.13 TRAINING

The Contract shall include for the training of the Purchaser's staff in the operation and maintenance of the system.

This shall take the form of a structured training programme and shall include the costs of all course materials.

Details shall be provided in the Schedule of Particulars of the training facilities offered.

The following aspects shall be included:

On-Line Training: Using built-in simulators with plant operational or non-operational.
Off-Line Training: Using off-line simulators.

Documentation: The provision of high quality documentation for training giving explicit and easy to understand step-by-step procedures, with explanatory diagrams, flowcharts and examples.

## 506. SYSTEM HARDWARE

### 506.1 DESIGN

The System Supervisory Unit shall incorporate microprocessor based units of suitable operating and storage capacity to provide the specified data handling, processing and graphics performance and having non volatile or on-board battery supported RAM and hard disk data storage capacity together with dual drive 3.5" 1.4 megabyte floppy disk drives, tape streamer, CD drive, 4 serial and 2 parallel ports. The disk operating system shall be provided with full documentation and spare copy. Full auto-restart after power failure is required, without manual intervention.

Hard disk data archive capacity shall be sufficient for 180 days on line availability at least. Each day over 180 days, the oldest data shall be overwritten by the latest information automatically. Both RAM and hard disk shall have 100% spare capacity in excess of max working load to allow for system development in the future.

The computer, hard disk, floppy disk and tape streamer shall be supplied in one integral unit. All devices shall be easily accessible from the front of the supervisory unit.

### 506.2 VISUAL DISPLAY UNITS

VDU's shall be 21 inch SVGA colour monitor screens in an anti-glare finish enclosure, matching that of the computer system supplied. The VDU shall have a frequency range suitable for the computer system supplied and shall be capable of displaying information in alpha-numeric and graphic form from a minimum of eight foreground and background colours. Characters shall be legibly and stably displayed. The unit shall include all necessary adjustable

picture controls to adjust the image.

### 506.3 KEYBOARDS

Keyboards shall be a low profile standard QWERTY pattern, complete with all necessary special function keys. The function keys shall be clearly labelled with any symbols or descriptions necessary, and those dedicated for reconfiguration shall be supplied with means of preventing unauthorised operation. The keyboard shall be a separate, free standing unit suitable for desk top mounting and shall have an ergonomical form design.

### 506.4 PRINTERS

Printers shall be robust and designed for continuous duty, capable of supporting alphanumeric and graphic output and shall be fully compatible with the character and graphic sets of the computer system supplied. Both serial (RS232) and Centronics parallel interfaces shall be supplied, along with a minimum printer buffer size of 2 Mb. The printer shall offer both

tractor and single sheet paper feeds without user modification. Text character printers for status report logging and alarm logging shall be at least 25 pin dot matrix pattern. They shall print in black with alarm messages in red at a speed of at least 150 ch/s (NLQ) on A4 size, fan-folded paper collected in a paper tray.

Colour graphics printers shall have A4 media size capability, with manual feed of cut-sheet paper and film or sprocket feed of 2-fold paper. The printer shall be a thermal inkjet drop-on-demand type having a graphics resolution of 600 x 600 dpi and near-letter quality (NLQ) text printout of 234 characters per second at 10 pitch. Graphics print speed on paper should be 0.5 minute or less and 1 minute or less on film.

Print cartridges shall be interchangeable to allow both colour and black printouts and the software shall permit a choice of font types and sizes including Roman, Letter Gothic and Courier with between 8-12 pitch print size.

### 506.5 MODEMS

Modems shall conform to Bell or CCITT standards. They shall provide full support to Data Terminating Equipment. Modems could be rack mounted type or stand alone type and shall have the following characteristics:

- External power supply: 220V AC
- Operating conditions: -5 °C to 55 °C
- Microprocessor based
- High data communication rate
- Synchronous/Asynchronous operation
- Data compression
- Error detection and correction
- Full and half duplex operation
- Data format: serial, binary
- Serial data interface: RS 232 unless otherwise specified

- Remote configuration capability through the network management system
- Automatic feature negotiation that selects the best combination of speed, error control and data compression.
- Password and callback security to control unauthorized access to attached Data Terminal Equipment
- Front panel password
- Help screens and visual indicators
- Diagnostics: Local digital and analogue loopback, remote digital loopback
- At - Command Set - support
- Volume controlled speaker
- Non volatile memory for the storage of configurations

Line modems shall support tone and pulse dialing and have an auto answer capability and hang-up control via the RS 232 interface. They shall support switched modem carriers for remote applications. The transmit level shall be maximum -9 dBm or as required by the PTT. The receiver sensitivity shall be -43 dBm.

Radio modems shall be of an integrated unit type (digital data modem with a radio transceiver).

### 506.6 MIMIC PANEL

The mimic panel allows the supervisor to have a global view of the installation configuration and the states of the various components represented by symbolic schematics.

It shall be an engraved panel, a relief panel or a panel with a painted front side.

#### 506.6.1 Engraved Panel

In this type of panels, the front side shall be made of methacrylate (Plexiglas), and shall be smooth, polished, translucent and varnished or mechanically polished to prevent reflection.

Engraving and paint shall be performed on the rear side.

The front side shall be completely smooth showing no unevenness. However, it is possible to slot signalling lamps and operating devices into the front side.

Each unit shall have a maximum size of 3000 x 1400 mm. For larger surfaces, the panel shall consist of several modular units.

Panels shall have fitted inside, the front side and the rear, a polyester tracing design representing the circuit identification charts to facilitate any future modification.

The signalling system shall be placed on the rear side with or without a plexi rear supporting plate and may comprise: continuous tracks, dot lights of different shapes, lighting surfaces, and the animation system.

It is possible to use the 3 following signalling types:
- MLD lamps (multileds)
- Incandescent lamps

- Fluorescent tubes located in a box at the rear side, for lighting the whole panel.

### 506.6.2 Panel with a front side or relief panel

The front side of these panels shall consist of plastic or metal elements.

a) Plastic elements shall be fixed on a checkered base, a painted sheet, or a methacrylate surface,...

   Following are the materials to be used:

   - Painted ABS, thickness 2 mm
   - Painted PVC, thickness 5/10 mm self adhesive according to a chart of colours or samples.

   - METHACRYLATE (Plexiglas, perspex, altuglass, etc,..) thickness 3 mm, tinted according to the manufacturer's schedule of colours.

   The fixing shall be carried out:

   - on checkered and methacrylate base,
   - through a chemical reaction
   - on sheet with adequate binding agents absorbing the differences due to the materials expansions.

b) Metal parts shall only be fixed on sheet bases. Anodized painted aluminium or chromium brass (thickness 3 or 4 mm) shall be used. These elements shall be bolted to the front side.

In either cases, the modification shall be carried out on site; the signalling system shall consist of flooding lamps with light transmission tube made of methacrylate.

The lighting type shall be multiled or incandescent.

### 506.6.3 Panel with a painted front side

The front side shall be executed on a checkered or painted sheet or methacrylate surface. This technique is suitable for panels with inserted operation and control devices. The front side may be polished, glazed or mat by applying a scratch-proof varnish, ensuring an excellent protection.

The signalling system shall be identical to that described above. The panel shall comprise all devices and main conduits of the installation. It shall be entirely painted according to the project submitted before execution to the Engineer for approval. Each motor shall be represented by a red signalling lamp showing its operation. This signalling lamp shall flicker in case of thermal fault.

Lamp test button shall be installed as well.

# 507. SCADA SYSTEM

## 507.1 MODES AND FUNCTIONS

The complete software package shall enable the system to function in accordance with the Functional Design Specification (FDS) and allow for the addition of future software tasks (e.g. monitoring of other process parameters) as and when required. The software shall therefore be written in a structured manner with a core of control routines that can be accessed by additional programme routines without having to rewrite the basic process control software.

## 507.2 ENVIRONMENT

The software conforms with the current main standards and uses the following packages:

- operating system
- database management system
- spread sheet
- graphic library
- graphic package.

The software is an OPEN system since it shall include a real-time acquisition database, thus allowing other applications (mathematic models, leakage detection, etc ...) to easily retrieve stored data and carry out very specific processings.

The software shall include an independent utility program running under DOS (UNIX) designed to convert stored data into a compact format such as a text or compatible formats with other packages such as EXCEL, ACCESS, etc ...

This utility program shall allow to sort data according to the following selection criteria:

- source station
- variable type : logic, analog, counter
- variable number
- date and time specifying the beginning and the end of a period.

Sorted data only are converted into the selected format.
This utility program shall not be run on the computer used for supervision. However, it can co-exist with the configuration function and other packages, especially those allowing to exploit the stored data.

The system includes all ETHERNET software layers and allows distributed Client / Server architectures.
Moreover, such system can be run under Windows (latest version) allowing operators to open simultaneously Windows work sessions (Excel, Word, ...).

The operating system being the latest version of DOS or UNIX or other approved O.S.

## 507.3 SYSTEM SECURITY

Security of the system shall be provided by allocation of passwords and varying degrees of privilege (eg. operator, supervisor, system engineer/manager). By default, there is no password. The configuration software allows to create a password by selecting the corresponding item within the Edit menu. The selection box will then open, showing the passwords various access levels and their respective poke points. The selection of a level shall open a dialogue box which will prompt the user to input the correct password. Passwords shall also be required before deletion of data or other operator actions which may cause serious malfunction or loss of data by inadvertent action required for a managerial function. Any successful or unsuccessful change in security level shall be logged. Passwords shall be blanked on the screen during entry, and should be confirmed for validation.

The software shall be capable of providing at least three levels of operation:

1) for operations personnel to monitor and control the plant (where applicable);

2) for the supervisor to change parameters

3) to enable a designated engineer to modify or add new sequence programmes or run diagnostic programmes. These procedures shall be carried out with the minimum disruption to the system.

Supervisors and Engineer's mode shall be selectable only after a unique password/key system has been satisfied for each user.

## 507.4 DATA PROCESSING

The basic processing of acquired data carried out by the system software (or Telemanagement Center) will provide the operators and managers with elaborated information, and generate information calculated from the acquired data.

### 507.4.1 Measurements

Following are the various basic processings of measurements:

- Correctness check
- Conversion
- Threshold detection
- Minima and maxima management
- Inhibition.

- Correctness check

The purpose of correctness checks is to verify that the measurement signal generated by standard output sensors (4-20 mA or 0-20 mA) is within the expected range, otherwise an alarm will be initiated and the measurement value frozen.

- Conversion

The value of a measurement sent by a PLC or an RTU shall be converted into a real value in terms of the configured maximum and minimum of the scale and the adopted resolution.

Consequently, a conversion formula shall be applied to each measurement to deduce the data real value. This configuration allows the establishment of simple as well as very complex conversion formulas.

- Threshold detection

Each measurement shall have a high and a low configured threshold. A dead band, adjustable around each threshold's theoretical value ensures a hysteresis to stabilize the detection of the threshold overstepping. Each threshold can have three configured detection modes:

- No detection
- Threshold overstepping (high or low)
- Overstepping of a high threshold and a low threshold.
- Absolute Minima and Maxima

At each data acquisition, the value of a measurement is compared to the minimal and maximal values recorded during previous data acquisitions. If the threshold is overstepped the minimum or maximum is updated.

- Inhibition

A measurement can be inhibited by means of a logic input. When the logic input is active, the measurement shall not be further processed and the value of the relevant channel will be frozen (ex : inhibition of a measurement due to a sensor failure). Declaring a measurement ″out of operation″ shall have the same effect as inhibition.

### 507.4.2 Setpoints

Setpoints and analog measurements have identical descriptors. Setpoints basic processings are the following:

- Execution control
- Inhibition.

- Execution control

Once a setpoint is modified, and received by the front end processor, the Center shall control that the absolute value of the setpoint deviation in comparison with the associated adjusted

variable becomes, after a configurable time, inferior to a configurable value; otherwise an alarm shall be initiated.

However, to prevent any disturbance to the operation of the adjusted equipment, the operator cannot modify a setpoint having an increment superior to a configured value (″hysteresis setpoint″).

– Inhibition

A setpoint can be inhibited by a logic input. When the latter is active, the setpoint cannot be transmitted to the local units.

### 507.4.3 Signalling

A signalling is a logic input; it could be a simple signalling, an alarm or an internal logic calculation.

The basic processings of logic information are:

– Operating time counting
– Status counting
– Inhibition.

– Operating time counting

An operating time counter can be associated to a real-time acquired logic input channel, to allow the calculation of the equipment operating time (ex: running time of a pump). The sampling period of the related channel status is configurable to 60, 180, 300 or 900 seconds or more.

– Status counting

A change-of-state counter can be associated to a real-time acquired logic input channel. According to the configuration, the counter determines :

– the number of passages to the active state
– the number of passages to the non-active state
– the number of changes-of-state.

Such a counter can be reset periodically or not; at hourly, daily or weekly intervals. The counter value shall be printed prior to any reset.

– Inhibition

An input channel can be inhibited by another logic information. When the latter is active, the data shall not be further processed.

The operator can, as well, inhibit the logic channel by declaring it ″out of operation″.

### 507.4.4 Counters

Digital information shall be subject to the following basic processings :

- Conversion
- Detection of alarm values
- Inhibition.

- Conversion

The acquired real value of a counter can be calculated by applying the following formula:

$$\text{Counter value} = (\text{acquired value} \times \text{coefficient}) + \text{Initial value}$$

The initial value and the coefficient are user configurable.

- Detection of alarm values

An alarm value can be associated to each counter. When this value is reached, an alarm is initiated and the message edited on the selected peripherals. For operation time counting, the message is re-edited daily until another threshold is set by the operator. This processing indicates after a configurable operation time the need for maintenance.

- Inhibition

A counter can be inhibited by a logic input channel. When the latter is active, the counter shall receive no further processing. Its value is frozen. The operator can also inhibit the counter by declaring it ″out of operation″.

### 507.4.5 Calculation

A data can be calculated from one to eight acquired or already calculated data, of whatever type (logic, analog, digital). The available calculation operations are : the four basic operations (+, –, ×, ÷) and the integral. The calculation period of each formula can be parameterized at 15, 30, 60, 120, 300, 900 seconds or more. Each result can be of whatever type and have a channel record like the acquired data.

Thus, calculation results can be subject to the same processings as the data (including storage).

N.B.: Integrals can be computed at an hourly, daily or weekly interval, and be reset at the end of the interval.

## 507.5 DATA STORAGE

All data shall be stored on the PC’s hard disk drives. Data required for management reports

shall be copied onto floppy disks on a selectable, regular basis and logged as an event and indicated to the operator.

The whole system shall be backed-up on to the tape streamer in a similar manner.

Acquired data, calculation results and historical events are stored in a relational database to allow for consultation and on line processing, or transfer to other systems (ex : Excel spread sheet under windows).

### 507.5.1 Values storage

The system can store the values acquired in real or deferred time. Stored values are either logic states, analog or digital values.

Analog and digital values are stored, periodically, or incrementally according to the evolution of processed values, or through data files in the event of a local storage in the PLC or the local data acquisition unit. The incremental mode activates the storage of a data if the latter has varied of a configurable minimal increment, and allows the sampling at variable time intervals.

The new state of logic values is stored at each change of state.

Each stored record includes the following data:

- data reference
- date
- data value (in real units)
- data status (valid, invalid).

Storage time, which is operator configurable and could reach 13 months on line, depends mainly upon the number of stored data, the storage frequency and the disk available free space.

The user can have access to database files for data query, specific reports, etc ... by using the database standard query language. He could also have access to the files to execute configured production reports, or draw curves on a colour graphic screen. Utility programs can also copy data on an ASCII format file and use them via standard spread sheet (EXCEL, LOTUS, ...).

### 507.5.2 Events storage

The software creates on the hard disk a daily log file where detected events (change-of-state, threshold overstepping, fault, ...) are saved as they are received regardless of their type. The relevant variable configuration shall determine whether to store a certain datum or not. Stored data are time-logged. A file comprising the local database is automatically associated to each daily log file in order to store the configuration parameters of the same day which shall be used in processing the stored data.

Following are the various types of data that could be stored:

- on/off events (change-of-states, appearance & disappearance of alarms)

- samples of analog values (recordings of measurements transmitted in deferred time, instantaneous images transmitted regularly in real time or analog events)
- counter readings.

The storage time is conditional upon the size of the hard disk and the volume of data to be stored daily. It is a constant, expressed in days, and may be modified within certain limits.

Outdated files (storage and database) are purged automatically upon expiry of the storage period. Such files may be stored on diskettes for future use.

### 507.5.3 Saving/Retrieval

Saving consists in copying on external magnetic support (floppy disk or magnetic tape) relevant data.

The files of the configuration database (description of data, mimics, curves, menus, logs, events, ...) and those of the storage database can be saved upon request.

## 507.6 USER INTERFACE

The operator communicates with the system to configure his application, consult data in real or deferred time, monitor the evolution of some data, command the printing or saving of other data, transmit remote commands, setpoints or values. Such interface is done through an operator dialog allowing a simple and quick access to the selected functionality.

The user dialog includes:

- pull down menus
- dialogs with:
  - acquisition lines
  - file selection boxes with scroll bars
  - poke points (such as push-buttons)
  - check boxes (such as in a form)
  - option buttons (such as mutual exclusion keyboards)
  - confirmation, information or error message boxes
  - standard use of the keyboard and mouse.

The status line is reserved for permanent display of the following:

- information on the communication with the front end processor (brief analysis of the protocol)
- availability of printer
- availability of hard disk
- availability of modem
- number of unacknowledged alarms (present or disappeared)
- number of unacknowledged ″stations″ faults (present or disappeared)
- number of present and unacknowledged ″remote commands″ faults
- a normal operation indicator (number of running tasks, flickering in normal operation)

Time, date and available free memory are displayed permanently.

There are three access levels corresponding to three levels of responsibilities from higher to lower: ″configuration″, ″remote control″, and ″consultation″.

The 2 higher levels are protected by a password. The access to a level entitles the access to the lower level. For example, the access to the ″configuration″ level gives access to both ″remote control″ and ″consultation″ levels. Password protection is a configuration option.

Following are the three responsibility levels that can be protected by passwords:

- administrator (System engineer).
- supervisor.
- duty staff (operator).

The administrator sets up the system configuration, back-up, extension, and the operator mode configuration.

The supervisor controls and monitors the installation through the supervisors menus configured by the administrator. It is possible to define several supervisors, having each access to a different function.

The main work of the duty staff (operator) is to be aware of, and acknowledge alarms.

### 507.6.1 Administrator (functions accessible at the ″configuration″ level)

The administrator sets up the system's configuration and monitors the evolution of the application. He prepares especially the operator mode, i.e. the system usual management organization.

The application configuration informs the descriptors of each elementary information. A descriptor allows the location and the definition of an information characteristics and required processing.

Elementary data may be defined from the data configuration, namely:

- networks
- slaves
- stations
- analog data
- digital data
- logic data.

Descriptors are stored in the configuration database files. Such function allows, especially, the programming of internal calculations carried out from other data, and the definition of the type of work of each peripheral connected to the Center (continuous printing, reports, log).

Upon the complete configuration of the application, the administrator can, during the system usual management, modify on line all the configuration parameters of one or a set of

information. Such modifications are taken into account immediately by the system and can be recorded on the on-line printer.

The application should be re-run only to take into account any added or deleted data.

The administrator is also responsible for the definition of the menus nesting in the supervisor mode, and the configuration of logs, menus, reports, ... put at the disposal of the supervisor for the network operation.

All functions accessible at the ″remote control″ level are obviously accessible at the ″configuration″ level. The operator authorized to this level can also create or modify on line, that is, when the other tasks of the application are running, the configuration parameters of the local database. The supervisor can carry out only minor modifications of this database (ex : during start-up or changing of password). He can exit to the operating system (DOS or UNIX) without quitting the application to execute commands under DOS or UNIX i.e. delete files or formatting diskettes.

### 507.6.2 Supervisor (functions accessible at the ″remote control″ level)

The supervisor is the daily user of the system: the user interface allows him to pilot his installation from the menu appearing on the screen, by simply using the mouse or the keyboard.

The supervisor having access to the ″remote control″ level can have access to all functions determined in the ″consultation″ level. He can also send remote ON/OFF commands, setpoints, and commands for counter index setting. One message can hold several commands of the same type issued to the same station.

#### 507.6.2.1 Consultation

The system consultation allows the supervisor to have either access to the instantaneous values of a number of information or to follow the evolution of several data in the form of logs or menus.

Data query may be pre-programmed by the administrator and configured in the consultation menu or specifically formulated by the supervisor through selection criteria (by function, station, channel ...).

#### 507.6.2.2 Alarms

The supervisor can request the selected list for each duty staff area :

- of all alarms
- of present and not acknowledged alarms
- of present and acknowledged alarms
- of absent and not acknowledged alarms

- of current duty staff calls.

Alarms are acknowledged one after the other or simultaneously for a same area. Acknowledgment is recorded on an on-line printer.

#### 507.6.2.3 Events

The call of the events dialog box allows to search for events stored in the daily files present on the hard disk according to different selection criteria (a station mnemonic, number of the channel, type of event, hours and dates of search, ...). Search result may be displayed on screen or printed. This command allows a simple and quick analysis of occurring faults.

#### 507.6.2.4 Maintenance

The list of machines and equipment requiring maintenance and their operation time list provide maintenance personnel with necessary information for maintenance and future replacements.

A maintenance log is edited automatically if one, or several equipment operation time has overstepped the configured alarm value.

#### 507.6.2.5 Remote management

Remote management consists in sending, to Local Units, remote commands, setpoints or values. Commands are sent either directly from a colour graphic mimic by selecting with the mouse the relevant equipment (with or without confirmation request as configured at the time of the image definition) or from the keyboard of the console. Therefore, the request to send an information displays a pop-up dialog box and the supervisor shall fill in the references and the relevant instruction value.

The Center controls the execution of remote commands or setpoints regardless of the mode used for sending commands. If the instruction is not correctly executed, an alarm message is generated and recorded on the on-line printer.

#### 507.6.2.6 Exploitation of stored data

Following are the required basic operations:

- size of the database files
- general status (list of stored data)
- status of each station
- stored values for a datum between two dates.

Such operations are executed by using the standard tools of a database; this allows the supervisor to create specific reports.

### 507.6.3 Duty-staff (functions accessible at the "consultation" level)

This user is authorized only to consult the different data types gathered in the following lists or pages:

- list of stations (PLC's or transmitters) with the indication of their status (not in use, not initialized, normal, fault)

- list of stations data points (or variables) with the indication of the last received time-logged value

- list of alarms: present and not acknowledged, and disappeared and not acknowledged

- list of running commands with a fault signal in case the normal delay limit is exceeded

- log of events

- page of data, configured upon request, holding information sent by different stations (i.e. a page gathering all the reservoirs levels of a network).

The ″consultation″ level allows the acknowledgement of alarms, stations faults (prolonged absence of communication) and faults in the execution of commands.

For each of the above-mentioned, and regardless of the selected view, a highlighted indication of the number of faults or unacknowledged alarms shall be displayed in the status line.

The duty staff can also consult stations to refresh data upon request. It is possible to query in a same station, all the variables, a block of variables or an isolated variable.

This level authorizes such agent to consult stored data, and save storage files and related configuration files on floppy disks. Stored data can be consulted by selecting a station, a variable and a date. The list of time-logged values can be printed upon request.

## 507.7 DUTY STAFF

Outside normal working hours, and in the major part of the installation, there are no supervisors in the Center. Major failures which might endanger the operation of installations are reported to the duty staff who shall act according to the notified instruction. Notification of duty staff is through the telephone (public switched telephone network and/or mobile phone).

### 507.7.1 Duty staff management

This function consists in transmitting to the duty staff processed data from the Center at the occurrence of determined events, such as major faults in terms of:

- date and hour of alarm appearance
- geographical area of alarm.

Information used to reach duty staff are held in a duty staff database configured by the administrator and including the following information:

- a table including, for each described area, a label, description of the area, datum references for inhibiting the duty staff function.

- a monthly schedule for each duty staff area consisting of 31 daily sheets, each having distinct hourly periods; each period being associated to a different duty staff

- a log describing the teams of duty staff; each staff may consist of several agents.

- a log describing the agents shall include:
  - name of agent
  - communication link
  - telephone number
  - deferred duty staff option.

The schedule is set for a one month period and is automatically reapplied if no modification occurs.

Upon appearance of an alarm requiring a duty staff, the Center consults the schedule to verify whether it is a duty staff period. In this case, the system locates the area and the relevant on-call duty staff. The first agent is called, and then the others, should the call remain unanswered. Each call attempt is printed out and stored in the events file.

If the system fails to reach the entire team on duty, the call is repeated after a preset time. Such call can be deferred according to the alarm importance and time of appearance.

### 507.7.2 Remote consultation

During a duty staff call, any supervisor aware of the access code can consult the system data remotely through a remote terminal with an autodialing modem. The interface is identical to that obtained when locally connected to the system console.

## 507.8 CONFIGURATION FUNCTIONS

Configuration shall use an independent software running under DOS, WINDOWS or UNIX on a desktop or a laptop computer which allows to set parameters for the supervision of a determined application. As in the supervision, the user interface uses pull down menus, dialog boxes and the mouse.

Such software is usually used by the author of the application and not the supervisors.

Configuration parameters, as well as the values of logic, analog and counter variables constitute the resident database of the application. This database is stored in a file, then loaded in the central memory as supervision instructions are launched. Variable values are set by default. It is of utmost priority to save such file.

### 507.8.1 Creation of a library of labels

The software includes a library of standard labels:

- name of parameters (″level″, ″flow″, ...)
- common names of machines (″pump″, ″valve″, ...)
- name of measurement units (″m″, ″$m^3$″, ″$m^3/h$″, ″ppm″, ...)

- status qualifiers (″On″, ″off″, ″fault″, ...)
- paragraph delimiters (″****″,″----″,″_____″,″....″).

Every user can customize such library by creating new labels or modifying the existing ones. Labels, except for paragraph delimiters can be modified. A label cannot be destroyed. The labels are classified and listed according to the ASCII characters order.

Every user can create his own library of labels.

### 507.8.2 System parameter setting

The system parameters are data which mainly describe the interface between the Center and the network. They depend greatly on the protocol. They describe mainly the characteristics of the asynchronous serial link with the front end processor.

### 507.8.3 Creation of pages

Pages can be created by giving them a name that shall be used during the configuration of the variables in order to indicate the pages where they could be displayed. Hence, it is possible to create a page named “RESERVOIRS LEVELS” where shall be listed all the latest acquired values of the reservoirs levels.

### 507.8.4 Creation of stations

The creation of a station consists in identifying it with a label to which is associated an identification number dependent on the adopted protocol, and defining some of its general parameters such as the analog - to - digital conversion resolution.

The user/supervisor shall be guided by two dialog boxes:

- the list box holding the alphabetical list of all created stations
- the edit box or the modification box of the station description.

By just executing the above-mentioned operation, the created station will remain empty unless all the constituent variables are described.

Creating first all stations in a network and then describing their respective variables shall be possible. This seemingly natural method - since it describes first the network - is not the most judicious, however, because the configuration allows the duplication of a station along with all the described variables. In fact, an installation consists often of stations of limited types; all stations of a given type being identical or very similar. The best procedure is to describe wholly the most representative station of each type and its variables, then duplicate it, and enter the eventual modifications on a case by case basis.

The list dialog box allows to delete a station with all its variables, end the dialog of variables creation by going back to the main menu, and activate the variables configuration dialog of the selected station.

### 507.8.5 Configuration of the variables of a station

The dialog of the configuration of variables of a station complies with the same principles as that of stations, and has a similar ergonomy. As mentioned in the previous paragraph, the user is guided by dialog boxes: a list box and secondary boxes.

The list box contains the list of all variables created in the station. The user shall set up the list to his discretion: paragraph titles and delimiters (asterisks line, simple line, double line, broken line, etc ...). The other functions of the list box are:

- creation of titles and delimiters
- creation of logic variables
- creation of analog variables
- creation of counter variables
- modification of the variable
- destruction of the variable, the title or the indexed delimiter
- closing the dialog box of dialogs configuration and return to the main dialog box of the creation of stations.

## 507.9 COPYRIGHT AND PRODUCT SUPPORT

The copyright of software specially developed for the control system shall become the property of the Purchaser on handover of the equipment.

The Contractor shall ensure that for software of a standard nature, product support shall be available for a period of ten years from the date of supply, and submit details of the various grades of maintenance contract which he can offer for both software and hardware. These shall include the approximate costs of the supply of updates of standard software which will run on the system, as well as enhancements and improvements to specialist system software.

The Contractor shall be able to offer for demonstration an operational system, whose configuration is similar to the requirements of this system, which utilises software programmed by the Contractor's staff in-house personnel.

## 507.10 PROGRAMMING

Programmes shall be based on approved structured techniques using a high level language capable of accepting alterations and additions easily.

All programmes shall be tidy in format, logical to follow and be accompanied by flow diagrams. Programmes shall be extensively annotated with comments and be self-documenting.

## 507.11 PROGRAM DOCUMENTATION

The Contractor shall supply the following documentation:

1. Full programme listing (including all comment/remark text)
2. Complete set of flow charts
3. Diagnostic programmes

4. Operation/instruction manual for this particular project.

### 507.12 DIAGNOSTIC ROUTINES

The system shall be complete with a set of diagnostic routines to enable maintenance personnel to fault-find on the equipment.

The routines offered will depend upon the system supplied, but shall contain or expand on the following:

a) A routine to enable all interface cards or devices to be checked for faults or malfunctions, particularly input and output cards.
b) A routine for testing individual control loops.

c) A programme to send dummy information to the various input/output gates to test action of circuits.
d) All routines shall be available only in the “engineer's mode”.

The integrity of all plant operations must be protected at all times, therefore diagnostic programmes will require additional security when switching outputs.

## 508. INFORMATION PRESENTATION

### 508.1 DISPLAY

The visual display unit (VDU) shall be capable of displaying mimic, graphical and alpha-numeric information. Mimic diagrams shall show all relevant plant status and alarm information along with process and analytical data, e.g. flows, levels. All such data shall be updated at regular intervals, chosen to suit the rate of change of data.

The mimic diagrams shall be capable of being easily developed and modified to include changes at a later date. The diagrams shall be clearly presented so that the operator may readily assimilate the information contained therein. Diagrams shall be nested at several levels to enable the operator to obtain detailed information quickly and yet retain an overview of a complete area of the plant.

Status information shall be updated as the change takes place and parameters which are out of limits shall initiate an alarm sequence.

Alarm messages shall be displayed on a dedicated section of the VDU screen, which shall be available at all times.

Displays shall be organised into a hierarchical structure, ranging from an overview down to individual detailed RTU displays. The displays shall be user definable and details of the building/modifications package shall be provided. A real time clock shall be included on all displays giving both time and date. Hard copies of screen displays will therefore always show time or events being portrayed. In the case of a management report covering a time period, any

hard copy taken within that period will clearly show the point of retrieval.

When an RTU is called up on the VDU mimic display, analogue values and the status of all units shall be displayed, ie. running, failed, open, closed, full, empty, flowing, etc.

## 508.2 COLOURS

Colours and layouts of the mimic diagrams shall be established during discussion with the Engineer during the development phase of the software.

The minimum requirements are sixteen colours, with 'blinking' facilities.

The colours shall be consistent with the VGA 16 colour choice and allocated for plant contents and flow lines as follows and where appropriate.

a) Process Colours

| Colour | Water Treatment | Sewage Treatment |
|---|---|---|
| Black | Background | Background |
| Green | Raw Water | Raw sewage |
| Light Green | Gas (Chlorine) | Settled sewage<br>Liquor/Storm tanks<br>Lagoon outflow |
| Cyan | Filtered, well or backwash water | - |
| Light Cyan | - | - |
| Brown | Dirty water | Raw sludge<br>Screenings Disposal |
| Yellow | Gas ($SO_2$) | Gas (Methane) |
| Red | - | - |
| Light Red | - | - |
| Magenta | Gas ($NH_3$) | Activated sludge |
| Light Magenta | - | - |
| Grey | - | Treated sludge |
| Light grey | - | - |
| White | Air | Air |
| Light Blue | - | - |
| Blue | Potable water | Final effluent |

Colours which are not defined above may be otherwise allocated to the approval of the Engineer.

Plant icons shall be : Running/open/on - Process colour (see above)
Stopped/closed/off - Light Grey

| | |
|---|---|
| Alarms (potential danger to personnel/major failure of plant/process) | Red |
| Faults (Motor tripped etc) | Yellow |

b) Text

Text should revert to background colour when not applicable (therefore not visible) or overwrite opposite condition (running/stopped).

| | |
|---|---|
| Status text (running, stopped etc) | White |
| Analogue values (e.g. flows, levels) | White |
| Engineering units | White |
| Alarms | Red |
| Faults | Yellow |

## 508.3 CURVES

Curves represent and display on a colour graphic console the changes of one or several analog, digital or logic information from the storage database.

Both real-time and historical trends shall be available for all analogue values (including summated and derived) by all the following methods.

a) As an integral part of a mimic diagram.

b) As a sub-mimic-accessed from one or more 'Poke Points' on process mimics.

c) As a separate function of the SCADA package with user friendly configuration.

In any of the above methods up to four (4) values shall be available for display on the same graph simultaneously with user defined time and unit scales.

Each variable shall be presented as a graph against time, the normal period being the last 24 hours or such other time scale as is most suitable for the particular parameter, with the facility for the operator to be able to input a start time and end time. Axes shall be clearly labelled,

tagged (variable name/identification) and scaled.

Each variable within a graph shall have a separate colour, either green, brown, magenta or blue.

An information can be displayed simultaneously over different time periods allowing thus the comparison of the evolution of a phenomenon in time.

Following are the main options of the curves module:

- a curve view configuration (references and display periods acquisition)
- call and loading of a curve view
- succession of curves views (following and previous view)
- query of values on a curve (selection with the mouse of the following, previous or any point)
- zoom (horizontal and vertical)
- grid display (to facilitate hardcopies reading)
- screen print on a graphic printer.

This functionality allows the comparison of a real-time variable with a previous evolution (e.g. comparison of a reservoir actual curve with that of the previous day).

The data retrieval utilities of the storage database allow the user to compare stored data with those of the on line available database.

Moreover, counter values shall be displayed in the form of histograms representing automatically the index differences over a one hour, a one day or a one month period. So, when activating the zoom, the system recalculates automatically the index differences over the zoomed in period.

Example:

- Consumption curve for a certain year: the system displays 12 bars representing each a monthly consumption.

- Zooming in on a certain month: the system displays 31 bars representing each a daily consumption.

- Zooming in on a certain day: the system displays 24 bars representing each an hourly consumption.

## 508.4 POKE POINTS

These are any area on the screen which, when selected by cursor, cause display or control actions to occur and shall, where appropriate, follow the guidance in BS EN 60073 for push buttons.
There shall be poke points to enable movement between process mimics both upstream and downstream without use of intermediate menus or mimics. The 'active' areas shall be sized for ease of use with a cursor and shall be represented as a symbol, icon, text or function box.

Poke points shall also be utilised for trends, menus, overviews and control activation (where applicable).

All control activation or changes of operational parameters shall require a `confirm before execute' routine.

## 508.5 OPERATING PARAMETERS AND SAMPLE RATES

These values shall be presented in a tabular form for each process area or sub-group.

It shall be possible to change analogue sample rates as an operator function (eg. 5 secs, 30 secs, 1 min, 30 min, etc).

## 508.6 LAYOUT AND STRUCTURE

The mimic displays of the overall process areas and RTU's, shall be configured based on the process and instrumentation as specified and approved.

Symbols shall be used to represent items of plant in a manner which is easily recognisable by the operator. The overview mimic shall use symbols, not just labelled blocks.

Wherever possible, flow and process direction shall be from left to right, top to bottom. The crossing of flowlines shall be avoided, however if this is unavoidable, the vertical line shall be

shown with a break. Junctions of flowlines shall be only single T junctions with no local

increase in line size at the joint.

In general, flowlines and symbols shall not be outlined. The colour shall be used in block or fill form, with graphical detail where necessary in white lines.

Plant status for running/stopped, open/close, available/unavailable etc... shall be indicated (on the process mimics) by text in addition to symbol colour.

Text associated with symbols shall be 3.5mm height. Text associated with headings shall be 5mm height. All text shall be in upper case.

Abbreviations of engineering shall be in accordance with SI nomenclature as detailed in BS 5555 or as otherwise approved by the Engineer. Where a percentage figure is given as data, this meaning shall be either percentage of full capacity or percentage open, e.g. 100% indicates a full tank or a fully open valve.

## 508.7 MENU HIERARCHY

On start up, the system shall automatically display the log on/off menu which shall be in the form of a graphical list offering the choice of access levels as follows:

1. Operator
2. Supervisor
3. System Engineer/Diagnostic Routines

Access to facilities from each level shall be changeable at the system engineer level.

Once logged on, the system shall display the main menu, offering the choice between the mimics/data pages.

'Help' screens shall be available for each mimic. These shall be user configurable by a combination of text and graphs via the SCADA package facilities.

Screen Burn: To minimise VDU screen burn, a changeable time out shall be used to either display a blank screen or remove all screen displays until any key reactivates the last screen display.

Legend: A mimic shall be provided to explain all symbols, icons, colours and functions of the system.

## 508.8 MIMICS (VDU)

A VDU mimic is a dynamic graphic view drawn and configured by the user. A mimic includes a number of animated objects in terms of the evolution of a set of logic, analog and digital channels.

Creation and animation of mimics shall be through a graphic tool which creates and manages a user interface based on graphic images and libraries of objects.
This graphic software has two main functions:

An EDIT function

Such a function creates images used as a dialog support with the computer system, and then sets up a link between the application variables and the image's elements. The latter being a dynamic representation of the first.

Following are the available graphic primitives:

– rectangle, circle, ellipse, text, polyline, polygon, curves.

The graphic functions are:

– bar-graphs (rectangular or circular)
– scales (linear or circular)
– discrete function (8 representations according to Boolean conditions)
– digital displays
– animated text
– mimics modifications
– objects designation (remote commands, remote setpoints).

ANIMATION function

This function ensures the display of graphic images and their animation on the basis of the data transmitted periodically by the system.

It allows also the management of input/output utilities tools provided for the user, namely : the mouse and an alphanumeric keyboard.

By using the mouse (designation, data acquisition) the supervisor can send messages which shall generate remote commands or setpoints.

Consequently, the grahic animation tool behaves like a real control board of the Center.

### 508.8.1 Mimic Design and Approval

The mimic design shall progress in parallel with the Functional Design Specification and Process and Instrument Diagrams. It is envisaged that at least three reviews will be required before final approval. Any changes required from these reviews shall be carried out by the Contractor and deemed to be included in this Contract.

All displays shall be submitted for approval either in floppy disk format (IBM PC (DOS based) compatible) or as a VHS video tape presentation. Whichever format is selected, it shall depict simulated changes of analogue and digital plant status. In addition colour hard copies of every page shall be submitted of an equal quality and content to that of the printer being supplied.

## 508.9 ALARMS

Special care is given to the management of alarms in order to facilitate and optimize interventions in case of major alarms. The system keeps an updated list of active alarms.

An alarm is present or missing, acknowledged or not acknowledged. An alarm is active in any of the following configurations:

- present and not acknowledged
- present and acknowledged
- missing and not acknowledged.

An alarm disappears in the following three cases:

- alarm missing but acknowledged
- oldest alarm on the saturated list when a new alarm appears
- alarm disappearing before the end of the delay.

In the second case an alarm message is initiated and edited on the continuous printing peripherals. An unacknowledged alarm which appears several times occupies one space only on the list, but the number of appearances is counted.

Upon initiation, alarm messages shall be displayed on the VDU and an audible alarm sounded. The visual alarm indication shall utilise colour and flashing effects to differentiate from normal information. When alarms are accepted by the operator, the audible alarm shall be silenced. Upon clearance of the alarm the VDU display shall revert to normal.

In addition to alarms listed in the instrument index, alarms derived from process evolved conditions shall be treated, displayed, logged, etc., in a similar manner to a direct alarm. The derived alarm is intended to indicate problems occurring within the process/control system and/or site equipment not covered by direct alarms. The Contractor shall ensure all problem conditions within the above parameters are included. Additional derived alarms shall be available for user definition.

Derived alarms shall signal when:

a) any item of equipment fails to respond to an initiating signal,

b) any item of equipment stops (or starts) other than when it has been instructed to,

c) any item of equipment fails to respond to a set point within an adjustable time limit,

d) any analogue signal becomes below 4 mA or above 20 mA,

e) when there is a disparity between two measureands, i.e. analogue and digital level monitoring.

The hierarchical level of an alarm determines the necessary action to be undertaken. There are eight alarm levels:

level 0 : no acknowledgment requested
level 1 : local acknowledgment requested
level 2 : acknowledgment requested, late duty staff call (if configured). Delay of call is authorized.
level 3 : alarm delay of 15 mn. In case of further delay, an acknowledgment is requested and a call is generated (if configured). If the alarm origin disappears before 15 mn, the alarm disappears from the list. Delay of call is authorized.
level 4 : idem level 3, with a 60 min delay
level 5 : idem level 3, with a 4 hours delay
level 6 : acknowledgment is requested, generation of call (if configured). Delay of call is not considered: Immediate duty staff call.
level 7 : reserved.

The alarm list may be displayed on the screen and printed upon request in whole or in part after selection of alarms in terms of their state.

## 508.10 ALARM LOGGING

The alarm printer shall log all alarm events as they occur, stating the following for each:

i) Alarm flagged
ii) Process area
iii) Description of alarm
iv) Tag number (if any)
v) Time alarm initiated
vi) Time alarm accepted
vii) Time alarm cleared

NB. `Engineer on Site' shall be treated as an alarm.

## 508.11 EVENT LOGGING

Continuous printing of events is either systematic or configured. Systematically printed events, are those related to the stations status:

- reversion to normal status after a voluntary operation or a communication failure
- detection of a communication failure after expiry of the maximum configured response time delay
- acknowledgment of the communication failure
- reversion to normal status without acknowledgment of the communication failure.

Printed events, should the associated variable be so configured, are:

- change-of-state, with alarm indication, if any
- alarms acknowledgment
- disappearance of unacknowledged alarms
- transmission of remote commands, setpoints and values
- non execution of remote commands within the set time limits
- transmission of remote commands (remote setpoints, counter index setting) which execution is monitored
- non execution of above-mentioned remote commands within the set time limits
- overstepping of a measurement threshold
- out-of-range measurements
- sensors faults
- local modifications of setpoints
- local modifications of counters
- counters reset
- updating the alarm list.

All printed messages are time-logged.

In the event of a failure in the continuous printing peripheral, the events to be printed are temporarily stored. They shall be printed as soon as the peripheral is back into operation or after they are switched over by the operator towards another peripheral.

Following is the message format:

- date of event
- label of the station
- number and type of channel
- label of channel
- description of event.

## 508.12 MANAGEMENT REPORTS

In order to configure reports and logs of accumulated data over a certain period, data shall be capable of being exported from the hard disk onto separate storage devices.

The reports shall be user redefinable and take the form of charts, data tables and graphs, both on demand and periodically configured.

Preconfigured reports shall be supplied as part of this Contract. Hard copies shall be submitted for comment/change/approval by the Contractor as part of the functional design specification procedure.

Reports are elaborated either by means of a spreadsheet or a graphic spreadsheet.

### Spreadsheet

The system includes an automated reports compiler. Simple tables can be easily drawn up for the normal use of the system.

Tables are constituted periodically using analogue or digital values from the storage database.

There are several types of reports : EVERY SIX HOURS, DAILY, WEEKLY, BI-MONTHLY, MONTHLY, and YEARLY ...

A report is identified by its name, type, and date.

A report can include the following data:

- For an analog value (measurement)
  - value at origin of time
  - mean hourly value
  - minimum hourly value
  - maximum hourly value
  - number of invalid samples.

- For a digital value
  - index value at origin of time
  - number of invalid samples.

**Graphic spreadsheet**

The graphic spreadsheet is a:

- 3D graphic tool
- sophisticated display tool
- development tool with compatible language.

Macro commands are created to retrieve simply the information of the storage database, namely:

- For analog values:
  - instantaneous value at a given date/hour
  - mini, maxi, or mean value between two dates
  - mini, maxi, or mean hourly value
  - mini, maxi, or mean daily value
  - number of samples between two dates.

- For a digital value:
  - index value for a given date/hour
  - index difference between two dates
  - index hourly difference
  - index daily difference
  - number of samples between two dates.

- For a logic variable:
  - number of change of states or hourly operation time

- number of change of states or daily operation time
- number of change of states or operation time between two dates.

Moreover, the graphic spreadsheet allows an easy insertion of graphs in reports and tables (2D or 3D curves, bar graphs, pie charts, ...).

### 508.13 MAINTENANCE ASSISTANCE

The Center holds two data lists used as maintenance assistance:

– the list of operation time of machines and equipment
– the list of machines and equipment requiring maintenance and which operation time has reached an alarm value.

### 508.14 MENUS AND LOGS

A log of values holds several logic, analog, or digital channels under a given name : for example, the “FLOW” log, gathers all flow measurements. When the log is displayed or printed, it shows the instantaneous values of all channels included therein at the time of consultation.

A faults log is an extract of a states and values log which contains only the values of defective channels.

A values menu is a set of logic, analog or digital channels displayed according to a determined pop up dialog box. The menu is identified by a name. Upon consultation, the menu displays all values and states and shows their real-time evolution.

The menu is a dynamic alpha-numeric mimic, it is created and configured by the system’s administrator.

## 509. FUNCTIONAL DESIGN SPECIFICATION

### 509.1 PURPOSE

The Functional Design Specification (FDS) shall be prepared by the Contractor and agreed jointly by the Contractor and the Engineer. It shall detail the manner in which the Contractor intends to provide a system to meet the Engineer's/user's needs as set out in this Specification. Once agreed by the Contractor and the Engineer it shall form part of the contractual documentation.

The FDS shall describe what the system will do, how it will be operated and maintained, and what facilities and services will be provided. It shall provide a list of design objectives and forms the baseline document for the functions and extent of the proposed system.

Besides covering all system functions, the FDS shall define the reliability, maintainability, acceptability, ease of training and operation, security and overall quality policy of the proposed system.

Any divergence between the FDS and this Specification shall be resolved, agreed and clearly documented, and the FDS amended to reflect the new understanding.

When the FDS has been approved and signed by the Engineer it shall be kept under formal change control by the Contractor to cover any subsequent amendments. Change control should also be applied to any dependent documents (see Section 7 of the "Guidelines for the Documentation of Software for Real Time and Interactive Systems" published by the Institution of Electrical Engineer (IEE) London).

## 509.2 STRUCTURE

The following structure is suggested for the Functional Specification:

**System Overview** - providing an overall plan of the Contractors proposed solution. This shall take the form of a functional block diagram accompanied by a descriptive text.

**System Functions and Facilities** - describing all the functions and facilities proposed to meet the system objectives as specified in this Specification.

**System Interfaces** - specifying all inputs and outputs of the system, including communication links.

**System Attributes** - specifying matters relating to the adaptability, availability, maintainability and usability of the system.

**Design, Development and Test Factors** - specifying aspects of software, design, development procedures and system acceptance testing.

## 509.3 DOCUMENTATION

The above document structure shall incorporate descriptions of operation for the following conditions:

Normal operation
Back-up operation
Modes of system failures
Modes of instrument failures
Watchdog functions
Modes of power failure
Return to normal conditions
Schedules of software adjustable operating parameters

All relative supporting documentation shall be included in the functional design specification before approval and should include the following:

Process and Instrumentation diagrams.
VDU mimics
Instrument panel layouts
Access levels
Control system and loop diagrams
Software packages documentation (SCADA, etc...).
Management Reports
Instrument Index

### 509.4 POST-INSTALLATION DOCUMENT

Documentation shall include, but not limited to, the following:

As-built drawings.

Test, commissioning and calibration reports.

Acceptance certificates.

Standards documentation.

Drawings.

Warranty-conditions, start dates, end dates.

Hardware maintenance agreements contracts.

Fault reporting procedures.

Post-installation special-to-project software upgrade and enhancement procedures, including documentation updates.

Notification procedure and maintenance contracts for supported software updates (e.g operating system, language compilers).

Transfer of title ownership of software modules.

Permits/certificates authorising the use of licensed or leased software.

## 510. COMMUNICATIONS

### 510.1 CONTROL AND COMMUNICATIONS

The control system shall communicate with plant via one or more Remote Terminal Units (RTU). The RTU's shall be linked by a common communications link so designed that failure of any RTU connected to it or failure of the computer system shall not cause the link or data highway to malfunction.

The configuration, communications speed and number of data highways shall be determined considering the response times, distribution and number of signals presented by the Plant requirements.

The communications network for the SCADA system shall accommodate both continuous real time and timed polling acquisition of data throughout the system. The RTU's/Outstations may be polled on a pre-determined rate but shall have a real time responses to alarms.

The means of communication shall be in accordance with the Particular Specification and the following clauses relevant to the selected medium.

## 510.2 TRANSMISSION MODES

The telemetry system is to transmit in the Time Division Multiplex mode (TDM) with Frequency Shift Keying (FSK) or Differential Phase Shift Keying (DPSK) modulation and shall employ an interrogation/response or an indeterministic (random acquisition) system.

Suitable modems shall be provided to match the system characteristics which shall have a transmission rate to meet the system performance requirements.

The system is to detect at least 98% of all and 100% of 1, 2 and 3 bit transmission errors.

The equipment shall be suitable for the future installation of UHF radio links as an alternative to transmission over public or dedicated private lines.

## 510.3 PRIVATE LINES/DEDICATED LINES

Where communications between sites is to be over 2 wire private circuits rented from the local communications authority or laid along the pipeline, by the Contractor, they shall be speechband circuits (2 wire, half duplex).

Where communication links between sites are specified to comprise two independent circuits, each circuit shall use separate routes where possible. Automatic changeover to the standby line shall occur in the event of duty line failure on the links between the specified sites. The standby lines shall be continually monitored and an alarm raised in the event of failure.

Adequate provisions shall be made to allow testing, debugging and servicing a faulty cable while the alternate one is in use. The data cables shall conform to ISO/IEC DIS 11801.

It shall be the Contractor's responsibility to negotiate and agree on behalf of the Purchaser with the local communications authority for the supply of all lines which must be suitable for the proper operation of the system. Any connection charges arising shall be submitted for payment by the Purchaser.

## 510.4 RADIO LINKS

Where it is envisaged that communication between outlying locations and the works will be by

radio, the Contractor shall be responsible for carrying out a site radio survey to confirm that this method is suitable.

The results and conclusions of the survey shall be collated into a report which shall contain all documents including correspondence, calculations, etc with any statutory bodies, landowners, etc.

It shall be the Contractor's responsibility to obtain licences from the relevant licensing authority to operate the required frequencies on behalf of the Purchaser.

The Contractor shall minimise the number of frequencies he intends to use and shall justify the use of all proposed frequencies.

The Contractor shall restrict the data transmission rates over the radio links to the minimum number required for the effective operation of the system. Calculations shall be provided justifying the signalling rates.

## 510.5 LOW POWER RADIO

Transmission between individual or small groups of instruments to local stations for monitoring purposes should be considered wherever hardwiring would be more costly. However, control functions should be hardwired or via approved PLC units and not performed within the radio station units.

The above individual or small groups of instruments should form 'cells' within the 'cells' transmitting to a master station via a radio data network.
All systems using low powered radio must be approved to the appropriate local communications authority and shall be installed in a manner which ensures operation within the allowable frequency and power restrictions.

Antenna shall be appropriately sized, orientated and safely installed. All systems shall be of a robust nature with a full consideration given to location, access and vandal interference.

Where radio networks are proposed, available network systems shall be used which optimise the available bandwidth in each channel. The network architecture shall utilise a well established protocol designed for the radio environment operating in real time and able to guarantee data security. In addition the network shall utilise an open architecture to allow for inclusion of a wide variety of devices either existing or in the future.

It may be necessary for more than one radio channel to be utilised to guarantee performance and response. Multiple channels may be used in a cell structure providing this can be demonstrated to be a well proven network facility and does not require custom software design.

## 510.6 FIBRE OPTIC LINKS

All fibre-optic networks are to be bidirectional, ie. the cable shall be such that if communication through the fibre should fail at a point along the network, polling shall then reverse, maintaining uninterrupted control.

# 511. COMPUTER ROOMS

## 511.1 GENERAL

Rooms accommodating SCADA computer equipment shall be designed, decorated and furnished in accordance with the following requirements, unless otherwise detailed in the Particular Specifications.

i) Lighting and decoration suitable for VDU viewing
ii) Air conditioning and ventilation
iii) Fire detection and alarm extinguishing equipment
iv) Electrical power outlet
v) Dust control mat
vi) Blinds
vii) Furniture

All items of equipment (control and electrical) as detailed in this specification shall be suitably housed and located taking into account ease of operation, noise, visitors, storage, possible future requirements, communications and external interference from adjoining rooms. Cables shall be concealed as far as possible.

All equipment and design shall be in accordance with the relative CIBSE Guides and Codes.

## 511.2 LIGHTING

Room lighting shall be by means of low brightness luminaires incorporating high frequency, flicker free, electronic ballasts to meet the following requirements and generally in accordance with CIBSE Lighting Guide LG3.

| | | |
|---|---|---|
| Average illumination (Eavg at the working surface) | - | 450 Lux minimum |
| Emin/Eavg | - | 0.8 minimum |
| Control | - | 100%-20% or less , continuously adjustable by 1 wall mounted control knob. |
| Colour Rendering | - | Colour No. 84 (4000° K) |
| Emergency lighting | - | Minimum 2.5 hours, by self contained module attached to luminaire. |

## 511.3 AIR CONDITIONING

Heating, ventilation and cooling systems shall be provided to meet the following requirements.

| | |
|---|---|
| Maintained Temperature | 21°C ±2° |
| Maintained Humidity | 50% RH ±10% |
| Heat Dissipation in room | To be calculated by the Contractor based on 2 persons and installed equipment occupancy |
| Number of Air Changes | 4 changes per hour minimum |

The systems shall be of the heat pump type, able to provide sufficient heating when required, either of one piece or split design.

The Contractor shall determine all fabric loads.

The installation shall include materials and labour for connection of the equipment to a suitable electricity and water supply within the building.

The method of drainage for the equipment shall be in accordance with the regulations as laid down by the local authority.

The systems shall be inter-connected with the fire detection equipment such that the air conditioning equipment shall be shut off with the ventilator firmly closed in the event of fire being detected within the room.

## 511.4 FIRE DETECTION AND EXTINGUISHING EQUIPMENT

Fire detection and warning equipment shall be provided in accordance with BS 5893 to include the following items:

Optical smoke detector
Break glass fire alarm switch
Single zone microprocessor controlled fire alarm panel compatible with the equipment herein specified, with battery back-up and failure monitoring.
Pulsed tone alarm mounted inside control room.
Audible alarm suitable for external use and audible for a distance of at least 200m to be mounted on the building exterior.

The components shall be mounted in a position to be agreed with the Engineer.

The system shall be supplied with suitable contacts to shutdown the air conditioning system and provide an alarm contact to the SCADA system. In addition, 2 spare contacts shall be supplied.

Fire extinguishing equipment shall be supplied and mounted in agreement with the local Fire Officer.

## 511.5 ELECTRICAL POWER OUTLETS

Where additional socket outlets are specified, they shall be switched socket outlets to match the local standards.

The outlets shall be installed approximately 20cm above floor level. Installation shall include for wiring back to the building distribution panel, additional components therein and connection thereto as required.

Where outlets are supplied from the UPS, traffolyte engraved labels approximately 25mm x 50mm shall be supplied and mounted above each such socket, with the following wording, white on red background.

FOR COMPUTER EQUIPMENT ONLY

## 511.6 DUST CONTROL MAT

A dust control mat, having anti-static properties shall be supplied of approximately 1m x 1.5m, dark grey carpet with bevelled non-trip edging to be placed in front of the doorway to trap foot borne dust and dirt.

## 511.7 BLINDS

All windows shall be fitted with fully adjustable vertical louvre window blinds which shall be light grey in colour.

## 511.8 FURNITURE

Purpose made computer tables, sized to accommodate the specified printers, VDU's, storage drawers and working space shall be provided, together with any other chairs, cupboards etc, as detailed in the Particular Specifications. All items shall be supplied with the following considerations:

a) Anti-static material
b) PC units mounting below desk top
c) Storage of paper consumable and transportable mediums
d) Storage of system disks and manuals
e) Paper trays (fan paper)
f) Working area
g) Phone locations
h) Cables hidden.

## 511.9 DECORATION

The walls and ceiling shall be painted in semi-matt emulsion of pastel shades to be agreed with the Engineer.
Prior to painting, the surfaces shall be well prepared (and primed) in accordance with the manufacturer's recommended painting system for the material.

# Volume 2

# Technical Specifications

# Division 1

# General Specifications

# Part 6

# Testing & Commissioning

# TABLE OF CONTENTS

| | Page No. |
|---|---|
| **601. GENERAL REQUIREMENTS** | **2** |
| **601.1 ABBREVIATIONS** | **2** |
| **602. IN FACTORY TESTS OF PUMPSETS** | **5** |
| **602.1 GENERAL** | **5** |
| **602.2 PUMPSET TESTS** | **5** |
| **602.3 "IN FACTORY TESTS" PENALTIES** | **7** |
| **603. TESTING ELECTRICAL PANELS IN WORKSHOPS** | **8** |
| **604. TESTING OF VALVES** | **9** |
| **605. ON SITE TESTS** | **10** |
| **605.1 VISUAL INSPECTION** | **10** |
| **605.2 ACOUSTIC TESTING (NFS 31-010 AND BS 7445-3)** | **10** |
| **605.3 TESTING OF ROTATING ELECTRIC EQUIPMENT** | **10** |
| 605.3.1 General | 10 |
| 605.3.2 Measurement of Insulation Resistance | 11 |
| 605.3.3 Determination of the Dielectric Absorption Ratio | 13 |
| 605.3.4 Cleaning of Windings | 13 |
| 605.3.5 Drying Windings with Air Circulation | 13 |
| **605.4 TESTING OF HANDLING EQUIPMENT** | **14** |
| **605.5 TESTING OF PLUMBING & SANITARY SYSTEM** | **14** |
| **605.6 TESTING OF HVAC SYSTEM** | **15** |
| 605.6.1 Test procedures | 15 |
| 605.6.2 Test on completion | 15 |
| 605.6.2.1 Testing, adjusting and balancing | 15 |
| 605.6.2.2 Temperature test | 15 |
| 605.6.2.3 Sound test | 15 |
| 605.6.3 Performance test | 15 |
| 605.6.4 Test reports | 16 |
| **605.7 TESTING OF CHLORINATING SYSTEM** | **16** |
| **605.8 TESTING OF ELECTRIC, HYDRAULIC, CONTROL & TELEMETRY SYSTEMS** | **16** |
| 605.8.1 Testing of Electric Systems | 17 |
| 605.8.2 Testing of Hydraulic systems | 17 |
| 605.8.3 Testing of Control & telemetry systems | 17 |
| **606. SETTING UP AND PRE-COMMISSIONING** | **18** |
| **607. TRAINING THE EMPLOYER PERSONNEL** | **19** |
| **608. COMMISSIONING** | **20** |
| **609. TAKING OVER OF WORKS** | **21** |
| **610. DEFECTS LIABILITY PERIOD** | **22** |
| **611. MAINTENANCE SUPERVISION DURING THE DEFECTS LIABILITY PERIOD** | **24** |
| **612. REJECTION OF EQUIPMENT** | **25** |
| **613. OPERATION AND MAINTENANCE MANUALS** | **26** |

# 601. GENERAL REQUIREMENTS

"In factory tests" shall be carried out if requested in the Particular Specifications.

"Commissioning tests" (tests on completion) shall be carried out at the end of the works following pre-commissioning.

"Performance tests" shall take place during the defects liability period. Test shall be consistant with the specifications of the contract document and the standards in force.

Analytical instruments for testing shall be sealed and supplied with recent calibration certificates provided by an official laboratory.

The results of tests shall be set out in a report signed by the Engineer or his representative and by the Contractor.

## 601.1 ABBREVIATIONS

The following abbreviations are used in these documents :

| | |
|---|---|
| 1/head/day | liters per head per day |
| AC | Asbestos Cement |
| AGMA | American Gear Manufacturer's Association |
| AOD | Above ordnance datum |
| BS | British Standard |
| CDR | Council for Development and Reconstruction. |
| CFM | cubic feet per minute |
| Ch | Chainage |
| CMR | Continuos Maximum Rating |
| CP | Code of Practice |
| CPU | Central Processing Unit |
| DI | Ductile Iron |
| DIN | Deutsch Industrie Normen |
| DOV | Double Orifice Valve |
| DPSK | Differential Phase Shift Keying |
| DTU | Documents Techniques Unifiés |
| EDL | Electricity of Lebanon |
| EMC | Electromagnetic Compatibility |
| EOH | End of hole. |
| FDS | Functional Design Specification |
| FIDIC | Federation Internationale des Ingénieurs- Conseils |
| FSK | Frequency Shift Keying |
| g | acceleration due to gravity ($9.807 m/s^2$) |
| GL | Ground level |
| gpm | gallons per minute |

| | |
|---|---|
| gr | gram |
| GRP | Glass Reinforced Plastic |
| GTSD | General Technical Specification Document |
| hr | hour |
| I/O | Input / Output |
| IEE | Institute of Electrical Engineer |
| ISO | International Standards Organization |
| ITS | Institute of Technical Studies |
| kgf | kilogram force |
| kPa | kilo Pascal |
| kVA | kilovolt-ampere |
| kW | kilowatts |
| kWh | kilowatt hour |
| LED | Light Emanating Diode |
| m | meters |
| $m/s^2$ | meters per second per second |
| $m^3$ | cubic meters |
| $m^3$/day | cubic meters per day |
| MDPE | Medium Density Polyethylene |
| mgd | million gallons per day |
| mhd | meters head |
| mm | millimeters |
| NFE | Normes Françaises - (Electrical) |
| NLQ | Near Letter Quality |
| NPSH | Net Positive Suction Head |
| PS | Particular Specification |
| PTT | Poste de Téléphone et de Télégraphe |
| PVC | Polyvinyl Chloride PWL |
| | Pumping Water Level |
| RAM | Random Access Memory |
| RBC | Rotating Biological Contractor |
| RTR | Reinforced Thermoplastic Resin |
| RTU | Remote Terminal Unit |
| SCADA | System Control And Data Acquisition |
| SOV | Single Orifice Valve |
| SPTD | Signal Pole Double Throw |
| SSU | System Supervisory Unit |
| SWL | Static Water Level |
| TDH | Total Dynamic Head TDM |
| | Time Division Multiplex |
| TEFC | Totally Enclosed Fan Cooled |
| UHF | Ultra High Frequency |
| UPS | Uninterrupted Power Supply |
| UPVE | Unsaturated Polyvinyl Chloride |
| VDU | Video Display Unit |
| VGA | Video Graphics Array |
| VHF | Very High Frequency |
| VHS | Video Home System |

# 602. IN FACTORY TESTS OF PUMPSETS

## 602.1 GENERAL

Pump testings shall be determined according to the pump tests carried out by an international control organisation, i.e. EUROPUMP, the committee of European manufacturers of pumps which divide them into two classes :

- Class A : special pumps
- Class B : small pumps manufactured in large quantities.

Class A

The Engineer or his representative shall determine, in the description of the project, whether the pump(s) or its (their) motor(s) shall be tested in factory.

The Contractor shall submit the original estimate of the manufacturer, justifying the costs of the required in factory tests. The price shall be detailed according to the requirements of the Engineer.

Class B

Equipment manufactured in large quantities shall not undergo in-factory tests.

The manufacturer shall produce, for the manufacture criteria and their justifications, the characteristic curves of each pump ordered by the Contractor :

- Flow curve
- Efficiency curve
- Power curve
- Suction curve (NPSH)

The complete control of operation conditions shall be carried out as soon as the equipment is installed on site.

Where pumps operate in series or in parallel, the Contractor shall justify the operation characteristics by producing analogous curves specifying the starting and releasing points for an automatic or manual operation.

## 602.2 PUMPSET TESTS

Verifications and tests shall be carried out in factory, in conformity with the international tests standards in force in the country of origin or with those equivalents to international standards adopted for the manufacture of the equipment before transporting the equipment.

These tests shall be carried out at the expense of the Contractor, and under the supervision of an international control organisation, i.e. EUROPUMP.

The international control organisation shall be considered as "The In-Factory Taking Over Agent". Nevertheless, in factory taking over shall not supersede the on-site "Taking Over Of Works".

These tests shall allow a complete control of all the guarantees stipulated in the tender document, as well as the verification of the equipment consistency with the adopted manufacture standards. They shall also provide the information mentioned hereinafter.

In particular, these tests shall be carried out at the maximum nominal speed and in conformity with the adopted standards.
However, no tolerances shall be permissible in any way regarding the guarantees of flows, lift heights, and efficiency.

Tests shall include, particularly:

For the pump:

- The determination of the lift head of water at the specified flow rate set out in the tender document.
- The determination of the flow at the TDH.
- The drawing of characteristic curves (efficiency, NPSH, required power, "head - flow" curve).
- The determination of the pump efficiency at the specified flow.
- The determination of the pressure when the discharge outlet is closed while pump is running.
- The hydrostatic test.
- The determination of the inertia of revolving parts.

For the electric motor

- The determination of the nominal power.
- The determination of the nominal speed at the nominal power.
- The determination of the nominal current under working voltage.
- The determination of the starting current in case of direct starting.
- The determination of output shaft torques (nominal, starting, breakdown) and the drawing of the characteristic "torque-speed" curve.

- The determination of the efficiency at the duty point.

- The determination of the efficiency at 2/4, 3/4, and 4/4 of the load.

- The determination of power factors at 2/4, 3/4 and 4/4 of the load.
- The determination of the inertia of revolving parts.

- Heating tests

- Dielectric tests

- Overspeed tests

- Measurement of the noise level.

Prior to the installation of equipment, the Contractor shall submit to the Engineer in triplicate the tests and "in factory taking over" certificates, duly certified by the International Control Organisation, attesting that the tests carried out on the equipment meet the conditions of the Contract and that the equipment is in conformity with the specifications of the tender document.

### 602.3 "IN FACTORY TESTS" PENALTIES

Unless otherwise specified, if the values of efficiencies and flow rates recorded during the "Factory Test" are not in conformity with the declared values, penalties shall be calculated as follows:

- Declared Overall Efficiency = (Declared Efficiency$_{Mtr}$ X Declared Efficiency$_{Pump}$) at the TDH.
- Declared Fow Rate = Flow rate at the TDH.

- 2% of the value of the equipment for each 1% of overall efficiency inferior to the declared values.
- 1% of the price of the equipment for each 1% flow rate inferior to the declared flow rate.
- 0.5% for each 1% flow rate superior to the declared flow rate.

The maximum total penalties on efficiency and flow rates shall be fixed at 5% of the motopumpset value, beyond this rate the motopumpset shall be rejected.

When the power required by the pump is not compatible with the motor provided, the motopumpset shall also be rejected.

## 603. TESTING ELECTRICAL PANELS IN WORKSHOPS

Tests of each electrical panel must include at least the following verifications:

- Verification of the aspect, accessibility of mechanical equipment, as well as strength and operation of mobile elements, precautions taken to prevent corrosion and protect paint, wires and cable runs, and marking operations, etc...
- Verification of the good functioning of mechanical and electrical control devices as well

as efficiency of locking mechanisms.
- Verification of the electrical insulation.
- Verification of the continuation of sheathings.
- Verification of Earthing connections.

Moreover, all electrical equipment constituting the panels should have undergone in-factory tests determined by the relevant standards: IEC 439, etc...

## 604. TESTING OF VALVES

All valves shall be tested in accordance with BS pressure and material test certificates shall be submitted to the Engineer for approval.

## 605. ON SITE TESTS

They are carried out on electromechanical plant, generating sets and control systems.

Tests shall comprise, but shall not be limited to, the following:

### 605.1 VISUAL INSPECTION

- Checking the state of the equipment and the quality of work.

- Checking levels and alignments.

- Verifying the effective characteristics of the equipment.

### 605.2 ACOUSTIC TESTING (NFS 31-010 AND BS 7445-3)

Regulations related to the noise caused by machinery, in order to protect the neighborhood and the environment, are stipulated by the legislation governing installations classified as noisy.

The surrounding noise level measured from outside the building must not exceed:

45 dB (A) during day time, throughout the week
40 dB (A) from 8:00 PM till 10:00 PM throughout the week and on Sundays
35 dB from 10:00 PM till 6:00 AM during the night

The noise level may be increased according to the surrounding and to the satisfaction of the Engineer or the Employer (increase in dB (A)).

- Suburban residential area with low road traffic + 5 dB (A).
- Urban residential area + 10 dB (A).
- Urban residential area with workshops and heavy road traffic + 15 dB (A).
- Commercial or industrial area + 20 dB (A).

The tests and controls shall be carried out in some particular cases, upon an explicit request stated in the description of the tender document.

## 605.3 TESTING OF ROTATING ELECTRIC EQUIPMENT

### 605.3.1 General

All rotating electric equipment shall undergo preliminary works before their operation such as:

- Verification of the inside of the machine: rotor, stator, and magnetic core gaps of windings, presence of foreign bodies, etc... Dust removing by vacuum or compressed air (maximal pressure 4 bars).

- Verification of the correct tightening of all bolts, nuts, screws.
- Verification of all electrical protection equipment and instrumentation connections.
- Performance of operation tests and verification of the protective devices.
- Verification of electric connections and rotation direction.
- Measurement of insulating resistance and determination of the dielectric absorption ratio as directed hereinafter.
- Elimination of any condensation or humidity on the winding or the terminal box, by heating or according to the instructions mentioned below.

Upon completion of these operations, the rotating electric equipment is ready for operation.

### 605.3.2 Measurement of Insulation Resistance

Before measuring the insulation resistance, separate all winding terminals of each phase.

Windings of phases : ($U_1$ - $U_2$ , $V_1$ -$V_2$ , $W_1$ - $W_2$)

- With windings ($V_1$ -$V_2$) and ($W_1$ - $W_2$) connected to the frame, measure the insulation resistance between the winding ($U_1$ - $U_2$) and the frame.

- With windings ($U_1$ - $U_2$) and ($W_1$ - $W_2$) connected to the frame, measure the insulation resistance between the winding ($V_1$ - $V_2$) and the frame.

- With windings ($U_1$ - $U_2$) and ($V_1$ - $V_2$) connected to the frame, measure the insulation resistance between the winding ($W_1$ - $W_2$) and the frame.

- Measurements shall be carried out as follows: every 10 seconds, during the first minute, then every minute for the following nine minutes. It is advisable to use a motorised Megger.

- Voltage measurement values are the following :

  250 volts dc for $U_N \leq 500$ V
  2500 volts dc for $U_N > 4500$ V

- Static electricity shall be discharged with care before and after each measurement.

- The following formula shall be applied :

$$Ri \geq K \frac{U_N}{D}$$

Ri : (M Ω) : insulation resistance

K : temperature adjustment factor
$U_N$ (KV) : Operation voltage of the machine
D (m) : Stator diameter Value = 1 if D ≤ 1 meter
Value = D if D > 1 meter

The value of the factor K in terms of the temperature is given in the following table:

| Winding temperature (°C) | K |
|---|---|
| 20 | 45 |
| 35 | 16 |
| 45 | 8 |
| 55 | 4 |
| 75 | 1 |

### 605.3.3 Determination of the Dielectric Absorption Ratio

The ratio is determined by the insulation resistance measurements corresponding to the first minute ($R_1$) and the tenth minute ($R_{10}$), as follows:

$$a = \frac{R10}{R_1} \text{ with } a \geq 2$$

Where a < 2, windings shall be cleaned and dried.

### 605.3.4 Cleaning of Windings

– If foreign bodies deposits are located in nooks inaccessible to dusters, it is advisable to use dry compressed air (max. 4 bars)

– Vacuum cleaning is required to prevent deposits from filling holes, setting between loose windings or damaging insulators when using compressed air.

– A solvent shall be used where oil or grease is mixed with dust. The solvent shall derive from petroleum and be selected so as not to damage insulators. Upon completion of the cleaning operation windings should be completely dry.

– Water may be used to clean dirty motors due to mud or eventual floods. This operation requires the disassembling of the motor in order to clean correctly and dry out all the parts.

### 605.3.5 Drying Windings with Air Circulation

Uncap the winding. Install a hot air blower (electrical resistance fitted with a fan) opposite the winding. The temperature of the air close to the winding shall not exceed 70°C.

Drying shall only require few hours, depending on the relative humidity and the power of the electrical blower.

## 605.4 TESTING OF HANDLING EQUIPMENT

All lifting equipment shall be tested at the manufacturer's works and on site. Tests on site shall comprise a full load test, including, where applicable, deflection checks on beams. Where the contractor wishes to use lifting equipment forming part of the permanent works for installation purposes he shall have the equipment tested and be in possession of a valid test certificate before using the equipment. All equipment must be tested or retested within one month of handing over to the Employer. Test certificates shall be provided in triplicate. The contractor shall be responsible at his own cost for the provision of all weights, slings and other equipment required for testing.

## 605.5 TESTING OF PLUMBING & SANITARY SYSTEM

The whole of the plumbing and sanitary system is to be tested on completion to the satisfaction of the Engineer and any defects shall be made good at the Contractor's expense.
The contractor shall provide all the labour, instrumentation, materials, temporary blank-off fittings, tools, plant and equipment required to complete all tests and commissioning.
Pressure tests shall be completed before any pipes are cleaned and before any insulation or protective covering is applied.
When a section of pipe work is complete and ready for testing, it shall be plugged and then slowly and carefully charged with water, allowing air to escape and avoiding all shock or water hammer. The contractor shall make arrangements for all water used in tests to be properly drained away.
Pipe work which fails under test, due to pressure loss or visible leakage, shall be relieved of pressure and all fault joints or other defects rectified to the complete satisfaction of the Engineer.
The Engineer or his representative will witness every test and the Contractor shall liaise with the Engineer, regarding the timing of the tests. All tests shall be repeated, if necessary, until such time as the engineer is satisfied. Test certificates shall be completed by the Contractor following each test and shall be submitted to the Engineer. The certificates shall state the following:

1. Pass / Failure
2. Pipe work section / Service tested
3. Equipment / Items on section excluded from test.
4. Test pressure and duration
5. Witness signature

Following testing, all pipe work and tanks shall be thoroughly flushed out and cleaned with potable water, to the entire satisfaction of the Engineer. After cleaning has been completed, the domestic hot and cold water lines shall be sterilised as follows:

1. All hot and cold water lines shall be thoroughly sterilised with a solution

containing 20 parts per million of available chlorine in the form of liquid chlorine, sodium hypochlorite or chlorinated lime.

2. The sterilising solution shall be introduced into the lines in an approved manner and shall be kept in the pipe work for 24 hours, during which time all valves shall be opened and closed several times.

3. After sterilisation, the solution shall be flushed from the lines with potable water until the residual chlorine content is not greater than 0.2 parts per million, or as directed by the Engineer.

## 605.6 TESTING OF HVAC SYSTEM

### 605.6.1 Test procedures

Proposed test procedures for duct leak and performance tests of systems, shall be submitted to the Engineer at least 4 weeks prior to the start of related testing.

### 605.6.2 Test on completion

Prior to taking over, the Contractor shall conduct the following tests:

#### 605.6.2.1 Testing, adjusting and balancing

Testing, adjusting, and balancing shall be as specified in ASHRAE and/or BRITISH STANDARD related to ADJUSTING AND BALANCING OF HVAC SYSTEMS. Testing and adjusting of ventilation systems shall begin only when the entire work has been completed, with the exception of performance tests.

#### 605.6.2.2 Temperature test

Temperature tests during 10 hours minimum, all doors and windows being closed, the premises dry, and the outdoor temperature between 28°C and 34°C in summer and between - 2° C and + 6° C in winter. Inside temperature shall be measured at 1.5 meter above ground level. Supply and return air temperatures in air-conditioned premises shall also be measured.

#### 605.6.2.3 Sound test

Sound level tests measured at 1.5 m from supply and extract gills by means of a variable frequency sound pressure level. Sound level shall not exceed 40 dBA.

### 605.6.3 Performance test

After testing and adjusting has been completed as specified, each system shall be tested as a whole to see that all items perform as integral parts of the system.
Correction and adjustments shall be made as necessary to produce the conditions indicated or specified. Capacity tests and general operating tests shall be conducted by an experienced engineer. Tests shall be carried out 4 weeks after all HVAC equipment has been put into operation successfully. Afterwards and after agreement with the engineer, the peak performance test shall be carried out at the time of peak outside conditions.
The equipment shall give the specified capacities at the peak conditions otherwise the equipment shall not be taken over.

### 605.6.4 Test reports

Test reports for the ductwork leak test and performance tests shall be submitted in booklet form, upon completion of testing. Reports shall document phases of tests performed including initial test summary, repairs/adjustments made, and final test results.

## 605.7 TESTING OF CHLORINATING SYSTEM

Prior to system start up all chlorination systems shall be pressure tested for leaks.

- The system shall be tested with nitrogen or dry air at a test pressure 50% higher than the service pressure. Soapy water shall be applied to all joints and connections to facilitates detection of leaks.
- The system shall be tested with chlorine. A rag soaked in liquid ammonia shall be brought to the vicinity of all potential leak points, leaks being evidenced by production of white ammonium chloride fumes. In the event of a leak, prior to effecting repairs, gas bottles shall be isolated and the lines drained through the dosing pumps.

**IMPORTANT** Procedure for Pressure Tests

1. Open all valves one turn except gas bottle valves.
2. Open gas bottle valves to achieve a system pressure of 1-2 kgf/cm$^2$ and close them again.
3. Search for leaks with an ammonia soaked rag.
4. In the event of a leak drain the lines with the dosing pumps and repair the leak.
5. Open gas bottle valves to achieve maximum system pressure.
6. Repeat 4 and 5 above.
7. When system is leak free open gas bottle valves one turn.

## 605.8 TESTING OF ELECTRIC, HYDRAULIC, CONTROL & TELEMETRY SYSTEMS

All tests shall be carried out according to BS 5772.

### 605.8.1 Testing of Electric Systems

- Time delay measurements of the units
- Insulation measurements of the various circuits

- Measurement of Resistance of Earthing bars
- Measurement of Voltage drops
- Measurement of Intensities conveyed through cables
- Measurement of Power consumption
- Correction of phases
- Measurement of Starting voltages, currents, etc...
- Measurement of Efficiency of Motors
- etc...

### 605.8.2 Testing of Hydraulic systems

- Surge protection
- Measurement of Pressure (upstream/downstream)
- Measurement of Flow
- Measurement of Efficiency of Motopumpsets
- Water analysis
- Valves
- etc...

### 605.8.3 Testing of Control & telemetry systems

- Communication links
- Safety
- Automatic operation, software
- Signals
- etc...

## 606. SETTING UP AND PRE-COMMISSIONING

Upon completion of works, and as soon as the equipment is ready to operate, the Contractor shall notify in writing the Engineer. The effective completion of the equipment assembling shall then be controlled in the presence of the Engineer and the Contractor by making the inventory of the equipment components. The good operation of all materials, especially of safety devices shall be checked.

The Contractor shall then set up the equipment.

During this period of "setting up", the Contractor can, upon the approval of the Engineer, stop or put in operation the equipment in order to make the necessary adjustments and be sure of their good operation.

When the Contractor deems that the equipment is ready to undergo the pre-commissioning operation, it shall be run for a period of time during which the equipment is operated according to a schedule set by the Engineer with the joint approval of the Contractor.

This period shall last fifteen days minimum, including, compulsorily, two days of continuous operation under the normal working conditions, as well as a number of successful consecutive startings to be agreed on with the Engineer.

During this period, equipment should operate without giving rise to any manufacture or setting up defect, that would lead compulsorily to putting them out of service. The Contractor can proceed to setting up operations during normal stop hours whenever he deems it necessary.

If, during this period, operating equipment give place to any incident, and, should the Contractor be bound to stop the equipment, outside normal stop hours, for any modification, setting up or adjustment, the period shall be extended to a duration equal to that of the interruptions.

In the same way, if the equipment should be stopped during the two days of continuous operation, the contractual period of 2 day continuous operation is counted all over again from the next starting.

Where frequent interruptions or the continuation of operation may cause any danger, the Engineer has the right to interrupt the operation, after having notified the Contractor. In this case, the Engineer gives the Contractor a delay reduced as much as possible and in accordance with the operation possibilities of the moment, to modify the equipment so that it conforms to the specifications of the Contract. After setting up defective parts, the equipment is put into service and the Contract during of the pre-commissioning period is counted all over again from that moment.

During setting up and operation periods, defined here above, the Contractor shall be responsible for the equipment. He shall overhaul, repair or carry out necessary modifications at his own costs.

## 607. TRAINING THE EMPLOYER PERSONNEL

During the period of assembling and especially during the period of pre-commissioning operation, the Contractor shall train the personnel assigned by the Employer. The training shall be carried out at 3 principal levels:

a) Engineers
b) Control and maintenance technicians (assistant engineers)
c) Skilled workers

The instruction of levels b) and c) shall be carried out with the collaboration of level a) already trained.

The training program, as well as the number of persons participating in the training shall be established by mutual agreement with the Employer, and upon his approval.

During the period of pre-commissioning, the Contractor shall hand over to the Employer's personnel the respective operating and maintenance manuals of the equipment.

## 608. COMMISSIONING

At the end of the satisfactory pre-commissioning operation, and if the Contractor has started training the Employer's personnel, the commissioning of the equipment shall start. It shall be deemed started and a report shall be drawn thereof provided that the Contractor has submitted

to the Engineer a written request, along with a copy of the drawings, notices and documents necessary to the operation and maintenance of the equipment.

Starting from the commissioning operation, the Employer's personnel takes over the operation and the maintenance of the equipment under the supervision of a sufficient number of qualified technicians assigned by the Contractor.

These technicians shall supervise the personnel till the end of the commissioning.

The commissioning period is fixed to a minimum continuous duration of twenty eight days, during which the equipment shall function satisfactorily and require only minor secondary setting up or adjustment entailing no stops and revealing no systematic defect.

In case any setting up, adjustment or defect entails the stopping of the equipment during the commissioning period, the minimum period of twenty-eight days mentioned above should compulsorily restart as from the resumption of the normal commissioning operation.

During the commissioning period set above, the Contractor's supervising technicians shall continue training the personnel assigned by the Employer.

Until the taking over, and provided the operation requirements permit it, the Contractor shall carry out, at his own costs, all necessary replacements, modifications, setting up and adjustments.

## 609. TAKING OVER OF WORKS

After the end of the commissioning period and upon a written request submitted by the Contractor, it shall be proceeded, in the presence of the Engineer and the Contractor, to the taking over provided that the equipment has functioned without requiring more than minor setting up or adjustments and without showing any systematic defect or default occurring during the minimum continuous period of twenty-eight days, and not in conformity with the technical specifications set in the tender document.

Taking over should include an inventory of the equipment and the tests set in the technical specifications, in order to verify whether the equipment meet, in quantity and quality, the conditions of the Contract.

The date and the schedule of the Taking Over are fixed by mutual agreement between the Engineer and the Contractor.

The Contractor shall carry out all necessary works and installations, and supply and assemble the equipment used for tests.

The Contractor is bound to inform the Engineer of all the defects he has detected.

In case operation incidents occur before taking over, the Engineer shall reserve the right to ask for an exhaustive inspection of the main components (pumps, motors, etc...).

The taking over shall be the subject of reports mentioning the necessary repairs and setting up.

The tests carried out eventually by the Contractor during the periods of setting up and

commissioning shall not be taken into consideration and shall be carried out once again during execution of the official tests on completion.

In case part of the equipment is rejected under any condition set hereafter in section "Rejection Of Equipment", the taking over of equipment, which is not rejected and is in accordance with the taking over conditions, is declared, provided that the equipment can be used independently from the rejected part.

Taking over takes place after achievement of satisfactory tests on completion.

The taking over shall be the subject of a report signed by the two parties.

It is agreed that, in case taking over is not declared, equipment remain under the responsibility of the Contractor.

Consequently, the Contractor shall bear along the consequences of all incidents or accidents occurring to the equipment before the signature of the taking over certificate.

The equipment shall, in no case, be considered as commissioned de facto.

## 610. DEFECTS LIABILITY PERIOD

The Contractor guarantees that all the supplies delivered according to the terms of the Contract are new, have never been used, are of the latest pattern put into service and have undergone all necessary improvements relating to design and materials.

Moreover, the Contractor guarantees that all the delivered supplies have no defects owing to their design, to the constituent material or to their use.

The Defects Liability Period remains valid for 12 months as from the date of Taking Over.

During the Defects Liability Period the Contractor shall supervise the maintenance of the installations.

During the Defects Liability Period, the Contractor is bound to carry out all modifications, setting up, adjustments required for the replacement of the defective parts, so that the equipment meet the conditions set out in the Contract.

If during the Defects Liability Period an equipment is stopped due to defects attributable to the Contractor, especially in the case of abnormal wear, deterioration or misfunction of a main component, the Defects Liability Period for this equipment is extended to cover the period of time during which the equipment was out of order.

If during the Defects Liability Period, it is necessary to replace a component due to an abnormal wear, deterioration or misfunction, the Defects Liability Period of this component is counted from the moment the replacing parts are put into service. In this case, the Engineer can, at the end of the Defects Liability Period retain an amount of money equal to twice the price of the component determined at the moment of the replacement. This amount shall not be fully paid up until the end of the Defects Liability Period proper to this component, provided that the latter was proved consistent with the clauses of the Contract.

The Contractor affords all the expenses resulting from the above-mentioned operations

including the cost of transportation, on site disassembling and reassembling and customs dues, etc...

Are excluded, expenses resulting from a deterioration owing to a negligence or an operation error and attributable to the Employer, or due to operation conditions that are not consistent with the instructions of operation and maintenance given by the Contractor. After having examined these defects not attributable to him, the Contractor shall inform the Engineer within a period of ten working days only, under a penalty of foreclosure.

The Contractor is not responsible for the components supplied, repaired, modified or replaced by the Employer or his representative without the written approval of the Contractor. However, this does not include the cases where the Employer carries out urgent repairs or replacements in the event of non compliance by the Contractor to the conditions mentioned hereinafter.

If it has been proved that the noticed defect is caused by a systematic error of design of equipment, the Contractor should replace or modify all identical parts used on the other equipment mentioned in the Contract, even though they did not give rise to any accident.

All works incumbent on the Contractor during the Defects Liability Period should be executed as soon as possible, taking into consideration the operation requirements.

The Contractor should, however, afford all provisional repairs to meet to the best these requirements, while reducing to the minimum the time during which equipment is partially or totally not operational.

The end of the Defects Liability Period will be declared following satisfactory Test On Completion results.

## 611. MAINTENANCE SUPERVISION DURING THE DEFECTS LIABILITY PERIOD

From the provisional taking over and till the end of the Defects Liability Period of all supplies, the Contractor shall ensure:

- the supervision of the maintenance of the installations carried out by competent technician
- the supervision of the necessary check-ups. The Employer shall bear the cost of workmanship, except those of the contractor's technicians.
- the supply of necessary spare parts. Therefore, the Contractor shall store on site all spare parts required for operation during the Defects Liability Period.
- the follow up and the further training of the Employer's personnel, as regards the operation and maintenance of the installations.

## 612. REJECTION OF EQUIPMENT

The Engineer reserves the right to reject the equipment under any of the following conditions:

a) If during the period of installation and assembling, several components of any equipment are discovered to be defective.

b) If the Tests On Completion show deviations with regard to the required flow and efficiency values specified in the Particular Specifications at the TDH.

c) If, during the Defects Liability Period serious defects occur (not allowing a safe operation and unlikely to be repaired by the Contractor within reasonable delays).

The Engineer can only reject the entire equipment if it shows serious defects which make its use dangerous or very expensive.

In the other cases, only the parts (of an entire machine) not answering the conditions of the Contract are rejected.

Before declaring the rejection, the Engineer shall examine, according to the elements submitted by the Contractor, the possibilities of :

a) either limiting the rejection to the seriously defective parts.
b) or fixing a delay to overhaul the equipment so that it meets the conditions of the Contract.

The Engineer may allow replacing the rejected equipment at the expense of the Contractor, during this time, he can:

– either renounce using the rejected equipment,

– or, use the equipment under the responsibility of the Contractor and upon his approval, on condition that several modifications, adjunctions or eventual adjustments are carried out, at the expense of the Contractor, either by him or by a supplier, if any. Therefore, the Engineer can, gratuitously, use the rejected equipment, and undertake to use it under the normal operation and maintenance conditions.

In all the cases mentioned above, rejected parts are returned to the Contractor.

## 613. OPERATION AND MAINTENANCE MANUALS

The Contractor shall supply for each set of installations provided for in the Contract, bilingual Operation and maintenance manuals (Arabic, French or English).

They shall include a table of contents and complete relevant material to the following sections as a minimum:

– Warnings
– General description
– Pumps control and protection
– Pumping station start up procedure and run operation
– Settings
– Preventive maintenance

- Trouble-shooting procedure
- Bill of material
- Drawings
- Manufacturer catalogues.

Unless otherwise specified, the instructions and the documents thereto shall be supplied in 3 copies properly presented and protected.

# Volume 2

# Technical Specifications

# Division 2

# Particular Specifications

# Part 3

# Mechanical Works

# TABLE OF CONTENT

300. MECHANICAL WORKS: COMMON TO ALL PUMPING STATIONS - PARTICULAR SPECIFICATIONS -.....3
300.1 PORTABLE FIRE EXTINGUISHERS.....3
300.2 HVAC INSTALLATIONS (NOT APPLICABLE).....3
300.2.1 Roof Exhaust Fan.....3
300.2.2 Installation Details.....4
300.3 PLUMBING AND DRAINAGE INSTALLATIONS.....4
300.3.1 Pipes and Fittings.....4
300.3.2 Roof Rain Water Outlets.....4
300.4 LIFTING AND HANDLING EQUIPMENT.....4
300.5 SURGE SUPPRESSION EQUIPMENT.....5
301. MECHANICAL WORKS: BAALOUL PS1 PUMPING STATION.....8
301.1 SUBMERSIBLE MOTOPUMPSETS.....8
301.1.1 Electric Motor.....8
301.1.2 Pump.....8
301.1.3 Motopumpset Assembly.....8
301.2 PIPING AND ACCESSORIES.....9
301.2.1 Scope of Works.....9
301.2.2 Piping.....9
301.2.3 Valves.....9
301.2.4 Check Valves.....9
301.3 LIFTING AND HANDLING EQUIPMENT.....10
301.4 SURGE SUPPRESSION EQUIPMENT.....10
302. MECHANICAL WORKS: BAALOUL PS2 PUMPING STATION.....11
302.1 SUBMERSIBLE MOTOPUMPSETS.....11
302.1.1 Electric Motor.....11
302.1.2 Pump.....11
302.1.3 Motopumpset Assembly.....11
302.2 PIPING AND ACCESSORIES.....12
302.2.1 Scope of Works.....12
302.2.2 Piping.....12
302.2.3 Valves.....12
302.2.4 Check Valves.....12
302.3 LIFTING AND HANDLING EQUIPMENT.....13
302.4 SURGE SUPPRESSION EQUIPMENT.....13
303. MECHANICAL WORKS: QARAOUN PS3 PUMPING STATION.....14
303.1 SUBMERSIBLE MOTOPUMPSETS.....14
303.1.1 Electric Motor.....14
303.1.2 Pump.....14
303.1.3 Motopumpset Assembly.....14
303.2 PIPING AND ACCESSORIES.....15
303.2.1 Scope of Works.....15
303.2.2 Piping.....15
303.2.3 Valves.....15
303.2.4 Check Valves.....15
303.3 LIFTING AND HANDLING EQUIPMENT.....16
303.4 SURGE SUPPRESSION EQUIPMENT.....16

304. MECHANICAL WORKS: QARAOUN PS4 PUMPING STATION ..... 17
304.1 SUBMERSIBLE MOTOPUMPSETS ..... 17
304.1.1 Electric Motor ..... 17
304.1.2 Pump ..... 17
304.1.3 Motopumpset Assembly ..... 17
304.2 PIPING AND ACCESSORIES ..... 18
304.2.1 Scope of Works ..... 18
304.2.2 Piping ..... 18
304.2.3 Valves ..... 18
304.2.4 Check Valves ..... 18
304.3 LIFTING AND HANDLING EQUIPMENT ..... 19
304.4 SURGE SUPPRESSION EQUIPMENT ..... 19
305. MECHANICAL WORKS: QARAOUN PS 5 PUMPING STATION ..... 20
305.1 SUBMERSIBLE MOTOPUMPSETS ..... 20
305.1.1 Electric Motor ..... 20
305.1.2 Pump ..... 20
305.1.3 Motopumpset Assembly ..... 20
305.2 PIPING AND ACCESSORIES ..... 21
305.2.1 Scope of Works ..... 21
305.2.2 Piping ..... 21
305.2.3 Valves ..... 21
305.2.4 Check Valves ..... 22
305.3 LIFTING AND HANDLING EQUIPMENT ..... 22
305.4 SURGE SUPPRESSION EQUIPMENT ..... 22
306. MECHANICAL WORKS: QARAOUN PS 6 PUMPING STATION ..... 23
306.1 SUBMERSIBLE MOTOPUMPSETS ..... 23
306.1.1 Electric Motor ..... 23
306.1.2 Pump ..... 23
306.1.3 Motopumpset Assembly ..... 23
306.2 PIPING AND ACCESSORIES ..... 24
306.2.1 Scope of Works ..... 24
306.2.2 Piping ..... 24
306.2.3 Valves ..... 24
306.2.4 Check Valves ..... 24
306.3 LIFTING AND HANDLING EQUIPMENT ..... 25
306.4 SURGE SUPPRESSION EQUIPMENT ..... 25

# 300. MECHANICAL WORKS: COMMON TO ALL PUMPING STATIONS - PARTICULAR SPECIFICATIONS -

## 300.1 PORTABLE FIRE EXTINGUISHERS

| Type / Location | "Gas" | "Powder" |
|---|---|---|
| Electrical room | 1 | 1 |
| Pumps room | 1 | 1 |

## 300.2 HVAC INSTALLATIONS (NOT APPLICABLE)

### 300.2.1 Roof Exhaust Fan

| | |
|---|---|
| Location | Roof of pumps room |
| Serving | Pumps room |
| Type | Roof Cowl Fan |
| Fan type | Axial |
| Fan flow ( $m^3$/hr ) | 2500 |
| Fan static pressure (Pa) | 50 |
| Motor Power ( W ) | 240 |
| Motor speed (rpm) | 1285 |
| Drive | direct on line |
| Voltage / Hz / Phase | 240 / 50 / 1 |
| Motor insulation class | F |
| Increased safety motor | EExell T3 ( explosion proof) |
| Automatic shutter | Yes |
| Storm-proof housing | Yes |
| Material of housing | Aluminum |
| Control unit | Wall room mounted Fan switch with timer?! |

| | |
|---|---|
| Flexible connector and Extract Diffuser | Yes |
| **Quantity (Set)** | 1 |

### 300.2.2 Installation Details

- Ventilation

The sump area shall be mechanically ventilated through a roof unit extract axial Fan and air taking via a ceiling extract diffuser. Electrical room ventilation shall be natural through louvers on the external wall.

All ductwork, flanges, grills, fans, supports, etc... shall be protected by a special anti-corrosion coating to withstand the attack due to the presence of local environment harmful gases.

- Electrical

Provide isolator switch near the extract fan, type and size as per electrical specification.

Connection shall be as shown on the detailed drawing.

- Controls

Roof extract Fan shall be provided with Room wall mounted Fan switch.

## 300.3 PLUMBING AND DRAINAGE INSTALLATIONS

### 300.3.1 Pipes and Fittings

- Above and below ground (Rain & Drainage) water installations with pipes and related accessories.

### 300.3.2 Roof Rain Water Outlets

| Location | Size (mm) | Quantity (No.) |
|---|---|---|
| Roof Slab | 200 x 200 | 2 |

## 300.4 LIFTING AND HANDLING EQUIPMENT

Two (2) lifting and handling systems consisting of a manual hoist and a monorail type structure shall be supplied and installed as follows:

– One electric hoist controlled by a pendant push button unit and a monorail type structure which spans the entire pump room enabling the hoist to lift any component from and to any location inside the pump room.
The safe working load (SWL) shall be mentioned in the individual particular specifications.

- One manual hoist and a monorail type structure which spans over the discharge gallery enabling the hoist to lift the sludge bucket for outside discharge.
  The safe working load (SWL) shall be mentioned in the individual particular specifications.

- Any other accessories and equipment deemed necessary for the complete installation.

### 300.5 SURGE SUPPRESSION EQUIPMENT

The surge suppression equipment shall include surge vessels(s) for the pumping line, air compressor unit, valves, fittings and also compressor control panel, complete with cabling and wiring. The above panel shall incorporate the power and control gear of the compressor and level indication and protection of the surge suppression system.

The control and monitoring of the surge suppression equipment shall be achieved by the compressor's control panel PLC. This PLC shall be linked to the main PLC in the control room.

It shall also include all accessories required for the complete installation such as pipes, bends, gaskets, bolts, nuts, supports, flanges, unions, couplings, adaptors, etc....

*Note: It is the responsibility of the Contractor to gather all necessary information and submit detailed calculation sheet for design justification, based on the pumping line profile and characteristics, and decide type of surge suppression equipment to be used.*

### 300.6 ODOR CONTROL SYSTEM

**Performance requirements**

The gases released from the flows are anticipated to be those consistent with raw sewage and will include various sulphides, mercaptans, amines, nitrides, skatoles, acid compounds and methane. The air purification plant shall reduce the levels of odors and gas emissions such that the air is effectively odorless when measure at a boundary, 15 m away, at all times.

To achieve the required performance the following estimated values of hydrogen sulphides ($H_2S$) may be used as guidelines:

i) Maximum concentration of $H_2S$ from any source – 10 ppm.

ii) Maximum concentration of $H_2S$ to be achieved in treated air at discharge to atmosphere – 0.03 ppm.

iii) Maximum concentration of $H_2S$ to be achieved in diluted treated air at the boundary fence 15 m away – 0.00047 ppm.

The Contractor shall note that the value given in (ii) is based upon the estimated degree of dilution between the discharge point and the boundary fence in order to achieve the value in (iii). The Contractor shall be responsible for determining the exact degree of dilution to achieve the value in (iii).

The figures given in items (i), (ii) and (iii) above relate only to $H_2S$. The Contractor shall still

nevertheless, be required to reduce the level of other odorous, contaminants to ensure that the treated air is effectively odorless at the boundary.

The equipment shall also be capable of withstanding short periods of high contaminant (shock loads) and long periods of low contaminant without detriment to the short or long term performance of the equipment.

**Bulk Carbon Regenerable Odor Control Units**

Water mist shall be removed from the air to be treated in an axial demister where the water is separated from the air by centrifugal force.

The air shall then be filtered over a foam type or Fiber type Regenerable pre-filter grade EU 3 or better. The pre-filter shall have a separate pressure gauge with a range of 0 – 500 Pa. the filter body and internals shall be in 316 stainless steels. The odorous air shall be blown through the unit with a dynamically balanced 316 stainless steel fan, which shall have a drain connection and inspection door. The fan shafts shall have double ball bearing and dynamic shafts seal to prevent Odor leakage. The motor shall be protection class IP 55 and shall be tropicalized.

After the pre-filter the air shall be discharged via a stainless-steel pipe to the absorber vessel. The flow shall be controlled by an integral airtight an externally lockable stainless-steel damper. The odorous air shall be blown through two beds of non-impregnated granular activated carbon. The beds shall be at least 900 mm deep and shall operate in parallel. The air shall stay in the bed at least 2.25 seconds and the maximum filtration rate shall not exceed 25 m per minute.

The activated carbon shall be bituminous coals based, non – impregnated granular and able to convert $H_2S$ to an Odor free form. When saturated the carbon shall be Regenerable using potable water only. The maximum water requirement shall not exceed 10 times the weight of carbon and the regeneration operation shall be completed within 24 hours. All water piping and valves for the inlet, outlet and overflow shall be provided with the adsorption system.

The granular carbon shall be US mesh size 4 x 7 and steam activated. The supplier shall guarantee that the carbon is non-impregnated in situ and has at 16 % W/W capacity for $H_2S$. The supplier must guarantee that he will take back the saturated carbon after several

regenerations and supply reactivated carbon with the same adsorption properties as the initials fill.

Appropriate supports shall be provided to support the carbon beds and distribute the air evenly. Provision shall be made to take air at 30,60 and 90% bed depth and a H2S detection system with colorimetric sensitive paper shall inform where the saturation front in the absorber has moved to the amount of air treated shall be controlled a differential pressure gauge for each bed. An outlet shall be provided for each bed and shall be fitted with a stainless-steel airtight butterfly valve mounted in an outlet pipe complete with a rain cap.

A bulk carbon regenerable Odor control unit shall be provided to deodorize the air extracted from the wet well. The extraction rate shall be sufficient to provide 12 air changes per hour in

the wet well when empty of sewage. The Odor control unit shall be provided with a bypass with provision of relief device to prevent the buildup of pressure in the sump under unusual operating conditions. The unit shall be located inside the building, sealed to prevent gas leakage and vented externally to a high level.

### 300.7 BAR SCREEN

A manual bar screen used for solids removing suitable for wastewater application field.

The opening size of the screen should be 50 mm.

The material of the bar screens: stainless steel of grade 316.

## 301. MECHANICAL WORKS: BAALOUL PS1 PUMPING STATION

Hydraulic schematic drawing No: 588-PS-01M01
Mechanical drawing No: 588-PS-01M02

### 301.1 SUBMERSIBLE MOTOPUMPSETS

#### 301.1.1 Electric Motor

| Minimum Power Factor at 75% to 100% Output | Efficiency at 75% to 100% Output | No. of Starts/Hour | Rotating speed (rpm) |
|---|---|---|---|
| ≥ 0.86 | ≥ 85.5% | ≥ 15 | ≤ 3000 |

#### 301.1.2 Pump

Type: Shrouded single channel impeller running in a volute / Grinder type.

Rotating speed: That of the electrical driving motor

| Flow (l/s) | Head (m) | N.P.S.H. (m) | Efficiency at Duty Point | Throughlet size (mm) | Remarks |
|---|---|---|---|---|---|
| 3.5 | 50 | ≤4 | ≥ 25% | ≥ 50 | Submersible pumps |

#### 301.1.3 Motopumpset Assembly

- Installation: Suitable for dry and wet sumps

– Accessories: Supply and install a complete automatic connecting/disconnecting system and a complete guidance system.

| Qty (No) |
|---|
| 2 |

– Motopumpsets shall be considered Class A and thus shall be tested at the factory.

Supply and installation of all the necessary miscellaneous mechanical accessories required for the assembly of the complete motopumpset system such as joints, couplings, adaptors, supports, bolts and nuts, etc...

## 301.2 PIPING AND ACCESSORIES

### 301.2.1 Scope of Works

The hydraulic system is composed of the following:

1 Two (2) submersible sewage motopumpset, specified in "Motopumpset" section

2 Two (2) motopumpset outlet sections 80 mm diameter

3 A 80 mm diameter discharge header

4 A 80 mm diameter discharge header drain section

5 Level, pressure and temperature measurements and oil leakage detector which are specified in 'Instrumentation, Control Equipment and accessories" section

### 301.2.2 Piping

| Location | Material | ND (mm) | NP (bars) |
|---|---|---|---|
| Motopumpset outlet section | Ductile Iron | 80 | 16 |
| Discharge header | Ductile Iron | 80 | 16 |
| Discharge header Drain Section | Ductile Iron | 80 | 16 |

### 301.2.3 Valves

| Location | Type | Material | ND (mm) | NP (bars) | Qty (No) |
|---|---|---|---|---|---|
| Motopumpset outlet section No. 1,2 | Gate | Cast Iron | 80 | 16 | 2 |
| Discharge header (Main) No. 5 | Gate | Cast Iron | 80 | 16 | 1 |

| | | | | | |
|---|---|---|---|---|---|
| Discharge header (Drain) No. 4 | Gate | Cast Iron | 80 | 16 | 1 |
| Air release valve | Double Function | Cast Iron | 60 | 16 | 2 |

### 301.2.4 Check Valves

| Location | Type | Material | ND (mm) | NP (bars) | Qty (No) |
|---|---|---|---|---|---|
| Motopumpset outlet section | Ball valve | Cast Iron | 80 | 16 | 2 |

- Supply and installation of all the necessary miscellaneous hydraulic accessories required for the assembly of the complete system such as inserts, flanges, gaskets, couplings, adaptors, bends, pipe supports, bolts and nuts, etc....

## 301.3 LIFTING AND HANDLING EQUIPMENT

Two (2) lifting and handling systems consisting of a manual hoist and a monorail type structure shall be supplied and installed as follows:

- One which spans the entire pumps row enabling the hoist to lift any component from/to the sump. Safe working load (SWL) 1000 kg.

- One which spans over the discharge gallery enabling the hoist to lift the sludge bucket for outside discharge.
  Safe working load (SWL): 250 kg.

- Any other accessories and equipment deemed necessary for the complete installation.

## 301.4 SURGE SUPPRESSION EQUIPMENT

The Contractor shall submit detailed sizing calculation for the vessel capacity based on the pumping line profile and characteristics.

Type: Ductile iron, DN 80, PN16
Flow: 3.5 l/s.
Length = 290 m.
Delta H = 45 m.

## 301.5 ODOR CONTROL SYSTEM

The Contractor shall submit detailed sizing calculation for the Odor control system, including a stainless-steel vessel, fan extractor, which is should be connected to H2S sensor for automatic mode of operation.

# 302. MECHANICAL WORKS: BAALOUL PS2 PUMPING STATION

Hydraulic schematic drawing No: 588-PS-02M01
Mechanical drawing No: 588-PS-02M02

## 302.1 SUBMERSIBLE MOTOPUMPSETS

### 302.1.1 Electric Motor

| Minimum Power Factor at 75% to 100% Output | Efficiency at 75% to 100% Output | No. of Starts/Hour | Rotating speed (rpm) |
|---|---|---|---|
| ≥ 0.86 | ≥ 85.5% | ≥ 15 | ≤ 3000 |

### 302.1.2 Pump

Type: Shrouded single channel impeller running in a volute / Grinder type.

Rotating speed: That of the electrical driving motor

| Flow (l/s) | Head (m) | N.P.S.H. (m) | Efficiency at Duty Point | Throughlet size (mm) | Remarks |
|---|---|---|---|---|---|
| 3.5 | 74 | ≤4 | ≥ 15% | ≥ 50 | Submersible pumps |

### 302.1.3 Motopumpset Assembly

- Installation: Suitable for dry and wet sumps
- Accessories: Supply and install a complete automatic connecting/disconnecting system and a complete guidance system.

| Qty (No) |
|---|
| 2 |

- Motopumpset shall be considered Class A and thus shall undergo witness test in factory.

Supply and installation of all the necessary miscellaneous mechanical accessories required for the assembly of the complete Motopumpset system such as joints, couplings, adaptors, supports, bolts and nuts, etc...

## 302.2 PIPING AND ACCESSORIES

### 302.2.1 Scope of Works

The hydraulic system is composed of the following:

1 Two (2) submersible sewage Motopumpset, specified in "Motopumpset" section

2 Two (2) Motopumpset outlet sections 80 mm diameter

3 A 80 mm diameter discharge header

4 A 80 mm diameter discharge header drain section

5 Level, pressure and temperature measurements and oil leakage detector which are specified in 'Instrumentation, Control Equipment and accessories" section

### 302.2.2 Piping

| Location | Material | ND (mm) | NP (bars) |
|---|---|---|---|
| Motopumpset outlet section | Ductile Iron | 80 | 16 |
| Discharge header | Ductile Iron | 80 | 16 |
| Discharge header Drain Section | Ductile Iron | 80 | 16 |

### 302.2.3 Valves

| Location | Type | Material | ND (mm) | NP (bars) | Qty (No) |
|---|---|---|---|---|---|
| Motopumpset outlet section No. 1,2 | Gate | Cast Iron | 80 | 16 | 2 |
| Discharge header (Main) No. 5 | Gate | Cast Iron | 80 | 16 | 1 |
| Discharge header (Drain) No. 4 | Gate | Cast Iron | 80 | 16 | 1 |
| Air release valve | Double Function | Cast Iron | 60 | 16 | 2 |

### 302.2.4 Check Valves

| Location | Type | Material | ND (mm) | NP (bars) | Qty (No) |
|---|---|---|---|---|---|
| Motopumpset outlet section | Ball valve | Cast Iron | 80 | 16 | 2 |

- Supply and installation of all the necessary miscellaneous hydraulic accessories required for the assembly of the complete system such as inserts, flanges, gaskets, couplings, adaptors, bends, pipe supports, bolts and nuts, etc....

## 302.3 LIFTING AND HANDLING EQUIPMENT

Two (2) lifting and handling systems consisting of a manual hoist and a monorail type structure shall be supplied and installed as follows:

- One which spans the entire pumps row enabling the hoist to lift any component from/to the sump. Safe working load (SWL) 1000 kg.

- One which spans over the discharge gallery enabling the hoist to lift the sludge bucket for outside discharge.
  Safe working load (SWL): 250 kg.

- Any other accessories and equipment deemed necessary for the complete installation.

### 302.4 SURGE SUPPRESSION EQUIPMENT

The Contractor shall submit detailed sizing calculation for the vessel capacity based on the pumping line profile and characteristics.

Type: Ductile iron, DN 80, PN16
Flow: 3.5 l/s.
Length = 685.4 m.
Delta H = 62 m.

### 302.5 ODOR CONTROL SYSTEM

The Contractor shall submit detailed sizing calculation for the Odor control system, including a stainless-steel vessel, fan extractor, which is should be connected to H2S sensor for automatic mode of operation.

## 303. MECHANICAL WORKS: QARAOUN PS3 PUMPING STATION

Hydraulic schematic drawing No: 588-PS-03M01
Mechanical drawing No: 588-PS-03M02

### 303.1 SUBMERSIBLE MOTOPUMPSETS

#### 303.1.1 Electric Motor

| Minimum Power Factor at 75% to 100% Output | Efficiency at 75% to 100% Output | No. of Starts/Hour | Rotating speed (rpm) |
|---|---|---|---|
| ≥ 0.86 | ≥ 85.5% | ≥ 15 | ≤ 3000 |

#### 303.1.2 Pump

Type: Shrouded single channel impeller running in a volute / Grinder type.

Rotating speed: That of the electrical driving motor

| Flow (l/s) | Head (m) | N.P.S.H. (m) | Efficiency at Duty Point | Throughlet size (mm) | Remarks |
|---|---|---|---|---|---|
| 4.58 | 50 | ≤4 | ≥ 20% | ≥ 50 | Submersible pumps |

### 303.1.3 Motopumpset Assembly

- Installation: Suitable for dry and wet sumps
- Accessories: Supply and install a complete automatic connecting/disconnecting system and a complete guidance system.

| Qty (No) |
|---|
| 2 |

- Motopumpsets shall be considered Class A and thus shall undergo witness test in factory.

Supply and installation of all the necessary miscellaneous mechanical accessories required for the assembly of the complete motopumpset system such as joints, couplings, adaptors, supports, bolts and nuts, etc...

## 303.2 PIPING AND ACCESSORIES

### 303.2.1 Scope of Works

The hydraulic system is composed of the following:

1 Two (2) submersible sewage motopumpset, specified in "Motopumpset" section

2 Two (2) motopumpset outlet sections 80 mm diameter

3 A 80 mm diameter discharge header

4 A 80 mm diameter discharge header drain section

5 Level, pressure and temperature measurements and oil leakage detector which are specified in 'Instrumentation, Control Equipment and accessories" section

### 303.2.2 Piping

| Location | Material | ND (mm) | NP (bars) |
|---|---|---|---|
| Motopumpset outlet section | Ductile Iron | 80 | 16 |
| Discharge header | Ductile Iron | 80 | 16 |

| | | | |
|---|---|---|---|
| Discharge header Drain Section | Ductile Iron | 80 | 16 |

### 303.2.3 Valves

| Location | Type | Material | ND (mm) | NP (bars) | Qty (No) |
|---|---|---|---|---|---|
| Motopumpset outlet section No. 1,2 | Gate | Cast Iron | 80 | 16 | 2 |
| Discharge header (Main) No. 5 | Gate | Cast Iron | 80 | 16 | 1 |
| Discharge header (Drain) No. 4 | Gate | Cast Iron | 80 | 16 | 1 |
| Air release valve | Double Function | Cast Iron | 60 | 16 | 2 |

### 303.2.4 Check Valves

| | | | | | |
|---|---|---|---|---|---|
| Motopumpset outlet section | Ball valve | Cast Iron | 80 | 16 | 2 |

- Supply and installation of all the necessary miscellaneous hydraulic accessories required for the assembly of the complete system such as inserts, flanges, gaskets, couplings, adaptors, bends, pipe supports, bolts and nuts, etc....

## 303.3 LIFTING AND HANDLING EQUIPMENT

Two (2) lifting and handling systems consisting of a manual hoist and a monorail type structure shall be supplied and installed as follows:

- One which spans the entire pumps row enabling the hoist to lift any component from/to the sump. Safe working load (SWL) 1000 kg.

- One which spans over the discharge gallery enabling the hoist to lift the sludge bucket for outside discharge.
  Safe working load (SWL): 250 kg.

- Any other accessories and equipment deemed necessary for the complete installation.

## 303.4 SURGE SUPPRESSION EQUIPMENT

The Contractor shall submit detailed sizing calculation for the vessel capacity based on the pumping line profile and characteristics.

Type: Ductile iron, DN 80, PN16
Flow: 4.58 l/s.
Length = 1185 m.
Delta H = 33 m.

### 303.5 ODOR CONTROL SYSTEM

The Contractor shall submit detailed sizing calculation for the Odor control system, including a stainless-steel vessel, fan extractor, which is should be connected to H2S sensor for automatic mode of operation.

## 304. MECHANICAL WORKS: QARAOUN PS4 PUMPING STATION

Hydraulic schematic drawing No: 588-PS-04M01
Mechanical drawing No: 588-PS-04M02

### 304.1 SUBMERSIBLE MOTOPUMPSETS

#### 304.1.1 Electric Motor

| Minimum Power Factor at 75% to 100% Output | Efficiency at 75% to 100% Output | No. of Starts/Hour | Rotating speed (rpm) |
|---|---|---|---|
| ≥ 0.88 | ≥ 85.5% | ≥ 15 | ≤ 3000 |

#### 304.1.2 Pump

Type: Shrouded single channel impeller running in a volute / Grinder type.

Rotating speed: That of the electrical driving motor

| Flow (l/s) | Head (m) | N.P.S.H. (m) | Efficiency at Duty Point | Throughlet size (mm) | Remarks |
|---|---|---|---|---|---|
| 12.38 | 64 | ≤4 | ≥ 35% | ≥ 50 | Submersible pumps |

#### 304.1.3 Motopumpset Assembly

- Installation: Suitable for dry and wet sumps
- Accessories: Supply and install a complete automatic connecting/disconnecting system and a complete guidance system.

| Qty (No) |
|---|
| 2 |

- Motopumpsets shall be considered Class A and thus shall undergo witness test in factory.

Supply and installation of all the necessary miscellaneous mechanical accessories required for the

assembly of the complete motopumpset system such as joints, couplings, adaptors, supports, bolts and nuts, etc...

## 304.2 PIPING AND ACCESSORIES

### 304.2.1 Scope of Works

The hydraulic system is composed of the following:

1 Two (2) submersible sewage motopumpset, specified in "Motopumpset" section

2 Two (2) motopumpset outlet sections 125 mm diameter

3 A 150 mm diameter discharge header

4 A 125 mm diameter discharge header drain section

5 Level, pressure and temperature measurements and oil leakage detector which are specified in 'Instrumentation, Control Equipment and accessories" section

### 304.2.2 Piping

| Location | Material | ND (mm) | NP (bars) |
|---|---|---|---|
| Motopumpset outlet section | Ductile Iron | 125 | 16 |
| Discharge header | Ductile Iron | 150 | 16 |
| Discharge header Drain Section | Ductile Iron | 100 | 16 |

### 304.2.3 Valves

| Location | Type | Material | ND (mm) | NP (bars) | Qty (No) |
|---|---|---|---|---|---|
| Motopumpset outlet section No. 1,2 | Gate | Cast Iron | 125 | 16 | 2 |
| Discharge header (Main) No. 5 | Gate | Cast Iron | 150 | 16 | 1 |
| Discharge header (Drain) No. 4 | Gate | Cast Iron | 100 | 16 | 1 |
| Air release valve | Double Function | Cast Iron | 60 | 16 | 2 |

### 304.2.4 Check Valves

| Location | Type | Material | ND (mm) | NP (bars) | Qty (No) |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| Motopumpset outlet section | Ball valve | Cast Iron | 125 | 16 | 2 |

- Supply and installation of all the necessary miscellaneous hydraulic accessories required for the assembly of the complete system such as inserts, flanges, gaskets, couplings, adaptors, bends, pipe supports, bolts and nuts, etc....

### 304.3 LIFTING AND HANDLING EQUIPMENT

Two (2) lifting and handling systems consisting of a manual hoist and a monorail type structure shall be supplied and installed as follows:

- One which spans the entire pumps row enabling the hoist to lift any component from/to the sump. Safe working load (SWL) 1000 kg.

- One which spans over the discharge gallery enabling the hoist to lift the sludge bucket for outside discharge.
  Safe working load (SWL): 250 kg.

- Any other accessories and equipment deemed necessary for the complete installation.

### 304.4 SURGE SUPPRESSION EQUIPMENT

The Contractor shall submit detailed sizing calculation for the vessel capacity based on the pumping line profile and characteristics.

Type: Ductile iron, DN 150, PN16
Flow: 12.38 l/s.
Length = 1038 m.
Delta H = 53 m.

### 304.5 ODOR CONTROL SYSTEM

The Contractor shall submit detailed sizing calculation for the Odor control system, including a stainless-steel vessel, fan extractor, which is should be connected to H2S sensor for automatic mode of operation.

## 305. MECHANICAL WORKS: QARAOUN PS 5 PUMPING STATION

Hydraulic schematic drawing No: 588-PS-05M01
Mechanical drawing No: 588-PS-05M02

### 305.1 SUBMERSIBLE MOTOPUMPSETS

#### 305.1.1 Electric Motor

| Minimum Power Factor at 75% to 100% Output | Efficiency at 75% to 100% Output | No. of Starts/Hour | Rotating speed (rpm) |
|---|---|---|---|
| ≥ 0.86 | ≥ 85.5% | ≥ 15 | ≤ 3000 |

### 305.1.2 Pump

Type: Shrouded single channel impeller running in a volute / Grinder type.

Rotating speed: That of the electrical driving motor

| Flow (l/s) | Head (m) | N.P.S.H. (m) | Efficiency at Duty Point | Throughlet size (mm) | Remarks |
|---|---|---|---|---|---|
| 6.28 | 60.18 | ≤4 | ≥ 25% | ≥ 50 | Submersible pumps |

### 305.1.3 Motopumpset Assembly

- Installation: Suitable for dry and wet sumps
- Accessories: Supply and install a complete automatic connecting/disconnecting system and a complete guidance system.

| Qty (No) |
|---|
| 2 |

- Motopumpsets shall be considered Class A and thus shall undergo witness test in factory.

Supply and installation of all the necessary miscellaneous mechanical accessories required for the assembly of the complete motopumpset system such as joints, couplings, adaptors, supports, bolts and nuts, etc...

## 305.2 PIPING AND ACCESSORIES

### 305.2.1 Scope of Works

The hydraulic system is composed of the following:

1 Two (2) submersible sewage motopumpset, specified in “Motopumpset” section

2 Two (2) motopumpset outlet sections 80 mm diameter

3 A 100 mm diameter discharge header

4 A 80 mm diameter discharge header drain section

5 Level, pressure and temperature measurements and oil leakage detector which are

specified in 'Instrumentation, Control Equipment and accessories" section

### 305.2.2 Piping

| Location | Material | ND (mm) | NP (bars) |
|---|---|---|---|
| Motopumpset outlet section | Ductile Iron | 80 | 16 |
| Discharge header | Ductile Iron | 100 | 16 |
| Discharge header Drain Section | Ductile Iron | 80 | 16 |

### 305.2.3 Valves

| Location | Type | Material | ND (mm) | NP (bars) | Qty (No) |
|---|---|---|---|---|---|
| Motopumpset outlet section No. 1,2 | Gate | Cast Iron | 80 | 16 | 2 |
| Discharge header (Main) No. 5 | Gate | Cast Iron | 100 | 16 | 1 |
| Discharge header (Drain) No. 4 | Gate | Cast Iron | 80 | 16 | 1 |
| Air release valve | Double Function | Cast Iron | 60 | 16 | 2 |

### 305.2.4 Check Valves

| Location | Type | Material | ND (mm) | NP (bars) | Qty (No) |
|---|---|---|---|---|---|
| Motopumpset outlet section | Ball valve | Cast Iron | 80 | 16 | 2 |

- Supply and installation of all the necessary miscellaneous hydraulic accessories required for the assembly of the complete system such as inserts, flanges, gaskets, couplings, adaptors, bends, pipe supports, bolts and nuts, etc....

## 305.3 LIFTING AND HANDLING EQUIPMENT

Two (2) lifting and handling systems consisting of a manual hoist and a monorail type structure shall be supplied and installed as follows:

- One which spans the entire pumps row enabling the hoist to lift any component from/to the sump. Safe working load (SWL) 1000 kg.

- One which spans over the discharge gallery enabling the hoist to lift the sludge bucket for outside discharge.
  Safe working load (SWL): 250 kg.

- Any other accessories and equipment deemed necessary for the complete installation.

### 305.4 SURGE SUPPRESSION EQUIPMENT

The Contractor shall submit detailed sizing calculation for the vessel capacity based on the pumping line profile and characteristics.

Type: Ductile iron, DN 100, PN16
Flow: 6.28 l/s.
Length = 938 m.
Delta H = 46 m.

### 305.5 ODOR CONTROL SYSTEM

The Contractor shall submit detailed sizing calculation for the Odor control system, including a stainless-steel vessel, fan extractor, which is should be connected to H2S sensor for automatic mode of operation.

## 306. MECHANICAL WORKS: QARAOUN PS 6 PUMPING STATION

Hydraulic schematic drawing No: 588-PS-06M01
Mechanical drawing No: 588-PS-06M02

### 306.1 SUBMERSIBLE MOTOPUMPSETS

#### 306.1.1 Electric Motor

| Minimum Power Factor at 75% to 100% Output | Efficiency at 75% to 100% Output | No. of Starts/Hour | Rotating speed (rpm) |
|---|---|---|---|
| ≥ 0.86 | ≥ 85.5% | ≥ 15 | ≤ 3000 |

#### 306.1.2 Pump

Type: Shrouded single channel impeller running in a volute / Grinder type.

Rotating speed: That of the electrical driving motor

| Flow (l/s) | Head (m) | N.P.S.H. (m) | Efficiency at Duty Point | Throughlet size (mm) | Remarks |
|---|---|---|---|---|---|
| 3.5 | 40 | ≤4 | ≥ 25% | ≥ 50 | Submersible pumps |

#### 306.1.3 Motopumpset Assembly

- Installation: Suitable for dry and wet sumps
- Accessories: Supply and install a complete automatic connecting/disconnecting system and a complete guidance system.

| Qty (No) |
|---|
| 2 |

- Motopumpsets shall be considered Class A and thus shall undergo witness test in factory.

Supply and installation of all the necessary miscellaneous mechanical accessories required for the assembly of the complete motopumpset system such as joints, couplings, adaptors, supports, bolts and nuts, etc...

## 306.2 PIPING AND ACCESSORIES

### 306.2.1 Scope of Works

The hydraulic system is composed of the following:

1 Two (2) submersible sewage motopumpset, specified in "Motopumpset" section

2 Two (2) motopumpset outlet sections 80 mm diameter

3 A 80 mm diameter discharge header

4 A 80 mm diameter discharge header drain section

5 Level, pressure and temperature measurements and oil leakage detector which are specified in 'Instrumentation, Control Equipment and accessories" section

### 306.2.2 Piping

| Location | Material | ND (mm) | NP (bars) |
|---|---|---|---|
| Motopumpset outlet section | Ductile Iron | 80 | 16 |
| Discharge header | Ductile Iron | 80 | 16 |
| Discharge header Drain Section | Ductile Iron | 80 | 16 |

### 306.2.3 Valves

| Location | Type | Material | ND (mm) | NP (bars) | Qty (No) |
|---|---|---|---|---|---|
| Motopumpset outlet section No. 1,2 | Gate | Cast Iron | 80 | 16 | 2 |

| | | | | | |
|---|---|---|---|---|---|
| Discharge header (Main) No. 5 | Gate | Cast Iron | 80 | 16 | 1 |
| Discharge header (Drain) No. 4 | Gate | Cast Iron | 80 | 16 | 1 |
| Air release valve | Double Function | Cast Iron | 60 | 16 | 2 |

### 306.2.4 Check Valves

| Location | Type | Material | ND (mm) | NP (bars) | Qty (No) |
|---|---|---|---|---|---|
| Motopumpset outlet section | Ball valve | Cast Iron | 80 | 16 | 2 |

- Supply and installation of all the necessary miscellaneous hydraulic accessories required for the assembly of the complete system such as inserts, flanges, gaskets, couplings, adaptors, bends, pipe supports, bolts and nuts, etc....

## 306.3 LIFTING AND HANDLING EQUIPMENT

Two (2) lifting and handling systems consisting of a manual hoist and a monorail type structure shall be supplied and installed as follows:

- One which spans the entire pumps row enabling the hoist to lift any component from/to the sump. Safe working load (SWL) 1000 kg.

- One which spans over the discharge gallery enabling the hoist to lift the sludge bucket for outside discharge.
  Safe working load (SWL): 250 kg.

- Any other accessories and equipment deemed necessary for the complete installation.

## 306.4 SURGE SUPPRESSION EQUIPMENT

The Contractor shall submit detailed sizing calculation for the vessel capacity based on the pumping line profile and characteristics.

Type: Ductile iron, DN 80, PN16
Flow: 3.5 l/s.
Length = 550 m.
Delta H = 33 m.

## 306.5 ODOR CONTROL SYSTEM

The Contractor shall submit detailed sizing calculation for the Odor control system, including a stainless-steel vessel, fan extractor, which is should be connected to H2S sensor for automatic mode of operation.

# 307. MECHANICAL WORKS: QARAOUN EXISTING PS 7 PUMPING STATION

Hydraulic schematic drawing No: 588-PS-07M01
Mechanical drawing No: 588-PS-07M02

## 307.1 SUBMERSIBLE MOTOPUMPSETS

### 307.1.1 Electric Motor

| Minimum Power Factor at 75% to 100% Output | Efficiency at 75% to 100% Output | No. of Starts/Hour | Rotating speed (rpm) |
|---|---|---|---|
| ≥ 0.86 | ≥ 85.5% | ≥ 15 | ≤ 3000 |

### 307.1.2 Pump

Type: Shrouded single channel impeller running in a volute / Grinder type.

Rotating speed: That of the electrical driving motor

| Flow (l/s) | Head (m) | N.P.S.H. (m) | Efficiency at Duty Point | Throughlet size (mm) | Remarks |
|---|---|---|---|---|---|
| 30 | 57 | ≤4 | ≥ 50% | ≥ 100 | Submersible pumps |

### 307.1.3 Motopumpset Assembly

- Installation: Suitable for dry and wet sumps
- Accessories: Supply and install a complete automatic connecting/disconnecting system and a complete guidance system.

| Qty (No) |
|---|
| 3 |

- Motopumpsets shall be considered Class A and thus shall undergo witness test in factory.

Supply and installation of all the necessary miscellaneous mechanical accessories required for the assembly of the complete motopumpset system such as joints, couplings, adaptors, supports, bolts and nuts, etc...

## 307.2 PIPING AND ACCESSORIES

### 307.2.1 Scope of Works

The hydraulic system is composed of the following:

1 Three (3) submersible sewage motopumpset, specified in "Motopumpset" section

2 Three (3) motopumpset outlet sections 200 mm diameter

3 A 200 mm diameter discharge header

4 A 200 mm diameter discharge header drain section

5 Level, pressure and temperature measurements and oil leakage detector which are specified in 'Instrumentation, Control Equipment and accessories" section

### 307.2.2 Piping

| Location | Material | ND (mm) | NP (bars) |
|---|---|---|---|
| Motopumpset outlet section | Ductile Iron | 200 | 16 |
| Discharge header | Ductile Iron | 200 | 16 |
| Discharge header Drain Section | Ductile Iron | 200 | 16 |

### 307.2.3 Valves

| Location | Type | Material | ND (mm) | NP (bars) | Qty (No) |
|---|---|---|---|---|---|
| Motopumpset outlet section No. 1,2 & 3 | Gate | Cast Iron | 200 | 16 | 3 |
| Discharge header (Main) No. 5 | Gate | Cast Iron | 200 | 16 | 1 |
| Discharge header (Drain) No. 4 | Gate | Cast Iron | 200 | 16 | 1 |
| Air release valve | Double Function | Cast Iron | 80 | 16 | 3 |

### 307.2.4 Check Valves

| Location | Type | Material | ND (mm) | NP (bars) | Qty (No) |
|---|---|---|---|---|---|
| Motopumpset outlet section | Ball valve | Cast Iron | 200 | 16 | 3 |

– Supply and installation of all the necessary miscellaneous hydraulic accessories required for the assembly of the complete system such as inserts, flanges, gaskets, couplings, adaptors, bends, pipe supports, bolts and nuts, etc....

## 307.3 LIFTING AND HANDLING EQUIPMENT

Two (2) lifting and handling systems consisting of a manual hoist and a monorail type structure shall be supplied and installed as follows:

- One which spans the entire pumps row enabling the hoist to lift any component from/to the sump.
  Safe working load (SWL) 2000 kg.

- One which spans over the discharge gallery enabling the hoist to lift the sludge bucket for outside discharge.
  Safe working load (SWL): 250 kg.

- Any other accessories and equipment deemed necessary for the complete installation.

## 307.4 SURGE SUPPRESSION EQUIPMENT

The Contractor shall submit detailed sizing calculation for the vessel capacity based on the pumping line profile and characteristics.

Type: Ductile iron, DN 200, PN16
Flow: 60 l/s.
Length = 965 m.
Delta H = 57 m.

## 307.5 ODOR CONTROL SYSTEM

The Contractor shall submit detailed sizing calculation for the Odor control system, including a stainless-steel vessel, fan extractor, which is should be connected to H2S sensor for automatic mode of operation.

# Volume 2

# Technical Specifications

# Division 2

# Particular Specifications

# Part 4

# Electrical Works

# TABLE OF CONTENT

400. ELECTRICAL EQUIPMENT AND ACCESSORIES: COMMON PARTICULAR SPECIFICATIONS - PUMPING STATIONS ..... 4
400.1 EDL TRANSFORMER ..... 4
400.2 GENERATOR SET ..... 4
400.3 MOTOPUMPSET SWITCHGEAR ..... 4
400.3.1 GENERAL CIRCUIT BREAKERS (G.C.B.) ..... 5
400.3.2 CIRCUIT BREAKERS FOR MOTOPUMPSETS (C.B.P.) ..... 5
400.3.3 AUXILIARIES SWITCHGEAR ..... 5
400.3.4 MANUAL TRANSFER SWITCH (M.T.S.) (MAIN/STANDBY SUPPLY CHANGEOVER) ..... 5
400.3.5 STARTER ..... 5
400.4 UNINTERRUPTIBLE POWER SUPPLY (U.P.S) ..... 6
400.5 GROUNDING SYSTEM - LIGHTNING & SURGE PROTECTIONS ..... 6
400.6 PROTECTION OF MOTOPUMPSETS ..... 7
400.7 ALARMS & SIGNALLING ..... 7
400.8 ELECTRICAL INSTALLATION FOR BUILDINGS ..... 8
400.8.1 ELECTRICAL PANEL BOARDS ..... 8
400.8.2 CIRCUIT BREAKERS ..... 8
400.8.3 ELECTRICAL CABLES ..... 9
400.8.4 CONDUITS ..... 9
400.8.5 JUNCTION AND DISTRIBUTION BOXES ..... 9
400.8.6 SWITCHES ..... 9
400.8.7 POWER OUTLET SOCKETS AND PLUGS ..... 9
400.8.8 LIGHTING FIXTURES ..... 9
400.8.9 EMERGENCY LIGHTING SYSTEM ..... 9
400.8.10 TESTING AND COMMISSIONING ..... 9
401. ELECTRICAL EQUIPMENT AND ACCESSORIES: BAALOUL PS 1 PUMPING STATION ..... 10
401.1 EDL TRANSFORMER ..... 10
401.2 GENERATOR SET ..... 10
401.3 GROUND-MOUNTED WEATHERPROOF ENCLOSURE ..... 10
401.4 MOTOPUMPSET SWITCH-GEAR ..... 11
401.4.1 GENERAL CIRCUIT BREAKERS (G.C.B.) ..... 11
401.4.2 CIRCUIT BREAKERS FOR MOTOPUMPSETS (C.B.P.) ..... 11
401.4.3 AUXILIARIES SWITCH-GEAR ..... 11
401.4.4 AUTOMATIC TRANSFER SWITCH (A.T.S) (MAIN/STANDBY SUPPLY CHANGEOVER) ..... 11
401.4.5 STARTER ..... 12
401.5 ELECTRICAL INSTRUMENTATION ..... 12
401.6 UNINTERRUPTIBLE POWER SUPPLY (U.P.S) ..... 12
401.7 GROUNDING SYSTEM - LIGHTNING & SURGE PROTECTIONS ..... 12
401.8 PROTECTION OF MOTOPUMPSETS ..... 12
401.9 ALARMS & SIGNALING ..... 13
401.10 ELECTRICAL INSTALLATION FOR BUILDING ..... 13
402. ELECTRICAL EQUIPMENT AND ACCESSORIES: BAALOUL PS 2 PUMPING STATION ..... 14

402.1 EDL TRANSFORMER ..... 14
402.2 GENERATOR SET ..... 14
402.3 GROUND-MOUNTED WEATHERPROOF ENCLOSURE ..... 14

402.4 MOTOPUMPSET SWITCH-GEAR....15
402.4.1 GENERAL CIRCUIT BREAKERS (G.C.B.)....15
402.4.2 CIRCUIT BREAKERS FOR MOTOPUMPSETS (C.B.P.)....15
402.4.3 AUXILIARIES SWITCH-GEAR....15
402.4.4 AUTOMATIC TRANSFER SWITCH (A.T.S) (MAIN/STANDBY SUPPLY CHANGEOVER)....15
402.4.5 STARTER....16
402.5 ELECTRICAL INSTRUMENTATION....16
402.6 UNINTERRUPTIBLE POWER SUPPLY (U.P.S)....16
402.7 GROUNDING SYSTEM - LIGHTNING & SURGE PROTECTIONS....16
402.8 PROTECTION OF MOTOPUMPSETS....16
402.9 ALARMS & SIGNALING....16
402.10 ELECTRICAL INSTALLATION FOR BUILDING....17
403. ELECTRICAL EQUIPMENT AND ACCESSORIES: QARAOUN PS 3 PUMPING STATION....17
403.1 EDL TRANSFORMER....17
403.2 GENERATOR SET....17
403.3 GROUND-MOUNTED WEATHERPROOF ENCLOSURE....18
403.4 MOTOPUMPSET SWITCH-GEAR....18
403.4.1 GENERAL CIRCUIT BREAKERS (G.C.B.)....18
403.4.2 CIRCUIT BREAKERS FOR MOTOPUMPSETS (C.B.P.)....18
403.4.3 AUXILIARIES SWITCH-GEAR....18
403.4.4 AUTOMATIC TRANSFER SWITCH (A.T.S) (MAIN/STANDBY SUPPLY CHANGEOVER)....19
403.4.5 STARTER....19
403.5 ELECTRICAL INSTRUMENTATION....19
403.6 UNINTERRUPTIBLE POWER SUPPLY (U.P.S)....20
403.7 GROUNDING SYSTEM - LIGHTNING & SURGE PROTECTIONS....20
403.8 PROTECTION OF MOTOPUMPSETS....20
403.9 ALARMS & SIGNALING....20
403.10 ELECTRICAL INSTALLATION FOR BUILDING....20
404. ELECTRICAL EQUIPMENT AND ACCESSORIES: QARAOUN PS 4 PUMPING STATION....21
404.1 EDL TRANSFORMER....21
404.2 GENERATOR SET....21
404.3 GROUND-MOUNTED WEATHERPROOF ENCLOSURE....21
404.4 MOTOPUMPSET SWITCH-GEAR....22
404.4.1 GENERAL CIRCUIT BREAKERS (G.C.B.)....22
404.4.2 CIRCUIT BREAKERS FOR MOTOPUMPSETS (C.B.P.)....22
404.4.3 AUXILIARIES SWITCH-GEAR....22
404.4.4 AUTOMATIC TRANSFER SWITCH (A.T.S) (MAIN/STANDBY SUPPLY CHANGEOVER)....22
404.4.5 STARTER....23
404.5 ELECTRICAL INSTRUMENTATION....23
404.6 UNINTERRUPTIBLE POWER SUPPLY (U.P.S)....23
404.7 GROUNDING SYSTEM - LIGHTNING & SURGE PROTECTIONS....23
404.8 PROTECTION OF MOTOPUMPSETS....23
404.9 ALARMS & SIGNALING....24
404.10 ELECTRICAL INSTALLATION FOR BUILDING....24
405. ELECTRICAL EQUIPMENT AND ACCESSORIES: QARAOUN PS 5 PUMPING STATION....25
405.1 EDL TRANSFORMER....25
405.2 GENERATOR SET....25
405.3 GROUND-MOUNTED WEATHERPROOF ENCLOSURE....25

405.4 MOTOPUMPSET SWITCH-GEAR....26
405.4.1 GENERAL CIRCUIT BREAKERS (G.C.B.)....26
405.4.2 CIRCUIT BREAKERS FOR MOTOPUMPSETS (C.B.P.)....26
405.4.3 AUXILIARIES SWITCH-GEAR....26
405.4.4 AUTOMATIC TRANSFER SWITCH (A.T.S) (MAIN/STANDBY SUPPLY CHANGEOVER)....26
405.4.5 STARTER....27
405.5 ELECTRICAL INSTRUMENTATION....27
405.6 UNINTERRUPTIBLE POWER SUPPLY (U.P.S)....27
405.7 GROUNDING SYSTEM - LIGHTNING & SURGE PROTECTIONS....27
405.8 PROTECTION OF MOTOPUMPSETS....27
405.9 ALARMS & SIGNALING....28
405.10 ELECTRICAL INSTALLATION FOR BUILDING....28
406. ELECTRICAL EQUIPMENT AND ACCESSORIES: QARAOUN PS 6 PUMPING STATION....29
406.1 EDL TRANSFORMER....29
406.2 GENERATOR SET....29
406.3 GROUND-MOUNTED WEATHERPROOF ENCLOSURE....29
406.4 MOTOPUMPSET SWITCH-GEAR....30
406.4.1 GENERAL CIRCUIT BREAKERS (G.C.B.)....30
406.4.2 CIRCUIT BREAKERS FOR MOTOPUMPSETS (C.B.P.)....30
406.4.3 AUXILIARIES SWITCH-GEAR....30
406.4.4 AUTOMATIC TRANSFER SWITCH (A.T.S) (MAIN/STANDBY SUPPLY CHANGEOVER)....30
406.4.5 STARTER....31
406.5 ELECTRICAL INSTRUMENTATION....31
406.6 UNINTERRUPTIBLE POWER SUPPLY (U.P.S)....31
406.7 GROUNDING SYSTEM - LIGHTNING & SURGE PROTECTIONS....31
406.8 PROTECTION OF MOTOPUMPSETS....31
406.9 ALARMS & SIGNALING....32
406.10 ELECTRICAL INSTALLATION FOR BUILDING....32
407. ELECTRICAL EQUIPMENT AND ACCESSORIES: QARAOUN EXISTING PS 7 PUMPING STATION....27
408 STANDBY POWER GENERATOR PART....30
409 SPLIT-SYSTEM AIR-CONDITIONERS....39
410 OFF GRID SOLAR SYSTEM....43

# 400. ELECTRICAL EQUIPMENT AND ACCESSORIES: COMMON PARTICULAR SPECIFICATIONS - PUMPING STATIONS

## 400.1 EDL TRANSFORMER

Power shall be made available on site by EDL at 15 kV and new transformers will be priced by the contractor where not available as per EDL requirements and to meet the station needs, it is the responsibility of the contractor to gather all the necessary information provide the needed justifications and coordinate with the engineer and the Electric Authority to finalize the electrical supply. The Contractor shall provide all cabling and wiring from the transformer or from the EDL cut outs at the metering location to the main distribution Panel board. All transformers, subscription to EDL, and power meters are included in the contractor's scope of work (Medium voltage power lines are not included).

## 400.2 GENERATOR SET

One standby diesel operated generated set with associated accessories, cooling air flow system, fuel water separator filter, start up, daily tank, fuel system, batteries & Charger, Instrumentation, protection and control equipment shall be installed to supply the pumping station equipment.

The primary distribution board shall include an incoming section with facilities for connection of a standby generator. An adequately sized opening with a hinged steel door shall be provided at low level in the external wall of the room of the building housing the primary distribution board. The incoming section shall incorporate an interlocked mains/standby supply, automatically operated, change over switch. "Mains supply available" and "standby supply on" indicator lights shall be provided on the panel face.

## 400.3 MOTOPUMPSET SWITCHGEAR

Distribution board: A primary distribution board shall be provided at each installation. The board shall have, as applicable, feeds to:
1. Each motor starter/control panel.
2. Chlorination panel.
3. Instrumentation and control equipment.
4. Building services electrical distribution board.
5. Other as particularly specified.

The primary distribution panel shall be located in the control room. It may be either wall mounted or free standing as appropriate to its rating power factor meter and size. The board shall incorporate door mounted ammeters, voltmeter with a phase-phase and phase-neutral selector switch, frequency meter and power factor meter.

Where the EDL transformer is not in a building or where the incoming EDL supply to the site is at 380 V, an earth fault relay shall be incorporated in the main distribution board to trip out the incoming supply under earth fault conditions.

### 400.3.1 General Circuit Breakers (G.C.B.)

- G.C.B. shall be a moulded case circuit breaker of type "A" as described in the general specifications.

- G.C.B. shall be installed upstream the Automatic-Transfer Switch, one for network supply and another for emergency supply.

**400.3.2 Circuit Breakers for Motopumpsets (C.B.P.)**

- C.B.P. shall be a moulded case circuit breaker of type "B" as described in the general specifications.

- C.B.P. shall be installed upstream the starters that control the motopumpsets.

**400.3.3 Auxiliaries Switchgear**

- Shall include all outgoing feeders and corresponding protection for the auxiliaries of the site.

- The circuit breakers, shall be supplied and installed to supply all Auxiliary equipment of the site.

- The circuit breaker shall be a moulded case circuit breaker of type "B" as described in the general specifications.

**400.3.4 Manual Transfer Switch (M.T.S.) (Main/Standby Supply Changeover)**

- M.T.S complete with mechanical inter-lock shall be installed for the pumping station.

- This Manual Transfer Switch shall be supplied with auxiliary contacts for monitoring and control.

**400.3.5 Starter**

A combined starter/control panel shall generally be provided at each installation. The panel shall incorporate a suitably screened section for instrumentation and PLC. Panels shall be arranged for front and back access.

The panel shall be fed from the primary distribution board and shall incorporate a main incoming section with door interlocked isolator, "supply on" indicator lamp, voltmeter and ammeters on the panel face.

The panel shall incorporate phase failure, phase reversal and undervoltage protection. It shall not be possible for unauthorised personnel to adjust the voltage protection devices.

Starter/control panels shall be fully compartmentalised with each motor starter enclosed within its own cubicle with a door interlocked isolator. Unless instrumentation is specific to a

particular motor separate instrumentation compartment(s) shall be provided, isolated as necessary to prevent pick up from the motor starters induced spurious signals.

All starters shall incorporate, mounted on the outside of the door, in addition to the features stated in the General Specification, the following:
1. Hand/off/auto selector switch.
2. Motor start and stop push buttons for use in hand control of the pump.
3. Emergency Stop push button shall be of the mushroom-headed push to stop/twist

to reset type.
4. Motor "running", "stopped", "fault" indicator lights.
5. Cyclometer type running hour's indicator.
6. PLC for control, monitoring and transmission purposes used to control:
   - The motopumpset operation.
   - The motopumpset protection and signalling.
   - The motopumpset discharge motorized valve with "local/remote/off" selector.

All panels shall have an audible alarm to sound under fault condition, together with a panel mounted mute push button to silence the alarm when acknowledged. This shall not clear the fault light which shall only be cleared when the fault is cleared.

Lamptest facilities with lamp test push button shall be provided.

In the event of multiple pump installations the panel face shall incorporate a duty selector.

Flow indication, integration and recording shall be provided at the station control panel.

**N.B.:** - A calculation sheet for design justification of all electrical switchgear shall be submitted.

## 400.4 UNINTERRUPTIBLE POWER SUPPLY (U.P.S)

Set of two U.P.S. systems each, of adequate power output operating in redundancy shall be installed to supply the control, protection, measuring, signalling, valve actuators,... circuits of the pump station and suction reservoir.

**Operation:** One source is on duty, the other is on standby. Should the first source be out of service, the automatic change over to the second source occurs within the cycle at zero voltage.

## 400.5 GROUNDING SYSTEM - LIGHTNING & SURGE PROTECTIONS

- The Contractor shall supply and install a lightning protection system, covering all the pumping stations and reservoir or chlorination sites, and using early streamer emission type lightning conductors which number and type will be determined according to the site protection demand and in compliance with general specifications and latest standards.

- The lightning protection down conductors shall be flat conductors.

- The Contractor shall implement also an Earthing circuit for the site, independent from the lightning ground network.

- The Contractor shall supply and install as well, a lightning current arrester at the point of entry of each power supply line into the stations and reservoir sites.

- The Contractor shall supply and install over-voltage protection systems for all power, data and communication networks in the station.

- The Contractor shall also connect to the grounding system all electromechanical equipment such as piping, electrical panels, H.V.A.C. system, switches, instruments, power outlets, luminaire chassis, etc...

## 400.6 PROTECTION OF MOTOPUMPSETS

The automatic shut off of the motopumpset shall occur in case of the following:

- Minimum water level in suction reservoir for motopumpsets fed from reservoirs.
- Minimum water level in borehole for well motopumpsets.
- High flow at the discharge of the motopumpset (with delay).
- Insufficient flow at the discharge of the motopumpset (with delay).
- High pressure at the discharge of the motopumpset (with delay).
- Low pressure at the discharge of the motopumpset (with delay).
- Unauthorized starting when main circuit-breakers are open.
- High water temperature at the suction of motopumpsets inside barrels (where applicable).
- High pressure at the suction of motopumpsets inside barrels.
- Low pressure at the suction of motopumpsets inside barrels.
- Minimum water level in barrels.

## 400.7 ALARMS & SIGNALLING

A visual indication and sound alarm shall be foreseen, in the electrical room with the switchgear, for the following faults (where applicable):

- Tripping of medium voltage circuit-breaker.
- Voltage fault.
- Minimum level in the suction and discharge reservoirs.
- Maximum level in the suction and discharge reservoirs.
- High pressure at the suction of motopumpsets.
- Low pressure at the suction of motopumpsets.
- Minimum water level in boreholes.
- Minimum water level in barrels.
- High pressure at the discharge of motopumpsets.
- Low pressure at the discharge of motopumpsets.
- Excessive flow at the discharge of motopumpsets.

- Insufficient flow at the discharge of motopumpsets.
- Motorized valve fault for each valve.
- Extreme levels in surge protection vessel (for each level).
- Emergency stop.
- Overheating of cooling air.
- Chlorine leakage.
- Fire alarm.

These defects shall be signalled on a luminous panel, constituted of labels of translucent material specific for each fault, and comprising two associated push buttons: lamp test and reset (acknowledge).

A visual signalling (independent) of the state of each set shall be provided: RUN, STOP.

## 400.8 ELECTRICAL INSTALLATION FOR BUILDINGS

### 400.8.1 Electrical Panel Boards

Including signalling lamps, measuring instruments, selectors, bus bars, glands, cables, wiring, connections, to incoming and outgoing feeders, installations, connection, labelling, accessories, identification, etc...

These panels shall be installed where shown on drawings.

### 400.8.2 Circuit Breakers

The ratings and types of circuit breakers shall be as indicated on the respective panel drawings including installation, connections, labelling, accessories, etc...

### 400.8.3 Electrical Cables

Including conduits, cable trays, connections, supports, installation, accessories, identification, etc...

### 400.8.4 Conduits

Including clamps, flexible, fittings, connections, installation, accessories, etc...

### 400.8.5 Junction and Distribution Boxes

Including glands, installation, connections, labelling, accessories, covers, etc...

### 400.8.6 Switches

Including boxes, covers, installation, accessories, cables, conduits, wiring, connections to panel boards, etc...

### 400.8.7 Power Outlet Sockets and Plugs

Including plugs, boxes, covers, installation, cables, conduits, wiring, connections to panel boards, labelling, accessories, etc...

### 400.8.8 Lighting Fixtures

Including lamps, supports, poles, installation as and where shown on drawings, accessories, cables, conduits, wiring, connections to switches, etc...

### 400.8.9 Emergency Lighting System

Including luminaires where shown on drawings, lamps, conduits, installation, labelling, accessories, cables, wiring, connections to power supply, etc...

### 400.8.10 Testing and Commissioning

Including measuring of resistances of the grounding and the lightning protection systems, luminaires, power, continuity and insulation meggering of cables installation, etc...

**N.B.:**

- All conduits used for domestic electrical installation shall be imbedded in walls or in floor.

- All outlet sockets and switches shall be flush mounted.

## 401. ELECTRICAL EQUIPMENT AND ACCESSORIES: BAALOUL PS 1 PUMPING STATION

| | |
|---|---|
| Electrical schematic | No.: 588-PS-01E01 |
| Electrical schematic | No.: 588-PS-01E02 |

### 401.1 EDL TRANSFORMER

The Contractor shall coordinate with EDL after gathering all necessary information, supply, install test and commission a High Voltage/Low Voltage pole mounted power transformer as follows:

- Dual primary voltage: 15/20kV
- Secondary voltage: 400 V.
- Rated Power: 100 KVA.

The transformer shall be supplied along with subscription to EDL and power meter and all necessary materials as per EDL requirements and recommendations (medium voltage power lines are not included).

### 401.2 GENERATOR SET

A standby generator set with connecting cables and accessories shall be installed on a concrete pad, inside sound proof canopy, to supply the plant with the following main characteristics:

- Rated Power (Continuous Rating): $P \geq 40$ kVA

- Fuel Storage Tank : V = 1,000 liters, carbon steel, 4 mm minimum thickness, fabricated with level indication, filling pipe and washout valve.
- Daily fuel tank: V = 500 liters with complete fuel transformer system and connection to the fuel storage tank.
- Class of Protection : IP 23
- Switch Gear: including monitoring, control, protection and displays.
- Installation: on concrete pad, inside soundproof canopy.

## 401.3 GROUND-MOUNTED WEATHERPROOF ENCLOSURE

It is an outdoor enclosure and climate control component which must withstand even the toughest wind and weather conditions, from basic requirements such as humidity, temperature fluctuations and sunlight, to extreme conditions such as seawater resistance or earthquake resistance, through to protection against vandalism.

## 401.4 MOTOPUMPSET SWITCH-GEAR

### 401.4.1 General Circuit Breakers (G.C.B.)

- G.C.B. shall be a Moulded Case Circuit Breaker of type "A" as described in the general specification.
- G.C.B. shall be installed upstream the Auto-Transfer Switch, one for network supply and another for Generator Supply.

| No. of Poles | Rating (A) at 380 V | Qty (No) |
|---|---|---|
| 4 | 150 | 1 |
| 4 | 60 | 1 |

### 401.4.2 Circuit Breakers for Motopumpsets (C.B.P.)

- C.B.P. shall be a Moulded Case Circuit Breaker of type "B" as described in the general specification.
- C.B.P. shall be installed upstream the starters that control the Motopumpsets.

| No. of Poles | Rating (A) at 380 V | Qty (No) |
|---|---|---|
| 3 | 22 | 2 |

### 401.4.3 Auxiliaries Switch-Gear

- Shall include all outgoing feeders and corresponding protection for the auxiliaries of the site.
- The circuit breakers, shall be supplied and installed to supply all Auxiliary equipment of the site.

- The circuit breaker shall be a Moulded Case Circuit Breaker of type "B" as described in the general specification.

| No. of Poles | Rating (A) at 380 V | Qty (No) |
|---|---|---|
| 4 | 20 | 1 |

**401.4.4 Automatic Transfer Switch (A.T.S) (Main/Standby supply changeover)**

- A.T.S. complete with mechanical and electrical inter-lock shall be installed for the Motopumpsets and auxiliaries.

| Mechanical Life (Cycles) | Switching Frequency (Cycles/Hour) | Qty (No) |
|---|---|---|
| ≥ 10 million | ≥ 2400 | 1 |

| No. of Poles | Rating (A) at 380 V | Qty (No) |
|---|---|---|
| 4 | 150 | 1 |

**401.4.5 Starter**

| Type | Rating (kW) at 380V | Contactors Mechanical Life (Cycles) | Contactors Switching Frequency (Cycles/Hour) | Qty (No) |
|---|---|---|---|---|
| Variable Speed Drive | ≥ 10 | ≥ 10 million | ≥ 2400 | 2 |

– Each starter shall be supplied with an "Electric Motor Manager" unit and accessories.

**NB:** i) The ATS system and the motopumpset operation, protection and signalling shall be controlled by the main PLC (MPLC) as described in the "Instrumentation, control equipment and accessories" section.

ii) A calculation sheet for design justification of all electrical switch-gear shall be submitted.

## 401.5 ELECTRICAL INSTRUMENTATION

| Local electrical instrumentation | Quantity (set) |
|---|---|
| Set of three digital Ammeters with current transformers | 4 |
| Set of digital voltmeters with selector switches | 2 |
| Digital hour-meters | 2 |
| Digital frequency meters | 2 |
| Digital power factor measurement (Response time ≤ 1 s) | 1 |
| Signalling lamps (Set of three) | 6 |

Current, voltage, power factor and frequency measurements shall also be transmitted to the main PLC (MPLC).

## 401.6 UNINTERRUPTIBLE POWER SUPPLY (U.P.S)

Set of two U.P.S. systems each, shall be as described in the common particular specifications.

### 401.7 GROUNDING SYSTEM - LIGHTNING & SURGE PROTECTIONS

Shall be as described in the Common Particular Specifications.

### 401.8 PROTECTION OF MOTOPUMPSETS

The automatic shut off of the motopumpsets shall be as described in the Common Particular Specifications.

### 401.9 ALARMS & SIGNALING

Shall be as described in the Common Particular Specifications.

### 401.10 ELECTRICAL INSTALLATION FOR BUILDING

Shall be as described in the Common Particular Specifications

## 402. ELECTRICAL EQUIPMENT AND ACCESSORIES: BAALOUL PS 2 PUMPING STATION

| | |
|---|---|
| Electrical schematic | No.: 588-PS-02E01 |
| Electrical schematic | No.: 588-PS-02 E02 |

### 402.1 EDL TRANSFORMER

The Contractor shall coordinate with EDL after gathering all necessary information, supply, install test and commission a High Voltage/Low Voltage pole mounted power transformer as follows:

- Dual primary voltage: 15/20kV
- Secondary voltage: 400 V.
- Rated Power: 100 KVA.

The transformer shall be supplied along with subscription to EDL and power meter and all necessary materials as per EDL requirements and recommendations (medium voltage power lines are not included).

### 402.2 GENERATOR SET

A standby generator set with connecting cables and accessories shall be installed on a concrete pad, inside sound proof canopy, to supply the plant with the following main characteristics:

- Rated Power (Continuous Rating): $P \geq 60$ kVA

- Fuel Storage Tank : V = 4,000 liters, carbon steel, 4 mm minimum thickness, fabricated with level indication, filling pipe and washout valve.

- Daily fuel tank: V = 500 liters with complete fuel transformer system and connection to the fuel storage tank.
- Class of Protection : IP 23
- Switch Gear: including monitoring, control, protection and displays.
- Installation: on concrete pad, inside soundproof canopy.

## 402.3 GROUND-MOUNTED WEATHERPROOF ENCLOSURE

It is an outdoor enclosure and climate control component which must withstand even the toughest wind and weather conditions, from basic requirements such as humidity, temperature fluctuations and sunlight, to extreme conditions such as seawater resistance or earthquake resistance, through to protection against vandalism.

## 402.4 MOTOPUMPSET SWITCH-GEAR

### 402.4.1 General Circuit Breakers (G.C.B.)

- G.C.B. shall be a Moulded Case Circuit Breaker of type "A" as described in the general specification.
- G.C.B. shall be installed upstream the Auto-Transfer Switch, one for network supply and another for Generator Supply.

| No. of Poles | Rating (A) at 380 V | Qty (No) |
|---|---|---|
| 4 | 150 | 1 |
| 4 | 90 | 1 |

### 402.4.2 Circuit Breakers for Motopumpsets (C.B.P.)

- C.B.P. shall be a Moulded Case Circuit Breaker of type "B" as described in the general specification.
- C.B.P. shall be installed upstream the starters that control the Motopumpsets.

| No. of Poles | Rating (A) at 380 V | Qty (No) |
|---|---|---|
| 3 | 40 | 2 |

### 402.4.3 Auxiliaries Switch-Gear

- Shall include all outgoing feeders and corresponding protection for the auxiliaries of the site.
- The circuit breakers, shall be supplied and installed to supply all Auxiliary equipment of the site.
- The circuit breaker shall be a Moulded Case Circuit Breaker of type "B" as described in the general specification.

| No. of Poles | Rating (A) at 380 V | Qty (No) |
|---|---|---|
| 4 | 20 | 1 |

### 402.4.4 Automatic Transfer Switch (A.T.S) (Main/Standby supply changeover)

- A.T.S. complete with mechanical and electrical inter-lock shall be installed for the Motopumpsets and auxiliaries.

| Mechanical Life (Cycles) | Switching Frequency (Cycles/Hour) | Qty (No) |
|---|---|---|
| ≥ 10 million | ≥ 2400 | 1 |

| No. of Poles | Rating (A) at 380 V | Qty (No) |
|---|---|---|
| 4 | 150 | 1 |

### 402.4.5 Starter

| Type | Rating (kW) at 380V | Contactors Mechanical Life (Cycles) | Contactors Switching Frequency (Cycles/Hour) | Qty (No) |
|---|---|---|---|---|
| Variable Speed Drive | ≥ 50 | ≥ 10 million | ≥ 2400 | 2 |

– Each starter shall be supplied with an "Electric Motor Manager" unit and accessories.

**NB:** i) The ATS system and the motopumpset operation, protection and signalling shall be controlled by the main PLC (MPLC) as described in the "Instrumentation, control equipment and accessories" section.

ii) A calculation sheet for design justification of all electrical switch-gear shall be submitted.

## 402.5 ELECTRICAL INSTRUMENTATION

| Local electrical instrumentation | Quantity (set) |
|---|---|
| Set of three digital Ammeters with current transformers | 4 |
| Set of digital voltmeters with selector switches | 2 |
| Digital hour-meters | 2 |
| Digital frequency meters | 2 |
| Digital power factor measurement (Response time ≤ 1 s) | 1 |
| Signalling lamps (Set of three) | 6 |

Current, voltage, power factor and frequency measurements shall also be transmitted to the main PLC (MPLC).

## 402.6 UNINTERRUPTIBLE POWER SUPPLY (U.P.S)

Set of two U.P.S. systems each, shall be as described in the common particular specifications.

## 402.7 GROUNDING SYSTEM - LIGHTNING & SURGE PROTECTIONS

Shall be as described in the Common Particular Specifications.

### 402.8 PROTECTION OF MOTOPUMPSETS

The automatic shut off of the motopumpsets shall be as described in the Common Particular Specifications.

### 402.9 ALARMS & SIGNALING

Shall be as described in the Common Particular Specifications.

### 402.10 ELECTRICAL INSTALLATION FOR BUILDING

Shall be as described in the Common Particular Specifications

## 403. ELECTRICAL EQUIPMENT AND ACCESSORIES: QARAOUN PS 3 PUMPING STATION

| | |
|---|---|
| Electrical schematic | No.: 588-PS-03E01 |
| Electrical schematic | No.: 588-PS-03E02 |

### 403.1 EDL TRANSFORMER

The Contractor shall coordinate with EDL after gathering all necessary information, supply, install test and commission a High Voltage/Low Voltage pole mounted power transformer as follows:

- Dual primary voltage: 15/20kV
- Secondary voltage: 400 V.
- Rated Power: 100 KVA.

The transformer shall be supplied along with subscription to EDL and power meter and all necessary materials as per EDL requirements and recommendations (medium voltage power lines are not included).

### 403.2 GENERATOR SET

A standby generator set with connecting cables and accessories shall be installed on a concrete pad, inside sound proof canopy, to supply the plant with the following main characteristics:

- Rated Power (Continuous Rating): $P \geq 40$ kVA
- Fuel Storage Tank : V = 1,000 liters, carbon steel, 4 mm minimum thickness, fabricated with level indication, filling pipe and washout valve.
- Daily fuel tank: V = 500 liters with complete fuel transformer system and connection to the fuel storage tank.
- Class of Protection : IP 23
- Switch Gear: including monitoring, control, protection and displays.

– Installation: on concrete pad, inside soundproof canopy.

## 403.3 GROUND-MOUNTED WEATHERPROOF ENCLOSURE

It is an outdoor enclosure and climate control component which must withstand even the toughest wind and weather conditions, from basic requirements such as humidity, temperature fluctuations and sunlight, to extreme conditions such as seawater resistance or earthquake resistance, through to protection against vandalism.

## 403.4 MOTOPUMPSET SWITCH-GEAR

### 403.4.1 General Circuit Breakers (G.C.B.)

- G.C.B. shall be a Moulded Case Circuit Breaker of type "A" as described in the general specification.
- G.C.B. shall be installed upstream the Auto-Transfer Switch, one for network supply and another for Generator Supply.

| No. of Poles | Rating (A) at 380 V | Qty (No) |
|---|---|---|
| 4 | 135 | 1 |
| 4 | 60 | 1 |

### 403.4.2 Circuit Breakers for Motopumpsets (C.B.P.)

- C.B.P. shall be a Moulded Case Circuit Breaker of type "B" as described in the general specification.
- C.B.P. shall be installed upstream the starters that control the Motopumpsets.

| No. of Poles | Rating (A) at 380 V | Qty (No) |
|---|---|---|
| 3 | 25 | 2 |

### 403.4.3 Auxiliaries Switch-Gear

- Shall include all outgoing feeders and corresponding protection for the auxiliaries of the site.
- The circuit breakers, shall be supplied and installed to supply all Auxiliary equipment of the site.
- The circuit breaker shall be a Moulded Case Circuit Breaker of type "B" as described in the general specification.

| No. of Poles | Rating (A) at 380 V | Qty (No) |
|---|---|---|
| 4 | 20 | 1 |

### 403.4.4 Automatic Transfer Switch (A.T.S) (Main/Standby supply changeover)

- A.T.S. complete with mechanical and electrical inter-lock shall be installed for the Motopumpsets and auxiliaries.

| Mechanical Life (Cycles) | Switching Frequency (Cycles/Hour) | Qty (No) |
|---|---|---|
| ≥ 10 million | ≥ 2400 | 1 |

| No. of Poles | Rating (A) at 380 V | Qty (No) |
|---|---|---|
| 4 | 135 | 1 |

**403.4.5 Starter**

| Type | Rating (kW) at 380V | Contactors Mechanical Life (Cycles) | Contactors Switching Frequency (Cycles/Hour) | Qty (No) |
|---|---|---|---|---|
| Variable Speed Drive | ≥ 16 | ≥ 10 million | ≥ 2400 | 2 |

– Each starter shall be supplied with an "Electric Motor Manager" unit and accessories.

**NB:** i) The ATS system and the motopumpset operation, protection and signalling shall be controlled by the main PLC (MPLC) as described in the "Instrumentation, control equipment and accessories" section.

ii) A calculation sheet for design justification of all electrical switch-gear shall be submitted.

## 403.5 ELECTRICAL INSTRUMENTATION

| Local electrical instrumentation | Quantity (set) |
|---|---|
| Set of three digital Ammeters with current transformers | 4 |
| Set of digital voltmeters with selector switches | 2 |
| Digital hour-meters | 2 |
| Digital frequency meters | 2 |
| Digital power factor measurement (Response time ≤ 1 s) | 1 |
| Signalling lamps (Set of three) | 6 |

Current, voltage, power factor and frequency measurements shall also be transmitted to the main PLC (MPLC).

## 403.6 UNINTERRUPTIBLE POWER SUPPLY (U.P.S)

Set of two U.P.S. systems each, shall be as described in the common particular specifications.

## 403.7 GROUNDING SYSTEM - LIGHTNING & SURGE PROTECTIONS

Shall be as described in the Common Particular Specifications.

### 403.8 PROTECTION OF MOTOPUMPSETS

The automatic shut off of the motopumpsets shall be as described in the Common Particular Specifications.

### 403.9 ALARMS & SIGNALING

Shall be as described in the Common Particular Specifications.

### 403.10 ELECTRICAL INSTALLATION FOR BUILDING

Shall be as described in the Common Particular Specifications

## 404. ELECTRICAL EQUIPMENT AND ACCESSORIES: QARAOUN PS 4 PUMPING STATION

| | |
|---|---|
| Electrical schematic | No.: 588-PS-04E01 |
| Electrical schematic | No.: 588-PS-04E02 |

### 404.1 EDL TRANSFORMER

The Contractor shall coordinate with EDL after gathering all necessary information, supply, install test and commission a High Voltage/Low Voltage pole mounted power transformer as follows:

- Dual primary voltage: 15/20kV
- Secondary voltage: 400 V.
- Rated Power: 160 KVA.

The transformer shall be supplied along with subscription to EDL and power meter and all necessary materials as per EDL requirements and recommendations (medium voltage power lines are not included).

### 404.2 GENERATOR SET

A standby generator set with connecting cables and accessories shall be installed on a concrete pad, inside sound proof canopy, to supply the plant with the following main characteristics:

- Rated Power (Continuous Rating): $P \geq 110$ kVA
- Fuel Storage Tank : V = 4,000 liters, carbon steel, 4 mm minimum thickness, fabricated with level indication, filling pipe and washout valve.
- Daily fuel tank: V = 500 liters with complete fuel transformer system and connection to the fuel storage tank.
- Class of Protection : IP 23

- Switch Gear: including monitoring, control, protection and displays.
- Installation: on concrete pad, inside soundproof canopy.

## 404.3 GROUND-MOUNTED WEATHERPROOF ENCLOSURE

It is an outdoor enclosure and climate control component which must withstand even the toughest wind and weather conditions, from basic requirements such as humidity, temperature fluctuations and sunlight, to extreme conditions such as seawater resistance or earthquake resistance, through to protection against vandalism.

## 404.4 MOTOPUMPSET SWITCH-GEAR

### 404.4.1 General Circuit Breakers (G.C.B.)

- G.C.B. shall be a Moulded Case Circuit Breaker of type "A" as described in the general specification.
- G.C.B. shall be installed upstream the Auto-Transfer Switch, one for network supply and another for Generator Supply.

| No. of Poles | Rating (A) at 380 V | Qty (No) |
|---|---|---|
| 4 | 220 | 1 |
| 4 | 170 | 1 |

### 404.4.2 Circuit Breakers for Motopumpsets (C.B.P.)

- C.B.P. shall be a Moulded Case Circuit Breaker of type "B" as described in the general specification.
- C.B.P. shall be installed upstream the starters that control the Motopumpsets.

| No. of Poles | Rating (A) at 380 V | Qty (No) |
|---|---|---|
| 3 | 60 | 2 |

### 404.4.3 Auxiliaries Switch-Gear

- Shall include all outgoing feeders and corresponding protection for the auxiliaries of the site.
- The circuit breakers, shall be supplied and installed to supply all Auxiliary equipment of the site.
- The circuit breaker shall be a Moulded Case Circuit Breaker of type "B" as described in the general specification.

| No. of Poles | Rating (A) at 380 V | Qty (No) |
|---|---|---|
| 4 | 20 | 1 |

### 404.4.4 Automatic Transfer Switch (A.T.S) (Main/Standby supply changeover)

- A.T.S. complete with mechanical and electrical inter-lock shall be installed for the Motopumpsets and auxiliaries.

| Mechanical Life (Cycles) | Switching Frequency (Cycles/Hour) | Qty (No) |
|---|---|---|
| ≥ 10 million | ≥ 2400 | 1 |

| No. of Poles | Rating (A) at 380 V | Qty (No) |
|---|---|---|
| 4 | 220 | 1 |

**404.4.5 Starter**

| Type | Rating (kW) at 380V | Contactors Mechanical Life (Cycles) | Contactors Switching Frequency (Cycles/Hour) | Qty (No) |
|---|---|---|---|---|
| Variable Speed Drive | ≥ 28 | ≥ 10 million | ≥ 2400 | 2 |

– Each starter shall be supplied with an "Electric Motor Manager" unit and accessories.

**NB:** i) The ATS system and the motopumpset operation, protection and signalling shall be controlled by the main PLC (MPLC) as described in the "Instrumentation, control equipment and accessories" section.

ii) A calculation sheet for design justification of all electrical switch-gear shall be submitted.

## 404.5 ELECTRICAL INSTRUMENTATION

| Local electrical instrumentation | Quantity (set) |
|---|---|
| Set of three digital Ammeters with current transformers | 4 |
| Set of digital voltmeters with selector switches | 2 |
| Digital hour-meters | 2 |
| Digital frequency meters | 2 |
| Digital power factor measurement (Response time ≤ 1 s) | 1 |
| Signalling lamps (Set of three) | 6 |

Current, voltage, power factor and frequency measurements shall also be transmitted to the main PLC (MPLC).

## 404.6 UNINTERRUPTIBLE POWER SUPPLY (U.P.S)

Set of two U.P.S. systems each, shall be as described in the common particular specifications.

## 404.7 GROUNDING SYSTEM - LIGHTNING & SURGE PROTECTIONS

Shall be as described in the Common Particular Specifications.

### 404.8 PROTECTION OF MOTOPUMPSETS

The automatic shut off of the motopumpsets shall be as described in the Common Particular Specifications.

### 404.9 ALARMS & SIGNALING

Shall be as described in the Common Particular Specifications.

### 404.10 ELECTRICAL INSTALLATION FOR BUILDING

Shall be as described in the Common Particular Specifications

## 405. ELECTRICAL EQUIPMENT AND ACCESSORIES: QARAOUN PS 5 PUMPING STATION

| | |
|---|---|
| Electrical schematic | No.: 588-PS-05E01 |
| Electrical schematic | No.: 588-PS-05E02 |

### 405.1 EDL TRANSFORMER

The Contractor shall coordinate with EDL after gathering all necessary information, supply, install test and commission a High Voltage/Low Voltage pole mounted power transformer as follows:

- Dual primary voltage: 15/20kV
- Secondary voltage: 400 V.
- Rated Power: 100 KVA.

The transformer shall be supplied along with subscription to EDL and power meter and all necessary materials as per EDL requirements and recommendations (medium voltage power lines are not included).

### 405.2 GENERATOR SET

A standby generator set with connecting cables and accessories shall be installed on a concrete pad, inside sound proof canopy, to supply the plant with the following main characteristics:

- Rated Power (Continuous Rating): $P \geq 60$ kVA
- Fuel Storage Tank : V = 4,000 liters, carbon steel, 4 mm minimum thickness, fabricated with level indication, filling pipe and washout valve.
- Daily fuel tank: V = 500 liters with complete fuel transformer system and connection to the fuel storage tank.
- Class of Protection : IP 23
- Switch Gear: including monitoring, control, protection and displays.

– Installation: on concrete pad, inside soundproof canopy.

## 405.3 GROUND-MOUNTED WEATHERPROOF ENCLOSURE

It is an outdoor enclosure and climate control component which must withstand even the toughest wind and weather conditions, from basic requirements such as humidity, temperature fluctuations and sunlight, to extreme conditions such as seawater resistance or earthquake resistance, through to protection against vandalism.

## 405.4 MOTOPUMPSET SWITCH-GEAR

### 405.4.1 General Circuit Breakers (G.C.B.)

- G.C.B. shall be a Moulded Case Circuit Breaker of type "A" as described in the general specification.
- G.C.B. shall be installed upstream the Auto-Transfer Switch, one for network supply and another for Generator Supply.

| No. of Poles | Rating (A) at 380 V | Qty (No) |
|---|---|---|
| 4 | 150 | 1 |
| 4 | 90 | 1 |

### 405.4.2 Circuit Breakers for Motopumpsets (C.B.P.)

- C.B.P. shall be a Moulded Case Circuit Breaker of type "B" as described in the general specification.
- C.B.P. shall be installed upstream the starters that control the Motopumpsets.

| No. of Poles | Rating (A) at 380 V | Qty (No) |
|---|---|---|
| 3 | 30 | 2 |

### 405.4.3 Auxiliaries Switch-Gear

- Shall include all outgoing feeders and corresponding protection for the auxiliaries of the site.
- The circuit breakers, shall be supplied and installed to supply all Auxiliary equipment of the site.
- The circuit breaker shall be a Moulded Case Circuit Breaker of type "B" as described in the general specification.

| No. of Poles | Rating (A) at 380 V | Qty (No) |
|---|---|---|
| 4 | 20 | 1 |

### 405.4.4 Automatic Transfer Switch (A.T.S) (Main/Standby supply changeover)

- A.T.S. complete with mechanical and electrical inter-lock shall be installed for the Motopumpsets and auxiliaries.

| Mechanical Life (Cycles) | Switching Frequency (Cycles/Hour) | Qty (No) |
|---|---|---|
| ≥ 10 million | ≥ 2400 | 1 |

| No. of Poles | Rating (A) at 380 V | Qty (No) |
|---|---|---|
| 4 | 150 | 1 |

**405.4.5 Starter**

| Type | Rating (kW) at 380V | Contactors Mechanical Life (Cycles) | Contactors Switching Frequency (Cycles/Hour) | Qty (No) |
|---|---|---|---|---|
| Variable Speed Drive | ≥ 21 | ≥ 10 million | ≥ 2400 | 2 |

– Each starter shall be supplied with an "Electric Motor Manager" unit and accessories.

**NB:** i) The ATS system and the motopumpset operation, protection and signalling shall be controlled by the main PLC (MPLC) as described in the "Instrumentation, control equipment and accessories" section.

ii) A calculation sheet for design justification of all electrical switch-gear shall be submitted.

## 405.5 ELECTRICAL INSTRUMENTATION

| Local electrical instrumentation | Quantity (set) |
|---|---|
| Set of three digital Ammeters with current transformers | 4 |
| Set of digital voltmeters with selector switches | 2 |
| Digital hour-meters | 2 |
| Digital frequency meters | 2 |
| Digital power factor measurement (Response time ≤ 1 s) | 1 |
| Signalling lamps (Set of three) | 6 |

Current, voltage, power factor and frequency measurements shall also be transmitted to the main PLC (MPLC).

## 405.6 UNINTERRUPTIBLE POWER SUPPLY (U.P.S)

Set of two U.P.S. systems each, shall be as described in the common particular specifications.

## 405.7 GROUNDING SYSTEM - LIGHTNING & SURGE PROTECTIONS

Shall be as described in the Common Particular Specifications.

## 405.8 PROTECTION OF MOTOPUMPSETS

The automatic shut off of the motopumpsets shall be as described in the Common Particular

### 405.9 ALARMS & SIGNALING

Shall be as described in the Common Particular Specifications.

### 405.10 ELECTRICAL INSTALLATION FOR BUILDING

Shall be as described in the Common Particular Specifications

## 406. ELECTRICAL EQUIPMENT AND ACCESSORIES: QARAOUN PS 6 PUMPING STATION

| | |
|---|---|
| Electrical schematic | No.: 588-PS-06E01 |
| Electrical schematic | No.: 588-PS-06E02 |

### 406.1 EDL TRANSFORMER

The Contractor shall coordinate with EDL after gathering all necessary information, supply, install test and commission a High Voltage/Low Voltage pole mounted power transformer as follows:

- Dual primary voltage: 15/20kV
- Secondary voltage: 400 V.
- Rated Power: 100 KVA.

The transformer shall be supplied along with subscription to EDL and power meter and all necessary materials as per EDL requirements and recommendations (medium voltage power lines are not included).

### 406.2 GENERATOR SET

A standby generator set with connecting cables and accessories shall be installed on a concrete pad, inside sound proof canopy, to supply the plant with the following main characteristics:

- Rated Power (Continuous Rating): $P \geq 30$ kVA
- Fuel Storage Tank : V = 1,000 liters, carbon steel, 4 mm minimum thickness, fabricated with level indication, filling pipe and washout valve.
- Daily fuel tank: V = 500 liters with complete fuel transformer system and connection to the fuel storage tank.
- Class of Protection : IP 23
- Switch Gear: including monitoring, control, protection and displays.
- Installation: on concrete pad, inside soundproof canopy.

### 406.3 GROUND-MOUNTED WEATHERPROOF ENCLOSURE

It is an outdoor enclosure and climate control component which must withstand even the toughest wind and weather conditions, from basic requirements such as humidity, temperature fluctuations and sunlight, to extreme conditions such as seawater resistance or earthquake resistance, through to protection against vandalism.

## 406.4 MOTOPUMPSET SWITCH-GEAR

### 406.4.1 General Circuit Breakers (G.C.B.)

- G.C.B. shall be a Moulded Case Circuit Breaker of type "A" as described in the general specification.
- G.C.B. shall be installed upstream the Auto-Transfer Switch, one for network supply and another for Generator Supply.

| No. of Poles | Rating (A) at 380 V | Qty (No) |
|---|---|---|
| 4 | 150 | 1 |
| 4 | 45 | 1 |

### 406.4.2 Circuit Breakers for Motopumpsets (C.B.P.)

- C.B.P. shall be a Moulded Case Circuit Breaker of type "B" as described in the general specification.
- C.B.P. shall be installed upstream the starters that control the Motopumpsets.

| No. of Poles | Rating (A) at 380 V | Qty (No) |
|---|---|---|
| 3 | 20 | 2 |

### 406.4.3 Auxiliaries Switch-Gear

- Shall include all outgoing feeders and corresponding protection for the auxiliaries of the site.
- The circuit breakers, shall be supplied and installed to supply all Auxiliary equipment of the site.
- The circuit breaker shall be a Moulded Case Circuit Breaker of type "B" as described in the general specification.

| No. of Poles | Rating (A) at 380 V | Qty (No) |
|---|---|---|
| 4 | 20 | 1 |

### 406.4.4 Automatic Transfer Switch (A.T.S) (Main/Standby supply changeover)

- A.T.S. complete with mechanical and electrical inter-lock shall be installed for the Motopumpsets and auxiliaries.

| Mechanical Life (Cycles) | Switching Frequency (Cycles/Hour) | Qty (No) |
|---|---|---|
| ≥ 10 million | ≥ 2400 | 1 |

| No. of Poles | Rating (A) at 380 V | Qty (No) |
|---|---|---|
| 4 | 150 | 1 |

**406.4.5 Starter**

| Type | Rating (kW) at 380V | Contactors Mechanical Life (Cycles) | Contactors Switching Frequency (Cycles/Hour) | Qty (No) |
|---|---|---|---|---|
| Variable Speed Drive | ≥ 9 | ≥ 10 million | ≥ 2400 | 2 |

– Each starter shall be supplied with an "Electric Motor Manager" unit and accessories.

**NB:** i) The ATS system and the motopumpset operation, protection and signalling shall be controlled by the main PLC (MPLC) as described in the "Instrumentation, control equipment and accessories" section.
ii) A calculation sheet for design justification of all electrical switch-gear shall be submitted.

## 406.5 ELECTRICAL INSTRUMENTATION

| Local electrical instrumentation | Quantity (set) |
|---|---|
| Set of three digital Ammeters with current transformers | 4 |
| Set of digital voltmeters with selector switches | 2 |
| Digital hour-meters | 2 |
| Digital frequency meters | 2 |
| Digital power factor measurement (Response time ≤ 1 s) | 1 |
| Signalling lamps (Set of three) | 6 |

Current, voltage, power factor and frequency measurements shall also be transmitted to the main PLC (MPLC).

## 406.6 UNINTERRUPTIBLE POWER SUPPLY (U.P.S)

Set of two U.P.S. systems each shall be as described in the common particular specifications.

## 406.7 GROUNDING SYSTEM - LIGHTNING & SURGE PROTECTIONS

Shall be as described in the Common Particular Specifications.

## 406.8 PROTECTION OF MOTOPUMPSETS

The automatic shut off of the motopumpsets shall be as described in the Common Particular Specifications.

## 406.9 ALARMS & SIGNALING

Shall be as described in the Common Particular Specifications.

### 406.10 ELECTRICAL INSTALLATION FOR BUILDING

Shall be as described in the Common Particular Specifications

## 407. ELECTRICAL EQUIPMENT AND ACCESSORIES: QARAOUN EXISTING PS 7 PUMPING STATION

| | |
|---|---|
| Electrical schematic | No.: 588-PS-07E01 |
| Electrical schematic | No.: 588-PS-07E02 |

### 407.1 EDL TRANSFORMER

The Contractor shall coordinate with EDL after gathering all necessary information, supply, install test and commission a High Voltage/Low Voltage pole mounted power transformer as follows:

- Dual primary voltage: 15/20kV
- Secondary voltage: 400 V.
- Rated Power: 250 KVA.

The transformer shall be supplied along with subscription to EDL and power meter and all necessary materials as per EDL requirements and recommendations (medium voltage power lines are not included).

### 407.2 GENERATOR SET

A standby generator set with connecting cables and accessories shall be installed on a concrete pad, inside sound proof canopy, to supply the plant with the following main characteristics:

- Rated Power (Continuous Rating): $P \geq 250$ kVA
- Fuel Storage Tank : V = 4,000 liters, carbon steel, 4 mm minimum thickness, fabricated with level indication, filling pipe and washout valve.
- Daily fuel tank: V = 500 liters with complete fuel transformer system and connection to the fuel storage tank.
- Class of Protection : IP 23
- Switch Gear: including monitoring, control, protection and displays.
- Installation: on concrete pad, inside soundproof canopy.

### 407.3 GROUND-MOUNTED WEATHERPROOF ENCLOSURE

It is an outdoor enclosure and climate control component which must withstand even the toughest wind and weather conditions, from basic requirements such as humidity, temperature

fluctuations and sunlight, to extreme conditions such as seawater resistance or earthquake resistance, through to protection against vandalism.

## 407.4 MOTOPUMPSET SWITCH-GEAR

### 407.4.1 General Circuit Breakers (G.C.B.)

- G.C.B. shall be a Moulded Case Circuit Breaker of type "A" as described in the general specification.
- G.C.B. shall be installed upstream the Auto-Transfer Switch, one for network supply and another for Generator Supply.

| No. of Poles | Rating (A) at 380 V | Qty (No) |
|---|---|---|
| 4 | 375 | 1 |
| 4 | 375 | 1 |

### 407.4.2 Circuit Breakers for Motopumpsets (C.B.P.)

- C.B.P. shall be a Moulded Case Circuit Breaker of type "B" as described in the general specification.
- C.B.P. shall be installed upstream the starters that control the Motopumpsets.

| No. of Poles | Rating (A) at 380 V | Qty (No) |
|---|---|---|
| 3 | 140 | 3 |

### 407.4.3 Auxiliaries Switch-Gear

- Shall include all outgoing feeders and corresponding protection for the auxiliaries of the site.
- The circuit breakers, shall be supplied and installed to supply all Auxiliary equipment of the site.
- The circuit breaker shall be a Moulded Case Circuit Breaker of type "B" as described in the general specification.

| No. of Poles | Rating (A) at 380 V | Qty (No) |
|---|---|---|
| 4 | 140 | 1 |

### 407.4.4 Automatic Transfer Switch (A.T.S) (Main/Standby supply changeover)

- A.T.S. complete with mechanical and electrical inter-lock shall be installed for the Motopumpsets and auxiliaries.

| Mechanical Life (Cycles) | Switching Frequency (Cycles/Hour) | Qty (No) |
|---|---|---|
| ≥ 10 million | ≥ 2400 | 1 |

| No. of Poles | Rating (A) at 380 V | Qty (No) |
|---|---|---|
| 4 | 400 | 1 |

**407.4.5 Starter**

| Type | Rating (kW) at 380V | Contactors Mechanical Life (Cycles) | Contactors Switching Frequency (Cycles/Hour) | Qty (No) |
|---|---|---|---|---|
| Variable Speed Drive | ≥ 70 | ≥ 10 million | ≥ 2400 | 3 |

– Each starter shall be supplied with an "Electric Motor Manager" unit and accessories.

**NB:** i) The ATS system and the motopumpset operation, protection and signalling shall be controlled by the main PLC (MPLC) as described in the "Instrumentation, control equipment and accessories" section.

ii) A calculation sheet for design justification of all electrical switch-gear shall be submitted.

## 407.5 ELECTRICAL INSTRUMENTATION

| Local electrical instrumentation | Quantity (set) |
|---|---|
| Set of three digital Ammeters with current transformers | 6 |
| Set of digital voltmeters with selector switches | 2 |
| Digital hour-meters | 3 |
| Digital frequency meters | 2 |
| Digital power factor measurement (Response time ≤ 1 s) | 1 |
| Signalling lamps (Set of three) | 7 |

Current, voltage, power factor and frequency measurements shall also be transmitted to the main PLC (MPLC).

## 407.6 UNINTERRUPTIBLE POWER SUPPLY (U.P.S)

Set of two U.P.S. systems each shall be as described in the common particular specifications.

## 407.7 GROUNDING SYSTEM - LIGHTNING & SURGE PROTECTIONS

Shall be as described in the Common Particular Specifications.

## 407.8 PROTECTION OF MOTOPUMPSETS

The automatic shut off of the motopumpsets shall be as described in the Common Particular Specifications.

## 407.9 ALARMS &

Shall be as described in the Common Particular Specifications.

### 407.10 ELECTRICAL INSTALLATION FOR BUILDING

Shall be as described in the Common Particular Specifications

## 408 STANDBY POWER GENERATOR PART

### 408.1 GENERAL

#### 408.1.1 SCOPE

A. The contractor is to supply and install emergency generator including:
   1. 1 set power generator (120 KVA prime rating each)
   2. Control, regulation and protection built-in panelboard.
   3. Electronic governor system
   4. Digital voltage regulator
   5. Cooling system
   6. Starting systems including batteries charger and storage batteries
   7. Fuel supply system and all fuel installations with all safety and isolation valves
   8. Complete exhaust system for the generator.
   9. Necessary sound proofing system (attenuators, anti-vibration pad,…) in order to reach a maximum noise level of 70 dBA at 1m from the generator
   10. Fuel drip tray
   11. All other necessary accessories
   12. Personnel training

B. All equipment shall be designed, fabricated, installed and tested in accordance with the latest revision, as of the date of tender of the relevant regulations and standards, and in particular the following as appropriate:
   1. The Institution of Electrical Engineers Regulations for Electrical Equipment in Buildings, 16$^{th}$ Edition.
   2. British Standards as applicable.
   3. IEC Standards as applicable.
   4. NFP A110 Regulations.
   5. Any additional requirements of the local fire officer.
   6. In the event of there being differences between Standards, Regulations, etc. the most stringent shall be deemed to apply. The Contractor shall clearly state in his tender the standards and codes he intends to adopt for the detailed design.

C. Where practicable, each item of equipment shall be clearly and indelibly marked to indicate the standard with which it complies. Alternatively, a Certificate of Compliance shall be provided.

#### 408.1.2 SUBMITTALS

A. The contractor shall prepare and submit for comment, design, shop drawings and as built drawings as required for the installation. These shall be at a scale that is no smaller than the Engineer's drawings and shall include, but not be limited to:
   1. Builder's Work drawings
   2. Generators, Plant and Equipment Layouts
   3. Drawings to show the loading imposed on foundation for generators
   4. Fully detailed Arrangement and Assembly Drawings of the generator set
   5. General Arrangements of Switchboards, Panels and Equipment

6. General arrangement and detail drawings of fuel system installation
7. General arrangement and detail drawings of electrical cabling of power and control of generator
8. General arrangement and detail drawings of exhaust installation
9. Schematic Diagrams and Wiring Diagrams of equipment and plant
10. Diagrams fully detailing interconnecting cabling
11. General arrangement drawings of fuel storage facility
12. General arrangements and detail drawings of air attenuators and ductwork
13. Manufacturer's 'As made' drawings
14. Isometric drawings for all piping systems
15. Detailed calculation notes for:
    a. Sound attenuation installation
    b. Generators ventilation installation
    c. Exhaust backpressure
    d. Cables sizing

B. The drawings shall be fully detailed and dimensioned. All critical dimensions and tolerances shall be shown.

C. The contractor shall submit full technical data of all equipment for approval.

D. Manuals

1. The Contractor shall prepare operation and maintenance manuals together with the drawings detailed above for the mechanical and electrical services. A copy of the manuals and drawings shall be submitted to the engineer three weeks prior to the commissioning of the works.

This shall be updated after commissioning to incorporate test results and comments made by the Employer and the Engineer during commissioning. All copies of the finalized manuals shall be submitted prior to practical completion.

2. The manuals shall include:
    a. Index
    b. A description of the installation and its method of operation written in non technical English to enable a non technical person to safely operate the plant. This should give guidance on action to be taken for failures
    c. Control adjustments and setting of all devices
    d. Full record of the commissioning performance details
    e. A detailed schedule of all equipment giving manufacturers reference.
    f. Detailed maintenance instructions for all items of plant including a planned maintenance scheme in chart format.
    g. A list of recommended spares.

E. Labeling and Notices

1. All labels and notices shall be provided in dual language, English and Arabic or French and Arabic. Whichever language combination is selected all labels for the works shall have the same combination.
2. All control panels, relay panels, control switches, isolators, junction boxes, distribution boards, feeder pillars, valves, thermostats, etc. and all other items of plant and equipment shall be provided with a suitably engraved laminated plastic label permanently fitted to the plant concerned. The label shall indicate the designation, plant item or equipment number and a brief description of the function of the plant, item or equipment.
3. In general, labels shall be of adequate size with black filled characters on a white

surface. The fixings of all labels shall be by means of machined brass screws Adhesives will not be permitted.

## 408.2 PART 2 - PRODUCTS

### 408.2.1 GENERATING SET PANELBOARD

A. Each generator is to be provided with a built-in panelboard made of 20/10 thick sheet steel supplied with lockable doors, painted with a finish in accordance with the client's choice. Cables are to be installed in adequate plastic trunking.

B. This panelboard includes:
   1. Push buttons:
      a. Emergency stop
      b. Engine starting
      c. Engine stopping
      d. Lamp Test
      e. Alarm cleared
      f. Alarm sounder off
   2. Protection and Control with indicating lamps or leds:
      a. Alternator overload protection: Electronic alternator overcurrent alarm shall be provided. The overcurrent alarm shall be indicated when the load current on the generator set is more than 110% of rated current for more than 60 seconds.

         The overcurrent shutdown shall match to the thermal damage curve of the generator set, and shall not have an instantaneous function.
      b. Alternator output protection: Controls shall be provided to initiate an alarm condition when generator set is at 90% of rated frequency for more than 20 seconds.
         Controls shall be provided to shut down generator set and initiate alarm when the generator set is at less than 85% of nominal voltage for more than 15 seconds, more than 110% of nominal voltage for more than 10 seconds, or more than 130% of nominal.
      c. Reverse power protection: Controls shall include three phase sensing reverse power equipment, to prevent sustained reverse power flow into the generator set. When the reverse power condition exceeds 10% of the generator set kW for 3 seconds, the paralleling circuit breaker shall be tripped open and the generator shut down
      d. A set of time activated and instantaneous relays allowing the starting and shut down of the generators in addition to the indicating lamps shall be provided.
      e. The control system shall monitor the paralleling breaker auxiliary contacts, and initiate a fault signal if the breaker fails to close within an adjustable time delay period after the control has signaled it to close (0.5-15 seconds). Breaker failure alarm shall cause the paralleling breaker to trip open, and lock out until manually reset.
   3. Metering apparatus:
      a. 3 ammeters with their current transformers
      b. 1 Voltmeter with a selector switch
      c. Power factor meter
      d. hourmeter
      e. Frequencymeter
      f. 1 Kilowatt hour meter
   4. Selector switches:

a. Running mode selector

5. Alarm and status indicating module

The alarm and status indicating panel shall indicate the following conditions:

| No. | Function | Lamp Color | Alarm Horn | Shutdown Unit |
|---|---|---|---|---|
| | | | | |
| a. | Emergency stop operated | Red | * | * |
| b. | System failure | Amber | * | |
| c. | No voltage | Amber | * | |
| d. | Low DC Voltage | Amber | * | |
| e. | High DC Voltage | Amber | * | |
| f. | Fail to Sync | Amber | * | |
| g. | Overcurrent Alarm | Amber | * | |
| h. | High oil temperature | Amber | * | |
| i. | Breaker Failure (ON/OFF) | Red | * | * |
| j. | Breaker Tripped | Red | * | * |
| k. | Overcurrent | Red | * | * |
| l. | Short Circuit | Red | * | * |
| m. | Reverse Power | Red | * | * |
| n. | Overcrank | Red | * | * |
| o. | Under Frequency | Red | * | |
| p. | Over frequency | Red | * | * |
| q. | Under Voltage | Red | * | * |
| r. | Over Voltage | Red | * | * |
| s. | Phase Rotation | Red | * | * |
| t. | Generator Running | Green | * | |
| u. | Breaker Open | Green | * | |
| v. | Breaker Closed | Green | * | |
| w. | Water temperature failure | Green | * | |
| x. | Oil pressure failure | Green | * | |
| y. | Overspeed | Red | * | |
| z. | No Starting | Green | * | |
| aa. | Daily fuel tank low level | Green | * | |
| bb. | Daily fuel tank high level | Green | * | |

A test lamp push button switch shall be provided.

The control panel shall be equipped with one push button for manual soft unloading of gen- set.

The contractor shall provide all other components required, such as properly sized current transformers, voltage transformers, transducers, terminal blocks, etc., for reliable system operation, as described herein under “SYSTEM OPERATION".

### 408.2.2 MASTER CONTROL PANEL

A. The master control shall monitor and control the operation of the entire system. The master control panel shall contain the following components:
   1. Programmable controller to provide load demand, load pick-up, and load shed functions.
   2. Load pick-up output contacts, rated 10 A at 600 VAC (3 contacts per level).
   3. Load shed output contacts, rated 10 A at 600 VAC (3 contacts per level).

B. A system status panel shall be provided and shall include the following features and functions:
   1. Alarm Silence Push-button Switch
   2. Alarm horn
   3. Lamp test push button
   4. LED Indicating lamps to indicate the following conditions:

| Function | Color | Alarm Horn |
|---|---|---|
| a. Generator Set #1 Running | green | |
| b. Generator Set #2 Running | green | |
| c. Load Demand Mode | green | |
| d. Priority 1 Load On | green | |
| e. Priority 2 Load On | green | |
| f. Priority 3 Load On | green | |
| g. Priority 4 Load On | green | |
| h. Load Shed Level 1 | red | * |
| i. Load Shed Level 2 | red | * |
| j. Load Shed Level 3 | red | * |
| k. Load Shed Level 4 | red | * |
| l. System Test | green | |
| m. Remote System Start | red | |
| n. Controller Malfunction | red | * |
| o. Alarm Station Battery | red | * |
| p. Alarm Generator Set #1 | red | * |
| q. Alarm Generator Set #2 | red | * |
| r. Bus Overload | red | * |
| s. System Not in Auto Mode | red | * |
| t. Over/Under Voltage | red | * |
| u. Over/Under frequency | red | * |

C. The contractor shall provide all other components required, such as properly sized current transformers, transducers, terminal blocks, etc., for reliable system operation.

D. The master control panel shall be provided with a set of DC-powered lamps with a switch to allow viewing of all functions on the front panel when normal lighting systems are not available.

### 408.2.3 TOTALIZING PANELBOARD

A. Refer to section 16422 for totalizing panelboard specifications.

### 408.2.4 AUXILIARIES PANELBOARD

A. This panel is to be made of 20/10 thick sheet steel , and includes, at least, the control and protection devices of the following auxiliaries:
   1. Fans
   2. Automatic battery chargers (protected on AC and DC sides)

B. This panel will include also the following:
   1. Indicating lamps showing the status of the auxiliaries
   2. A voltmeter that monitors the charger voltage
   3. An ammeter that monitors the charging current.

### 408.2.5 ENGINE MOTOR

A. The following characteristics are to be observed:
   1. Normal conditions of climate:
      a. Maximum temperature 37 °C
      b. Relative humidity 70 %
      c. Atmospheric pressure at sea level 1012 pa
   2. Design conditions:
      a. Maximum temperature 45°C
      b. Minimum temperature - 5°C
      c. Maximum wind speed 180 km/hour
      d. Dynamic pressure 122 daN/ m2
      e. Site altitude sea level
   3. The manufacturer shall determine his choice of diesel motor according to the site climatic and geographic conditions as well as to the projected running mode.

B. Engine description
   1. The engine is of the compression-ignition type with mechanical or pneumatic injection water cooled, 4 stroke industrial Diesel with a maximum rpm of 1500. All parts must be easily accessible.
   2. Greasing must be done under pressure. In case of low pressure, a manometer provided with electrical contacts will automatically shut down the generator and initiates the relative alarm.
   3. All rotating/movable parts such as flywheel, must be protected with caps or fence if they are accessible.
   4. An electronic isochronous and load sharing governor is to be provided. Governing shall be in accordance with BS 5514 Type 1 accuracy Class A1 or better with governor speed droop adjustable between 1% and 5% of the nominal speed. Maximum transient speed change shall not exceed 5 % with the maximum anticipated step load applied. Manual adjustment shall be provided for 5% rated speed. Steady load band shall not exceed 1% of rated speed.

C. Standard equipment:
   1. Diesel engine operating on domestic fuel
   2. Inertia flywheel

3. Electronic governor
4. Underpressure greasing circuit
5. Electric starter
6. Dry Air filter
7. Oil filter
8. Fuel filter and prefilter
9. Water thermostatic valve
10. Oil cooling agent
11. Oil drainage
12. System keeping the oil at an admissible temperature. If this device includes parts subject to wear, it should be of the duplex type.
13. All electrical installations & piping must be solidly fixed in order to withstand vibrations.
14. Systems dedicated to protect the engine in the following cases:
    a. If the oil pressure drops below a presetted limit.
    b. If the cooling water temperature rises above a presetted limit.
    c. Overspeed

D. Motor control panel:
1. The engine shall be provided with a control panel which must not be fixed on any part subject to vibrations. This panel, includes at the front, the following:
    a. Time: hourmeter with a 10,000 running hours totalizer (sealed)
    b. Oil: manometer and thermometer installed on the greasing circuit.
    Alarm contacts relative to minimum pressure and temperature excess are to be wired to this panel in order to be connected to the main control and regulation panel.
    c. Water: thermometers relative to high and low temperatures are to be provided.
    A contact relative to temperature excess is to be wired to this panel in order to be connected to the control and regulation panel.
    d. Engine starting: On/Off push buttons.

**408.2.6 ALTERNATOR**

A. The Alternator shall be synchronous, four pole, revolving field, dripproof construction, single prelubricated sealed bearing and directly connected to the engine.

B. Alternator Characteristics:

| | | |
|---|---|---|
| 1. | Rating as indicated on the drawings | |
| 2. | Power factor | 0.8 |
| 3. | Voltage | 380 V |
| 4. | Connection: | star with neutral |
| 5. | Frequency: | 50 Hz |
| 6. | Speed: | 1500 rpm |
| 7. | Insulation class: | H |
| 8. | Service: | continuous |
| 9. | Overload: | 10 % for one hour every 12 hours |

C. Electrical characteristics:
1. Voltage regulation must be done at ± 1 % of the nominal voltage irrespective of the set status and in the following cases:
    a. When the load varies from 0% to 100 %

b. When the power factor varies between 1 and 0.8
c. When the speed varies between the admissible limits.

2. Time response must be less than 5 seconds. The alternator must be the only equipment that is connected to any other one subject to vibration.

D. Mechanical characteristics:

1. The alternator and its (exciter) must be protected against vertical water flow. The location of connection boxes must be defined according to the power cables routing. The alternator must be provided with handling devices. Cable entrances must be done through cable glands and connected to a MCCB with solid state trip.

E. Electrical Protections:

1. The alternator will be protected at the low voltage side by:
   a. Thermistor relay.
   b. An overload (2 thresholds: 2.5-3 In with timer and 1.8 In).
   c. Stator earth leakage relay.

**408.2.7 STARTING SYSTEM**

A. Electrical starting using 24 volt starter motor, and lead acid batteries shall be provided. Batteries shall be provided with a non corrodible battery tray and insulated cover.

B. Electrical battery starting circuit shall consist of the following:

1. Electrical direct current motor
2. Battery with capacity to supply the control panel standing load for 24 hours after three consecutive diesel engine starts;
3. Ammeter,
4. Electrical charger supplied from the mains electricity supply (220V/24V), having float and boost modes. After 6 hours a relay will disconnect the boost mode. Float mode shall maintain full charge with normal load and boost mode shall be capable of restoring the battery from fully discharged to fully charged in a maximum of 7 hours
5. Required cabling for starting system.
6. Suitable plastic acid protection to all parts.

**408.2.8 EXHAUST SYSTEM**

A. A complete system is to be provided. It will include:

1. A flexible pipe installed on top of each motor
2. A residential silencer, for each generator, horizontally fixed to the ceiling
3. After the silencer, the system must be insulated (10 cm minimum thickness) in addition to a galvanized steel housing
4. All electrical wires must run 20 cm at least from the horizontal and vertical runs of the exhaust.
5. The exhaust must be fixed at least 20 cm from the concrete or any other material
6. The system must include a water drain installed at the lowest point as well as at each silencer
7. All connections must be done using flanges and bolts

### 408.2.9 FUEL SYSTEM

A. Generators shall be supplied from a 1000 L daily tank made from welded steel and installed on a metallic structure.

B. The tank will be equipped with:
1. A Level indicator
2. A vent
3. Supply and drain valves
4. Filling and return points
5. A steel retention tank of 1200 L capacity
6. Low level and high level detection
7. Manual pump

C. A security valve installed outdoor between main fuel tank and daily tank shall be provided.

D. All fuel pipework shall be fabricated from seamless steel tubing with welded a compressed type steel fittings. Flexible sections shall be synthetic rubber with stainless steel braided sheaths and flame retardant sleeves.

## 408.3 PART 3 - EXECUTION

### 408.3.1 SYSTEM OPERATION

A. Loss of normal power:
1. System is given signal to start by receipt of start signal. On receipt of this signal, the generator set automatically and independently start, accelerate to rated frequency and build up to rated voltage. At this time transfer switches begin the time delay transfer sequence, and on its completion transfer their loads to the system bus.
2. The priority (load add) controls prevent overloading of the system bus by providing inhibit signals to prevent transfer of selected loads to the emergency system until sufficient generating capacity is available on the bus.

B. Failure of the unit to start:
1. If the unit fails to start, after the overcrank time delay (in the generator set control) has expired, the unit will be shut down, and an alarm will sound. The priority control will prevent the lowest priority loads from being added to the system without manual intervention. Bus overload monitoring shall protect the first priority loads in the event that the bus is inadvertently overloaded due to operator error.

C. Bus overload:
1. If a bus overload occurs for any reason, a load shed signal will be generated to initiate load shedding in the system.
2. If the bus does not return to proper frequency within a predetermined period of time, additional load shed signals will be generated.
3. Total discrimination shall be provided between time delays of master panel overload protection and individual overload protection of the generators.

D. Load demand mode:
1. When the system is running the emergency mode controls shall continuously monitor the total load on the bus. If the total load on the bus falls below preset limits

for a period of 15 minutes, the controller will automatically shut down generator set in a predetermined order, until the minimum number of generators required to operate the load remain on the bus. The purpose of this function is to allow the generator set to operate closer to their rated capacity, thereby decreasing fuel consumption, and reducing wear on the system.

2. On sensing that the available bus capacity is being approached, the standby units will automatically be restarted (in the reverse order of which they were shut down) and paralleled with the bus to assume their proportional share of system load.

E. Return of Normal Power:

1. When all of the system start signals are removed from the generator set, the generator set paralleling breakers shall all open, and the generator set shall operate at no load for a cool down period. When the cool down period has been completed, the generator set shall shut down.
2. If a system start signal is received during the cool down period, the generator set shall immediately close to the system bus, as described in "Loss of Normal Power" above.

### 408.3.2 GENERATOR OPERATION

A. Automatic Mode:

1. In normal ways, the mains supply the whole installation.
2. Upon receiving a signal from the voltage supervisory system indicating a voltage anomaly on the local network, are to start simultaneously meaning an adjustable time switch (0-2 minutes).

B. Manual Mode:

1. This mode must allow each generator to run in the presence or absence of any load and to shut down manually or meaning a push button.

C. Test Mode:

1. This mode must allow the set to start without any load while the mains is available. Switching to the "automatic" or "out-of-order" mode are the only ways to shut down the generators.

If the starting signal is received during the "test mode", then the generators must supply the load automatically.

D. Out-of-order Mode:

1. This mode forbids the starting of the generators in any case. Switching to this mode stops the set immediately.

## 409 SPLIT-SYSTEM AIR-CONDITIONERS

### 409.1 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.

1. Warranty Period: [**two**] years from date of Substantial Completion.

## 409.2 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Filters: One set of filters for each unit.

## 409.3 PART 1 -PRODUCTS

### 409.3.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Carrier Air Conditioning; Div. of Carrier Corporation.
2. Evcon Industries, Inc.
3. First Co.
4. Friedrich Air Conditioning Company.
5. Koldwave, Inc.
6. Lennox Industries Inc.
7. Mitsubishi Electric Sales Canada, Inc.
8. Mitsubishi Electronics America, Inc.; HVAC Division.
9. Mitsubishi Heavy Industries America, Inc.; Air-Conditioning & Refrigeration Division, Inc.
10. Sanyo Fisher (U.S.A.) Corp..
11. Tadiran Electronic Industries Inc.; Appliance Division.
12. Trane Company (The); Unitary Products Group.
13. York International Corp.
14. <**Insert manufacturer's name.**>

### 409.3.2 WALL-MOUNTING, EVAPORATOR-FAN COMPONENTS

A. Cabinet: with removable panels on front, and discharge drain pans with drain connection.

1. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
2. Drain Pan and Drain Connection: Comply with ASHRAE 62.1-2004.

B. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with thermal-expansion valve.

C. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements with refractory ceramic support bushings; automatic-reset thermal cutout; built-in magnetic contactors; manual-reset thermal cutout; airflow proving device; and one-time fuses in terminal box for overcurrent protection.

D. Fan: Direct drive, centrifugal fan.

E. Fan Motors: Comply with Common Motor Requirements for HVAC Equipment."

1. Special Motor Features: Multitapped, multispeed with internal thermal protection and permanent lubrication.

F. Filters: [**Permanent, cleanable**].

### 409.3.3 AIR-COOLED, COMPRESSOR-CONDENSER COMPONENTS

A. Casing: Steel, finished with baked enamel, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.

B. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.

1. Compressor Type: [**Scroll**].
2. Two-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.
3. Refrigerant: R-407C or R-410A.

C. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with liquid subcooler.

D. Heat Pump Components: Reversing valve and low-temperature air cut-off thermostat.

E. Fan: Aluminum-propeller type, directly connected to motor.

F. Motor: Permanently lubricated, with integral thermal-overload protection.

G. Low Ambient Kit: Permits operation down to 45 deg F (7 deg C).

H. Mounting Base: Polyethylene.

I. Minimum Energy Efficiency: Comply with ASHRAE/IESNA 90.1-2004, "Energy Standard for Buildings except Low-Rise Residential Buildings." (Inverter Type)

### 409.3.4 ACCESSORIES

A. Thermostat: Low voltage with subbase to control compressor and evaporator fan.

B. Thermostat: Wireless infrared functioning to remotely control compressor and evaporator fan, with the following features:

1. Compressor time delay.
2. 24-hour time control of system stop and start.
3. Liquid-crystal display indicating temperature, set-point temperature, time setting, operating mode, and fan speed.
4. Fan-speed selection, including auto setting.

C. Automatic-reset timer to prevent rapid cycling of compressor.

D. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.

1. Minimum Insulation Thickness: [**1/2 inch (13 mm)**] thick.

## 409. 4 PART 2 – EXECUTION

### 409.4.1 INSTALLATION

A. Install units level and plumb.

B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

C. Install wall-mounting, compressor-condenser components on galvanized steel brackets.

D. Install and connect pre-charged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

### 409.4.2 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Remove and replace malfunctioning units and retest as specified above.

### 409.4.3 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

2.

### 409.4.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain units.

# 410 OFF GRID SOLAR SYSTEM

## 410.1 INTRODUCTION and PURPOSE

The existing pumping station in Qaraoun (PS7) houses one pumping set of 3 identical pumps (1 duty + 1 assist +1 stand by) designed to convey wastewater peak flow of about 28 l/s each by means of single ID175 mm HDPE pipeline. Each pump is powered by a 20.4 KW submersible motor thru a variable frequency drive (VFD).
The objective of this current note, is to describe an Electrical OFF GRID HYBRID Solar System to supply the submersible pumps with an uninterruptable electric supply on a 24-hour basis relying on Solar Energy, EDL supply and existing power generation unit.

## 410.2 QARAOUN EXISTING PUMPING STATION (PS7) CONDITIONS

Qaraoun existing pumping station (PS7) is powered with three (3) electric sources:

1. ON GRID PV farm: 160 PV panels each 450 W peak.
2. EDL supply.
3. Diesel Generator 250 KVA.

Since the existing photovoltaic ON GRID system requires the presence of voltage from EDL or Diesel Generator to be operational, a consumption of around 20 liters per hour of diesel oil is mandatory to operate the system.
The operator, and for the sake of optimization of this system and to reduce the cost of power, is requiring to shift the existing ON GRID Solar system to an OFF GRID Solar System.
In the following, a Hybrid OFF GRID Solar System will be described based on the needed electric power for PS7 operation optimization.

## 410.3 SEQUENCE OF OPERATION

Qaraoun Pumping Station (PS7) is a critical wastewater collection point receiving flow from upstream stations and networks; therefore, continuous operation is essential and power interruption is not acceptable. The proposed OFF-GRID hybrid system shall be designed based on reliability, redundancy, and operational safety, not minimum commercial sizing.

As previously mentioned, the Qaraoun existing pumping station (PS7) houses three (3) submersible sewage pumps each is powered by a submersible motor of about 20.4 KW and are working as one (1) duty + one (1) assist and one (1) stand by. The operation of this pumping station is very critical and could not be out of service for more than 1-hour buffering time; since it is a collecting node in the system (receiving sewage from the neighborhood by gravity line and from the six (6) pumping stations PS1 to PS6). For this reason, the power failure is not allowed at any time in this pumping station.

## 410.4 DESCRIPTION OF THE NEW PROPOSED SYSTEM

In the full power operation of the Qaraoun existing pumping station (PS7) two (2) submersible pumps are in operation simultaneously requiring a continuous load of around 40.8 KW.
Existing PV farm, as previously mentioned, generates at peak time around 57KWh. As per the Panel Data Sheet, the 1st year power degradation is 2% and the annual degradation is 0.55%. These Panels are installed 5 years ago.
As per the Panel Data Sheet, the 450W is at STC where the module temperature is 25°C. And according to the same Data Sheet, at 20°C the panel generates 25% less (339.40W as per NMOT Testing Condition). So, the efficiency of the panel varies according to the ambient temperature. Therefore, we can't confirm it will generate 100% of its power and we have to consider a loss of 20% to be on the safe side.

A Hybrid OFF GRID inverter set of two (2) 60 KW each (one master and one slave) for a total power of 120 KW; will be installed to receive the generated power from the panels as well as the power from EDL supply.
The Inverters will prioritize the solar power to operate the submersible pumps and the excess of generated power will be stored in a battery bank to be reused during night time.
A 200 KWh battery bank could allow an autonomy of 3.4 hours of operation of the two (2) submersible pumps in operation. Programming the DOD at 30%; The Autonomy = (200*(1-30%)) / 40.8 = 3.40 Hours
In case only one pump is in operation, the autonomy will be doubled to be 6.5 hours.
During day time, solar power is produced, the pumps are fully operated on solar power. In case of solar power leakage due to clouds, the power will be withdrawn from the battery bank till DOD 30%, the power will be shifted to the EDL source if available; if not, order will be sent to turn on the diesel generator that will drive the pumps and charge the battery bank.
During night time, the pumps will be powered by the battery bank until DOD 30% then the power will be shifted to the EDL source if available; if not, order will be sent to turn on the diesel generator that will drive the pumps and charge the battery bank. Once the Battery bank is full again, the power will be shifted again to the Battery bank and the generator is off.

1. Priority 1: Solar Power.
2. Priority 2: Batteries
3. Priority 3: EDL supply.
4. Priority 4: Diesel Generator.

The inverter will be programmed to initiate the generator at 30% battery SOC. And will be programmed to turn off the generator at 80% SOC or any other SOC that we find suitable.

## 410.5 TECHNICAL SPECIFICATIONS OF THE INVERTER

1. Three (3) phase OFF GRID Hybrid Inverter set capacity 2x60 KW one master and one slave
2. Battery Voltage range 180-1000 V
3. Max charging current 150 A
4. Max discharging current 150 A
5. Peak power (off grid) 1.5 times of rated power for 10 s
6. Power factor adjustment range +/- 0.8
7. Rated IN/OUT 220V/380V
8. Grid connection for 3ph+N+PE
9. Efficiency >97%
10. Transfer time <10ms
11. Warranty > 5 years
12. Integrated:
    - Polarity reverse protection
    - AC output overcurrent protection
    - Thermal protection
    - AC output overvoltage protection
    - AC output short circuit protection
    - DC component monitoring
    - Overvoltage load drop protection
    - Ground fault current monitoring
    - Surge type II (DC)
    - Surge type II (AC)

## 410.6 SPECIFICATIONS OF THE BATTERY BANK

1. Lithium Ion Battery of minimum capacity of 200 KWh.
2. In case of multiple modules type batteries, total capacity of all modules to be equal to a minimum of 200 KWh capacity.
3. Charge / Discharge current 100A
4. Max Charge/Discharge current 160 A
5. Recommended depth of discharge min. 90%
6. Cycle life > 5000
7. Warranty > 5 years
8. Ventilation requirements
9. Battery Management System (BMS) integration
10. Temperature monitoring
11. Emergency isolation and shutdown
12. Required enclosure/IP protection

## 410.7 ACCESSORIES

All necessary accessories and fittings required for the proper installation of the system will be included and installed such as:

1. DC cables
2. AC cables
3. Connectors
4. Lugs
5. Racks
6. Clusters
7. Junction boxes
8. Fuses and Porte Fuse
9. Breaker for Batteries MCCB
10. AC Breaker
11. DC Breaker
12. Adaptation of the existing ATS
13. Generator auto-start
14. Inverter by pass arrangement
15. Maintenance by pass
16. Emergency fail-safe operation
17. Installation, transportation, programming,..
18. Two (2) A/C units each 18,000 BTU/Hr (1 duty and 1 Std-by) will be installed in the electric room to provide suitable indoor conditions in terms of temperature and humidity for the inverters and the batteries as well as for the electric control panels and the PLC.

# Volume 2

# Technical Specifications

# Division 2

# Particular Specifications

# Part 5

# Instrumentation & Control

# TABLE OF CONTENT

500. INSTRUMENTATION AND CONTROL: COMMON PARTICULAR SPECIFICATIONS - PUMPING STATIONS ..... 3
500.1 INSTRUMENTATION ..... 3
500.1.1 LEVEL MEASUREMENTS ..... 3
500.2 CONTROL EQUIPMENT ..... 3
500.3 SURGE SUPPRESSION EQUIPMENT ..... 3
501. INSTRUMENTATION, CONTROL EQUIPMENT AND ACCESSORIES: BAALOUL PS 1 PUMPING STATION ..... 7
501.1 INSTRUMENTATION ..... 7
501.1.1 LEVEL MEASUREMENTS ..... 7
501.1.2 PRESSURE MEASUREMENTS ..... 7
501.1.3 TEMPERATURE MEASUREMENTS ..... 7
501.1.4 OIL LEAKAGE DETECTOR ..... 7
502. INSTRUMENTATION, CONTROL EQUIPMENT AND ACCESSORIES: BAALOUL PS 2 PUMPING STATION ..... 8
502.1 INSTRUMENTATION ..... 8
502.1.1 LEVEL MEASUREMENTS ..... 8
502.1.2 PRESSURE MEASUREMENTS ..... 8
502.1.3 TEMPERATURE MEASUREMENTS ..... 8
502.1.4 OIL LEAKAGE DETECTOR ..... 8
503. INSTRUMENTATION, CONTROL EQUIPMENT AND ACCESSORIES: QARAOUN PS 3 PUMPING STATION ..... 9
503.1 INSTRUMENTATION ..... 9
503.1.1 LEVEL MEASUREMENTS ..... 9
503.1.2 PRESSURE MEASUREMENTS ..... 9
503.1.3 TEMPERATURE MEASUREMENTS ..... 9
503.1.4 OIL LEAKAGE DETECTOR ..... 9
504. INSTRUMENTATION, CONTROL EQUIPMENT AND ACCESSORIES: QARAOUN PS 4 PUMPING STATION ..... 10
504.1 INSTRUMENTATION ..... 10
504.1.1 LEVEL MEASUREMENTS ..... 10
504.1.2 PRESSURE MEASUREMENTS ..... 10
504.1.3 TEMPERATURE MEASUREMENTS ..... 10
504.1.4 OIL LEAKAGE DETECTOR ..... 10
505. INSTRUMENTATION, CONTROL EQUIPMENT AND ACCESSORIES: QARAOUN PS 5 PUMPING STATION ..... 11
505.1 INSTRUMENTATION ..... 11
505.1.1 LEVEL MEASUREMENTS ..... 11
505.1.2 PRESSURE MEASUREMENTS ..... 11
505.1.3 TEMPERATURE MEASUREMENTS ..... 11
505.1.4 OIL LEAKAGE DETECTOR ..... 11
506. INSTRUMENTATION, CONTROL EQUIPMENT AND ACCESSORIES: QARAOUN PS 6 PUMPING STATION ..... 12
506.1 INSTRUMENTATION ..... 12
506.1.1 LEVEL MEASUREMENTS ..... 12
506.1.2 PRESSURE MEASUREMENTS ..... 12
506.1.3 TEMPERATURE MEASUREMENTS ..... 12
506.1.4 OIL LEAKAGE DETECTOR ..... 12

# 500. INSTRUMENTATION AND CONTROL: COMMON PARTICULAR SPECIFICATIONS - PUMPING STATIONS

## 500.1 INSTRUMENTATION

### 500.1.1 Level Measurements

Self-cleaning, maintenance free, mercury bulb, immersed level regular switches with a polypropylene housing will be used for starting and stopping of each duty motopumpset and for alarm signalling.

## 500.2 CONTROL EQUIPMENT

Unless otherwise specified, the control system shall be designed and implemented on the following basis:

- One main P.L.C. unit (MPLC) shall be installed and shall be responsible for the automation and control of the pumping station according to the relevant parameters and variables.

  Shall be connected and/or controlled by the main P.L.C. (MPLC) the following:

  - All general circuit breakers (GCB), the corresponding ATS system, the circuit breaker for auxiliaries and the relevant signalling.
  - The circuit breaker (CBP), the starter, the "Electric Motor Manager" unit, the discharge pressure, the motor temperature and oil leakage measuring instruments and the relevant signalling of each motopumpset.
  - The pressure measuring instrument at the discharge pipe and the immersed level regulator switches in the sump pit.

- The Contractor shall supply one Hand Held programmer unit for the above PLC unit.

- The motopumpsets shall be operated cyclically according to the level in the sump pit. Unless otherwise specified the maximum number of pumps simultaneously running is the total number of pumps less one.

- In addition to the control and indication equipment (measurements display, alarms, push buttons, etc…) installed in the control room of the pumping station, this latter shall be designed to house a mimic panel representing the pumping system.

## 500.3 SURGE SUPPRESSION EQUIPMENT

Where a surge suppression equipment is needed then its controller shall be connected to the main PLC of the pumping station for protection, monitoring and supervision.

## 500.4 ELECTRO-MAGNETIC FLOWMETER

The flowmeters shall be of electro-magnetic inductive type having a DC pulsed field with

automatic zero error averaging and low power consumption. They shall have no moving or protruding parts nor cause any restriction in the flow path and be capable of setting adjustments without the need to stop the flow.

Each metering system shall comply with the latest international standard and comprise a flow sensor mounted in the pipework line and a transmitter which degree of protection is IP67, either integrally mounted or remotely located preferably within the main control panel.

The system accuracy shall be a maximum at normal operating flow with an error not more than 0.2% of the reading. When operating in the lower 30% of the meter range, the accuracy shall be within $\pm$0.5%.

a) **Flow sensors** These shall comprise electrodes located in a meter tube which shall be of watertight construction, suitable for operation without loss of accuracy when totally submerged to a depth of 3 metres or even buried into the ground together with the water pipe. Its degree of protection shall be IP68. They will not contain any active components such as amplifiers or memory modules.

The meter tubes shall be made from a non-magnetic material lined with an inert material suitable for the medium. The flow-meter may be flanged or welded ends type. On flanged type the lining shall cover the external parts of both flanges.

The measuring electrodes shall be continuously cleaned by means which do not interrupt the process flow or the measurement. A sensing electrode shall also be provided to detect when the flow meter is not fully charged with liquid.

The flowmeter body shall be effectively bonded by non-corrodible, tinned copper braid links at each end, to the adjacent pipework to ensure a good connection between the body and the metered liquid, an earthing flange being inserted where non-conducting pipework is employed.

**b) Transmitter**

The transmitter shall provide the following minimum functions:

- Conversion of its supply voltage (85 to 260 VAC or 11 to 40 V DC) with galvanic separation up to 500 V in a pulsed signal which feeds the coils in the flow sensor. This method allows the transmitter to compensate for a zero drift of the flowmeter and shall give the flowmeter a perfect zero stability.
- Supervision of the flow sensor: the transmitter shall be able to generate an alarm signal when the following conditions occur:
  - ♦ water conductivity below a pre-set level
  - ♦ flow meter empty
  - ♦ reverse flow direction

- Output signals to inform the control/display equipment. Thus, the transmitter shall have as a minimum the following independent output signals:

  - ♦ Standard analogue current signal 4-20 mA fully isolated from input and other outputs, and where the zero and full-scale mA - value are configurable as well as the measuring range. The range adjustment shall be continuous, and the units shall be configurable in flow

engineering units.

This analogue signal shall represent forward and reverse flows.

An output digital signal shall be provided to indicate flow direction.

Moreover, the transmitter shall provide the possibility to switch automatically to a second selected range where the flow is heavily variable; in this case an output contact shall be provided as well to indicate the selected measuring range.

- Serial port for down - loading data.
- Two pulse signals, fully configurable in volume and length. The pulse signals shall be open collector transistors or voltage free contacts.
- Two alarm signals, fully configurable and representing the following error signals (each error signal can be assigned through configuration to the first, the second or none of the two alarm contacts):
  - empty pipe
  - conductivity out of range
  - no signal from electrodes
  - coils broken (open circuit)
  - flow above or below selected alarm level
  - reverse flow direction
  - output pulse frequency above maximum selected rate.

The alarm signals shall be open collector transistors or voltage free contacts.

- One contact input signal, used to reset the built-in flow totaliser, configurable as being enabled or disabled.
- Local, user-friendly indicator, used to inform the operator about the measurement. The indicator shall provide at least the following information and functions:
  - actual flow with direction, in selected units
  - alarm indication with full description
  - selection of total positive, negative and net flow as well as velocity in the pipe and actual flow in percentage of full scale.
- Configuration tool: It consists of a password protected menu from which the operator shall be able to access and set all configurable parameters grouped by function: measuring range, totalisers, alarms.... A test function shall be available as well to test the wiring and the complete configuration.
- Where specified, removable data storage memory, non-volatile memory module (EEPROM) chip for instruments data and process data in case of replacement of the instrument.

**c) Flowmeter Cabling**

Where remote mounted converters are specified, cables shall be provided, installed and terminated between the sensor and converter/ pulse power unit for the following purposes:

flow signal;

reference signal;

coil supply;

Such cables and sealing glands shall be suitable for submersible operation (IP68) of the sensor to the depth specified. The length of each cable shall be as specified.

**d) Spool Piece**

A flanged steel pipe spool piece shall be provided of the same diameter and length as the respective flowmeter and flanged for insertion in the pipe should it be necessary to remove the flowmeter.

Isolating gate valves shall be provided on either side of the flow meter.

**e) Accuracy**

The accuracy of the flowmeter shall be independent of the range which has been selected for the analogue signal and shall be better than 0.2% of the actual measurement. Thus, the flowmeter shall be supplied with a calibration certificate mentioning also the pressure at which the meter has been factory tested.

**Note**: the flow test shall be made on a recognised test bench which is traceable to international standards.

## 501. INSTRUMENTATION, CONTROL EQUIPMENT AND ACCESSORIES: BAALOUL PS 1 PUMPING STATION

| | |
|---|---|
| Control system schematic | No.: 588-PS-01I01 |
| Electrical schematic | No.: 588-PS-01E01 |
| Hydraulic schematic | No.: 588-PS-01M01 |

### 501.1 INSTRUMENTATION

The Contractor shall supply and install the following system for the measurement of the operation parameters of the pumping installation and of their local display.

#### 501.1.1 Level measurements

| Location | Qty (No) |
|---|---|
| Pumping station Sump pit (L1, L2, L3) | 3 |

#### 501.1.2 Pressure measurements

| Location | Type | Qty (No) |
|---|---|---|
| Motopumpset outlet (P1,P2) | Piezoresistive | 2 |
| Discharge Pipe (P4) | Piezoresistive | 1 |

#### 501.1.3 Temperature measurements

| Location | Type | Qty (No) |
|---|---|---|
| Motopumpset electric motor (T1…T6) | Pt 100 | 2(3 per motor) |

#### 501.1.4 Oil Leakage Detector

| Location | Qty (No) |
|---|---|
| Motopumpset electric motor (O1, O2) | 2 |

### 501.1.5 Electro-Magnetic Flowmeter

| Location | Type | DN (mm) | PN (bars) | Qty (No) |
|---|---|---|---|---|
| Discharge pipe (F) | Electromagnetic | 80 | 16 | 1 |

## 502. INSTRUMENTATION, CONTROL EQUIPMENT AND ACCESSORIES: BAALOUL PS 2 PUMPING STATION

Control system schematic No.: 588-PS-02I01
Electrical schematic No.: 588-PS-02E01
Hydraulic schematic No.: 588-PS-02M01

### 502.1 INSTRUMENTATION

The Contractor shall supply and install the following system for the measurement of the operation parameters of the pumping installation and of their local display.

### 502.1.1 Level measurements

| Location | Qty (No) |
|---|---|
| Pumping station Sump pit (L1, L2, L3) | 3 |

### 502.1.2 Pressure measurements

| Location | Type | Qty (No) |
|---|---|---|
| Motopumpset outlet (P1,P2) | Piezoresistive | 2 |
| Discharge Pipe (P4) | Piezoresistive | 1 |

### 502.1.3 Temperature measurements

| Location | Type | Qty (No) |
|---|---|---|
| Motopumpset electric motor (T1…T6) | Pt 100 | 2(3 per motor) |

### 502.1.4 Oil Leakage Detector

| Location | Qty (No) |
|---|---|
| Motopumpset electric motor (O1, O2) | 2 |

### 502.1.5 Electro-Magnetic Flowmeter

| Location | Type | DN (mm) | PN (bars) | Qty (No) |
|---|---|---|---|---|
| Discharge pipe (F) | Electromagnetic | 80 | 16 | 1 |

## 503. INSTRUMENTATION, CONTROL EQUIPMENT AND ACCESSORIES: QARAOUN PS 3 PUMPING STATION

Control system schematic No.: 588-PS-03I01
Electrical schematic No.: 588-PS-03E01
Hydraulic schematic No.: 588-PS-03M01

### 503.1 INSTRUMENTATION

The Contractor shall supply and install the following system for the measurement of the operation parameters of the pumping installation and of their local display.

#### 503.1.1 Level measurements

| Location | Qty (No) |
|---|---|
| Pumping station Sump pit (L1, L2, L3) | 3 |

#### 503.1.2 Pressure measurements

| Location | Type | Qty (No) |
|---|---|---|
| Motopumpset outlet (P1,P2) | Piezoresistive | 2 |
| Discharge Pipe (P4) | Piezoresistive | 1 |

#### 503.1.3 Temperature measurements

| Location | Type | Qty (No) |
|---|---|---|
| Motopumpset electric motor (T1…T6) | Pt 100 | 2(3 per motor) |

#### 503.1.4 Oil Leakage Detector

| Location | Qty (No) |
|---|---|
| Motopumpset electric motor (O1, O2) | 2 |

#### 503.1.5 Electro-Magnetic Flowmeter

| Location | Type | DN (mm) | PN (bars) | Qty (No) |
|---|---|---|---|---|
| Discharge pipe (F) | Electromagnetic | 80 | 16 | 1 |

## 504. INSTRUMENTATION, CONTROL EQUIPMENT AND ACCESSORIES: QARAOUN PS 4 PUMPING STATION

| | |
|---|---|
| Control system schematic | No.: 588-PS-04I01 |
| Electrical schematic | No.: 588-PS-04E01 |
| Hydraulic schematic | No.: 588-PS-04M01 |

### 504.1 INSTRUMENTATION

The Contractor shall supply and install the following system for the measurement of the operation parameters of the pumping installation and of their local display.

#### 504.1.1 Level measurements

| Location | Qty (No) |
|---|---|
| Pumping station Sump pit (L1, L2, L3) | 3 |

#### 504.1.2 Pressure measurements

| Location | Type | Qty (No) |
|---|---|---|
| Motopumpset outlet (P1,P2) | Piezoresistive | 2 |
| Discharge Pipe (P4) | Piezoresistive | 1 |

#### 504.1.3 Temperature measurements

| Location | Type | Qty (No) |
|---|---|---|
| Motopumpset electric motor (T1…T6) | Pt 100 | 2(3 per motor) |

#### 504.1.4 Oil Leakage Detector

| Location | Qty (No) |
|---|---|
| Motopumpset electric motor (O1, O2) | 2 |

#### 504.1.5 Electro-Magnetic Flowmeter

| Location | Type | DN (mm) | PN (bars) | Qty (No) |
|---|---|---|---|---|
| Discharge pipe (F) | Electromagnetic | 125 | 16 | 1 |

## 505. INSTRUMENTATION, CONTROL EQUIPMENT AND ACCESSORIES: QARAOUN PS 5 PUMPING STATION

| | |
|---|---|
| Control system schematic | No.: 588-PS-05I01 |
| Electrical schematic | No.: 588-PS-05E01 |
| Hydraulic schematic | No.: 588-PS-05M01 |

## 505.1 INSTRUMENTATION

The Contractor shall supply and install the following system for the measurement of the operation parameters of the pumping installation and of their local display.

### 505.1.1 Level measurements

| Location | Qty (No) |
|---|---|
| Pumping station Sump pit (L1, L2, L3) | 3 |

### 505.1.2 Pressure measurements

| Location | Type | Qty (No) |
|---|---|---|
| Motopumpset outlet (P1,P2) | Piezoresistive | 2 |
| Discharge Pipe (P4) | Piezoresistive | 1 |

### 505.1.3 Temperature measurements

| Location | Type | Qty (No) |
|---|---|---|
| Motopumpset electric motor (T1…T6) | Pt 100 | 2(3 per motor) |

### 505.1.4 Oil Leakage Detector

| Location | Qty (No) |
|---|---|
| Motopumpset electric motor (O1, O2) | 2 |

### 505.1.5 Electro-Magnetic Flowmeter

| Location | Type | DN (mm) | PN (bars) | Qty (No) |
|---|---|---|---|---|
| Discharge pipe (F) | Electromagnetic | 80 | 16 | 1 |

# 506. INSTRUMENTATION, CONTROL EQUIPMENT AND ACCESSORIES: QARAOUN PS 6 PUMPING STATION

| | |
|---|---|
| Control system schematic | No.: 588-PS-06I01 |
| Electrical schematic | No.: 588-PS-06E01 |
| Hydraulic schematic | No.: 588-PS-06M01 |

## 506.1 INSTRUMENTATION

The Contractor shall supply and install the following system for the measurement of the operation parameters of the pumping installation and of their local display.

### 506.1.1 Level measurements

| Location | Qty (No) |
|---|---|
| Pumping station Sump pit (L1, L2, L3) | 3 |

### 506.1.2 Pressure measurements

| Location | Type | Qty (No) |
|---|---|---|
| Motopumpset outlet (P1,P2) | Piezoresistive | 2 |
| Discharge Pipe (P4) | Piezoresistive | 1 |

### 506.1.3 Temperature measurements

| Location | Type | Qty (No) |
|---|---|---|
| Motopumpset electric motor (T1…T6) | Pt 100 | 2(3 per motor) |

### 506.1.4 Oil Leakage Detector

| Location | Qty (No) |
|---|---|
| Motopumpset electric motor (O1, O2) | 2 |

### 506.1.5 Electro-Magnetic Flowmeter

| Location | Type | DN (mm) | PN (bars) | Qty (No) |
|---|---|---|---|---|
| Discharge pipe (F) | Electromagnetic | 80 | 16 | 1 |

## 507. INSTRUMENTATION, CONTROL EQUIPMENT AND ACCESSORIES: QARAOUN EXISTING PS 7 PUMPING STATION

| | |
|---|---|
| Control system schematic | No.: 588-PS-07I01 |
| Electrical schematic | No.: 588-PS-07E01 |
| Hydraulic schematic | No.: 588-PS-07M01 |

### 507.1 INSTRUMENTATION

The Contractor shall supply and install the following system for the measurement of the operation parameters of the pumping installation and of their local display.

### 507.1.1 Level measurements

| Location | Qty (No) |
|---|---|
| Pumping station Sump pit (L1, L2, L3 & L4) | 4 |

### 507.1.2 Pressure measurements

| Location | Type | Qty (No) |
|---|---|---|
| Motopumpset outlet (P1, P2 & P3) | Piezoresistive | 3 |
| Discharge Pipe (P4) | Piezoresistive | 1 |

### 507.1.3 Temperature measurements

| Location | Type | Qty (No) |
|---|---|---|
| Motopumpset electric motor (T1…T9) | Pt 100 | 3(3 per motor) |

### 507.1.4 Oil Leakage Detector

| Location | Qty (No) |
|---|---|
| Motopumpset electric motor (O1, O2) | 3 |

### 507.1.5 Electro-Magnetic Flowmeter

| Location | Type | DN (mm) | PN (bars) | Qty (No) |
|---|---|---|---|---|
| Discharge pipe (F) | Electromagnetic | 200 | 16 | 1 |