SIALKOT TANNERY ZONE

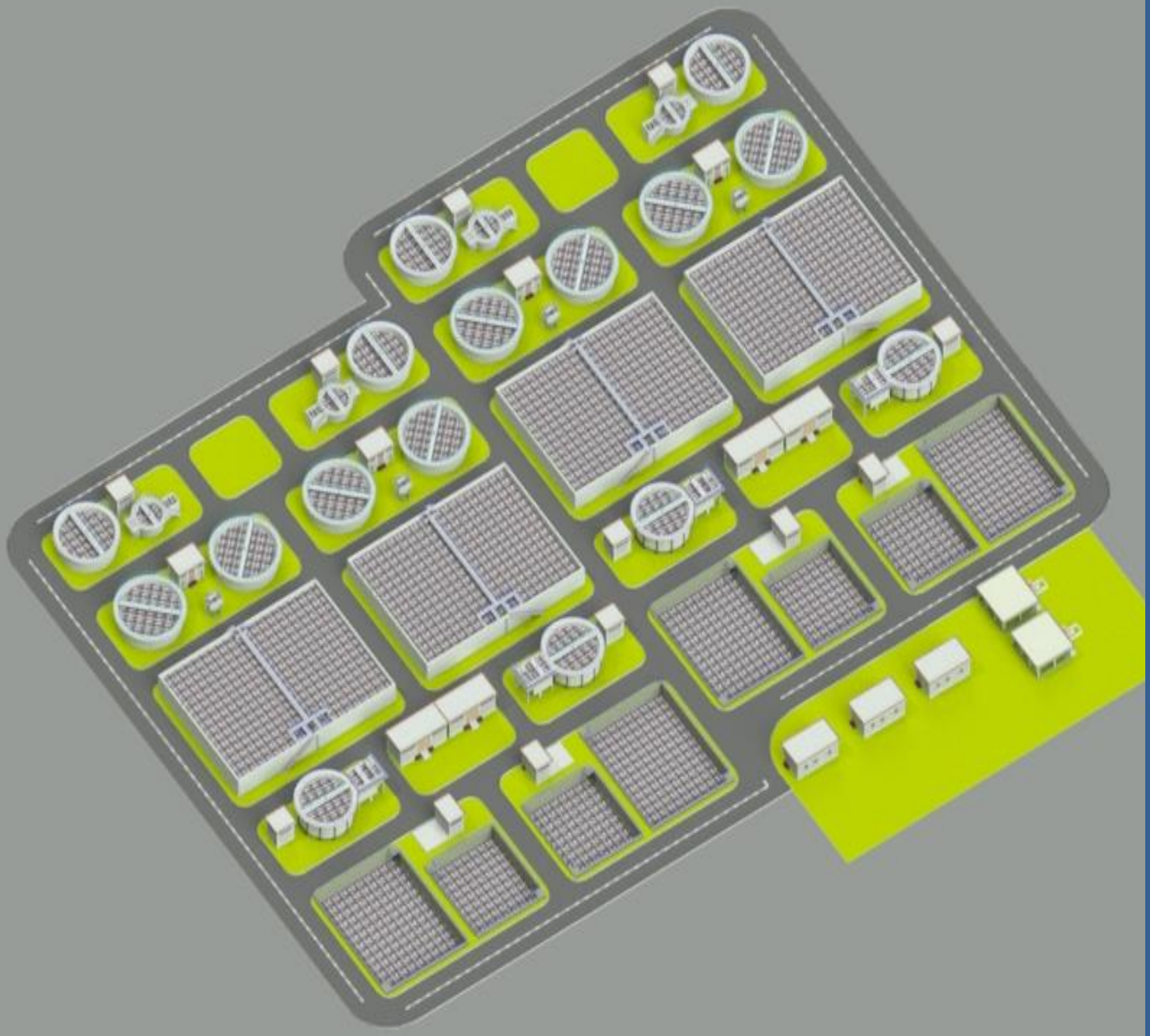
UNIDO

Project: "Mainstreaming Climate Change Adaptation through Water Resource Management in Leather Industrial Zone Development"
(GEF ID 5666; SAP ID 150052)

"Common Effluent Treatment Plant for Sialkot Tannery Zone"

22 FEBRUARY, 2019

APPENDIX 1 - ANNEX H - Tender Document – Electrical



Project:

"Mainstreaming Climate Change Adaptation through Water Resource Management in Leather Industrial Zone Development"
(GEF ID 5666; SAP ID 150052)

Common Effluent Treatment Plant

For
Sialkot Tannery Zone

Tender Document (Electrical)

October 01, 2018

A project of:
United Nations Industrial Development Organization (UNIDO)

CONTENTS

ELECTRICAL BUILDING-1

S. No.	Ref. Spec.	Item Description	UNIT	QTY	UNIT RATE		Amount
					Figures	Words	
1	**16**	**E. ELECTRICAL WORKS**					
1.1		Following items of works (unless specifically stated otherwise) required for proper completion of each item as per specifications (Section-16 "General Provision for Electrical Works" shall be applicable to all BOQ items).					
2	**16.1, 16.13**	**LOW VOLTAGE DIESEL GENERATOR (DG) SET**					
2.1		Following are the Low Voltage Diesel generator Sets.					
		a) 1000 kW	Nos.	2			
		b) Spare parts for 1000 kW Low voltage D.G. Set as per standard requirement.	Lot	2			
						Sub-Total	
3	**16.4,16.9, 16.13**	**L.T SWITCHBOARD**					
3.1		Following are the L.V Switchboard.					
		a) SB-1 including 360 kVAR automatic cum manual PFI plant (7 stages).	Job	1			
		b) ESB-0	Job	1			
						Sub-Total	
4	**16.6, 16.13**	**MOTOR CONTROL CENTERS**					
4.1		Following are the MCC-Panels.					
		a) MCC-Panel-1	Job	1			
						Sub-Total	
5		**CONTROL PANELS**					
5.1		Following are the equipment for SCADA Control Panel.					
		a) Power Supply	Nos	2			
		b) PLC	Nos	1			

S. No.	Ref. Spec.	Item Description	UNIT	QTY	UNIT RATE		Amount
					Figures	Words	
		c) Backplane 1	Nos	2			
		d) Backplane Expander	Nos	2			
		e) Backplane Expander Cable (1 m)	Nos	1			
		f) Empty Module	Nos	5			
		g) Terminal Strip 40 Points	Nos	22			
		h) Communication Module	Nos	1			
		i) Discrete input Module	Nos	11			
		j) Analoge input Module	Nos	4			
		k) Discrete output Module	Nos	6			
		l) Analoge output Module	Nos	1			
		m) EGX-100 GATEWAY	Nos	4			
		n) Power Supply	Nos	4			
		o) Ethernet Switch(Ethernet Managed Switch 6TX/2FX Multi-mode)	Nos	1			
		p) Ethernet Switch(Ethernet Managed Switch 2TX/2FX Multi-mode)	Nos	1			
		q) Patch Panel	Nos	2			
		r) Patch cord	Nos	8			
		s) Relays	Nos	192			
		t) PC Vue(single station) with SQL Server ad Dream Repor	Nos	1			
		u) SQL Server	Nos	1			
5.2		Battery backup Panels.	Job	1			
						Sub-Total	
						Total Carried to Summary	

Component List of P.F

Project: Sialkot Power Factor

S #	DESCRIPTION	RATING	MANUFAC.	PCS
1	**PFIP - 1 (250KVAr)**			
1.1	**P.F Correction Auto / Manual Step**			
	LBS	630A	Socomec	1
	Current Transformer	1200/5A	DEIF/ Dixsen	1
	PFI Relay	6 Stages	Nokian / Schneider	1
	PF Capacitor	25KVAR	Schneider Electric	2
	Magnetic Contactor TP	65A	Schneider Electric	2
	HRC Fuse Disconector	63A	ELCO	2
	PF Capacitor	50KVAR,	Schneider Electric	4
	Magnetic Contactor TP	95A	Schneider Electric	4
	HRC Fuse Disconector	125A	ELCO	4
	Push Button	On/Off	Camsco / Emas	12
	On / Off Indication Lights	RG	Camsco / Emas	12
	Control Fuse With Base	2/32A	ELCO	4
	Control Relay With Base	14pin	Finder/ Phenix	3
	HOA	CA10 A710	K & N / Schneider	1
	Temperature Regulator		Leipold	1
	Exhaust Fan		Leipold	1

VFD for MCC Panel

Project: Sialkot VFD

S #	DESCRIPTION	APPLICATION	BRAND	QUANTITY
1	260KW VFD	For Blower	SCHNEIDER	03
2	37KW VFD	For Ejector	SCHNEIDER	02
3	30KW VFD	For Pump	SCHNEIDER	02
4	11KW VFD	For Pump	SCHNEIDER	04

Component List MCC Panel

Project: Sialkot

S #	DESCRIPTION	RATING	MANUFAC.	PCS
1	**MCC PANEL**			
1.1	**INCOMING**			
	ACB TP	2000A,65KA	Schneider Electric	2
	Motor	230VAC	Schneider Electric	2
	UVT	230VAC	Schneider Electric	2
	Shunt Opening	230VAC	Schneider Electric	2
	Shunt Closing	230VAC	Schneider Electric	2
	Analyzer	LCD	DEIF	2
	C.T	2000/5A	DEIF	6
	Phase Indication Lights	RYB	Schneider Electric	6
	SP MCB	2A	Schneider Electric	6
1.2	**OUTGOING**			
	SP MCB	10A	Schneider Electric	15
1.3	**3.7 KW DOL C # 1**	**Qty. 2Nos.**		
	MPCB	6 TO 10A	Schneider Electric	2
	Aux Contact		Schneider Electric	2
	Magnetic Contactor	4KW	Schneider Electric	2
	H.O.A		Schneider Electric	2
	On Trip Indication Lights		Schneider Electric	4
	Push Button	On/Off	Schneider Electric	4
	SP MCB	2A	Schneider Electric	2
	Line up Terminal		Onka	10
1.4	**4 KW DOL C # 2**	**Qty. 2Nos.**		
	MPCB	6 TO 10A	Schneider Electric	2
	Aux Contact		Schneider Electric	2
	Magnetic Contactor	4KW	Schneider Electric	2
	H.O.A		Schneider Electric	2
	On Trip Indication Lights		Schneider Electric	4
	Push Button	On/Off	Schneider Electric	4
	SP MCB	2A	Schneider Electric	2
	Line up Terminal		Onka	10
1.5	**0.75KW DOL C # 3,4,5 & 6**	**Qty. 10Nos.**		
	MPCB	1 TO 1.6A	Schneider Electric	10
	Aux Contact		Schneider Electric	10
	Magnetic Contactor	4KW	Schneider Electric	10
	H.O.A		Schneider Electric	10
	On Trip Indication Lights		Schneider Electric	20
	Push Button	On/Off	Schneider Electric	20
	SP MCB	2A	Schneider Electric	10
	Line up Terminal		Onka	50

S #	DESCRIPTION	RATING	MANUFAC.	PCS
1.6	**1.65KW DOL C # 7 & 8**	**Qty. 4Nos.**		
	MPCB	2.5 TO 4A	Schneider Electric	4
	Aux Contact		Schneider Electric	4
	Magnetic Contactor	4KW	Schneider Electric	4
	H.O.A		Schneider Electric	4
	On Trip Indication Lights		Schneider Electric	8
	Push Button	On/Off	Schneider Electric	8
	SP MCB	2A	Schneider Electric	4
	Line up Terminal		Onka	20
1.7	**0.18KW DOL C # 9**	**Qty. 2Nos.**		
	MPCB	1 TO 1.6A	Schneider Electric	2
	Aux Contact		Schneider Electric	2
	Magnetic Contactor	4KW	Schneider Electric	2
	H.O.A		Schneider Electric	2
	On Trip Indication Lights		Schneider Electric	4
	Push Button	On/Off	Schneider Electric	4
	SP MCB	2A	Schneider Electric	2
	Line up Terminal		Onka	10
1.8	**0.37KW DOL C # 10**	**Qty. 2Nos.**		
	MPCB	1 TO 1.6A	Schneider Electric	2
	Aux Contact		Schneider Electric	2
	Magnetic Contactor	4KW	Schneider Electric	2
	H.O.A		Schneider Electric	2
	On Trip Indication Lights		Schneider Electric	4
	Push Button	On/Off	Schneider Electric	4
	SP MCB	2A	Schneider Electric	2
	Line up Terminal		Onka	10
1.9	**37KW DOL VFD C # 11**	**Qty. 2Nos.**		
	MCCB TP	100A, 15KA	Schneider Electric	2
	VFD	30KW	Client Provided	2
1.10	**2.5KW DOL C # 12**	**Qty. 5Nos.**		
	MPCB	4 TO 6A	Schneider Electric	5
	Aux Contact		Schneider Electric	5
	Magnetic Contactor	4KW	Schneider Electric	5
	H.O.A		Schneider Electric	5
	On Trip Indication Lights		Schneider Electric	10
	Push Button	On/Off	Schneider Electric	10
	SP MCB	2A	Schneider Electric	5
	Line up Terminal		Onka	25
1.11	**0.18KW DOL C # 13**	**Qty. 1Nos.**		
	MPCB	1 TO 1.6A	Schneider Electric	1
	Aux Contact		Schneider Electric	1
	Magnetic Contactor	4KW	Schneider Electric	1
	H.O.A		Schneider Electric	1
	On Trip Indication Lights		Schneider Electric	2

S #	DESCRIPTION	RATING	MANUFAC.	PCS
	Push Button	On/Off	Schneider Electric	2
	SP MCB	2A	Schneider Electric	1
	Line up Terminal		Onka	5
1.12	**1.5KW DOL C # 14**	**Qty. 1Nos.**		
	MPCB	2.5 TO 4A	Schneider Electric	1
	Aux Contact		Schneider Electric	1
	Magnetic Contactor	4KW	Schneider Electric	1
	H.O.A		Schneider Electric	1
	On Trip Indication Lights		Schneider Electric	2
	Push Button	On/Off	Schneider Electric	2
	SP MCB	2A	Schneider Electric	1
	Line up Terminal		Onka	5
1.13	**3KW DOL C # 15**	**Qty. 2Nos.**		
	MPCB	6 TO 10A	Schneider Electric	2
	Aux Contact		Schneider Electric	2
	Magnetic Contactor	4KW	Schneider Electric	2
	H.O.A		Schneider Electric	2
	On Trip Indication Lights		Schneider Electric	4
	Push Button	On/Off	Schneider Electric	4
	SP MCB	2A	Schneider Electric	2
	Line up Terminal		Onka	10
1.14	**1.5KW DOL C # 16**	**Qty. 1Nos.**		
	MPCB	2.5 TO 4A	Schneider Electric	1
	Aux Contact		Schneider Electric	1
	Magnetic Contactor	4KW	Schneider Electric	1
	H.O.A		Schneider Electric	1
	On Trip Indication Lights		Schneider Electric	2
	Push Button	On/Off	Schneider Electric	2
	SP MCB	2A	Schneider Electric	1
	Line up Terminal		Onka	5
1.15	**0.25KW DOL C # 17 & 18**	**Qty. 3Nos.**		
	MPCB	1 TO 1.6A	Schneider Electric	3
	Aux Contact		Schneider Electric	3
	Magnetic Contactor	4KW	Schneider Electric	3
	H.O.A		Schneider Electric	3
	On Trip Indication Lights		Schneider Electric	6
	Push Button	On/Off	Schneider Electric	6
	SP MCB	2A	Schneider Electric	3
	Line up Terminal		Onka	15
1.16	**0.37KW DOL C # 19**	**Qty. 1Nos.**		
	MPCB	1 TO 1.6A	Schneider Electric	1
	Aux Contact		Schneider Electric	1
	Magnetic Contactor	4KW	Schneider Electric	1
	H.O.A		Schneider Electric	1
	On Trip Indication Lights		Schneider Electric	2

S #	DESCRIPTION	RATING	MANUFAC.	PCS
	Push Button	On/Off	Schneider Electric	2
	SP MCB	2A	Schneider Electric	1
	Line up Terminal		Onka	5
1.17	**30KW VFD C # 20**	**Qty. 2Nos.**		
	MCCB TP	100A, 15KA	Schneider Electric	2
	VFD	30KW	Client Provided	2
1.18	**245KW VFD C # 21**	**Qty. 3Nos.**		
	MCCB TP	630A, 50KA	Schneider Electric	3
	VFD	245KW	Client Provided	3
1.19	**4 KW DOL C # 22**	**Qty. 2Nos.**		
	MPCB	6 TO 10A	Schneider Electric	2
	Aux Contact		Schneider Electric	2
	Magnetic Contactor	4KW	Schneider Electric	2
	H.O.A		Schneider Electric	2
	On Trip Indication Lights		Schneider Electric	4
	Push Button	On/Off	Schneider Electric	4
	SP MCB	2A	Schneider Electric	2
	Line up Terminal		Onka	10
1.20	**9.3KW VFD C # 23**	**Qty. 4Nos.**		
	MCCB TP	40A, 15KA	Schneider Electric	4
	VFD	9.3KW	Client Provided	4
1.21	**3KW DOL C # 24**	**Qty. 2Nos.**		
	MPCB	6 TO 10A	Schneider Electric	2
	Aux Contact		Schneider Electric	2
	Magnetic Contactor	4KW	Schneider Electric	2
	H.O.A		Schneider Electric	2
	On Trip Indication Lights		Schneider Electric	4
	Push Button	On/Off	Schneider Electric	4
	SP MCB	2A	Schneider Electric	2
	Line up Terminal		Onka	10
1.22	**2.2KW DOL C # 25**	**Qty. 2Nos.**		
	MPCB	4 TO 6A	Schneider Electric	2
	Aux Contact		Schneider Electric	2
	Magnetic Contactor	4KW	Schneider Electric	2
	H.O.A		Schneider Electric	2
	On Trip Indication Lights		Schneider Electric	10
	Push Button	On/Off	Schneider Electric	10
	SP MCB	2A	Schneider Electric	2
	Line up Terminal		Onka	10
1.23	**0.026KW DOL C # 26 & 34**	**Qty. 19Nos.**		
	MCB DP	6A	Schneider Electric	19
	Aux Contact		Schneider Electric	19
	Magnetic Contactor	4KW	Schneider Electric	19
	H.O.A		Schneider Electric	19

S #	DESCRIPTION	RATING	MANUFAC.	PCS
	On Trip Indication Lights		Schneider Electric	38
	Push Button	On/Off	Schneider Electric	38
	SP MCB	2A	Schneider Electric	19
	Line up Terminal		Onka	95

SPECIFICATIONS: TECHNICAL PROVISIONS

SECTION 16: FUNCTIONAL DESCRIPTION (ELECTRICAL)

1. INTRODUCTION

This document briefly describes the operation and control of the Combined Effluent Treatment Plant of Sialkot Tanneries Zone (STZ).

1.1 Screen Chambers (SC)

The two wastewater streams, beam-house and tanning, shall enter into the two separate dedicated screen chambers provided at the inlet to the Plant, for removing the coarse material from the influent. There shall be two screen channels, each, out of which one shall be operational and other shall be standby. Each screen channel comprises of a mechanical screen. At upstream side of screen a level switch shall be installed which shall activate an optic and sound alarm if the wastewater builds up to an already specified level before the screens.

The mechanical screen is driven by an electric motor and its operation shall be controlled by the plant operator with the help of an on-off selector switch which is located on the front side of MCC and also with the help of selector switches icon in the SCADA based system.

1.2 Vortex Grit Chambers (GC01 – GC02)

Two grit chambers (1 duty + 1 standby) are provided. In grit chamber, mixture of water and sand is kept in continuous rotation by the force of water itself and by continuous rotation of special blades installed on machine. The particular motion, due to mechanical action of blades, creates secondary transversal currents that, overlapping to the main current of wastewater, help concentration and selection of sand in the bottom conical part of tank. Sand settled in the bottom, is sucked by Airlift, while instead the clarified water exits from the discharge channel.

1.3 Airlift Pump (AP01/01 – AP01/02)

An Airlift pump with every grit chamber is installed for the withdrawal of grit accumulated. It shall transport the grit collected from the bottom to the top of the grit chamber platform for removal.

The operation of this pump shall be continuous and shall be controlled by the plant operator with the help of an on-off selector switch which is located on the front side of MCC and also with the help of selector switches icon in the SCADA based system.

1.4 Oil Separator (OGS01 – OGS02)

Two oil separators (1 duty + 1 standby) are provided after grit removal. Device is equipped with a thermostat on automatic models to operate in cold conditions for preventing oil to be frozen. Inner oil container is equipped with a level switch. When the excess oil level is high, the operator is warned by the control board with sound and lights.

1.5 Equalization Tanks (EQ01 & EQ02)

After oil removal, beam house and tanning wastewater streams shall flow under gravity and accumulate in their respected equalization tanks. The purpose of equalization tank is to homogenize the wastewater flows and pollutants'

concentration, as it will avoid shock loading to the subsequent units and also provide mixing and agitation. The main purpose of beam-house equalization tank, beside homogenization, is the sulphide oxidation aided by catalyst.

1.6 Jet Aerators (JA01/01 – JA01/02 & JA02/01 – JA02/02)

Each equalization tank is equipped with two (02) submersible self-aspirating jet aerators to provide air for sulphide oxidation and suspension of solids.

The operation of jet aerators shall be continuous and shall be controlled by the plant operator with the help of an on-off selector switch which is located at the front side of MCC and also with the help of selector switches icon in the SCADA based system.

1.7 Wastewater Pumping Station (WPS)

There shall be four (04) level switches installed in each equalization tank which shall control the operation of wastewater pumps. Also in the dry well level switches will be installed to control the operation of two bilge pumps for the removal of any water accumulated because of leakage, rain or any other reason.

1.8 Wastewater Pumps (WSP01/01 – WSP01/02 & WSP02/01 – WSP02/02)

a. These wastewater pumps are dry mounted and located inside the pump room as two sets of two (1 duty + 1 standby) each. They are installed to convey the wastewater from the EQs to the Rapid Mixing Tank 01 (Coagulation Tank).

b. These pumps can operate in two modes i.e. automatic and manual with different controls. Mode selection can be done with the help of selector switch icons (M-O-A) provided for each pump in the SCADA based system. This Mode selection can also be done with the help of selector switch (M-O-A) which is located at the front side of MCC.

c. In manual mode, the standby selection can be done with the help of a spare selector switch icon in the SCADA based system. This selection can also be done with the help of a spare selector switch which is located at the front side of MCC.

d. In automatic mode, standby selection must be done automatically ensuring that each pump operates for the equal amount of time in a cycle of certain time period. Any operating pump in need of repair may be spared by replacing with standby pump which shall be controlled by the same parameters defined for the spared pump.

e. In each EQ, there are four (04) levels marked, namely; one HH (High-High), one H (High), one L (Low) and one LL (Low-Low), for wastewater pumps. At each level, a level switch is installed. Each operating pump shall be controlled by a pair of H and L level switches. At H level the pump starts and at L level it stops. At HH level an optic and sound alarm is activated and the pumps continue their operation, whereas, at LL level not only an optic and sound alarms are activated but also the operation of pumps is stopped.

f. The control of pumps through level switches shall be provided in automatic mode only.

1.9 Rapid Mixing Tank 01 (RP01) (Coagulation Tank)

a. Both wastewater streams are pumped to mixing tank, where they get mixed and move towards Rapid-mix Tank for coagulant chemical mixing. In RP01, mixing of wastewater with chemical is provided with the help of flash mixer.

b. The operation of the mixer shall be continuous and shall be controlled by the plant operator with the help of an on-off selector switch which is located on the front side of MCC and also with the help of selector switches icon in the SCADA based system.

1.10 Flocculation Tank (FT)

a. Wastewater after coagulant mixing enters into flocculation tank for flocculation of the solids. In FT, mixing is provided to bring about the formation of flocs and to mix wastewater with polymer with the help of Paddle Mixer.

b. The operation of the mixer shall be continuous and shall be controlled by the plant operator with the help of an on-off selector switch which is located on the front side of MCC and also with the help of selector switches icon in the SCADA based system.

1.11 Primary Sedimentation Tank (PST)

Wastewater after FT shall be fed into the primary sedimentation tank. In the PST, mixed liquor is allowed to settle under dormant condition. The settled sludge is then removed from the bottom with the help of sludge scraper installed in the tank. The clarified water flows to the distribution box 01 of biological reactors.

1.12 Sludge Scraper (PSCR01/01)

The operation of this scraper shall be continuous and shall be controlled by the plant operator with the help of an on-off selector switch which is located at the front side of MCC and also with the help of selector switches icon in the SCADA based system.

The scraper motor shall be protected by means of a torque switch. It shall automatically stop the scraper motor upon the detection of overloading and an optic and sound alarm shall also be activated.

1.13 Primary Sludge Pumping Station (PSPS)

a. There are two (02) primary sludge pumps (1 duty + 1 standby), mounted dry in PSPS, to pump the sludge from PST to sludge thickener.

b. Each pump shall be protected by means of a high pressure switch and a dry sensor. On activation of any of these devices, an alarm shall be generated and the pumps shall be stopped.

c. These pumps can operate in two modes i.e. automatic and manual with different controls. Mode selection can be done with the help of selector switch icons (M-O-A) provided for each pump in the SCADA based system. This Mode selection can also be done with the help of selector switch (M-O-A) which is located on the front side of MCC.

d. In manual mode, the standby selection can be done with the help of a spare selector switch icon in the SCADA based system. This selection can also be done with the help of a spare selector switch which is located on the front side of MCC.

e. In automatic mode, standby selection must be done automatically ensuring that each pump operates for the equal amount of time in a cycle of certain time period. The operating pump needing to be spared shall be replaced by the standby pump which shall be controlled by the same parameters defined for the spared pump

1.14 Pre-selectors (PS01 – PS02)

Wastewater from distribution Box 01 shall be evenly distributed into two pre-selectors. In pre-selectors, agitation of wastewater is provided to thoroughly mix the contents and to keep the solids from settling, with the help of agitators.

The operation of these agitators shall be continuous and shall be controlled by the plant operator with the help of an on-off selector switch which is located on the front side of MCC and also with the help of selector switches icon in the SCADA based system.

1.15 Aeration Tanks (AT01 – AT02)

a. Wastewater from pre selectors shall flow into the aeration tanks where the biological treatment of wastewater is facilitated by introducing air into it. The prime purpose of aeration is to supply the required amount of oxygen to the metabolizing microorganisms, and secondly, to provide mixing, so that the microorganisms may come into intimate contact with the dissolved and suspended organic matter.

b. A DO meter shall be installed in each aeration tank and shall control the operation of its respective blower. It stops the blower when the DO meter reading reaches a certain higher value and starts it when DO meter reaches a specified minimum reading.

c. The DO meter control shall be provided in automatic mode only.

1.16 Blowers

a. These blowers are meant to supply air to the aeration tanks.

b. There are three blowers (2 duty + 1 standby) installed in blower room.

c. These blowers can operate in two modes i.e. automatic and manual with different controls. Mode selection can be done with the help of selector switch icons (M-O-A) provided for each blower in the SCADA based system. This Mode selection can also be done with the help of selector switch (M-O-A) which is located at the front side of MCC.

d. In manual mode, the standby selection can be done with the help of a spare selector switch icon in the SCADA based system. This selection can also be done with the help of a spare selector switch which is located at the front side of MCC.

e. In automatic mode, standby selection must be done automatically ensuring that each blower operates for the equal amount of time in a cycle of certain time period. Any operating blower needing to be spared shall be replaced by the standby blower which shall be controlled by the same parameters defined for the spared blower.

1.17 Recirculation Pumps

There shall be one dry mounted recirculation pump for each aeration tank.

The operation of these pumps shall be continuous and shall be controlled by the plant operator with the help of an on-off selector switch which is located on the front side of MCC-2 and also with the help of selector switches icon in the SCADA based system.

1.18 Secondary Sedimentation Tanks (SST01 - SST02)

Wastewater from the aeration tanks shall be divided into two secondary sedimentation tanks through Distribution Box 02.

In the sedimentation tanks, mixed liquor is allowed to settle under dormant condition. The settled sludge is then removed from the bottom with the help of sludge scraper installed in each tank.

1.19 Sludge Scraper (SSCR02/01 - SSCR02/02)

The operation of this scraper shall be continuous and shall be controlled by the plant operator with the help of an on-off selector switch which is located at the front side of MCC and also with the help of selector switches icon in the SCADA based system.

The scraper motor shall be protected by means of a torque switch. It shall automatically stop the scraper motor upon the detection of overloading and an optic and sound alarm shall also be activated.

1.20 Secondary Sludge Pumping Station (SSPS)

Four (04) dry mounted sludge recirculation pumps are located in the secondary sludge pumping station.

1.21 Sludge Recirculation Pumps (SSP01/01 – SSP01/04)

a. There are two sets of sludge recirculation pumps with (1 duty + 1 standby) each, to pump the sludge from secondary sedimentation tanks to distribution box 1. Each set is dedicated to one SST.

b. Each pump shall be protected by means of a high pressure switch and a dry sensor. On activation of any of these devices, an alarm shall be generated and the pumps shall be stopped.

c. These pumps can operate in two modes i.e. automatic and manual with different controls. Mode selection can be done with the help of selector switch icons (M-O-A) provided for each pump in the SCADA based system. This Mode selection can also be done with the help of selector switch (M-O-A) which is located on the front side of MCC.

d. In manual mode, the standby selection can be done with the help of a spare selector switch icon in the SCADA based system. This selection can also be done with the help of a spare selector switch which is located on the front side of MCC.

e. In automatic mode, standby selection must be done automatically ensuring that each pump operates for the equal amount of time in a cycle of certain time period. Any operating pump needing to be spared shall be replaced by the standby pump which shall be controlled by the same parameters defined for the spared pump.

1.22 Rapid Mixing Tank 02 (RP02) (Chemical Oxidation Tank)

a. The secondary effluent enters into RMT02, where it gets mixed with oxidation chemical. In RMT02, mixing of wastewater with chemical is provided with the help of flash mixer.

b. The operation of the mixer shall be continuous and shall be controlled by the plant operator with the help of an on-off selector switch which is located on the front side of MCC and also with the help of selector switches icon in the SCADA based system.

1.23 Chemical Oxidation Tank (COT)

Wastewater after RMT02 flows into the Chemical Oxidation Tank where chemical is dosed in it. For proper mixing of the chemical, a mixer is installed in the tank.

The operation of these agitators shall be continuous and shall be controlled by the plant operator with the help of an on-off selector switch which is located on the front side of MCC and also with the help of selector switches icon in the SCADA based system.

1.24 Thickened Sludge Pumping Station (TSPS)

Two (02) dry mounted thickened sludge feed pumps (1 duty + 1 standby) are located in the TSPS.

1.25 Thickened Sludge Feed Pumps (TSP01/01 - TSP01/02)

a. These pumps shall be used to pump the sludge from the combined sludge thickener to the sludge belt press.

b. Each pump shall be protected by means of a high pressure switch and a dry sensor. On activation of any of these devices, an alarm shall be generated and the pumps shall be stopped.

c. These pumps can operate in two modes i.e. automatic or manual with different controls. Mode selection can be done with the help of selector switch icons (M-O-A) provided for each pump in the SCADA based system. This Mode selection can also be done with the help of selector switch (M-O-A) which is located on the front side of MCC.

d. In manual mode, the standby selection can be done with the help of a spare selector switch icon in the SCADA based system. This selection can also be

done with the help of a spare selector switch which is located on the front side of MCC.

e. In automatic mode, standby selection must be done automatically ensuring that each pump operates for the equal amount of time in a cycle of certain time period. Any operating pump needing to be spared shall be replaced by the standby pump which shall be controlled by the same parameters defined for the spared pump.

1.26 Sludge Belt Filter Press (SP01/01 – SFP01/02)

Sludge Belt Press shall be used to dewater the sludge. The filtrate shall be made to flow into any of the EQs and the Dried Sludge from the press shall be transported and disposed to the designated landfill.

There are two (02) sludge belt press (1 duty + 1 standby) provided in sludge dewatering shed. The SFP shall be in operation only when the thickened sludge feed pump is in operation. The operation belt press shall be controlled by the plant operator with the help of an on-off selector switch which is located on the front side of MCC and also with the help of selector switches icon in the SCADA based system.

1.27 Bilge Pumps (SBP01/01 – SBP01/08)

a. In each wastewater and sludge pumping station, two submersible bilge pumps (1 + 1 standby) are installed to discharge the water accumulated due to any leakages, rain etc.

b. These pumps can operate in two modes i.e. automatic or manual with different controls. Mode selection can be done with the help of selector switch icons (M-O-A) provided for each pump in the SCADA based system. This Modes selection can also be done with the help of selector switch (M-O-A) which is located at the front side of MCC.

c. In each bilge pit, there are four levels marked, namely; HH (High-High), H (High), L (Low) and LL (Low-Low). At each level, a level switch is installed. At H level the bilge pump starts and it stops when the water level falls below L level. At HH level, the pump continues its operation and an optic and sound alarm is activated to indicate that water level has risen above the tolerated level. At LL level the pump shall be stopped and an optic and sound alarm shall also be activated.

d. The pumps shall be controlled through level switches in automatic mode only.

1.28 Chemical Containers (CC01 – CC09)

Eight (08) chemical containers are used for storing $MnSO_4$, Alum, A-Ploymer, HCl, NaOH, $FeCl_3$ and H_2O_2, Polyelectrolyte.

1.29 Agitators for CC (AG05/01 – AG05/08)

There shall be an agitator for each chemical container in order to keep the chemical in properly mixed condition.

The operation of these agitators shall be continuous and shall be controlled by the plant operator with the help of an on-off selector switch which is located on the front

side of the appropriate MCC and also with the help of selector switches icon in the SCADA based system.

1.30 Dosing Pump (DP01/01 – DP01/02)

a. This pump is used for dosing $MnSO_4$ into the equalization tank 01.

b. These dosing pumps shall be one duty and one standby.

c. The dosing pump must stop, if all the wastewater pumps are not in operation.

d. These pumps can operate in two modes i.e. automatic or manual with different controls. Mode selection can be done with the help of selector switch icons (M-O-A) provided for each pump in the SCADA based system. This Mode selection can also be done with the help of selector switch (M-O-A) which is located on the front side of MCC.

e. Only in the automatic mode, level switch (located in CC01) control is provided. The level switch is provided at LL (Low-Low) level in the $MnSO_4$ dosing tank. Above this level, the pump starts and below this level the pump stops and an optic and sound alarm are activated. The operation of this pump can also be controlled manually.

1.31 Dosing Pump (DP02/01 - DP02/02)

a. This pump is used for dosing Alum into the RMT01.

b. These dosing pumps shall be one duty and one standby.

c. The dosing pump must stop, if all the wastewater pumps are not in operation.

d. These pumps can operate in two modes i.e. automatic or manual with different controls. Mode selection can be done with the help of selector switch icons (M-O-A) provided for each pump in the SCADA based system. This Mode selection can also be done with the help of selector switch (M-O-A) which is located on the front side of MCC.

e. Only in the automatic mode, level switch (located in CC03) control is provided. The level switch is provided at LL (Low-Low) level in the Alum dosing tank. Above this level, the pump starts and below this level the pump stops and an optic and sound alarm are activated. The operation of this pump can also be controlled manually.

1.32 Dosing Pump (DP03/01 - DP03/02)

a. This pump is used for dosing A-Polymer into the FT.

b. These dosing pumps shall be one duty and one standby.

c. The dosing pump must stop, if all the wastewater pumps are not in operation.

d. These pumps can operate in two modes i.e. automatic or manual with different controls. Mode selection can be done with the help of selector switch icons (M-O-A) provided for each pump in the SCADA based system. This Mode selection can

also be done with the help of selector switch (M-O-A) which is located on the front side of MCC.

e. Only in the automatic mode, level switch (located in CC04) control is provided. The level switch is provided at LL (Low-Low) level in the Alum dosing tank. Above this level, the pump starts and below this level the pump stops and an optic and sound alarm are activated. The operation of this pump can also be controlled manually.

1.33 Dosing Pump (DP04/01 – DP04/04)

a. There are two sets of HCl dosing pumps each having two (1 duty + 1 standby).
b. One set is used for neutralization of equalization tank effluent before coagulation/flocculation.

c. Other set of pumps is used for dosing HCl into COT.

d. These dosing pumps shall be one duty and one standby.

e. The dosing pump must stop, if all the wastewater pumps are not in operation.

f. These pumps can operate in two modes i.e. automatic or manual with different controls. Mode selection can be done with the help of selector switch icons (M-O-A) provided for each pump in the SCADA based system. This Mode selection can also be done with the help of selector switch (M-O-A) which is located on the front side of MCC.

g. Only in the automatic mode, level switch (located in CC02 & CC05) control is provided. The level switch is provided at LL (Low-Low) level in the Alum dosing tank. Above this level, the pump starts and below this level the pump stops and an optic and sound alarm are activated. The operation of this pump can also be controlled manually.

1.34 Dosing Pump (DP05/01 - DP05/02)

a. This pump is used for dosing $FeCl_3$ into COT.

b. These dosing pumps shall be one duty and one standby.

c. The dosing pump must stop, if all the wastewater pumps are not in operation.

d. These pumps can operate in two modes i.e. automatic or manual with different controls. Mode selection can be done with the help of selector switch icons (M-O-A) provided for each pump in the SCADA based system. This Mode selection can also be done with the help of selector switch (M-O-A) which is located on the front side of MCC.

e. Only in the automatic mode, level switch (located in CC06) control is provided. The level switch is provided at LL (Low-Low) level in the Alum dosing tank. Above this level, the pump starts and below this level the pump stops and an optic and sound alarm are activated. The operation of this pump can also be controlled manually.

1.35 Dosing Pump (DP06/01 - DP06/02)

a. This pump is used for dosing H_2O_2 into COT.

b. These dosing pumps shall be one duty and one standby.

c. The dosing pump must stop, if all the wastewater pumps are not in operation.

d. These pumps can operate in two modes i.e. automatic or manual with different controls. Mode selection can be done with the help of selector switch icons (M-O-A) provided for each pump in the SCADA based system. This Mode selection can also be done with the help of selector switch (M-O-A) which is located on the front side of MCC.

e. Only in the automatic mode, level switch (located in CC07) control is provided. The level switch is provided at LL (Low-Low) level in the Alum dosing tank. Above this level, the pump starts and below this level the pump stops and an optic and sound alarm are activated. The operation of this pump can also be controlled manually.

1.36 Dosing Pump (DP07/01 - DP07/02)

a. This pump is used for dosing NaOH into neutralization chamber.

b. These dosing pumps shall be one duty and one standby.

c. The dosing pump must stop, if all the wastewater pumps are not in operation.

d. These pumps can operate in two modes i.e. automatic or manual with different controls. Mode selection can be done with the help of selector switch icons (M-O-A) provided for each pump in the SCADA based system. This Mode selection can also be done with the help of selector switch (M-O-A) which is located on the front side of MCC.

e. Only in the automatic mode, level switch (located in CC08) control is provided. The level switch is provided at LL (Low-Low) level in the Alum dosing tank. Above this level, the pump starts and below this level the pump stops and an optic and sound alarm are activated. The operation of this pump can also be controlled manually.

1.37 Dosing Pump (DP08/01 - DP08/02)

a. This pump is used for dosing Polyelectrolyte inline into sludge filter press delivery line.

b. These dosing pumps shall be one duty and one standby.

c. The dosing pump must stop, if all the wastewater pumps are not in operation.

d. These pumps can operate in two modes i.e. automatic or manual with different controls. Mode selection can be done with the help of selector switch icons (M-O-A) provided for each pump in the SCADA based system. This Mode selection can also be done with the help of selector switch (M-O-A) which is located on the front side of MCC.

e. Only in the automatic mode, level switch (located in CC09) control is provided. The level switch is provided at LL (Low-Low) level in the Alum dosing tank. Above this level, the pump starts and below this level the pump stops and an optic and sound alarm are activated. The operation of this pump can also be controlled manually.

SECTION – 16.1: LOW VOLTAGE D.G. SET

1.0 SCOPE

The work under this section consists of supplying, installing, testing and commissioning of all material and services of the complete Diesel generator set including auto main failure panel and other equipment, as specified herein, shown on the Tender Drawings and given in the Bill of Quantities.

The Contractor shall discuss the electrical layout with the Engineer and co-ordinate at Site with other services for exact location and position of the electrical equipments, underground storage tanks and routing of cables.

The Diesel generator set, Instrument/Control Panel, auto main failure panel and accessories shall comply with the General Specifications for Electrical Works, Section-16, and other relevant provisions of the Tender Document.

2.0 GENERAL

The Diesel generator set shall be a standard design of reputed manufacturer, who shall have similar units in operations for similar applications and field conditions. The manufacturer shall also have adequate maintenance facilities in the vicinity of Project with technically qualified and experienced personnel trained for operation and on-site maintenance of equipment offered by the Contractor in the tender bid.

The set shall be rated for continuous duty and suitable for indoor installation with protection rating IP23. It shall be capable for unbalance loads up to 30% of actual load and for continuous part load operation. The set shall be capable of starting and operation at the rated output at 45^{o} Centigrade and at an altitude of 50 meters above mean sea level. The ratings must be substantiated with manufacturer's standard published data.

The Diesel Generator set shall, after reducing the power absorbed by the auxiliaries, deliver continuously rated power output under the site conditions. All auxiliaries, accessories and connections between systems along with all necessary cables, fittings, hardware, etc., for complete installation of Diesel Engine, Generator, Control / Instrument Panel, Auto-Main Failure (AMF) Panel, Duty Selection Switch, Fuel and Oil Storage, Batteries, Exhaust System, etc., shall be furnished by the Contractor.

The engine shall be directly coupled to the generator, and shall have a rated speed of 1500 rpm. The set shall be capable of sustaining without damage, 25% over speed under any abnormal operating condition.

The engine-generator set shall be mounted on suitable rigid steel frame skid with vibration isolators. Heavy duty lifting eyes and jacking screws shall be provided on the skid. The foundation bolts and all other material/hardware for complete installation of the set shall be furnished with the set. Any excessive torsional vibration shall be avoided for both engine and alternator.

The set shall be suitable for full load starting. When the generator is operating at no-load, the application of full load current, taking into account the surge due to starting of equipment, should be possible with maximum transient voltage drop of 15% of the rated voltage, and the time taken to restore the generator voltage to 97% of rated value should not exceed 1.5 seconds.

The set shall be capable for parallel operation.

The Contractor shall submit the equipment layout and other installation details as per manufacturer's recommendations for approval of the Engineer at least 60 days prior to the installation of the set.

Necessary provision, including connections and a Local / OFF / Remote control switch shall be made in the Generator Panel of each of the D.G. Set. The cost of such provision, connection, testing and commissioning are deemed to be included in the Cost of D.G. Sets and no separate payment shall be made against such works.

3.0 APPLICABLE STANDARDS/CODES

The Diesel engine and generator shall conform to the following standards as applicable.

BS 5514 - Reciprocating Internal Combustion Engine.

BS 4999 - General Requirements for Rotating Electrical Machines.

BS 5000-99 - Rotating Electrical Machines of particular types or for particular application.

For other equipment and materials related to the Diesel generator set, the Contractor shall follow relevant international standards, details of which shall be submitted to the Engineer for approval.

4.0 MATERIAL

4.1 Diesel Engine

The Diesel Engine shall be four strokes, compression ignition, suitable for continuous duty.

Starting shall be through electric starter motor operated on DC supply from lead acid batteries mounted on the skid. The batteries shall be furnished with the set.

The engine shall be equipped with an alternator type automatic charging system to charge the batteries during running of engine. A static battery charger installed in the control panel shall also be provided to charge the batteries when the engine is not running. Suitable interlocks shall be provided to prevent simultaneous operation of both charging systems.

The batteries shall be adequate to satisfy the following requirements:

a. Crank the engine at firing speed for at least 15 seconds.
b. If the engine does not start on the first attempt, crank the engine two more times for the above duration at an interval of 30 seconds between each cranking operation.

Engine shall be rated for continuous duty with overload capability for operating at least 10% above the rated capacity for 1 hour continuously in any 12 hours operation.

4.1.1 Air Intake

Air intake shall be through turbo charger and equipped with dry type filter. Suitable attenuators shall be installed to reduce noise at the air inlet.

4.1.2 Engine Lubrication

A gear type positive pressure lubrication pump shall be provided with efficient filtration arrangement for the lubrication system. A 230V AC mains operated heater with thermostat shall be provided in the crankcase.

The heater shall be designed for automatic switching to ensure that temperature of oil is maintained for proper operation of the engine.

Engine shall have a constant oil level regulator, gravity fed from an engine mounted lube oil reservoir. Reservoir shall be equipped with an oil level gauge.

A crankcase pressure release valve shall be provided to operate during excess pressure.

4.1.3 Engine Cooling

Engine shall have a forced air draft, water-cooled radiator supplied with a core guard. Cooling system shall have an engine driven centrifugal pump for cooling water circulation. Cooling shall be thermostatically controlled. An engine shut down timer shall be provided to keep the engine running on no-load after any operation of set, so that the engine is sufficiently cooled to start again instantly, if required, without rise in temperature above safe limits.

4.1.4 Exhaust System, Noise, Pollution

Exhaust system shall be equipped with a residential type silencer complete with muffler, exhaust manifold, flexible connector, exhaust elbow, exhaust pipe, rain cap, and associated fittings. The exhaust line shall be taken outside the building through the shortest possible and practical route, without any undue bends. This exhaust line shall be adequately covered with thermal insulation material over its entire length i.e. from the engine to the termination point. All supports for exhaust system shall be furnished.

The sound level in the diesel generator room shall not exceed the values of the noise rating curve NRC 95 to ISO TI 43-1961 standard, measured at 1 m distance from the object but in no case greater than 90 dB (A) under all operating conditions.

The exhaust fumes shall be burnt completely and be free of solid matters before escaping to the air. Special measures shall be adopted to collect solid particles and control pollution in accordance with the recommendations laid down for the airport installations.

4.1.5 Speed Governor

Governor shall regulate engine speed so as to maintain the generator frequency within plus or minus 2% of the rated frequency. Stable engine speed shall be attained within 15 seconds after the engine has been started. Stable engine speed shall be restored within 10 seconds of any sudden change in load, from no load to full load.

During this change of load or surge, the speed shall not vary by more than plus or minus 5% of the rated speed

4.2 Fuel System

Engine of the generator shall operate on commercial high speed Diesel oil. A fuel oil strainer/filter shall be provided in the fuel line. Fuel system for Diesel engine shall be through explosion proof self-priming pump. The fuel system shall comprise:

a. Underground fuel storage tank. (Common for all D.G. Sets)
b. Fuel transfer pump(s). (Separate for each D.G. Set)
c. Fuel piping network. (Separate for each D.G. Set)
d. Fuel day tank. (For each D.G. Set)

4.2.1 Underground Fuel Storage Tank

The underground indoor fuel storage tank shall have the capacity as mentioned in BOQ item or shown on the drawings to store fuel for operation of the set at the rated output. The tank shall have high and low level float switches for monitoring the fuel level in the tank. The high and low level switches shall provide an annunciation while the low level switch shall in addition to above annunciation also prevent starting of set and to stop the set when the fuel in storage tank is at this level. The tank shall be provided with overflow, vent, supply and discharge valves, inspection cover, drain valve and glass sight gauge.

The fuel storage tank shall be of mild steel plates and shall be designed, fabricated and finished in accordance with the requirements of DIN 6608 - Horizontal Steel Tanks for underground storage of Petroleum Products in Liquid Form.

Underground fuel storage tank and supports shall be fabricated in accordance with the specified code and the following:

a. Tank shall be capable to withstand maximum loads encountered during installation and operation for all conditions from empty tank to tank filled to capacity or overflow.
b. Tank shall be in accordance with the relevant BOCA or UBC code requirement for seismic load which ever is more stringent.
c. Tanks shall be capable to withstand safely the forces and moments imposed by connecting piping.
d. The buried tank shall be capable of sustaining lateral backfilling load of equivalent fluid pressure.
e. The tank shall be capable of resisting flotation by providing concrete beams or saddles installed over the top of the tank or by hold-down straps bolted to a concrete foundation pad.
f. The thickness of tank elements shall be increased over the thickness required by code requirements by 2mm for corrosion allowances.
g. The tanks shall be of welded construction in compliance with specified DIN standard and/or section VIII of the ASME code, DIV I.
h. The tanks shall be provided with at least two lifting eyes.
i. A nameplate shall be attached to manhole flange marked in accordance with the requirements of the code, and shall include following information:

    i. Manufacturer's name/mark and year of fabrication,
    ii. Manufacturer's serial number,
    iii. Design gauge pressure,

iv. Test gauge pressure,
v. Design temperature,
vi. Applicable code stamp,
vii. Fluid stored,
viii. Storage capacity,
ix. Tank size.

Welding procedure qualifications, electrodes, preheat, post weld treatment, welder performance tests and submittals shall be in accordance with relevant international codes and standards.

Shell plate joints shall be butt welded with complete penetration and fusion. All joints in the attachments to the shell shall be fully seal welded to prevent rust staining.

Sharp welds and sharp corners shall be ground smooth and blended into the base material. All bottoms of the shell connections shall be flush with the inside of the shell unless otherwise indicated.

The interior surfaces of the tank shall be cleaned of all mill scale, cuttings, weld spatter and other foreign matter and shall receive a commercial sandblast in accordance with SSPC-SP 5.

All openings shall be sealed immediately after the last shell joint is made.

The exterior surfaces of all tank and piping shall be given a protective coating of the epoxy-phenolic-amine type.

All interconnecting steel pipes shall be seamless in accordance with ASTM-A 53 or approved equivalent. Pipefittings shall be butt-welded type according with ASTM-A 53. All underground pipe and fittings shall be buried in accordance with ASTM D 1557. The pipe surface shall be given a protective coating of the epoxy-phenolic-amine type.

Welds shall be inspected in accordance with section VIII of the ASME Code, DIV-I.

Non-destructive examination procedures shall be submitted for approval before they are implemented.

Results of non-destructive inspection shall be submitted prior to installation as per requirement of section VIII, DIV-I of the ASME Code.

Tank shall be hydrostatically shop tested as required by ASME code, section VIII DIV-I, and shall be dried immediately after the test.

Before a hydrostatic test procedure is implemented, it shall be submitted for approval, and shall include the recommended minimum and maximum hydro-test pressure with the corresponding minimum and maximum temperature.

All test results shall be submitted.

4.2.2 Fuel Transfer Pumps

An explosion proof electric self-priming, fuel pump of suitable capacity to fill the fuel day tank from the indoor underground fuel storage tank in 30 minutes or lesser time shall be provided. A manual fuel pump shall also be furnished and connected in

parallel to the electric fuel pump, with a capacity to fill the tank in 2 hours maximum. All interconnected piping, valves, etc., for parallel connection of the two pumps shall be furnished. The electric starter, circuit breaker, wiring, etc., for the electric pump shall be provided along with the Fuel Storage Tank by the Contractor without any extra cost.

4.2.3 Fuel Piping Network

The fuel piping network separate for each D.G. set to be furnished shall include fuel supply pipe from storage tank to day tank in the skid of the D.G. set, over flow pipe from the tank to the set, drain pipe from the tank to a location approved by the Engineer.

The arrangement of pipe work with respect to the location of equipment shall be prepared by the Contractor and submitted to Engineer for approval. A full flow oil filter shall be installed in the fuel supply lines with a by-pass arrangement.

4.2.4 Fuel Day Tank

The engine generator skid mounted fuel day tank for each D.G. Set shall have capacity to store fuel for 8 hours operation of the set at the rated output. The tank shall have level switch for monitoring low fuel level in the tank. The low level switch shall provide an annunciation and prevent starting of set and to stop the set when the fuel in storage tank is at this level. The tank shall be provided with overflow, vent, supply and discharge valves, inspection cover, drain valve and glass sight gauge.

4.3 Generator

Generator shall be synchronous. The generator shall be capable of carrying continuously for 1 hour in every 12 hours, overload equal to 10% of rated output with field set for normal rated load excitation.

4.3.1 Excitation

Excitation shall be from brush less rotating diodes mounted on the main shaft for 3-phase full wave rectification.

4.3.2 Windings

Alternator windings shall have Class-F insulation and shall be impregnated for tropical use. The temperature rise of winding under normal operating conditions and at rated load shall not exceed the limits specified for Class-B insulation. Anti-condensate heaters shall be provided for windings. The heaters shall be thermostatically controlled for switching ON after the set has stopped. The thermostat range shall be adjustable and set to prevent overheating of windings. For protection of windings from damage due to overheating, thermistors shall be embedded to stop the set in case the temperature of winding rises above the safe value.

4.3.3 Voltage Regulation

Voltage regulator shall be solid state with provision for manual setting. Regulator shall be so designed to protect the exciter when the set is running at reduced speed during starting or idling of the prime mover.

Voltage regulation shall be plus or minus 2.5% from no-load to full load. Transient voltage drop shall be less than 15% at full load and 0.8 power factor. Time required to restore to steady state conditions after transient voltage fluctuation shall not exceed 10 seconds.

4.3.4 Short Circuit Capability

Generator shall be capable of withstanding without injury, a 30 seconds three-phase short circuit at its terminal when operating at rated output and power factor with fixed excitation.

4.3.5 Deviation Factor

The deviation factor of the open-circuit line-to-line terminal voltage shall not exceed 0.1

4.4 Control / Instrument Panels

The Control / Instrument Panel for each generator shall be designed for front access, completely assembled, wired and tested. The control panel shall conform to the constructional requirements as stated in these specifications for Switchboards. The panel shall comprise but not limited to the following main components.

4.4.1 Generator Panel

This shall incorporate protection and control equipment, measuring instruments, control and instrument transformers, voltage regulator, governor controls, battery charger, indicating lamps, etc.

One cubicle for each genset shall be provided.

All functions of the generator panel shall be capable to achieve the functionality of SCADA system.

4.4.1.1 Circuit Breaker

The circuit breaker shall be triple pole with adjustable releases for thermal overload, instantaneous over current, under voltage and over voltage protections.

4.4.1.2 Instruments

- Ammeter with selector switch
- Voltmeter with selector switch
- Frequency meter
- Kilowatt-hour meter.
- Ammeter for battery charging current
- Kilowatt-meter.
- Local / OFF / Remote Control Switch

4.4.2 Engine Panel

An instrument panel on the skid shall have calibrated gauges/meters to measure the following:

- Engine speed
- Lube oil pressure
- Lube oil temperature
- Engine water temperature
- Engine running hours

4.4.3 Safety Devices

Following safety devices shall be provided. The audible alarm shall operate on any fault condition and shall be resettable manually and automatically through a timer after 15 minutes whichever is earlier:

A = Alarm, SD = Shutdown, TD = Adjustable Time Delay

a.	Engine Over speed	A SD
b.	Low lube oil pressure	A SD
c.	High water temperature	A SD
d.	Over voltage	A SD (TD=0-30 Sec)
e.	Under voltage	A
f.	Short circuit and tripping of circuit breaker	A SD (TD=0-1 min.)
g.	Low level in fuel day tank	A SD (TD=0-5 min.)
h.	High level in fuel day tank	A
i.	Charger failure	A
j.	Winding temperature high	A SD (TD=0-2 min.)
k.	Over crank	A SD
l.	Low crankcase oil level	A
m.	High crankcase oil level	A
n.	Charging alternator failure	A

After shut down, the set shall lockout and it shall not be possible to start it unless manually reset after the cause of fault has been removed.

4.4.4 Battery Charger

Battery charger shall be static type and shall provide for both trickle and boost charging of the batteries when the engine is not in operation. The charger shall be of suitable capacity to fully recharge the completely discharged batteries within four hours at boost charge.

4.4.5 Lamp Test Facility

A common lamp test facility shall be provided for each control panel/instrument panel.

4.5 Auto-Main Failure (AMF) Panel

The AMF panel shall incorporate automatic changeover system, which shall be designed for the following functions:

a. To start the set immediately when the main supply fails.
b. To start the set whenever the main supply voltage drops to 360 volts or rise to 440 volts. The setting voltages shall be adjustable within - 5% and +5% respectively for the lower and upper ranges.
c. To transfer the load from generator to main supply whenever the mains voltage returns +5% and persists for at least 3 minutes.

d. To make two successive attempts, in case the set fails to start in the first attempt.
e. The system shall provide for immediate transfer of load to the generator, after the rated speed/frequency and voltage have been achieved.
f. The system shall be self-resetting after each cycle of operation.
g. A four-position selector switch shall be provided for selecting the operation mode i.e. Test-Manual-Automatic-Stop/Maintenance mode to facilitate the following operation :-

    i. Automatic
    As described in (a) to (f) above.

    ii. Manual
    Manual starting of the set and load transfer from transformer to generator and vice versa.

    iii. Test
    Testing the changeover operation when so desired, and also for starting and running the set without interrupting the normal operation. In case of failure of main supply during testing, the set shall automatically revert to automatic mode of operation.

    iv. Stop/Maintenance
    Provision shall be made to isolate the system for troubleshooting and maintenance without interruption of mains power supply. The set shall not be capable of starting in this condition.

h. Two normally open and two normally close potentially free contacts rated for 3 Amps at 230V AC shall be provided, which shall operate when the set is started with the operation mode selector switch in auto or manual position. The contacts shall be wired up to the terminal block in panel.

5.0 INSTALLATIONS & TESTING

The Diesel generator set and associated equipment with accessories shall be installed at location shown on the drawing. The concrete foundation pad shall be constructed as part of civil works. The Contractor shall ensure co-ordination with the civil works for providing any openings, holes, etc. to avoid any breakage to completed works. In case the provisions in civil works for installation of electrical equipment are not made or made incorrect the same shall be rectified by the Contractor at his own cost and to the satisfaction of Engineer. The Contractor shall provide foundation bolts and grout them in cement concrete floor using non-shrinkable material with the approval of Engineer.

All installation materials for physically installing the Diesel generator set and associated equipment, such as bolts, nuts, washers, supporting steel, etc., shall be provided and installed by the Contractor. The generator shall be installed upright and in level and shall be firmly and rigidly bolted to the steel frame skid with vibration isolators.

The Diesel generator set shall be completely erected as per manufacturer's instructions and as approved by the Engineer. Loose parts dispatched by the manufacturer shall be installed and connected as per assembly drawing provided by the manufacturer. Any safety locking of meter, relays, etc., provided by the manufacturer for safe transport shall be released only after the generator/ control panel is erected in position.

The incoming and outgoing cables shall be connected as recommended by cable manufacturer. The cable armour shall be connected effectively to ground.

The Diesel generator and associated equipment body shall be connected to earth as per instructions given in section "Earthing" of these Specifications. The Diesel generator set shall be tested and commissioned in the presence of the Engineer. The tests to be carried out are described in article "Testing" of General Specifications for Electrical Works, Section-16 of these Specifications.

The tank shall be installed in accordance with best engineering practice/international codes, the approved shop drawings, applicable code requirements and manufacturer's instructions.

The piping shall be hydrostatically shop tested as required by ASME code, section VIII, DIV-I and will be dried immediately after the test.

No separate payment is admissible for testing and commissioning of low voltage D.G. set associated equipment and piping and is deemed to have been included in the BOQ rates of the Low voltage D.G. set and fuel system

SECTION – 16.2: INDOOR POWER TRANSFORMER

1.0 SCOPE

The work under this section consists of supplying, installing, testing, connecting and commissioning of all materials and services of the complete Indoor Power Transformer as specified herein, or as given in the Tender Drawings and in the Bill of Quantities.

The Contractor shall discuss the electrical layout with the Engineer and co-ordinate at site with other services for exact route, location and position of the equipment.

The Indoor Power Transformer with accessories shall also comply with the General Specifications for Electrical Works, Section-16 and with other relevant provisions of the Tender Documents.

2.0 GENERAL

The capacity of transformers to be provided are shown on the drawings and mentioned in Bill of Quantities. The transformers shall be complete, with all accessories and attachments as detailed in these specifications or otherwise required for satisfactory service.

All pertinent details, drawings, data, etc. shall be provided to the Engineer for approval prior to manufacturing.

Transformer built to these specifications and the standards given in this section or other relevant standards approved by the Engineer will be acceptable.

3.0 APPLICABLE STANDARDS/CODES

The following standards and codes shall be applicable for all materials in scope of this section: -

IEC 76	-	Recommendation for Power transformers
BS 171	-	Specifications for power transformer
BS 223	-	High voltage bushings
IEEE C57.12.01	-	General Requirements for Dry-Type Distribution and Power Transformers Including Those with Solid Cast and / or Resin-Encapsulated Windings
ANSI C57.12.51	-	Requirements for Ventilated Dry-Type Power Transformers, 501 KVA and Larger, Three-Phase with High-Voltage 601 to 34 500 Volts, Low Voltage 208Y/120 to 4160Volts.
ANSI C57.12.55	-	Dry-Type Transformers in Unit Installations, Including Unit Substations –Conformance Standard.
ANSI/IEEE C57.98	-	Impulse Tests, Guide for Transformer (Appendix to ANSI/IEEE C57.12.90).
IEEE C57.12.91	-	Test Code for Dry-Type Distribution and Power Transformers.
IEEE C57.94	-	Recommended Practice for Installation, Application, Operation and Maintenance of Dry-Type General Purpose Distribution and Power Transformers.
NEMA ST 20	-	Dry Type Transformers for General Applications

4.0 MATERIAL

4.1 Power Transformer Construction

The transformer shall be of dry type vacuum pressure encapsulated construction, the preferred open-wound dry type technology, and shall be mounted in a suitably ventilated (indoor, outdoor) enclosure.

Primary terminations shall be stub bus inside transformer enclosure/close-coupled to high voltage switchgear/cable connected in air-filled terminal chamber. Secondary terminations shall be stub bus inside transformer enclosure/close-coupled to low voltage switchgear / busway or cable connected in air-filled terminal chambers.

The transformer core shall be constructed of high grade non-aging silicon steel laminations with high magnetic permeability and low hysteresis and eddy current losses. Magnetic flux densities are to be kept well below the saturation point. A step-lap mitered core joint shall be used to minimize losses, exciting currents and sound levels. The core laminations shall be clamped together with heavy steel members. The finished core shall be coated to protect against corrosion.

The average temperature rise of the transformer windings shall be rated 80 °C. The transformer shall not exceed the specified temperature rise when the unit is operated continuously at full nameplate rating. The transformer shall be capable of carrying 100% of the nameplate rating in a 30°C average, not to exceed 40°C maximum ambient in any 24 hour period.

Both the high and low voltage winding conductors shall be copper. The low voltage windings, nominal system voltage 400V shall be wound using epoxy resin impregnated insulation with foil or sheet conductors. The low voltage coil shall be hermetically sealed with epoxy. The coil shall be blocked radially to the core to ensure short circuit integrity. The high voltage windings, insulation class 2.5 KV (2400V) and above, shall be epoxy cast coil hermetically sealed in epoxy with reinforced multi -directional glass fiber. The glass fiber to epoxy ratio must be a minimum of 70:30 based on insulation weight and must be uniformly distributed throughout the coil. The reinforced glass fiber is essential to ensure mechanical strength in both radial and axial directions for short circuit withstand capability and to avoid the possibility of cracking caused by mechanical stresses due to temperature variations or sudden load peaks.

The coil must be hermetically cast in epoxy utilizing a proven manufacturing system that demonstrates its ability to minimize hot spots and partial discharge. An induced partial discharge test shall be performed on each winding. The induced partial discharge test shall be performed by measuring partial discharge levels beginning at 80% rated voltage and continuing in 10% step increments through 200% rated voltage. Partial discharge inception and extinction levels are defined as levels above 10 Pico-Coulombs and shall be recorded. Acceptance criteria is Partial discharge extinction at or above 120% rated voltage.

Taps Transformer primary winding shall have {four 2-1/2 percent full capacity taps, two above and two below} rated nominal voltage. No load tap connections shall be made by re-connectable links on the face of the primary winding and shall be located behind removable panels on the front of transformer enclosure. Taps shall be for de-energized operation only.

After installation of windings on core and stacking of the top yoke core steel, core and coil assembly is to be secured with a rigid frame. Primary and secondary coordination bus assemblies, as required for connection to associated switchgear are to be of bolted construction.

The transformer shall have vibration isolation pads installed between core and coil assembly and enclosure base structures to prevent the transmission of structure borne vibration.

The enclosure shall be constructed of heavy gauge sheet steel and shall be finished in ANSI 61 paint color applied using an electrostatically deposited dry powder paint system.

All ventilating openings shall be in accordance with NEMA and the NEC standards for ventilated enclosures.

The base of the enclosure shall be furnished with ground pads located on opposite diagonal corners. The base shall have jacking pads and shall be constructed of heavy steel members to permit skidding or rolling in any direction.

The core shall be visibly grounded to the enclosure frame by means of a flexible grounding strap.

4.2 Principal Data of Power Transformer

The transformer shall meet the following specifications:

a.	Capacity (Rated continuous	:	As stated on drawings and BOQ output at full load)
b.	Voltage ratio at no-load	:	11000/400 Volts
c.	Frequency	:	50 Hz
d.	Vector group	:	Dyn 11
e.	Off load tapping arrangement	:	$\pm$2.5%, $\pm$5%, -7.5% on H.T side
f.	H.T connection	:	11 kV Delta
g.	L.T connection	:	400 V with grounded star point.
h.	Neutral on L.T side	:	Brought out & solidly earthed
i.	Temperature rise of winding	:	50^{o}C maximum over ambient temperature
j.	Impedance voltage	:	5% to 6%
k.	Voltage regulation for	:	Not to exceed 2.5% of rated operating condition no-load secondary voltage at 85% power factor
l.	Rated maximum voltage H.T/L.T	:	15kV / 0.6 kV
m.	Rated short-time current	:	Equal to the rating of associated H.T. Switchboard.
n.	Rated Basic Impulse Level (BIL):		95 kV

The design data to be furnished by the Contractor for approval of the Engineer shall include, but not limited to the following:

a. Iron losses.
b. Copper losses.
c. Rated short-time current.

d. Switching in-rush current.
e. Efficiencies at different loads.
f. Voltage regulation
g. Type and quantity of oil for complete filling of transformer.
h. Transformer weight.

4.3 Accessories

In addition to the standard accessories of the power transformer as offered by the manufacturer, the transformer shall also be provided with following accessories:

a. Diagrammatic instruction nameplate
b. Provisions for lifting and jacking
c. Removable case panel for access to HV taps
d. Stainless steel ground pads
e. Line voltage adjustment taps, 2 - FCAN and 2 - FCBN, All at 2 ½%

5.0 INSTALLATION

Transformer shall be installed in transformer room as shown on drawings. All civil works, including provision of cable trench, openings in wall, steel channel, etc., shall be carried out under civil works. The Contractor shall be responsible for general checking and co-ordination with civil works to ensure compliance with the requirements of transformer manufacturer for installation of equipment. For installation, connecting, testing and commissioning of transformers, the Contractor shall provide all required labour, materials, tools and testing equipment.

The transformer installation shall be carried out in accordance with specifications and the best-accepted practice. Any loose components supplied by manufacturer shall be assembled, installed and connected in place as to form a complete assembly as per manufacturer instructions. After the transformer is placed in position and aligned for H.T & L.T termination, the roller wheels shall be locked with the foundation steel channel to avoid any unintentional movement of the wheels.

The H.T cable shall terminate at the flange terminals on the H.T side. The supporting channels, fixing material, etc., required for H.T cable shall be furnished by the Contractor, details of which shall be approved by the Engineer prior to installation. The cable end box/termination kit will be supplied with the cable.

After the transformer is installed and connected, a thorough check shall again be made for the proper fixing of accessories, neutral connections, oil level, etc. The transformer shall be tested before energizing as per instructions contained in the article "Testing" of General Specifications for Electrical Works, Section - 16 of these Specifications.

SECTION – 16.3: HT SWITCHBOARDS

1.0 SCOPE

The work under this section consists of supplying, installing, testing, connecting, commissioning of all material and services of the complete HT switchboard as specified herein or stated on the Tender Drawings and in the Bill of Quantities.

The Contractor shall discuss the electrical layout with the Engineer and co-ordinate at site with other services for exact route, location and position of the equipment.

The HT switchboard with accessories shall also comply with the General Specifications for Electrical Works Section-16 and with other relevant provisions of the Tender Document.

2.0 GENERAL

2.1 H.T. Switchboard

The HT switchboard shall be sheet steel fabricated, cassette type, indoor, totally enclosed, dust tight and vermin proof, and shall have protection class IP-42. It shall be complete in all respect with material and accessories, factory assembled, type tested and finished according to the specifications and to the normal requirements.

The switchboard shall be suitable for front operation only and shall:

a. be suitable for addition of units, on either side, in future.
b. be provided with adequate clearance from live parts so that flashovers cannot be caused by switching surges, vermin, pests, etc.
c. be designed for flush mounting of all instruments on the front side.
d. have all incoming and outgoing connections from the bottom.
e. have the components mounted so as to facilitate ease of maintenance from the front.
f. have provision for lamp test, alarm test, alarm accept and reset facility.
g. be mounted on cable trenches having their own supporting structure of angular or U steel profiles.
h. be provided with anti-condensate heater, in each individual enclosure controlled automatically through adjustable humidistat for maintaining required safe operating condition inside the panel and also avoid condensation. The heater shall also be manually operable and provided with protective miniature circuit breaker and ON indication lamp.

All pertinent details and drawings shall be provided to the Engineer for approval prior to manufacturing.

3.0 APPLICABLE STANDARDS/CODES

The latest editions of the following standards and codes shall be applicable for the materials within the scope of this section:

BS 1432 - Bus bars

BS 37 - Meters

IEC 56 - High voltage AC circuit breaker

IEC 298	-	AC metal-enclosed switchgear and control gear
IEC 694	-	Common Clauses for high voltage switchgear and control gear standards
IEC 185	-	Current transformers
IEC 186	-	Potential transformers
IEC 51-1,2,3,5&8-		Direct acting indicating analogue electrical measuring instruments and their accessories

4.0 MATERIAL

4.1 HT Switchboard

The switchboard shall be fabricated with angle-iron framework, welded, grinded, finished and cladded with 12 SWG sheet steel. It shall be suitably divided into panels and compartments for accommodating the required number of circuit components, instruments and accessories.

All instruments, relays, control and selector switches, indicating lamp, push buttons and trip levers shall be flush mounted and located at convenient heights on the front doors of switchgear in logical and clear manner. Means shall be provided to limit the opening angle of doors to about 100^{o}.

The switchboard shall be supplied complete with foundation bolts and other installation materials as recommended by the manufacturer. Proper size cable clamping channels shall be provided for fixing required size of 11 kV XLPE cable.

An earth bar of appropriate cross section to safely carry the fault current shall be provided on full length of H.T switchboard and connected to the body of all sections of the switchboard. The external earth terminal shall be provided for main earth connection. The doors shall be grounded by flexible strap of copper braids.

The control cabling inside the switchboard shall be suitably numbered and harnessed by means of straps or cords. All indicating, selecting and control equipment shall be suitably arranged and clearly labelled with flameproof material using indelible ink/marking, indicating the rating and designation of fuses, switches etc. The nameplates shall be provided on the front of panel for each circuit and component, which is accessible from outside. The nameplates shall be of stainless steel with engraved equipment designation having minimum width of 5mm. Other labeling on the switchboard such as danger signs, voltages, switchboard/panel identification shall be of sufficient size to be legible from a distance of 5 metres.

All metal work of the switchboard shall be cleaned down to bare shining metal phosphated and the surfaces chemically prepared for powder coating. Then these shall be coated with powder of colour RAL 7032 and then baked in oven. The thickness of powder coating shall not be less than 100 microns.

4.1.1 Capacity and Basic Data

The switchboard shall be designed to conform to the following requirements:

a.	Rated Current	:	As shown on drawings.
b.	Rated Nominal Voltage	:	11 kV
c.	Rated Maximum Voltage	:	12 kV
d.	Rated Power Frequency	:	28 kV for 1 minute
e.	Withstand Voltage (r.m.s.)		
f.	Rated Short Circuit Capacity	:	500 MVA at 11 kV for one second.
g.	Rated Symmetrical Breaking	:	25 kA
h.	Current (1 second rating)		
i.	Rated Peak with stand Current current.	:	2.55 times rated symmetrical breaking
j.	Operating Duty	:	B-0.3”-MB-3' -MB
k.	Rated Basic Impulse Level (BIL)	:	75 kV
l.	Control Voltage	:	
	i. Indication/Metering	:	110 volt a.c. from secondary of P.T.
	ii. Tripping	:	60 Volts D.C. from D.C. Supply System

4.1.2 Interlocking

Any interlocking if required inside the HT switchboard and between HT switchboard and other equipment shall be provided as stated on the drawings.

4.2 Bus Bars

The bus bars shall be made of high conductivity electrolytic copper conductors suitably protected against corrosion, and shall be completely insulated by heat shrink coloured sleeves of specified voltage and mechanically braced to safely withstand the stresses due to short-time momentary current under the fault conditions. The phase identification of bus bars shall be red, yellow and blue. The clearances shall not be reduced on account of the bus bar insulation or the phase barriers.

4.3 Circuit Breaker

The circuit breakers shall be triple pole, withdrawable type, with arc interruption in SF6. The operating characteristics and technical data shall be as given in art. 4.1.1 of this section. The bidder shall submit with his offer the type and details of equipment proposed.

The circuit breaker shall have trip free, direct acting and manually operated drive mechanism. For manual operation a handle shall be provided. The unit shall have rollout trucks and channels for horizontal withdrawal. Interlocking device shall be provided such that the breaker can be closed only when it is in fully plugged-in or fully withdrawn position, and withdrawal of circuit breaker is only possible in the open or isolated position. Safety shutters shall be provided which will automatically cover the live contact as the circuit breaker is withdrawn. Other interlocks as essentially required for safe and proper operation of circuit breaker shall be provided. The circuit breaker phases shall be separated by barriers of approved heat resisting, non-tracking insulating material.

Each circuit breaker shall have a device to register the number of closing operation.

A triple pole grounding switch shall be provided for cable and bus bars earthing, complete with mechanism for interlocking it with the circuit breaker and the roll-out truck, and mechanical indication to show the position of grounding switch. The grounding switch shall be rated to safely carry the fault current due to inadvertent closing of supply circuit breaker and also for making duty on the fault.

The circuit breaker shall have automatic, mechanically operated `ON' and `OFF' position indications. Luminous indications shall be provided with 'ON' 'OFF' and 'TRIPPED' position. Additional indication lamps as shown on the drawings shall also be furnished. The circuit breakers shall be provided with ON-OFF push buttons.

Each circuit breaker shall be provided with at least three normally closed and three normally open potential free auxiliary contacts rated for 10 Amp, 230V AC as spares. Provision shall be made for remote indication and controlling of the circuit breakers position/status.

A test position shall also be provided to facilitate testing operation of circuit breaker manually and by protective relays. Test socket with plug shall be provided for testing the relays.

The circuit breaker shall be complete with necessary secondary wiring with ferrules to indicate the circuit. Protection shall also be provided for all control circuits.

4.4 Load Break Switch

The triple pole load break switch shall be suitable for switching on load. The load break switch shall be similar to circuit breaker as specified in Para 4.3 above but without any protective relays.

A triple pole grounding switch shall be provided for cable and bus bar earthing and shall be rated to safely carry the fault current due to inadvertent closing of supply circuit breaker and also for making duty on a fault.

4.5 Current Transformers

Each circuit breaker shall be provided with current transformers having following ratings and characteristics:

a.	Type	:	Cast resin
b.	Number	:	Three single phase units
c.	Burden	:	Suitable for load of protection and instrumentation circuits.
d.	Accuracy	:	5P 20 for protection and 1.0 for measuring with security factor 5.
e.	Duty	:	For operating relays/meters and instruments.
f.	CT ratio	:	As shown on the Tender Drawings.
g.	No. of cores	:	1 or 2 as required and as shown on Tender drawings.
h.	Rating and Insulation	:	As shown on drawings and/or requirement specification in Article 4.1.1
i.	Rated dynamic current	:	2.55 times rated symmetrical short circuit Current

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4.6 Potential Transformers

Potential transformers (PT) shall be provided as shown on the Tender Drawings and having the following ratings and characteristics:

a.	Type	:	Cast resin
b.	Number	:	Three single phase units.

c. Burden : Suitable for load of protection and instrumentation circuits .
d. Accuracy : Class 1.0
e. Duty : For operating relays/meters and instruments.

PT's shall be designed to have either two independent secondary windings of specified ratio for connection in star or open delta or with a single secondary windings as required and as shown on single line diagram.

- Voltage ratio : $\frac{11\ kV}{\sqrt{3}} / \frac{110V}{\sqrt{3}} - \frac{110V}{\sqrt{3}}$ for double secondary winding
  : $\frac{11\ kV}{\sqrt{3}} / \frac{110V}{\sqrt{3}}$ for single secondary winding

- Rated voltage : 1.2 continuous and 1.5 for 30 seconds factor

- Rating & insulation : As shown on drawings and/or requirements specification in Article - 4.1.1

4.7 Protective relays

The circuit breakers shall be provided with inverse definite minimum time directional or non-directional over-current relays for phase and earth fault protection as shown on drawings. The relays shall have the following common characteristics, unless otherwise specifically mentioned:

a. Phase fault over current setting range
b. Inverse : 50-200% of CT secondary rating
c. Instantaneous : 200-800% of CT secondary rating. The instantaneous elements shall also have infinity setting to block their operation, if necessary.
d. Ground-fault : 20-80% of CT secondary rating with instantaneous element as for phase fault unit.
e. Time setting range: 0-1 second
f. Connection : 5 Amp secondary of CT
g. Auxiliary supply : 60 Volts DC from DC Supply Tripping System
h. Indications/Control: 60 Volts DC from DC Supply System
i. Heaters and audible: 220 VAC from substation LT alarm switchboard.
j. Auxiliary Contacts : Provision for remote indication and controlling as required.

The relay shall preferably be triple pole type and have positive action without chatter.

4.8 Auxiliary Tripping / Control Supply

Auxiliary tripping / control / charging motor supply shall be fed from DC supply system

4.9 Meters & Selector Switches

The meters to be provided on HT switchboard are shown on drawings and shall be as specified below:

4.9.1 Ammeter and Voltmeter

The ammeter and voltmeter shall be moving iron spring controlled having front dimensions of 96 x 96 mm. Voltmeters shall have measuring range of 0-15 kV and ammeters measuring range shall be as shown on the drawings. Ammeters and voltmeters shall conform to B.S.S. accuracy class 1.5 and suitable for connection to the secondary of PTs and CTs installed on the switchboard.

4.9.2 Selector Switches

Ammeter selector switch shall be R-Y-B-OFF and voltmeter selector switch RY-YB-BR-OFF. The selector switches shall be complete with front plate and operating lever.

4.9.3 kWh and kVArh Meters

Kilowatt-hour (kWh) and reactive Kilovolt ampere-hour (kVArh) meters shall be suitable for 3 phase, 3 wire, 50 cycles balanced and unbalanced loads. The kWh meter shall also be provided with maximum demand indicator and built in switch for operation at an interval of 30 minutes.

4.9.4 Alarm Indication

On occurrence of any fault in the system and subsequent tripping of circuit breakers, audio alarm shall be provided on the HT Switchboard. Push buttons shall be provided on HT Panel for independent resetting of the audio alarm and fault-indicating lamp. At least two potential free contacts rated 10 Amp AC or DC shall be available for remote connection.

4.10 Surge Protection

Surge Arresters shall be provided in H.T. switchboard, wherever required, as shown on drawing. The 11 kV surge arrester shall have the following characteristics:

- Voltage Class (highest system voltage) : 12 kV rms
- Service (rated voltage) : 11 / 1.732 kV rms

This equipment will be tested in accordance with the relevant IEC Standard.

4.11 Tools

One complete set of tools for routine operation, setting and maintenance of HT switchboard including protective relays as recommended by manufacturer of each component shall be furnished within the price quoted for the HT Switchboard.

HT switchboard shall be provided with independent set of tools placed in suitable box. Details of tools shall be furnished by the bidder with his offer in Appendix J-3 form of tender volume - I.

4.12 Insulation Mat

Insulation mat shall be placed in front of the HT panels all along the length. They shall be one meter wide and 6 mm thick and suitable for providing insulation for 15 kV working.

5.0 INSTALLATION

The HT switchboard shall be installed at location shown on the drawing. The cable trenches shall be constructed as part of civil works. The Contractor shall co-ordinate with the civil works for providing any openings, holes, etc., in time to avoid any breakage/damage to completed works. In case such provisions in civil works for installation of electrical equipment are not made or made incorrect, the same shall be rectified by the electrical Contractor at his own cost and to the satisfaction and approval of Engineer.

The Contractor shall provide foundation bolts and grout them in cement concrete floor using non-shrinkable material approved by the Engineer. All installation materials for physically erecting the switchboard, such as bolts, nuts, washers, supporting steel, etc. shall be provided and installed by the Contractor. The switchboard shall be installed upright and in level and shall be firmly and rigidly bolted on the floor and concrete supports. All wiring external from HT Switchboard to alarm indication control unit protection interlock circuits and for auxiliary power supply for heaters, etc., will be furnished and installed by the Contractor in consultation with the Engineer.

The switchboard shall be erected as per manufacturer's instructions and as approved by the Engineer. Loose parts dispatched by the manufacturer shall be installed and connected as per assembly drawing provided by the manufacturer. Any safety locking of meters relays, etc., provided by the manufacturer for safe transport shall be released only after the switchboard is erected in position.

Necessary provision shall be made in the HT switchboard for incoming/outgoing cables, and installation of cable termination kits, keeping in view both cable and switchboard manufacturer's recommendations. The cable armour shall be connected to the earth system.

The switchboard body shall be connected to earth as per instructions given in section "Earthing" of these Specifications. The switchboard shall be tested and commissioned in the presence of the Engineer. The tests to be carried out shall be as recommended by the international standard to which the switchboard is manufactured and/or as recommended by manufacturer; but as a minimum the tests given in article “Testing" of General Specifications for Electrical Works, section 16 of these Specifications shall be carried out.

SECTION – 16.4: LT SWITCHBOARDS

1.0 SCOPE OF WORK

The work under this section consists of supplying, installing, testing, connecting, commissioning of all material and services of the complete LT Switchboards as specified herein and/or shown on the Tender Drawings and given in the Bill of Quantities.

The Contractor shall discuss the electrical layout with the Engineer and coordinate at site with other services for exact route, location and position of the L.T Switchboard.

The LT Switchboard shall also comply with the General Specifications for Electrical Works Section-16 and with other relevant provisions of the Tender Documents.

2.0 GENERAL

The LT Switchboard shall be of sheet steel fabricated, floor mounting, cubicle type, form-4 category, totally enclosed, dust tight and vermin proof, and shall have protection class IP-54. It shall be complete in all respect with material and accessories, factory assembled, type tested and finished all according to the specifications and to the normal requirements.

The switchboard with all components and accessories shall be suitable for front operation only and shall:

a. have a rated service short circuit breaking capacity, Ics, of 70 kA at 400V AC conforming to IEC 947-2 unless stated otherwise on the drawings/in the BOQ.
b. be provided with adequate clearance from live parts so that flashovers cannot be caused by switching, vermin, pests, etc.
c. have all components rated for insulation class of 600-volt minimum.
d. be designed for flush mounting of all instruments on the front side.
e. have all incoming and outgoing connection from the top or bottom as required.
f. have the components mounted so as to facilitate ease of maintenance from the front.
g. have common lamp test facility for all lamps.
h. have wiring diagram in the pocket on the inside of each door of the panel.
i. be suitable for 400 volts AC, 3 phase 4 wire, 50 Hz system.
j. be labeled with stainless steel nameplate on the front side of door for each incoming and outgoing circuit.
k. have doors grounded by flexible copper cable/strip.
l. have arrangements for extension of panel in future.
m. have the SCADA functionality.

Wherever withdrawable type LT switchboard is specified on the drawings/BOQ, the switchboards shall also comply with the following requirements:

a. All circuit breakers and switch fuse units shall be as shown on the drawing. Where two or more feeders are contained in the same cubicle, they are to be separated by barriers of steel or fire resistant insulating material. If required, the metal surface of the cubicle shall be protected by fire resistant insulating material. Each panel shall combine in tier form all respective components with their incoming and outgoing power feeders.

b. The draw out switching units shall be mounted on trucks or slide-in chassis having adequate guidance by greased sliding rails and/ or rollers. They shall be connected to the busbars by means of a self-aligning plug and socket arrangement and complete isolation of each circuit shall be attained by drawing out the switching unit.

c. The main contacts shall have shutters, which automatically close upon withdrawal of switchgear unit. The withdrawal of circuit breaker shall be accomplished by means of a crank, with as little effort as possible.

d. The contact surfaces of the plugs and sockets shall be silver-plated. The contacts shall be amply sized and sufficiently strong to withstand maximum prevailing short circuits and carry continuously their normal rated currents without damage or overheating of any kind.

e. Also, the control circuits shall be provided with plugs and sockets.

f. The withdrawable units shall have clearly marked service, test and isolated (ready for complete withdrawal) positions. A mechanical interlock is to be provided to prevent withdrawal of the unit unless the power circuit has been interrupted. The unit shall, furthermore, positively be locked in the test position before it is manually released for complete withdrawal.

3.0 APPLICABLE STANDARDS/CODES

The latest editions of the following standards and codes shall be applicable for the materials specified within the scope of this Section:

BS 3871	-	Miniature & moulded Case Circuit Breaker.
IEC 947-2	-	Low Voltage Switch gear and Control gear.
IEC 439-1	-	Low Voltage Switchgear and Control gear Assemblies.
IEC 408	-	Low Voltage Air break Switches, Air Break Disconnectors, Air break Switch Disconnectors and Fuse combination Units.
BS 1432	-	Bus Bars.
BS 88	-	HRC Fuses.
BS 89/90	-	Ammeters and Voltmeters.
IEC 70	-	Power Capacitors.
BS 3938	-	Low Voltage Current Transformers.
IEC 73	-	Colours for indicator lights and push buttons.

4.0 MATERIAL

4.1 Sheet Metal Work

The L.T. switchboard shall be fabricated, welded, grinded, finished with angle iron framework and cladded with 14 SWG MS sheet. It shall be suitably divided into panels and compartments for accommodating the required number of circuit components, instruments and accessories.

The switchboard shall be supplied complete with foundation bolts and other installation materials as recommended by the manufacturer. Proper size cable clamping channels with galvanized steel clamps and brass cable glands respectively for unarmoured and armoured cables shall be provided. All holes, cutout shall be tool or jib manufactured and free from burrs and rough edges. An earth bar of appropriate

cross section shall be provided and connected to the bodies of all sections of the switchboard. Two external earth terminals shall be provided for main earth connection to the body of switchboard. The doors shall be earthed by means of flexible copper strip**.** Means shall be provided to limit the opening angle of doors to about 100^0.

The cabling inside the switchboard shall be suitably numbered and harnessed by means of straps or cords. Wiring to door mounted components shall be in flexible PVC conduit. All indicating, selecting and control equipment shall be suitably arranged and clearly labelled by means of flame proof material using indelible ink/marking indicating the rating of fuse, switches, etc. The nameplates provided on the front of panel shall be of flame retardant material preferably stainless steel. Use of plastic or any inflammable material shall not be permitted for nameplates.

All metalwork of the switchboards shall be cleaned down to bare shining metal phosphated and the surfaces chemically prepared for powder coating. Then these shall be coated with powder of colour RAL 7032 and then baked in oven. The thickness of powder coating shall not be less than 100 microns.

4.2 Components

The switchboards shall be provided with all components as specified or shown on the Drawings and as necessary for the satisfactory operation of the switchboard and of the electrical system. Typical specifications are given hereunder.

4.2.1 Bus Bars

The bus bars shall be made of high conductivity electrolytic copper and shall be completely isolated and mechanically braced for the specified fault level. The phase identification of bus bars shall be by providing colours sleeves on bus bars ends and these shall be red, yellow and blue for phase and black for neutral. The earth bus bar shall be green.

The bus bars shall be triple pole, neutral & earth and shall be of appropriate size to meet the electrical and mechanical requirements of the system. The temperature rise shall not exceed 45 degree centigrade at rated current.

Neutral bus bar shall be of the same cross section as phase bus bars. Earth bus bar shall be of half cross section area as phase bus bars.

4.2.2 Circuit Breakers

The circuit breaker shall be triple pole, manually operated or motor operated, spring charged type as shown on the drawings with front drive grip handle. ON-TRIP-OFF indication shall be provided on circuit breakers. The all circuit breakers shall have the following protections and setting range unless otherwise shown on the drawings:

a. Adjustable three pole, manual reset thermal overload release of setting range 80 to 100% of rated current.
b. Magnetic triple pole short circuit release having range according to manufacturer's standard range.

The incoming circuit breakers of main LT panel shall be air circuit breakers whereas outgoing circuit breakers shall be moulded case type, unless stated otherwise on the drawings.

Provision shall be made for remote indication and controlling of the circuit breakers position/status.

The incoming circuit breaker shall have two numbers normally open and two number normally closed auxiliary contacts rated for 2 Amp, 230 VAC. The incoming circuit breaker shall also have ON-TRIP-OFF indicating lamps. Where shown on the drawings indication lamps shall also be provided for outgoing circuit breakers. The circuit breaker shall have specified rupturing capacity without the use of back-up fuses. Auxiliary release and trip coils shall be provided for desired operation and/or interlocking as stated on the drawings.

The motor operated, spring charged type circuit breakers shall be provided with anti-pumping circuit to prevent repeating cycle of TRIP reset and ON even if the close command is given while the circuit breaker has tripped due to fault.

4.2.3 Switch - Fuse Units

The switch-fuse unit shall comprise a triple pole on load isolating switch with HRC fuses. The fuse shall be supplied complete with the fuse base and shall conform to BS-88 Class Q1 with a fusing factor of 1.5.

4.2.4 Ammeters and Voltmeters

All meters shall be flush mounting, moving iron, spring controlled. The front dimensions shall be 96 x 96 mm for meters.

The meters shall be of accuracy class 1.5 according to BS-89 and 90. The ammeter shall be suitable for connection to 5 Amps secondary of current transformers or directly through shunt as shown on drawings. The ammeters and voltmeters shall have measuring range as indicated on the drawings.

4.2.5 Current Transformers

Air-cooled, ring type current transformers shall be provided having transformation ratio as indicated on the drawings. The current transformers shall be of suitable burden having accuracy class 1.0 according to BS 3938. The current transformers shall have 5 amps secondary.

4.2.6 Selector Switches

Ammeter and voltmeter selector switches shall be complete with front plate and grip handle. R-Y-B and OFF position for ammeters and RY-YB-BR-RN-YN-BN and OFF position for voltmeters shall be marked on the respective selector switches.

The selector switches for controls shall be rotary cam type, having required number of positions. It shall be provided complete with knob and front plate showing all positions as required.

4.2.7 Air Break Contactors

The contactors shall be air break, triple pole 400 VAC type and suitable for the type of duty to be performed. The main contacts shall be silver tipped, butt type with double break per pole. Each contactor shall be provided with single phase 230 VAC operating coil and minimum one spare normally open and one normally closed

auxiliary contact. The number of working auxiliary contacts shall be provided according to the system requirements.

4.2.8 Push Buttons

The push buttons shall be momentary make/break contact type (normally open/normally close) and suitable for flush mounting. The push button for on and off switching shall be red and green respectively.

4.2.9 HRC Fuses

HRC fuses shall be provided complete with fuse bases, fuse etc. The fuses shall have a fusing factor as specified for class Q1 in accordance with BS 88.

4.2.10 Indicating Lamps

Indicating lamps shall be suitable for flush mounting, complete with base, 230 volt AC/60V DC incandescent lamp and shall have rosettes of suitable colour.

4.2.11 Line up Terminals

Line up terminals wherever provided for control or power circuits shall be suitable for voltage and size of conductors as indicated on drawing.

The line-up terminals for controls shall be suitable for channel mounting. All necessary accessories such as end plates, fixing clips, transparent label holder caps and label sheets with marking shall be provided.

4.2.12 Power Factor Improvement Plant

The power factor improvement plant shall be used for improving the power factor of the system on 400 volts side. The plant shall be automatic-cum-manual.

The power factor improvement plant shall be aligned with the Main LT Switchboard. The control panel for the plant shall be a part of Main LT Switchboard, whereas the power factor correction capacitors shall be mounted in a ventilated panel. The capacitors shall be suitable for three phase, 400 volts, 50 Hz system and shall be self cooled, designed for indoor use in tropical climate for maximum ambient temperature as specified in section-16, General Specifications for Electrical Works. The capacitors shall be in the form of banks divided for required stages. Each capacitor bank unit shall be of kVAr capacity as shown on drawings. Each capacitor unit shall be complete with discharge resistors and internal fuses and shall be connected with control panel with proper size of single core PVC insulated cables.

The control panel of the plant with all accessories shall be installed within LT Switchboard. The panel shall be supplied complete with a set of 3-phase, full capacity, insulated copper busbars, interconnections, risers, designation labels, cable sockets, holdings down bolts, wiring with cleats and ferrules, earthing sockets and studs, etc. The control panel shall at least accommodate, but not limited to the following:

a. 1 No. Multi-stage power factor correction relay for automatic/manual control.
b. 1 No. 3-phase, 4 wire, 400 volts, unbalanced load power factor indicator.
c. 1 No. Current transformer with 5 amps secondary current, having suitable output burden and accuracy.

d. 3 Nos. Instrument potential fuses.

Following equipment shall be provided for every capacitor bank:

a. 1 No. Triple pole 400 volts air break contactor with auxiliary contacts.
b. 1 Set 3 Nos. HRC back-up fuses with base and carrier having the fuse factor as required for capacitors in accordance with BS-88.
c. 1 No. Auto-Off-Manual selector switch.
d. 1 No. Red lamp for 'ON' indication of the contactor.

4.2.13 Surge Protection

Surge Arresters shall be provided in L.T. switchboard, wherever required, as shown on drawing. The 400 Volts surge arrester shall have the following characteristics:

a. Voltage Class (highest system voltage) : 440 V rms
b. Service (rated voltage) : 400 / 1.732 kV rms

This equipment will be tested in accordance with the relevant IEC Standard**.**

4.3 Internal Wiring and Ferrules

Wiring inside the cubicles shall be carried out using 1100/ 650 V grade, PVC insulated, stranded, single core conductor wires. For power circuits, the minimum size shall be 4 sq.mm copper. For control circuits the minimum size shall be 1.5 sq.mm copper; for CT circuits the minimum size shall be 2.5 sq.mm copper.

Spare auxiliary contacts shall be wired up to the terminal block.

Not more than two connections shall be made at any one terminal.

Wires for interpanel wiring shall be taken through the bottom most tier of the switchgear, which shall be kept vacant for this purpose.

All metal cutouts provided for facilitating wiring shall be pushed.

Each wire shall be identified at both sides by ferrules. Ferrules shall be of interlocking type of yellow colour with black engraved lettering. Equipotential ferrules shall carry the same identification number.

4.4 Terminal Blocks

Terminal blocks shall be 650V grade, of non-hygroscopic, non-tracking moulded plastic type. Terminal blocks shall be segregated based on the circuit voltage. Individual terminals shall be numbered with engraved black-on-white labels. Where it is necessary to duplicate terminals, same shall be done with solid links.

Power terminals shall be stud type with phase separation barriers control terminals shall be rated for 10A min. and they shall be suitable for 2.5 sq.mm conductor. At least 20% spare control terminals shall be provided in each block.

Terminals for CT secondary leads shall be provided with shorting and disconnecting / earthing facilities and shall be similar to CATD M4 design of Elmex.

Power and control terminals shall be shrouded. It shall be possible to carry out work on any module separately without coming into accidental contact with the immediately located modules.

4.5 Labeling and Name Plates

Labels shall be provided for each component of each module of the switchgear. These shall be white engraved on block, PVC type. Paper labels are not acceptable. Labeling shall be done as per approved scheme drawings.

Nameplates shall be provided for each feeder each vertical and for the switchgear as a whole. These shall be of anodised aluminium with engraved lettering on a black background.

In addition, danger plates shall be provided for each switchboard. In case of single front switchgear, the rear side of each panel shall be marked with the panel number.

4.6 Cable Termination Accessories

Undrilled G.I gland plates of minimum 3 mm thickness and double compression type brass glands shall be provided for termination of cables. The gland plates shall have gaskets. Required number of tinned, crimping type copper lugs shall be provided. Provision for terminating ½ core on to earth bus and neutral bus shall be made.

4.7 Earthing

Two earth terminals shall be provided on each cubicle, at back. An earth bar of specified cross section shall be fixed to the terminals. The earth bar shall be electrically continuous and shall run the full extent of each board. Terminals shall be provided for external earth connections. One separate green earth conductor shall earth all relay and meter bodies.

4.8 Special Tools

A set of special tools required for the normal operation and maintenance shall be supplied with each switchboard. The tenderer shall include along with each switchboard one height adjustable circuit breaker trolley for removal and replacement of the withdrawable circuit breaker carriage as well as one no. Fuse puller.

4.9 Painting

Metal parts of all equipment shall be painted adopting approved painting procedure. Two coats of finished paint of specified colour shade shall be supplied.

5.0 INSTALLATION

The LT Switchboard, outdoor distributors shall be installed at location shown on the drawing. The concrete pedestal shall be constructed as part of civil works. The Contractor shall ensure co-ordination with the civil works for providing any openings, holes, etc to avoid any breakage to completed works. In case the provisions in civil works for installation of electrical equipment are not made or made incorrect the same shall be rectified by the Contractor at his own cost and to the satisfaction of Engineer. The Contractor shall provide foundation bolts and grout them in cement concrete floor using non-shrinkable material with the approval of Engineer.

All installation materials for physically erecting the switchboard, such as bolts, nuts, washers, supporting steel, etc., shall be provided and installed by the Contractor. The switchboard shall be installed upright and in level and shall be firmly and rigidly bolted to the floor and concrete supports.

The switchboard shall be completely erected as per manufacturer's instructions and as approved by the Engineer. Loose parts dispatched by the manufacturer shall be installed and connected as per assembly drawing provided by the manufacturer. Any safety locking of meter, relays, etc., provided by the manufacturer for safe transport shall be released only after the switchboard is erected in position. The incoming and outgoing cables shall be connected as recommended by cable manufacturer. The cable armour shall be connected effectively to ground.

The switchboard body shall be connected to earth as per instructions given in section "Earthing" of these Specifications. The switchboard shall be tested and commissioned in the presence of the Engineer.

The L.T. switchboard, outdoor distributors shall be tested before energizing as per instructions contained in article "Testing" of General Specifications for Electrical Works, Section-16 of these Specifications.

SECTION – 16.5: LT DISTRIBUTION BOARDS

1.0 SCOPE OF WORK

The work under this section consists of manufacturing, fabricating, supplying, installing, testing, and commissioning of all material and services of the complete Low Tension (LT) Distribution Boards as specified herein, shown on the Tender Drawings and stated in the Bill of Quantities.

The Contractor shall discuss the electrical layout with the Engineer and co-ordinate at site with other services for exact location and position of the each L.T. Distribution Board.

The Low Tension Distribution Board with accessories shall also comply with the General specifications for Electrical Works, section - 16 and with other relevant provisions of the Tender Document.

2.0 GENERAL

The Low Tension Distribution Board (DB) shall be sheet steel fabricated suitable for surface/recessed mounting on wall or floor standing totally enclosed, dust and damp proof. It shall be complete in all respect with material and accessories, factory assembled, type tested as per IEC 60439-3, and finished according to the Specifications and to the normal requirements.

The Low Tension Distribution Board shall be front operation type and shall:

a. have a rated service short circuit breaking capacity, Ics, of 15kA at 400 V AC rating to IEC 947-2 unless stated otherwise on the drawings / in the BOQ.
b. be suitable for 400 Volts, 3 phase 4 wire, 50 Hz system.
c. be designed for flush mounting of all instruments on the front side.
d. have incoming and outgoing cable termination arrangement, terminal block/line up terminals.
e. be provided with stainless steel name plate on the front side of door and wiring diagram on inside of door.
f. have all incoming and outgoing connections from top or bottom according to site requirements.
g. have door grounded by flexible copper strip/cable.
h. have wiring diagram in the pocket inside the door of Distribution Board.
i. have index of protection IP31 as per IEC 60529.

3.0 APPLICABLE STANDARDS/CODES

The latest editions of the following standards and codes shall be applicable for the materials specified within the scope for this section:

IEC 51	-	Direct setting electrical measuring instruments
IEC 73	-	Colours for indicator lights and push buttons
IEC 947-2	-	Low voltage switchgear and control gear
IEC 439-1	-	Low Voltage Switchgear and Controlgear Assemblies.
IEC 60529	-	Degrees of protection provided by enclosures (IP Code).
BS 3871	-	Miniature & Moulded Case Circuit Breakers
BS 88	-	HRC fuses
BS 89/90	-	Ammeters and Voltmeters

BS 3938 - Low voltage current transformers
BS 1432 - Bus Bars

4.0 MATERIAL

4.1 Sheet Metal Work

The Low Tension Distribution Board (DB) shall be fabricated with zinc coated metal sheet 1.2mm, without any welding points and painted in polar white colour, recessed / surface mounted with adjustable pan assembly and as approved by the Engineer. All the components shall be installed on a common component mounting plate inside the enclosure and protected from the front with screwed sheet steel front plate. The enclosure shall be provided with rubber gasketting and a lockable hinged door with cam fastener. The top and bottom removable gland plates should be provided.

The distribution board shall be supplied complete with all installation materials as recommended by the manufacturer. The incoming and outgoing cable connections shall be according to the wiring requirements. If required, an adapter box for accommodating the cables and conduits may be provided. The box shall be of the same material and finish as the DB. All holes, cutout etc. shall be tool or jib manufactured and free from burrs and rough edges. Earth and neutral terminal holes shall be equal to number of outgoing devices.

The cabling inside the DB shall be suitably harnessed by means of straps or cords. An earth bar shall be provided for connection of incoming and outgoing earth conductors. The earth bar shall be permanently connected to the body of DB at two points. Flexible copper strip shall be provided for earthing of the door of DB.

Circuit numbers/ designation on all circuits shall be conspicuously marked to facilitate connection and maintenance.

4.2 Components

The Low Tension Distribution Boards (DB) shall be provided with components as specified, as shown on the Tender Drawings and required for the satisfactory operation of the distribution board and of the electrical system.

Typical component specifications are given below:

4.2.1 Bus Bars

The Bus bars shall be made of 99.9% pure high conductivity electrolytic copper and shall be completely isolated and mechanically braced for the specified fault level. The identification of bus bars shall be by providing colour sleeves on bus bar ends and these shall be red, yellow and blue for phases and black for neutral. The earth bus bar shall be green.

The bus bars shall be for three phase, neutral and earth and shall be of appropriate size to meet the electrical and mechanical requirements of the system. The temperature rise shall not exceed $45^{o}C$ at rated current.

The neutral bus bar shall be available in both sides and completely shrouded.

4.2.2 Moulded Case Circuit Breaker (MCCB)

The MCCBs shall be moulded case triple pole 400 Volts or single pole 230 Volts of current ratings as shown on the drawings. These shall have fixed magnetic short circuit and adjustable/fixed thermal overload protection.

The MCCBs shall be installed such that their switching levers are accessible through the front plate for operation.

The single and triple pole MCCBs shall have short circuit rupturing capacity suitable for the distribution system as approved by the Engineer or as shown on the drawings. The MCCBs shall be suitable for working on lighting and power circuits.

4.2.3 Ammeters and Voltmeters

All meters shall be flush mounting, moving iron, spring controlled. The front dimensions shall be 96 x 96 mm for meters.

The meters shall be of accuracy class 1.5 according to BS-89 and 90. The ammeter shall be suitable for connection to 5 Amps secondary of current transformers or directly through shunt as shown on drawings. The ammeters and voltmeters shall have measuring range as indicated on the drawings.

4.2.4 Current Transformers

Air cooled, ring type current transformers shall be provided having transformation ratio as indicated on the drawings. The current transformers shall be of suitable burden having accuracy class 1.0 according to BS 3938. The current transformers shall have 5 amps secondary.

4.2.5 Selector Switch

The voltmeter selector switch shall be complete with front plate, grip handle, and RY-YB-BR-RN-YN-BN and OFF position.

4.2.6 Air Break Contactors

The contactor shall be air break, triple pole, 400 Volts. Each contactor shall be provided with a 230 Volt operating coil, one 6 Watt, 230 Volt red coloured signaling lamp, control fuse and two normally open and two normally closed type auxiliary contacts wired up to terminals for electrical interlocking.

4.2.7 Push Buttons

Push Button shall be momentary contact type and suitable for flush mounting on the door of panel and on remote area. The push button for ON and OFF witching shall be spring loaded.

4.2.8 Indicating Lamps

Indicating lamps shall be suitable for flush mounting, complete with base and 230 Volts incandescent lamp. It shall have rosettes of suitable colours as approved by the Engineer.

5.0 INSTALLATION

The location of low tension distribution boards (DB) are shown diagrammatically on the drawings. The actual location shall be determined at site, keeping in view the site conditions and in co-ordination with other equipment, as approved by the Engineer.

Low tension distribution board for recessed mounting in wall shall be installed such that the door shall finish flush with the surface of wall. The recess mounted distribution board shall be installed before the plastering of walls. The DB shall be protected to avoid any damage due to the civil work.

All loose parts dispatched separately with the DB shall be installed as per manufacturer instructions and all adjustments or setting shall be made as required. All screws, nuts and bolts used for fixing the distribution board shall be galvanized.

The distribution board’s installation shall include connecting all incoming and outgoing cables. The cable entry in the boards shall be provided from top or bottom as required.

The distribution boards shall be tested as per instructions contained in article "Testing" of General Specifications for Electrical Works, Section-16 of these Specifications.

SECTION – 16.6: MOTOR CONTROL CENTRES

1.0 SCOPE OF WORK

The work under this Section consists of supplying, installing, testing, connecting, commissioning of all material and services of the complete Motor Control Centres as specified herein or stated on the Tender Drawings and in the Bill of Quantities.

The Contractor shall discuss the electrical layout with the Engineer and co-ordinate at Site with other services for exact route, location and position of the electrical lines and equipment.

The Motor Control Centres (MCCs) with accessories shall also comply with the General Specifications for Electrical Works, Section - 16 and with other relevant provisions of the Tender Documents.

2.0 GENERAL

The Motor Control Centres (MCCs) shall be of sheet steel fabricated, floor mounting, cubicle type, form-4 category, totally enclosed, dust tight, water and vermin proof, and shall have protection class IP-54. These shall be complete in all respect with material and accessories, factory assembled, type tested and finished all according to the specifications and to the normal requirements. All wiring and equipment for control, protection, indication, etc. required for the safe and intended operation of the systems as specified herein or shown on the drawings shall be furnished by the Contractor.

The Motor Control Centres with all components and accessories shall be suitable for front operation only and shall:

a. have a rated service short circuit breaking capacity, Ics of 70 kA at 400 V or conforming to IEC 947-2 unless stated otherwise on the drawings.
b. be suitable for 400/230 volts, 3 phase, 4 wire, 50 Hz system.
c. be provided with adequate clearance from live parts so that flashovers cannot be caused by switching, vermin, pests, etc.
d. have incoming and outgoing cable termination arrangement, terminal blocks, line-up terminals, etc.
e. be provided with steel nameplate on the front side of door and wiring diagram on inside of door.
f. have all components rated for insulation class of 600-volt minimum.
g. be designed for flush mounting of all instruments on the front side.
h. have all incoming and outgoing connections from the top or bottom as per site requirements.
i. have the components mounted so as to facilitate ease of maintenance from the front.
j. have common lamp test facility for all lamps.
k. have the SCADA functionality.

Wherever Motor Control Centres is specified on the drawings/BOQ, they shall also comply with the following requirements:

a. All circuit breakers shall be as shown on the drawing. Where two or more feeders are contained in the same cubicle, they are to be separated by barriers of steel or fire resistant insulating material. If required, the metal surface of the cubicle shall

be protected by fire resistant insulating material. Each panel shall combine in tier form all respective components with their incoming and outgoing power feeders.

b. The draw out switching units shall be mounted on trucks or slide-in chassis having adequate guidance by greased sliding rails and/ or rollers. They shall be connected to the busbars by means of a self-aligning plug and socket arrangement and complete isolation of each circuit shall be attained by drawing out the switching unit.

c. The main contacts shall have shutters, which automatically close upon withdrawal of switchgear unit. The withdrawal of circuit breaker shall be accomplished by means of a crank, with as little effort as possible.

d. The contact surfaces of the plugs and sockets shall be silver-plated. The contacts shall be amply sized and sufficiently strong to withstand maximum prevailing short circuits and carry continuously their normal rated currents without damage or overheating of any kind.

e. Also, the control circuits shall be provided with plugs and sockets.

f. The withdrawable units shall have clearly marked service, test and isolated (ready for complete withdrawal) positions. A mechanical interlock is to be provided to prevent withdrawal of the unit unless the power circuit has been interrupted. The unit shall, furthermore, positively be locked in the test position before it is manually released for complete withdrawal.

3.0 APPLICABLE STANDARDS/CODES

The latest editions of the following standards and codes shall be applicable for the materials specified within the scope of this Section:

BS	3871	-	Miniature and Moulded Case Circuit Breaker
IEC	947-2	-	Low Voltage Switchgear and Control gear.
IEC	439-1	-	Low Voltage Switchgear & Control gear Assemblies.
IEC	292	-	Low Voltage Motor Starter.
BS	88	-	HRC Fuses.
BS	89/90	-	Ammeters and Voltmeters.
IEC	73	-	Colours for indicator lights and push buttons.
IEC	70	-	Power Capacitors.
BS	3938	-	Low Voltage Current Transformers
BS	1432	-	Bus Bars

4.0 MATERIAL

4.1 Sheet Metal Work

The Motor Control Centre shall be fabricated, welded, grinded, finished with angle-iron framework and cladded with 14 SWG MS sheet. It shall be suitably divided into panels and compartments for accommodating the required number of circuit components, instruments and accessories.

The Motor Control Centre shall be supplied complete with foundation bolts and other installation materials as recommended by the manufacturer. Proper size cable clamping channels with galvanized steel clamps and brass cable glands respectively for unarmoured and armoured cables shall be provided. All holes, cutout shall be tool or jib manufactured and free from burrs and rough edges. An earth bar of appropriate cross section shall be provided and connected to the bodies of all sections of the Motor Control Centre. Two external earth terminals shall be provided for main earth connection to the body of switchboard. The doors shall be earthed by means of flexible copper strip**.** Means shall be provided to limit the opening angle of doors to about 100^0.

The cabling inside the Motor Control Centre shall be suitably numbered and harnessed by means of straps or cords. Wiring to door mounted components shall be in flexible PVC conduit. All indicating, selecting and control equipment shall be suitably arranged and clearly labelled by means of flame proof material using indelible ink/marking indicating the rating of fuse, switches, etc. The nameplates provided on the front of panel shall be of flame retardant material preferably stainless steel. Use of plastic or any inflammable material shall not be permitted for nameplates.

All metalwork of the Motor Control Centre shall be cleaned down to bare shining metal phosphated and the surfaces chemically prepared for powder coating. Then these shall be coated with powder of colour RAL 7032 and then baked in oven. The thickness of powder coating shall not be less than 100 microns.

4.2 Components

The Motor Control Centres shall be provided with all components as specified herein, shown on the Tender Drawings and necessary for the satisfactory operation of the system. In general, the various components installed in MCC's shall be as specified in Section-16.4 "LT Switchboards" of these Specifications. The specifications of other components not furnished in Section - 16.4 are given below:

4.2.1 Bus Bars

The bus bars shall be made of high conductivity electrolytic copper and shall be completely isolated and mechanically braced for the specified fault level. The phase identification of bus bars shall be by providing colours sleeves on bus bars ends and these shall be red, yellow and blue for phase and black for neutral. The earth bus bar shall be green.

The bus bars shall be triple pole, neutral & earth and shall be of appropriate size to meet the electrical and mechanical requirements of the system. The temperature rise shall not exceed 45 degree centigrade at rated current.

Neutral bus bar shall be of the same cross section as phase bus bars. Earth bus bar shall be of half cross section area as phase bus bars.

4.2.2 Moulded Case Circuit Breakers (MCCB)

1.	Type	:	Air break
2.	No. of poles	:	3
3.	Utilization category	:	A
4.	Rated ultimate short circuit breaking capacity	:	70 kA / 50kA(min)

5.	Rated service short circuit breaking:		-
6.	capacity	:	SCADA compatibility
	Communication		
7	Protection functions to be provided in: release		Yes, with options for both inverse time and Definite time
	a) Over current	:	Yes, inverse-time type
	b) Short circuit	:	Yes, with options for both inverse time and definite time
	c) Earth fault	:	Yes, with options for both inverse time and definite time
	d) Under voltage release with independently adjustable voltage range and	:	Preferable
	time setting range	:	220 V AC
	e) Motor Mechanism, if indicated in the Main Single Line Diagram		

4.2.3 Motor Protection Circuit Breakers (MPCB)

1.	Type	:	Thermal magnetic break
2.	No. of poles	:	3
3.	Utilization category	:	A
4.	Rated ultimate short circuit breaking capacity	:	70 kA / 50 kA(min)
5.	Rated service short circuit breaking	:	-
6.	capacity	:	SCADA compatibility
	Communication		
7	Protection functions to be provided in release	:	Yes, with options for both inverse time and definite time
	a) Over current	:	Yes, inverse-time type
	b) Short circuit	:	Yes, with options for both inverse time and definite time
	c) Phase-failure	:	Yes, with options for both inverse time and definite time
	d) Under voltage release with independently adjustable voltage range and time setting range	:	Preferable
8.	Auxiliary contacts	:	1 NO + 2 NC

4.2.4 Motor Management Starter Combination Unit (MMS)

Motor Management Starter Combination Unit with two integrated functions in one unit (contactor and electronic trip against thermal overload) shall be installed for full voltage direct-on-line (DOL) starting of the motor. Necessary protection is provided by the motor protection breakers. The operating coil shall be rated for 230 volts AC, 50 Hz.

1.	Conforming to standards	:	IEC/EN 60947-6-2, CSA C22-2 N°14, Type E
2.	No. of Poles	:	UL 508 type E: with phase barrier LU9 SP0
3.	Rated Insulation voltage	:	3 690V
4.	Rated ultimate short circuit breaking capacity	:	70 kA / 50 kA(min)
5.	Rated service short circuit breaking	:	-
6.	capacity Degree of Protection	:	IP 40
7	Protection functions to be provided in release	:	Yes, with options for both inverse time and definite time
	a) Over current	:	Yes, inverse-time type
	b) Short circuit	:	Yes, with options for both inverse time and definite time
	c) Phase-failure	:	Yes, with options for both inverse time and definite time
	d) Under voltage release with independently adjustable voltage range and time setting range	:	Preferable
8.	Auxiliary contacts	:	1 NO + 2 NC
9.	Control Voltage	:	24V DC
10.	Communication	:	SCADA compatibility

4.2.5 Soft Starters

Soft starters shall be installed for controlled starting of high rating motors. They shall consist of one line contactor and one by-pass contactor (if the motor rating is above 30kW then it is recommended to use the bypass contactor for long life of Soft starter).

The contactor shall be suitable for utilization category AC-53a and 1 million switching operations and duty cycle of 20 switching per hour. The main contacts shall be silver tipped, but type with double break per pole. Adequate provision for cooling of the connectors during switching shall be provided. The coil voltage shall be 230 Volts AC., 50 Hz. At least two normally open/normally closed auxiliary contacts shall be provided with the contractor.

The time-delay shall be by means of mechanical timers with motor drive, climate proof and shall be of delayed pick-up design, having same utilization category as the contactor.

The Soft starter shall be designed for automatic operation of the system in conjunction with level transmitter, float switches, pressure switches, etc. Manual operation will be selector switch. The starter is also to have auxiliary contacts and phase failure protection

Provision shall be provided for remote indication and controlling through SCADA.

4.2.6 Auxiliary Relays

The auxiliary relays used for control purposes shall generally by provided with operating coil voltage rating 230 volts AC, 50 Hz. The auxiliary relays shall have

appropriate number of pins/contacts as required for normal operation of the system. Similar type and make of auxiliary relays shall be used for all MCCs and LT Switchboards for ease of maintenance and replacement. Use of different types and makes shall be avoided as much as possible.

4.2.7 Switch - Fuse Units

The switch-fuse unit shall comprise a triple pole on load isolating switch with HRC fuses. The fuse shall be supplied complete with the fuse base and shall conform to BS-88 Class Q1 with a fusing factor of 1.5.

4.2.8 Ammeters and Voltmeters

All meters shall be flush mounting, moving iron, spring controlled. The front dimensions shall be 96 x 96 mm for meters.

The meters shall be of accuracy class 1.5 according to BS-89 and 90. The ammeter shall be suitable for connection to 5 Amps secondary of current transformers or directly through shunt as shown on drawings. The ammeters and voltmeters shall have measuring range as indicated on the drawings.

4.2.9 Current Transformers

Air-cooled, ring type current transformers shall be provided having transformation ratio as indicated on the drawings. The current transformers shall be of suitable burden having accuracy class 1.0 according to BS 3938. The current transformers shall have 5 amps secondary.

4.2.10 Air Break Contactors

The contactors shall be air break, triple pole 400 VAC type and suitable for the type of duty to be performed. The main contacts shall be silver tipped, butt type with double break per pole. Each contactor shall be provided with single phase 230 VAC operating coil and minimum one spare normally open and one normally closed auxiliary contact. The number of working auxiliary contacts shall be provided according to the system requirements.

4.2.11 Push Buttons

The push buttons shall be momentary make/break contact type (normally open/normally close) and suitable for flush mounting. The push button for on and off switching shall be red and green respectively.

4.2.12 HRC Fuses

HRC fuses shall be provided complete with fuse bases, fuse etc. The fuses shall have a fusing factor as specified for class Q1 in accordance with BS 88.

4.2.13 Indicating Lamps

Indicating lamps shall be suitable for flush mounting, complete with base, 230 volt AC/60V DC incandescent lamp and shall have rosettes of suitable colour. It shall be possible to replace the lamp from without opening the compartment door.

Breaker modules shall be provided with ON, OFF, AUTOTRIP indications. Incomer modules shall be provided with R, Y, B phase indication lamps.

The colours of indication lamps for various applications shall be as follows:

a)	ON, OPEN/CLOSE, FORWARD / REVERSE etc.	:	Red
b)	OFF	:	Green
c)	TRIP	:	Amber

Each indication lamp shall be provided with an escutcheon plate indicating its function.

4.2.14 Line up Terminals

Line up terminals wherever provided for control or power circuits shall be suitable for voltage and size of conductors as indicated on drawing.

The line-up terminals for controls shall be suitable for channel mounting. All necessary accessories such as end plates, fixing clips, transparent label holder caps and label sheets with marking shall be provided.

4.2.15 Programme Selector Switches

Programme selector switches shall be rotary or cam type, 2-position, 2-pole and 3-position, 3-pole as required, complete with knob and front plate with position indication.

4.2.16 Operation Hour Counters

Operation hour counters shall be provided with each pump motor. These shall be suitable for front panel mounting and operation on 230 volts AC, 50 Hz.

4.2.17 Alarm Hooter

Alarm hooter shall be suitable for operation on 230 volts AC, 50 Hz, and be of such loudness level appropriate for a control room. The hooter shall be mounted on top of the floor mounted MCCs or outside the control room at a suitable location as approved by the Engineer. All necessary wiring and conduiting for alarm hooter shall be carried out by the Contractor and its cost deemed to have been included in the cost of MCCs.

4.3 CONTROL SYSTEM HMI (Human Machine Interface)

4.3.1 HMI Requirement

HMI should have real time graphical representation, alarms, alarm history, trends, database, etc as described below

4.3.2 Graphical Representation

Graphics should represent the real time behavior of the plant using color and object animation. It should be user friendly (i.e. SLD for Electrical System, PFD for Process Flow Diagram, etc). Proper colors scheme and symbols should be used according to application. Analogue variables show their behavior along with values.

4.3.3 User Rights

Multiple users can work according to their rights; administrator can manage the right of users.

4.3.4 Control

Devices can be controlled using graphical buttons with warnings and accessible to authorized persons only.

4.3.5 Alarms

Real time alarms should be available in all windows / mimics or Pop-up in order to alert operator for disorder. Object related to alarm should blink until alarm is acknowledged. After acknowledgement object should show alarm condition until reset. It shows recent alarms only. Alarm History of at least last 100 alarms should be available separately.

Only authorized persons can acknowledge / reset alarm.

4.3.6 Trends

Real time trends with single or multiple variable can be viewed with reference to linear or exponential time. Different variables can be distinguished by the color. Trends could be print, pause, zoom, etc.

4.3.7 Historical Trends

Trends of at least last 7 days can be viewed using historical trend function, so that previous data can be access anytime.

4.3.8 HMI (Touch Screen) Requirement

HMI should be a colored touch screen with graphical views. It should represent real time graphical representation, with atleast 800x600 Pixels (i.e 12” size). Recent alarms should pop-up and authorized persons can acknowledge alarm. History of alarm should be available. Real time trends can be view. Only authorized persons can send command. The HMI must have atleast 32MB built-in memory, and can be extended as per requirement.

4.3.9 Log Window

Data logging of actions and reaction, also logging of exceeding the thresholds values, such as increase or decrease in PH, tank level, etc.

4.3.10 Database

Database in spread sheet and tabular format should be available for further usage.

4.3.11 I/O Tags

All inputs of PLC should be displayed in the HMI, hence I/O Tags must be must be 20% greater than that of physical inputs for future enhancement

4.3.12 Hardware & Software Requirement:

The HMI software can work on Windows XP SP2, with minimium Hardware requirement as follow.
Processor - Pentium 1 GHz or equivalent.
Memory - 512 Mbytes
Hard disk space - 200 MBytes.
CD ROM - Required for installation only.

4.4 Internal Wiring and Ferrules

Wiring inside the cubicles shall be carried out using 1100/ 650 V grade, PVC insulated, stranded, single core conductor wires. For power circuits, the minimum size shall be 4 sq.mm copper. For control circuits the minimum size shall be 1.5 sq.mm copper; for CT circuits the minimum size shall be 2.5 sq.mm copper.

Spare auxiliary contacts shall be wired up to the terminal block.

Not more than two connections shall be made at any one terminal.

Wires for interpanel wiring shall be taken through the bottom most tier of the switchgear, which shall be kept vacant for this purpose.

All metal cutouts provided for facilitating wiring shall be pushed.

Each wire shall be identified at both sides by ferrules. Ferrules shall be of interlocking type of yellow colour with black engraved lettering. Equipotential ferrules shall carry the same identification number.

4.5 Terminal Blocks

Terminal blocks shall be 650V grade, of non-hygroscopic, non-tracking moulded plastic type. Terminal blocks shall be segregated based on the circuit voltage. Individual terminals shall be numbered with engraved black-on-white labels. Where it is necessary to duplicate terminals, same shall be done with solid links.

Power terminals shall be stud type with phase separation barriers control terminals shall be rated for 10A min. and they shall be suitable for 2.5 sq.mm conductor. At least 20% spare control terminals shall be provided in each block.

Terminals for CT secondary leads shall be provided with shorting and disconnecting / earthing facilities and shall be similar to CATD M4 design of Elmex.

Power and control terminals shall be shrouded. It shall be possible to carry out work on any module separately without coming into accidental contact with the immediately located modules.

4.6 Labeling and Name Plates

Labels shall be provided for each component of each module of the switchgear. These shall be white engraved on block, PVC type. Paper labels are not acceptable. Labeling shall be done as per approved scheme drawings.

Nameplates shall be provided for each feeder each vertical and for the switchgear as a whole. These shall be of anodised aluminium with engraved lettering on a black background.

In addition, danger plates shall be provided for each switchboard. In case of single front switchgear, the rear side of each panel shall be marked with the panel number.

4.7 Cable Termination Accessories

Undrilled G.I gland plates of minimum 3 mm thickness and double compression type brass glands shall be provided for termination of cables. The gland plates shall have gaskets. Required number of tinned, crimping type copper lugs shall be provided. Provision for terminating ½ core on to earth bus and neutral bus shall be made.

4.8 Earthing

Two earth terminals shall be provided on each cubicle, at back. An earth bar of specified cross section shall be fixed to the terminals. The earth bar shall be electrically continuous and shall run the full extent of each board. Terminals shall be provided for external earth connections. One separate green earth conductor shall earth all relay and meter bodies.

4.9 Special Tools

A set of special tools required for the normal operation and maintenance shall be supplied with each switchboard. The tenderer shall include along with each switchboard one height adjustable circuit breaker trolley for removal and replacement of the withdrawable circuit breaker carriage as well as one no. Fuse puller.

4.10 Painting

Metal parts of all equipment shall be painted adopting approved painting procedure. Two coats of finished paint of specified colour shade shall be supplied.

5.0 INSTALLATION AND TESTING

The motor control centers shall be installed at locations shown on the drawings and approved by the Engineer. The installation shall be carried out as specified in Sections-16.4 and 16.5 for LT Switchboards and Distribution Boards of these Specifications.

The control system shall be installed as per manufacturers instructions and recommendations. Loose parts dispatched by the manufacturer shall be installed and connected as per assembly drawing of the manufacturer. The level transmitter, float switch, pressure switch, etc. shall be properly aligned and adjusted to operate at the required levels or pressure values. After installation, the equipment shall be sequentially tested to confirm that the switching of the pumps is effective at the specified levels in the tanks or pressure values. The tests shall be carried out in the presence of the Engineer and to his entire satisfaction.

No separate payment for supplying, installing the control cables for the complete system and testing and commissioning of the entire system is admissible and is deemed to have been included in the BOQ rates for the motor control centers.

SECTION – 16.7: LIGHT FIXTURES

1.0 SCOPE OF WORK

The work under this section consists of supplying, installing, testing and commissioning of all material and accessories of the complete Light fixtures as specified herein and/or shown on the drawings and given in the Bill of Quantities.

The Contractor shall discuss the electrical layout with the Engineer and co-ordinate at Site with other services for exact locations and positions of the light fixtures.

The lighting fixtures with accessories shall also comply with the General Specifications for Electrical Works, Section-16 and with other relevant provisions of the Tender Document.

2.0 GENERAL

The description of light fixtures is given in the bill of quantities, and stated on the drawings, and all relevant material is described in this Section. The determination of quality is based on certified photometric data covering the coefficient of utilization, light distribution curves, construction material, shape, finish, operation, etc.

The Contractor shall submit the samples of each and every light fixture specified and obtain approval of the Engineer before purchasing. The quality and finishes of the local make light fixtures (if mentioned in BOQ) shall be same as that of standard manufacturer. The accessories such as ballast, lamp/starter holders, starters, lamps, ignitors, etc. for all type of light fixtures shall be of Philips make or approved equivalent. Approved equivalent against those specified will be accepted if the specified one is/will not be available. For any substitution the Engineer's approval is necessary.

All fixtures shall be finished in standard color schemes as mentioned in the manufacturer's catalogue for respective fixtures, unless specifically stated in the Specifications, Drawings or Bill of Quantities or directed by the Engineer.

3.0 APPLICABLE STANDARDS/CODES

The latest editions of the following standards/codes shall be applicable to the material specified within the scope of this section:

IEC 81 & BS 1853	-	Tubular fluorescent lamps
IEC 82 & BS 2818	-	Ballast for tubular fluorescent lamps
IEC 155 & BS 3772	-	Starters for fluorescent lamps
IEC 400	-	Lamp holders and starter holders for fluorescent lamps
IEC 1048, 1049	-	Capacitors for use in TL, HP Mercury and LP Sodium Vapour Lamps.
BS 3677/3767/4017	-	Discharge Lamp Circuits
IEC 922/923	-	Luminaires
BS 5266	-	Emergency Lighting
BS 2560	-	Exit Signs

4.0 MATERIAL

4.1 Fluorescent Light Fixtures

The fluorescent light fixtures shall have lamps and ballasts of proper rating as shown on the drawings. Each lamp shall be provided with independent ballast.

The fluorescent lamps shall be tubular, 1214/604mm long, 28-mm. dia. for 36/18 watts respectively as specified. The fluorescent shall be cool white, with colour rendering and light colour of 840 characteristics with an average output of 3350 lumens (± 5%) for 36 watts and 1350 lumens (±5%) for 18 watts after 100 burning hours. The ballast shall be 'Low Loss' polyester filled type, totally enclosed and suitable to operate upto 250 VAC. The power loss shall not be more than 6 watts for 36/18 watts ballast. A wiring diagram, wattage, voltage and current figures shall be printed on the body of the ballast.

Flicker free, warm start, electronic regulated ballasts for high switching frequency shall be used for fluorescent lamp luminaires of the control tower complete with dimming facility to attain variable Lux level.

The lamp holders shall be rotary lock-in type. The starters shall be glow type with radio interference suppressor/by-pass capacitor. The internal wiring of the fluorescent light fixtures shall be done with heat resistant wires at the manufacturer's factory. The internal wiring shall be clipped properly and heat resistant sleeves be provided on cables passing near ballasts. All light fixtures shall be provided with power factor improvement capacitor to give a minimum power factor of 0.90. Connectors suitable for connecting 2.5 sq.mm cable conductors shall be provided for supply connections. An earth terminal for connection to 2.5-sq.mm cable conductor shall be provided.

The body of the fluorescent light fixtures shall be minimum 24 SWG sheet steel, derusted, degreased, finished in heat resistant paint, stove enameled. Appropriate size bushed wire entry holes, fixing holes, and earth terminal shall be provided.

The light fixtures shall be furnished with Perspex diffusing panels "040 opal acrylic" (minimum sheet thickness 3mm), polystrene louvers or metal grid louvers or mirror optic reflectors, etc. as specified on the drawings or in BOQ. The louvers shall be secured firmly and in level. The louvers shall be in one section and not in pieces.

The design of light fixture for recess mounting shall be coordinated with the design of false ceiling prior to commencement of manufacture. Shop drawings shall be submitted for approval of Engineer.

IP degree of protection shall comply with the requirements laid down in section 16. Standard luminaires with manufacturer's recommended modifications, such as, additional gasket, etc. shall be provided to attain required protection level**.**

4.2 Incandescent / Incandescent reflector/ compact fluorescent Light Fixtures

The incandescent/incandescent reflector/compact fluorescent light fixtures shall be as stated on drawings and bill of quantities. The light fixture shall be finished in standard colours unless otherwise stated on drawings or directed by Engineer. All incandescent/incandescent reflector/compact fluorescent light fixtures shall be of international standard and quality. The types of fixtures with manufacturer's catalogue reference are given on the fixture schedule and in bill of quantities.

Equivalent fixture may be acceptable provided that the contractor submits for review all necessary data indicating photometric curves to show that the fixture proposed are of the same type, construction and quality.

The lamps for incandescent/incandescent reflector/compact fluorescent light fixtures shall be GLS lamps or incandescent reflector (PAR) or compact fluorescent lamp with normal or electronic control gear and shall be supplied and installed according to the wattage/type as indicated on drawings.

Weatherproof bulkhead incandescent/compact fluorescent light fixture shall comprise of plastic body and gasketted clear glass cover secured to the body by means of wing nuts/screws to give a weatherproof and watertight fit. The gasket shall be weather resistance type. The lamp holder shall be of bi-pin brass having porcelain outer ring or 2/4-pin base for compact fluorescent lamps with normal control gear as per requirements.

The glass shade of the light fixtures shall be opal white or clear as furnished by the manufacturer with the light fixture unless specified and free from any air bubbles or voids. The shade may be spherical, cylindrical, flattened bottom or any other shape as specified in the drawings or BOQ.

4.3 High / Low Bay Light Fixture

The industrial type mercury light fixture shall consist of circular reflector of anodized aluminum providing bare lamp cut-off at an angle of 62^{o} to the vertical, glass cover and gasket. The reflector shall have aluminium canopy having ¾" (19mm) threaded hole for fixing on the bracket. The lamp holder shall be of porcelain and wired to the mains terminals with heat resistant wires. The fixture shall be provided with mercury vapour lamp of 400 or 250 watts, with appropriately rated ballast, power factor correction capacitor and have terminals provided for connecting to minimum size of 4 sq.mm single core wires. The ballast to be housed in the choke box provided integral with the fixture.

4.4 Flood Light Lanterns

Outdoor lanterns for road and parking shall be suitable for post top and as bracket mounting. The lanterns shall be installed on light poles with construction height of 20 m, 15 m and 12 m in single and multiple arrangements.

The passenger parking area illumination shall be carried out by means of 20 metres high light columns. While light poles 15 and 12 metres shall be used for road lighting.

4 lanterns each with 1 x 600 Watts high-pressure sodium vapour lamps shall be used for illumination of passenger parking area while 1x400 Watts and 1x250 Watts high-pressure sodium vapour lamp shall be used for road lighting.

Outdoor illumination shall be carried out by means of photoelectric cell units.

All lanterns shall belong to protection class II in accordance with the VDE 0710 regulations. Type of protection shall be IP65.

The housing shall be of weather resistant grey coloured aluminium alloy sheet, deep drawn, resistant to industrial and corrosive atmosphere. The housing shall be weather resistant finish, grey stove enameled. Post inserts shall be manufactured of cast aluminium.

All lanterns shall be equipped with a post – insert – system and shall be suitable for post top or bracket mounting. A flap in the post insert bearing swivels and seals either the post top or side entry spigots.

The optical system shall be manufactured of high gloss anodized pure aluminum polished and re-anodized. The lanterns shall provide high efficiencies with good uniformity of illumination and glare limitation. It shall be possible by altering the mirror position to spread the light distribution for wide or curved roads uniformly and with good efficiency.

The lanterns shall be shielded in such a way that glare is limited for car drivers. Prismatic bowls only shall be used. The bowls shall be manufactured from impact proof heat resistant polycarbonate and shall be hinged and detachable. At both sides of the bowl bent lever locks shall be provided to allow opening and hinging without tools in both directions.

All lanterns shall be equipped with a built-in terminal block, control gears, power switch units and power factor correction capacitor. Cable supports with cable protection tongue for protection to the cables shall also be provided in the lamp compartment. The connection compartment shall be closed by hinge able cover.

5.0 LIGHT FIXTURE INSTALLATION

5.1 General

The mounting heights of light fixtures are indicated on the drawings, and positions of fixtures are according to the mentioned scale.

The Contractor must ensure that the light fixtures are installed uniformly with respect to the dimensions of the area. Any modifications due to site conditions may be made with the approval of Engineer. All fixtures shall be carefully aligned before fixing in position.

The wiring between ceiling rose or terminal box and the fixture shall be carried out with 3-core 1.0 sq.mm and 1.5-sq.mm flexible copper conductor PVC/PVC cable respectively for circuits protected by 10 amps and 15/20 amps mcbs. The wiring inside light fixture body shall be done with heat resistant cables or PVC insulated cable in heat resistant sleeves as approved by the Engineer.

Glasses, shades, reflectors, diffusers, etc., must be in a clear condition after installation. All light fixtures shall be earthed by an earth wire connected to the earth terminal in the fixture.

5.2 Fluorescent Light Fixtures

The fluorescent light fixtures on the surface of ceiling shall be installed with the back of the body flush with the ceiling surface, and in a manner so as to facilitate wiring. Nylon plugs and galvanized steel bolts or screws shall be used for fixing the light fixture to the ceiling. For light fixtures installation on false ceiling the installation method/detail shall be coordinated with ceiling design and submitted for approval of Engineer. Care shall be taken to prevent the weight of the fixture from being transferred to the false ceiling.

Pendant light fixtures shall have two holes in the top of each casing for supporting to the ceiling by a 3/4" dia. galvanized pipe or any other standard method as approved

by the Engineer. Wiring from ceiling rose to the fixture shall be done through the pipe. Proper arrangements such as long threads with check nuts, etc. for minor adjustment in the mounting heights of the fixtures shall also be provided.

5.3 Incandescent/Incandescent reflector/compact fluorescent Light Fixtures

The incandescent/incandescent reflector / compact fluorescent light fixture shall be installed on the surface of ceiling or wall by means of nylon plugs and galvanized steel screws, such that their back finish flush with the surface for exposed conduits and flush with outlet box for concealed conduit system. Wherever convenient, screws for fixing light fixtures shall be screwed into the holes of the outlet box. The lights on false ceiling shall be installed in a manner as described for fluorescent light fixture.

5.4 High / Low Bay Light Fixture

The high/low bay mercury vapour light fixture shall be installed in the roof surface/ trusses. Appropriate size and shape of steel clamps shall be fixing to the truss member for supporting the light fixture, and the light fixture shall be suspended to the required level with a steel rod. Rod length shall vary to keep the fixtures at a uniform level. The wiring between ceiling rose and fixture shall be with three core 1.5 sq.mm. PVC insulated PVC sheathed flexible cable.

5.5 Flood Light Lanterns

Fixing of the lanterns shall be carried out with approved three point fixing. Screws for fixing the lantern to the pole shall be manufactured from stainless steel and be easy to handle even after long duration of use.

SECTION – 16.8: HIGH TENSION CABLES

1.0 SCOPE

The work under this section consists of supplying, installing, testing and commissioning of all material and services of High Tension (HT) cable and accessories as specified herein or as stated on the Tender Drawings and in the Bill of Quantities.

The Contractor shall discuss the electrical layout with the Engineer and co-ordinate at site with other services for exact route, location and position of the H.T. cables.

The HT cable with accessories shall also comply with the General Specifications for Electrical Works Section-16 and with other relevant provisions of the Tender Documents.

2.0 GENERAL

The 15kV cable shall be three core, copper conductor, cross-linked polyethylene (XLPE) insulated, shielded, armoured and overall sheathed. It shall be suitable for indoor and outdoor use in the transmission and distribution of electrical energy.

The cable shall be treated for vermin proofing and be protected against rodents during storage, laying and all protective pipes/ sleeves shall be plugged to attain the same after installation.

3.0 APPLICABLE STANDARD/CODES

The following standards and codes shall be applicable for the materials within the scope of this Section:

IEC 502 - Extruded solid electric insulated power cable for rated voltage from 1 kV to 30 kV.
IEC 540 - Test methods for insulation and sheaths of electric cables and cords.
IEC 228 - For resistance of conductors.
IEC 332-1 - For flame retardant test.
IEC 332-3 - For fire resistant test on fire resistant cables.
IEC 227 - For core identification by colours.

4.0 MATERIAL

4.1 15kV Cable

The cable shall meet the following specifications:

Nominal/System Voltage	-	11 kV
Frequency	-	50 Hz
System	-	3 phase with solidly star point of Conductor Size mm^2 As given in BOQ
Number of Cores	-	3
Rated Voltage	-	15/8.76 kV phase to phase/phase to ground.
Continuous operating temperature of conductor	-	90^oC
Conductor material	-	Copper stranded
Insulation	-	Cross-linked polyethylene (XLPE)

Shielding	-	Copper tape
Jacket	-	PVC
Armouring	-	Galvanized steel wire
Oversheathing	-	Extruded PVC
Phase identification	-	Red, Yellow, Blue

4.1.1 Conductor

The conductors shall be of high conductivity electrolytic copper, stranded in accordance with specified standard.

4.1.2 Insulation

The insulation shall be cross-linked polyethylene extruded over the conductor. The insulation shall be laid to avoid any gap/air pockets between the conductor and insulation. The insulation shall be colour coded red, yellow and blue for phase identification.

The insulation shall be easy strip from individual conductors and to separate for jointing/termination purposes.

4.1.3 Shielding

Each core shall be shielded by a layer of semi-conducting material applied directly over the insulation. The semi-conducting insulation shall be covered by a bare copper tape applied with suitable overlapping.

4.1.4 Assembly

The three insulated conductors shall be assembled with PVC or any non-hydroscopic filler and bounded with tape. The tape binder shall then be covered with extruded PVC jacket. The PVC jacket shall be padded with a suitable material before application of armour.

4.1.5 Armour

Armouring shall be provided with single layer of galvanized steel wire to provide cable protection and also act as a low resistance earth return path. The armouring shall be covered with binder tape. The armour shall be of appropriate size to carry the system fault current.

4.1.6 Oversheath

The entire cable assembly shall be covered with a PVC jacket of thickness not less than 2.5 mm. The colour of the jacket shall be black.

Embossed marking on the oversheath at suitable intervals shall give the following information:

a. name of Manufacturer
b. year of Manufacture
c. size of cable in sq.mm.
d. voltage grade
e. type of cable i.e. Cu./XLPE/SWA/PVC

4.2 Factory Tests

Physical and electrical acceptance tests in accordance with applicable standard shall be carried out at the manufacturer works. Three copies of test reports will be furnished to the Engineer, which shall include brief description of tests, test records and results.

4.3 Termination Kits

Termination kits for 15 kV cable shall be outdoor type recommended by cable manufacturer and as approved by Engineer. The termination kits shall be complete with all materials.

4.4 Cable Reels

The cable shall be supplied in non-returnable, mechanically strong, sea/rail/road worthy, wooden or metallic cable drums, protected against weather. The cable drum should bear the markings for cable type, cable size, voltage grade, year of manufacture, name of manufacturer, direction of unreeling, and any other additional marking normally provided by the manufacturer. Cable ends on cable reels shall be protected by means of suitable seal.

4.5 Cable Markers

Direct burial cables routes shall be marked every 60 meters along/straight the cable runs, at each change of direction of cable, and each cable splice. The cable marker shall be of reinforced concrete of dimensions as shown on the drawing. The cable marker shall have the information impressed upon it on its top surface as shown on drawing. The letters shall not be less than 10 cm. high, 7 cm wide and 1 cm. deep.

5.0 INSTALLATION

5.1 General

All installation material, labour, tools and accessories for cable installation shall be furnished by the Contractor. The cable and accessories shall be installed as described in accordance with the installation instructions given in the Section for Low Tension Cable of these Specifications, drawings and in accordance with manufacturer's instructions.

Necessary precautions for safety of cables shall be taken during the laying of cables to avoid scratches/ cuts to the cable surface. Pulling force on cable at all times shall remain well within the manufacturer's recommended limits.

The exact cut lengths for cable shall be confirmed by the Contractor by actual measurements at site prior to the commencement of manufacturing. The cable lengths where shown on the drawing are tentative and only for general guidance. The Contractor shall be solely responsible for furnishing correct lengths of cable to avoid joints in cable length except where necessary, after obtaining approval of the Engineer.

No separate payment for such joints shall be admissible.

Prior to installation of jointing and termination kits, the cable lengths shall be checked and tested to ensure that the cables are in sound condition, and no damage has

been done during handling and installation. After the H.T cable and jointing/termination kits are installed, it shall again be tested prior to commissioning and in accordance with recommendations of standard to which the cable is manufactured.

5.2 Underground Cables

The cables to be installed directly underground shall be laid in trenches in single tiers. Unless shown specifically on the drawing the depth of cable below finished ground level shall be 900 mm minimum measured from the top of the largest cable to the general ground level. The burial depth may be increased as required due to site conditions or when crossing other service pipes and roads. Burial depth less than 900mm and more than 1500mm shall require Engineer's approval.

When cables cross road, paved area, other services or other cables, they shall be laid in protective pipes of required size. Cables entering the buildings shall also be laid in protective pipes. All the protective pipe ends, after installation of cables, shall be plugged water tight by means of sealant as approved by the Engineer. A minimum clearance of 250mm vertically and 500mm horizontally shall be maintained between cables and other services.

The cable trench shall be excavated as per route and location shown on the drawing. Before laying of cables in the trench, the bed of the trench shall be leveled and filled with a 100mm thick layer of fine sand (1.3mm diameter maximum particles size). The sand layer shall be levelled and the cables placed thereon. The cables shall be covered with a layer of fine sand 100mm thick measured above the top of the largest cable. The cable protective tiles placed above the top of sand cover shall be of class-C cement concrete, minimum 50mm thick and 300mm square. Good quality bricks of proper strength and shape, well formed can also be used for the purpose of protection. The tiles or bricks shall be placed over the sand layer end to end to cover the entire length and breadth of the cable trench. After the concrete tiles/bricks are placed, the remainder of the trench shall be backfilled with earth in layer 300mm thick. Each layer shall be thoroughly tamped and compacted.

A PVC warning tape shall be provided at 300 mm below normal ground level covering the entire length and breadth of the trench. The warning tape shall be yellow in colour with markings of danger and voltage of the cables printed in black.

Cable identification tags of water resistant material with indelible marking shall be fixed to cables with ties at a maximum of 20 metres interval along the cable length for identification of cable and circuit. The earth continuity conductor/counterpoise conductor shall be laid in the trench as shown on drawing. The Contractor shall submit to the Engineer for approval, schedule of cable markers showing location of marker and instructions on each.

Sufficient slack shall be left in cables for which purpose the cut lengths of cables shall allow about 3% more in the measured lengths between terminations. At underground joint box, ample slack shall be left to prevent straining of cable joints due to settlement of the cable trench.

The cut lengths of cables wherever stated are only as a guide. The Contractor shall measure lengths between terminations of each circuit and if the discrepancy between measured lengths at site and where given on the drawing differ by more than 5%, the Contractor shall report to Engineer and act as directed. Cables, whether installed

underground, or in cement concrete trenches, shall not be bent to a radius less than that recommended by the cable manufacturers.

The cable marker shall be installed on finally compacted trench at mentioned distances.

SECTION – 16.9: LOW TENSION CABLES

1.0 SCOPE OF WORK

The work under this section consists of supplying, installing, testing and commissioning of all material and services of low tension (LT) cables and the accessories as specified herein or as shown on the Tender Drawings and in the Bill of Quantities.

The Contractor shall discuss the electrical layout with the Engineer and coordinate at site with other services for exact route, location and position of the L.T. cables.

The LT cables with accessories shall also comply with the General Specifications for Electrical Works, Section-16 and with other relevant provisions of the Tender Document.

2.0 GENERAL

All multi-core and single core PVC insulated and sheathed cables for light circuits, socket outlets and circuits operating up to 250 volts shall be 300/500 volts grade. All single core PVC insulated, non-sheathed cables shall be of 450/750-volt grade. Power cables for main feeders, main to sub main feeders, power equipment, etc., armoured or unarmoured shall be of 600/1000-volt grade. Armouring of multi-core/ single core cables shall be done with appropriate size galvanized steel/aluminium wire as per relevant codes.

The conductors shall be stranded or solid, high conductivity, soft annealed copper. Conductors of single core cables shall be circular, whereas of multi-core cables may be circular or shaped according to standard practices and codes. The PVC insulation, bedding and overall sheath shall be of extruded PVC compound having good flexibility, resistance to ageing and ability to withstand deformation at high temperatures. Fillers of PVC or jute shall be used between the laid up cores, where necessary. All cables shall be treated for vermin proofing and be protected against rodents during storage, laying and all protective pipe/sleeves shall be plugged to attain the same after installation.

Embossed marking on the oversheath at suitable intervals shall give the following information:

a. name of Manufacturer
b. year of Manufacture
c. size of cable in sq.mm.
d. voltage grade
e. type of cable i.e. Cu./PVC/SWA/PVC

3.0 APPLICABLE STANDARDS/CODES

The latest editions of the following standards and codes shall be applicable for the materials specified within the scope of this section:

BS 6004/6346	-	PVC insulated cables for lighting & power
BS 6746	-	PVC insulation for electrical cables
BS 6360	-	Copper conductors
BS 6500	-	Insulated flexible cords

4.0 MATERIAL

4.1 General

The power, lighting and control cables shall be furnished and installed in accordance with the routes and requirements shown on the drawings.

All cables shall have phase identification colours on insulation of each core. The colour code for three phase circuits shall be red, yellow and blue for phase conductors and black for neutral conductor. Where insulated earth conductor is installed, it shall have green or green-yellow colour insulation.

Single-phase circuits shall have insulation of red colour for phase/line, black colour for neutral and green or green-yellow colour for earth conductor.

All DC circuits shall have insulation of white colour for positive, black colour for negative and green or green-yellow colour for earth conductor.

The ends of each length of multi-core armoured or unarmoured cables shall be properly marked for clock-wise and anti clock-wise sequence of core colours.

4.2 Cables for Conduit or Channel Wiring

All cables/wiring in concealed or surface mounted PVC conduits or in covered channel shall be single core PVC insulated of specified grade and size, unless specifically shown on the drawings or given in BOQ.

4.3 Cables on surface/concrete trenches

Cables for distribution system to be installed on surface, in cable ducts, in concrete trenches or on trays shall be single or multi-core PVC insulated and PVC sheathed of specified voltage grade and size, unless specifically shown on the drawings or given in BOQ.

4.4.1 Cable/Wiring Inside Lighting Column

All cables/wiring in side lighting column from cable connection box to light fixtures / lanterns shall be 3 core PVC insulated PVC sheathed, high temperature resistant of specified grade and size, unless specifically shown on the drawing or given in the BOQ.

4.5 Underground Cables

Cables for laying directly underground shall be PVC insulated, PVC sheathed and armoured with galvanized steel/ aluminium wire. Cables fully installed in underground ducts/pipes and mechanically protected from end to end shall be PVC insulated and PVC sheathed unless specifically shown on the drawings or given in BOQ.

4.6 Cable Markers

Cable marker shall be made from 4mm thick sheet steel plate having dimension of (250 x 300) mm welded to a (50 x 50 x 4) mm angle iron fixed to a square shaped cement concrete base or as directed by the Engineer. The cable marker shall be finished in gray heavy enamel paint over two base coats of antirust red oxide paint.

The Contractor shall submit sample of cable marker for approval of the Engineer before installation.

4.7 Cable Accessories

All cable accessories shall be provided for the complete cabling and wiring system without any additional cost unless specifically mentioned in BOQ. These shall include but not limited to the items such as saddles, clamps, fixing channels, connectors, cable joints (where necessary and as approved by the Engineer), clips, lugs, tapes, colour sleeves, identification tags, bushes, glands, etc.

5.0 INSTALLATION

5.1 General

All installation material, labour, tools, cable rollers and accessories for cable installation shall be furnished by the Contractor. The cable and accessories shall be installed as described in accordance with these Specifications, drawings and manufacturer's instructions.

The Contractor shall confirm the exact cut lengths for cable by actual measurements at site prior to the ordering. The cable lengths where shown on the drawings or in BOQ are tentative and only for general guidance. The Contractor shall be solely responsible for furnishing correct lengths of cable to avoid joints in cable length except where necessary, after obtaining approval of the Engineer.

No separate payment for such joints is admissible.

Necessary precautions for safety of cables shall be taken during the laying of cables to avoid scratches/ cuts to the cable surface. Pulling force on cable at all times shall remain well within the manufacturer’s recommended limits.

Prior to installation of jointing and termination kits, the cable lengths shall be checked and tested to ensure that the cables are in sound condition, and no damage has been done during handling and installation. After installation, these shall again be tested prior to commissioning as per recommendations of the standards according to which the cable is manufactured.

5.2 Conduit or Channel Wiring

The wiring through conduit shall be started only after the conduit and channel system is completely installed and all outlet boxes, junction boxes, etc., are fixed in position.

The wires shall be pulled in conduit or channel with care, preferably without the use of any lubricant. Where necessary and if approved by the Engineer, the cable manufacturer's recommended lubricant may be used. Where several wires are to be installed in the same conduit, they shall be pulled together along with the earth conductor. All wires of same circuit shall be run in one conduit.

The wires shall not be bent to a radius less than ten times the overall diameter of the wire, or more if otherwise recommended by the manufacturer.

The wiring shall be continuous between terminations and looping-in system shall be followed throughout. Any joint in wires shall not be allowed. The use of connectors shall only be allowed at locations where looping-in is rendered difficult. The consent

of the Engineer shall be required for using connectors. The connector shall be of suitable rating having porcelain body with sunk-in screw terminals. The connector shall be wrapped with PVC insulation tape after its installation. A minimum of 150 mm extra length of cable/wire shall be provided at each termination to facilitate repairs in future.

5.3 Cables on Surface/Trenches

All cables for installation on surface of wall, column, ceiling, trenches, etc., shall be fixed to the surface by means of galvanized steel clips secured to a steel channel using suitable stud plate, nuts and washers. The distance between each cable clip shall be such so as to support the entire weight of the cable and that distance between the cable & surface and also the vertical clearance between two adjacent cables at any point is 50mm minimum. Common mounting channels are to be furnished for cable along the same route. The Contractor can offer alternate cable fixing arrangement, which shall be approved by the Engineer before commencement of installation.

5.4 Cable / Wiring inside Lighting Column

All cables for installation inside lighting, column shall be fixed at the ends by means of galvanized steel clips secured to a steel channel using suitable stud plate, nuts and washers ensuring no tension on cable terminations. The Contractor can offer alternate cable fixing arrangement, which shall be approved by the Engineer before commencement of installation.

5.5 Underground Cables

The cables to be installed directly underground shall be laid in trenches in single tiers. Unless shown specifically on the drawing the depth of cable below finished ground level shall be 900 mm minimum measured from the top of the largest cable to the general ground level. The burial depth may be increased as required due to site conditions or when crossing other service pipes and roads. Burial depth less than 900mm and more than 1500mm shall require Engineer's approval.

When cables cross road, paved area, other services or other cables, they shall be laid in protective pipes of required size. Cables entering the buildings shall also be laid in protective pipes. The protective pipe ends, after installation of cables, shall be plugged watertight be means of bituminised hesian or equivalent method as approved by the Engineer. A minimum clearance of 250mm vertically and 500mm horizontally shall be maintained between cables and other services.

The cable trench shall be excavated as per route and location shown on the drawings. Before laying of cables in the trench, the bed of the trench shall be leveled and filled with a 100mm thick layer of fine sand (1.3mm diameter maximum particles size). The sand layer shall be leveled and the cables placed thereon. The cables shall be covered with a layer of fine sand 100mm thick measured above the top of the cable. Cable protective bricks shall be placed over the sand cover which shall be of class-C cement concrete, minimum 50mm thick and 300mm square. The bricks shall be placed over the sand layer and end-to-end to cover the entire length and breadth of the cable trench. After the concrete bricks are placed, the remainder of the trench shall be backfilled with earth in layer 300mm thick. Each layer shall be thoroughly tamped and compacted.

A PVC warning tape shall be provided 300 mm below normal ground level covering the entire length and breadth of the trench. The warning tape shall be yellow in colour with marking of danger and voltage of the cable printed in black and as approved by the Engineer.

Cable identification tags of corrosion resistant material shall be tied to cables with PVC cable tie at a maximum of 20 metre interval along the cable length for identification of cable and circuit. The earth continuity conductor shall be laid in the trench with the cables.

Sufficient slack shall be left in cables for this purpose the cut lengths of cables shall allow about 3% more in the measured lengths between terminations. At underground joint box, ample slack shall be left to prevent straining of cable joints due to settlement of earth. Payment shall be done as per actual lengths measured at site after installation.

The cut lengths of cables wherever stated are only as a guide. The Contractor shall measure lengths between terminations of each circuit and if the discrepancy between measured lengths at site and the one given on the drawing differ, the Contractor shall report to Engineer and act as directed. Cables, whether installed underground or in concrete trenches, shall not be bent to a radius less than 12 times the diameter of the cable or as recommended by the cable manufacturer, whichever is higher.

Cable markers shall be installed on finally compacted trench at 60 meters interval along straight cable runs, at each change of direction of the cable and at each cable joint.

SECTION – 16.10: WIRING ACCESSORIES (INDUSTRIAL)

1.0 SCOPE OF WORK

The work under this section consists of supplying, installing, testing and commissioning of all material and services of wiring cables and the accessories as specified herein or as shown on the Tender Drawings and in the Bill of Quantities.

The Contractor shall discuss the electrical layout with the Engineer and coordinate at site with other services for exact route, location and position of the wiring cables.

The wiring cables with accessories shall also comply with the General Specifications for Electrical Works, Section-16 and with other relevant provisions of the Tender Document.

2.0 GENERAL

All multi-core and single core PVC insulated and sheathed cables for light circuits, socket outlets and circuits operating up to 250 volts shall be 300/500 volts grade. All single core PVC insulated, non-sheathed cables shall be of 450/750-volt grade. Power cables for main feeders, main to sub main feeders, power equipment, etc., armoured or unarmoured shall be of 600/1000-volt grade. Armouring of multi-core/ single core cables shall be done with appropriate size galvanized steel/aluminium wire as per relevant codes.

The conductors shall be stranded or solid, high conductivity, soft annealed copper. Conductors of single core cables shall be circular, whereas of multi-core cables may be circular or shaped according to standard practices and codes. The PVC insulation, bedding and overall sheath shall be of extruded PVC compound having good flexibility, resistance to ageing and ability to withstand deformation at high temperatures. Fillers of PVC or jute shall be used between the laid up cores, where necessary. All cables shall be treated for vermin proofing and be protected against rodents during storage, laying and all protective pipe/sleeves shall be plugged to attain the same after installation.

Embossed marking on the oversheath at suitable intervals shall give the following information:

a. name of Manufacturer
b. year of Manufacture
c. size of cable in sq.mm.
d. voltage grade
e. type of cable i.e. Cu./PVC/SWA/PVC

3.0 APPLICABLE STANDARDS/CODES

The latest editions of the following standards and codes shall be applicable for the materials specified within the scope of this section:

BS 6004/6346	-	PVC insulated cables for lighting & power
BS 6746	-	PVC insulation for electrical cables
BS 6360	-	Copper conductors
BS 6500	-	Insulated flexible cords

4.0 MATERIAL

4.1 General

The power, lighting and control cables shall be furnished and installed in accordance with the routes and requirements shown on the drawings.

All cables shall have phase identification colours on insulation of each core. The colour code for three phase circuits shall be red, yellow and blue for phase conductors and black for neutral conductor. Where insulated earth conductor is installed, it shall have green or green-yellow colour insulation.

Single-phase circuits shall have insulation of red colour for phase/line, black colour for neutral and green or green-yellow colour for earth conductor.

All DC circuits shall have insulation of white colour for positive, black colour for negative and green or green-yellow colour for earth conductor.

The ends of each length of multi-core armoured or unarmoured cables shall be properly marked for clock-wise and anti clock-wise sequence of core colours.

4.2 Cables for Conduit or Channel Wiring

All cables/wiring in concealed or surface mounted PVC conduits or in covered channel shall be single core PVC insulated of specified grade and size, unless specifically shown on the drawings or given in BOQ.

4.3 Cables on surface/concrete trenches

Cables for distribution system to be installed on surface, in cable ducts, in concrete trenches or on trays shall be single or multi-core PVC insulated and PVC sheathed of specified voltage grade and size, unless specifically shown on the drawings or given in BOQ.

4.4 Cable/Wiring Inside Lighting Column

All cables/wiring in side lighting column from cable connection box to light fixtures / lanterns shall be 3 core PVC insulated PVC sheathed, high temperature resistant of specified grade and size, unless specifically shown on the drawing or given in the BOQ.

4.5 Cable Markers

Cable marker shall be made from 4mm thick sheet steel plate having dimension of (250 x 300) mm welded to a (50 x 50 x 4) mm angle iron fixed to a square shaped cement concrete base or as directed by the Engineer. The cable marker shall be finished in gray heavy enamel paint over two base coats of antirust red oxide paint. The Contractor shall submit sample of cable marker for approval of the Engineer before installation.

4.6 Cable Accessories

All cable accessories shall be provided for the complete cabling and wiring system without any additional cost unless specifically mentioned in BOQ. These shall include but not limited to the items such as saddles, clamps, fixing channels,

connectors, cable joints (where necessary and as approved by the Engineer), clips, lugs, tapes, colour sleeves, identification tags, bushes, glands, etc.

5.0 INSTALLATION

5.1 General

All installation material, labour, tools, cable rollers and accessories for cable installation shall be furnished by the Contractor. The wiring cables and accessories shall be installed as described in accordance with these Specifications, drawings and manufacturer's instructions.

The Contractor shall confirm the exact cut lengths for cable by actual measurements at site prior to the ordering. The cable lengths where shown on the drawings or in BOQ are tentative and only for general guidance. The Contractor shall be solely responsible for furnishing correct lengths of cable to avoid joints in cable length except where necessary, after obtaining approval of the Engineer.

No separate payment for such joints is admissible.

Necessary precautions for safety of cables shall be taken during the laying of cables to avoid scratches/ cuts to the cable surface. Pulling force on cable at all times shall remain well within the manufacturer’s recommended limits.

Prior to installation of jointing and termination kits, the cable lengths shall be checked and tested to ensure that the cables are in sound condition, and no damage has been done during handling and installation. After installation, these shall again be tested prior to commissioning as per recommendations of the standards according to which the cable is manufactured.

5.2 Conduit or Channel Wiring

The wiring through conduit shall be started only after the conduit and channel system is completely installed and all outlet boxes, junction boxes, etc., are fixed in position.

The wires shall be pulled in conduit or channel with care, preferably without the use of any lubricant. Where necessary and if approved by the Engineer, the cable manufacturer's recommended lubricant may be used. Where several wires are to be installed in the same conduit, they shall be pulled together along with the earth conductor. All wires of same circuit shall be run in one conduit.

The wires shall not be bent to a radius less than ten times the overall diameter of the wire, or more if otherwise recommended by the manufacturer.

The wiring shall be continuous between terminations and looping-in system shall be followed throughout. Any joint in wires shall not be allowed. The use of connectors shall only be allowed at locations where looping-in is rendered difficult. The consent of the Engineer shall be required for using connectors. The connector shall be of suitable rating having porcelain body with sunk-in screw terminals. The connector shall be wrapped with PVC insulation tape after its installation. A minimum of 150 mm extra length of cable/wire shall be provided at each termination to facilitate repairs in future.

5.3 Cables on Surface/Trenches

All cables for installation on surface of wall, column, ceiling, trenches, etc., shall be fixed to the surface by means of galvanized steel clips secured to a steel channel using suitable stud plate, nuts and washers. The distance between each cable clip shall be such so as to support the entire weight of the cable and that distance between the cable & surface and also the vertical clearance between two adjacent cables at any point is 50mm minimum. Common mounting channels are to be furnished for cable along the same route. The Contractor can offer alternate cable fixing arrangement, which shall be approved by the Engineer before commencement of installation.

5.4 Cable / Wiring inside Lighting Column

All cables for installation inside lighting, column shall be fixed at the ends by means of galvanized steel clips secured to a steel channel using suitable stud plate, nuts and washers ensuring no tension on cable terminations. The Contractor can offer alternate cable fixing arrangement, which shall be approved by the Engineer before commencement of installation.

SECTION – 16.11: WIRING ACCESSORIES (GENERAL)

1.0 SCOPE OF WORK

The work under this Section consists of supplying, installing, and commissioning of all material and services of the complete switches switch sockets, etc., as specified herein, as shown on the Tender Drawings and explained in the Bill of Quantities.

The Contractor shall discuss the electrical layout with the Engineer and coordinate at Site with other services for exact location and position of all wiring accessories.

The wiring accessories such as switch, switch socket outlet, socket outlets and ceiling rose etc. shall also comply with the General Specifications for electrical works Sec. 16 and with other relevant provisions of the Tender Documents.

2.0 GENERAL

The locations of the wiring accessories such as sockets, switches etc. are tentatively shown on the drawings. The Contractor shall ensure the exact positions and locations of wiring accessories in coordination with other services drawings, as per site requirements and as directed by the Engineer. The Contractor shall be responsible for proper functioning of wiring accessories after installation and commissioning.

3.0 APPLICABLE STANDARDS/CODES

The latest edition of following standards & codes shall be applicable for the materials specified within the scope of this section:

BS 3676	-	Switches for domestic and similar purposes.
BS 4343	-	Industrial plugs, socket outlets and couplers for AC and DC supplies.
BS 2135	-	Capacitors for radio interference suppression.
BS 67	-	Ceiling roses.
BS 546	-	2-pole and earthing pin plugs, socket outlets and socket outlet adaptors.

4.0 MATERIAL

4.1 Switches

Switches for controlling light and fan points shall be single pole, rated for 10 Amps, 250 volts AC. The body of the switches shall be of thermoplastic with faceplate suitable for flush mounting and colour as approved by the Engineer. The switches shall be gang type having silver tipped contacts and shall operate with snap action.

Unless otherwise specified wherever switches control only the light points, these shall be plate type gang switches installed on common outlet boxes.

Where specified weather proof or metal front plates shall be used with single grid type switches. The plate shall be finished in specified colour or as otherwise directed by the Engineer.

The bell push switches shall be spring loaded type with the identification symbol embossed on it.

Two-way switches shall be used to control lights from two different locations as shown on the drawings.

4.2 5A/15Amp Switch-Socket Outlets

Switch socket units shall be 3 pin, 5 Amps / 3 pin, 15 Amps 250V, AC with face plate of colour as approved by Engineer. The outlets shall be heavy-duty type suitable for mounting on sheet steel outlet box. The 15Amps Switch sockets outlets shall have sheltered live contacts and designed such that the earth pin of plug is engaged to socket earth before making of live contacts.

Where metal plate switches are installed, the switch socket units shall also be provided with front plate of similar design.

4.3 16 Amp Socket Outlets

16 Amp Socket Outlets shall be 2 pin + earth German type (Schuko) socket outlets with face plate of colour as approved by the Engineer. The outlets shall be heavy-duty type suitable for mounting on sheet steel outlet box. The 16 Amp Schuko Socket Outlet shall be designed such that the earth pin of plug is engaged to socket earth prior to making contact to the live contacts.

4.4 16A / 32A Industrial Socket Outlet

The 16A or 32A, 230/400 V, single/ 3 Phase plus neutral & earth 3/5 pin, industrial type socket outlet shall be weather proof conforming to the standard and requirements of relevant IEC codes.

The socket outlets shall be of heavy duty type suitable for outdoor installation. The socket outlet shall be mounted on polycarbonate enclosure and have gasketed cover and window, captive cover screw type. All socket outlets shall be supplied with matching plugs.

4.5 Sheet Steel Back Boxes

The sheet steel boxes for installation of switches, fan regulators, dimmers and socket outlets shall be made of 16 SWG sheet steel having appropriate dimensions. The box shall have suitable arrangement for receiving the conduit(s). An earth terminal shall be provided for connecting at least three earth wires of 4-sq.mm size. The outlet box shall be finished in powder-coated paint. The sheet steel shall be as approved by the Engineer.

4.6 Ceiling Rose

The ceiling rose shall be suitable for 5 amps 250 volts single-phase ac. It shall have white plastic moulded base plate, copper or brass terminals for connecting at least two wires of 2.5-sq.mm size. The ceiling rose shall have a cover with cable inlet hole suitable for multicore PVC insulated and PVC sheathed cable.

5.0 INSTALLATION

5.1 General

The mounting heights of all wiring accessories are stated on the drawings. In case the mounting height is not mentioned, the instructions of the Engineer shall be obtained before fixing.

5.2 Switches, and Socket/ Industrial Socket Outlets

All wiring accessories shall be installed on 1.63 mm (16 SWG) thick sheet steel box recessed in wall. The face plate shall be fixed on sheet steel box by means of flat head galvanized screws sunk in the face plate so as to finish flush with the surface. Matching screw covers shall be installed on the opening for screw in faceplates.

The industrial type sockets in polycarbonate enclosure shall be installed on wall as shown on drawing.

SECTION – 16.12: CONDUITS AND PIPES

1.0 SCOPE OF WORK

The work under this section consists of supplying, installing and commissioning of all material and services of the complete Conduits and Pipes as specified herein and/or shown on Tender Drawings and stated in the Bill of Quantities.

The Contractor shall discuss the electrical layout with the Engineer and co-ordinate at Site with other services for exact route, location and position of the conduits and pipes.

The conduits and pipes with accessories shall also comply with the General Specifications for Electrical Works, Section-16 and with other relevant provisions of the Tender Document.

2.0 GENERAL

The extent of works shown on the drawing does not indicate the exact position of conduits and pipes. The Contractor shall ensure exact location and route of conduit and pipes in coordination with other services drawings, as per site requirements and as directed by the Engineer.

The quality and material for the accessories of conduits and pipes such as sockets, end cap, elbows, bushings, bends, inspection/pull boxes, round boxes, etc., necessary for the completion shall be similar to that of conduits or pipes. All the accessories shall be supplied by the Contractor without any extra cost and deemed to have been included in the price of conduits/pipes.

3.0 APPLICABLE STANDARD/CODES

The latest edition of the following standards and codes shall be applicable for the materials specified within the scope of this section:

BS 31 - Steel conduits and accessories.
BS 4607 - PVC conduits and accessories.
BS 3505 - PVC Pipes and accessories.
BS 1378 - Galvanized Iron pipes & accessories.

4.0 MATERIAL

4.1 PVC Conduits and Accessories

The PVC conduits and accessories for lighting and power circuits shall be furnished by the Contractor as shown in the drawings or given in BOQ. The PVC bends shall have enlarged ends to receive conduit without any reduction in the internal diameter at joint. Manufactured smooth bends shall be used where conduit changes direction. Bending of conduits by heating or otherwise will be allowed in special situations only, for which the consent of the Engineer shall be required. The use of sharp 90-degree bends and tees will not be allowed for concealed wiring.

The round PVC junction boxes for ceiling light or fan points shall have minimum dimensions of 63 mm diameter and depth. The junction boxes for wall light points shall have minimum dimensions of 63 mm diameter and 38 mm deep. Round

junction boxes shall be provided with one-piece PVC cover plate fixed to the box by means of brass screws.

4.2 Inspection / Pull and Adaptable Boxes

Inspection/Pull boxes and adaptable boxes shall be provided in conduit runs wherever required to facilitate pulling operation. The drawings are diagrammatic and do not indicate the position and spacing of inspection/pull boxes or adaptable boxes. However, these shall meet the following requirements:-

Inspection/Pull Boxes

The rectangular inspection/pull boxes shall be made of 16 SWG heavy gauge sheet steel of suitable design to receive conduits. The box shall be painted inside and outside with black enamel paint over a base coat of red oxide primer paint. The minimum length of the box shall not be less than four times the cable manufacturer recommended bending radius of the cable. All concealed type boxes shall have a white plastic sheet of appropriate size fixed to the box by means of galvanized screws.

If the spacing between the end points of conduit run with respect to bends exceeds the following, an inspection/pull box of suitable size according to the number and size of cables and as approved by the Engineer shall be provided:

a. - Straight run without bend : Max. spacing 30 metres
b. - Run with one 90^{o} bend : Max. spacing 20 metres
c. - Run with two 90^{o} bends : Max. spacing 15 metres

Adaptable Boxes:

Adaptable boxes shall also be made of 16 SWG sheet steel and painted and finished to the same quality as the Lighting distribution boards. The adaptable box shall preferably be fixed adjacent to the DB and have suitable dimensions to match the installation with DB. However, in any case, the depth of adaptable box shall be according to number & size of cables & conduits and shall not be less then the following:

a. Conduits upto 25 mm dia. : Min. depth = 50 mm
b. Conduits upto 38 mm dia. : Min. depth = 65 mm
c. Conduits upto 50 mm dia. : Min. depth = 90 mm
d. Conduits more then 50 mm dia. : Min. depth = 2 x dia.

4.3 Galvanized Iron (G.I.) Pipes and Accessories

The G.I. pipes shall be made of mild steel, galvanized inside and outside by hot-dip galvanizing process. The pipes shall be free from stains, burrs or any other defect. The accessories for G.I. Pipes such as sockets, bends, etc. shall be also galvanized inside and outside and of same quality and specifications as the pipes.

These pipes shall be installed for crossing of cables above nallas and culverts wherever specified or as shown on drawing or given in BOQ. The pipes and accessories shall be provided with one thick coat of bituminous paint on the outer surface prior to installation. All pipes shall be secured in position by means of galvanized clamps, supports, etc.

4.4 PVC Pipes and Accessories

The PVC pipe shall be rigid. All pipes shall be minimum Class 'D' (Working pressure - 12 bar), unless otherwise stated on Drawings or Bill of Quantities. The buried PVC pipe should be able to withstand the external load acting upon it by continuous movement of heavy-duty vehicles such as trucks, cranes, forklift, etc. Where pipe changes direction, manufactured smooth bends shall be used.
Fittings and accessories for use with PVC pipes shall be of the same class and manufacturer as the pipe and shall have the required shapes and dimensions of turned ends to fit the PVC pipes. PVC pipes and accessories shall be suitable for jointing with rubber rings or solvent.

Bending of pipes by heating or otherwise will not be allowed. The use of sharp 90 degree bends and tees will not be allowed. The bends shall conform to same specifications as given for PVC conduits. For jointing of pipe all precautions and procedures recommended by manufacturer shall be followed.

Hard PVC or reinforced concrete pipe range spacers shall be used if there is more than one pipe running in parallel. The distance between range spacers shall be maximum 2 meters. Range spacers shall be prefabricated/pre-cast and decay resistant.

5.0 INSTALLATION

5.1 PVC Conduits and Accessories

5.1.1 Concealed Conduits

Where concealed conduit system is stated on drawings, the conduit shall be installed concealed in roof, wall, column, etc. Conduits shall be laid under floor only where specifically stated. The entire conduit system shall be installed and checked before wiring is carried out. Any obstruction found shall be cleared before the installation of cable.

When concealed, the conduit shall have a minimum of 32 mm cover of concrete measured from the top of conduit to finished surface. In the reinforced cement concrete (RCC) work the conduit shall be laid before pouring of concrete. Under no circumstances shall chases be made in the RCC structure for concealing conduit and accessories after pouring of concrete. The conduit shall be supported on top of bottom reinforcement of slab. All outlet boxes to be firmly supported and installed such that they finish flush with the soffit of slab or beam.

Where conduits have to be concealed in cement concrete (CC) work after concreting or in block masonry, chase shall be made with appropriate tools and shall not be made deeper than required. The conduit shall then be fixed firmly in the recess and covered with cement concrete mixture. The work of cutting in the cement concrete work or block masonry work shall be co-ordinate with the civil work. The Contractor shall obtain approval from the Engineer before starting chasing and cutting.

The termination of conduits at or near the equipment/ switchboard is shown diagrammatically on the drawings. The exact locations of the termination shall be co-ordinated with the equipment/ switchboard to be installed. Any extension of conduit to suit the site condition shall be made without any extra cost. Conduit ends pointing upwards or downwards shall be properly plugged in order to prevent the entry of foreign materials. All openings through which concrete may leak shall be carefully

plugged and boxes shall be suitably protected against filling with concrete. At all terminations of conduit, sharp edges of conduit ends shall be prevented to avoid the cutting or damaging of wires or cables during pulling through the conduits.

Under floor conduit shall be installed at a minimum depth of 2 inch from the finished floor level or as shown on the drawings. The conduits shall be installed empty, before finishing of floor or in RCC work, with an 18 SWG steel wire drawn through the conduit for pulling cable. No conduits shall be laid under floor in bathroom.

Wherever the conduit lengths cross the expansion joint either along the columns or slab, suitable arrangement shall be provided so that when the conduit lengths in the expansion joint are stressed, the conduit shall not crack or break.

5.1.2 Surface Conduits

The surface conduits shall be installed where shown on drawings only. The conduits shall be installed parallel or perpendicular to the surface of wall, structural members, ceiling, etc., by means of PVC or steel saddles and clamps of approved design. The conduits shall be kept at least 150 mm away from parallel runs of flues, steam pipes and hot water pipes.

The saddles shall be installed on surface by means of nylon or wooden plugs and galvanized screws. Appropriate size of holes in structure shall be made by drilling. The thickness of saddles and clamps shall be of appropriate thickness and prime quality. The surface conduits shall be supported at a maximum of one metre spacing along horizontal and vertical runs. All accessories for complete installation of conduit system shall be provided by the Contractor. The pull boxes, etc. as stated for concealed conduits shall also be applicable for surface conduit system.

5.2 Galvanized Iron Pipes

The galvanized iron (G.I.) pipes shall be installed at a minimum depth of 900 mm measured from the top of pipes to finished ground level. The pipe shall be laid and checked for soundness before completion of civil works. The G.I. pipes shall be installed at locations as shown on the drawings.

At all joints the pipes shall be firmly screwed and cotton yarn with waterproof compound shall be used to make the joint waterproof.

At each termination, the pipe end shall have threads and socket screwed on thread for installing soft metal bush. The soft metal bush shall be of approved quality and shall be male type.

The installation of pipes shall be complete in all respects including its fixing at terminations before the work is started. All sharp edges and burrs shall be removed by using reamer or any approved device.

The pipe shall be checked before installation of cable for any obstruction and if found, it shall be cleared without damaging the installation. All pipe ends shall be plugged to prevent entry of water, rodents etc.

5.3 PVC Pipe & Accessories

Rigid PVC pipes shall be installed under roads, paved areas, at crossing with other services and at cable entering building as shown on the drawings. The depth of the pipe shall vary according to the conditions at site, and approval of Engineer shall be obtained prior to installation. In general the pipes shall be installed underground at the following depths measured from the top of the pipe:

a. Under roads/pavement : 900mm below finished surface.
b. When crossing outer : 250/500mm vertical/horizontal services clearances with concrete cover

The trench of required dimensions shall be excavated and the bottom of trench cleaned and levelled. A 100mm bed of fine sand shall be provided over which the PVC pipes installed after proper alignment. Where two or more pipes are installed in the same trench the clearance between pipes shall not less than 50mm. This shall be done by the provision of pipe range spacer as per Engineer's approval. After laying of pipe the trench shall be backfilled with clean-screened sand at least 100mm above the top most pipes. The remaining portion & trench shall be backfilled with selected earth in layers and each layer shall be properly tamped and compacted.

After installation, the ends of the pipe shall be plugged with material impervious to water and chemicals. All joints shall be sealed adequately to prevent entry of foreign elements, but water tightness shall be ensured.

The installation of pipes shall be completed in all respects including its fixing at termination, before cabling work is started. All sharp edges and burrs shall be removed by using reamer or any approved device. The pipe shall be through cleaned of dirt and dust from inside; the pipes shall be installed in proper co- ordination with other works.

The protective PVC pipe for cable entering building shall be installed so as to lead cable into the cable trench. The required number of pipes shall be fixed before completing the work in the plinth. If an opening is provided to the cable trench from outside, the required number of pipes shall be installed and part of the opening remained unutilized shall be properly packed and sealed using suitable packing material impervious to water and chemical to make it completely water-tight.

Spare pipes shall be provided with 5 mm dia rope pulled from end to end and plugged with manufactured end cap.

Flexible pipes of compatible material and size shall be used wherever deemed essential.

SECTION – 16.13: EARTHING

1.0 SCOPE OF WORK

The work under this section consists of supplying, installing, testing and commissioning of all material and accessories of the complete Earthing system as specified herein, as shown on the Tender Drawings and given in the Bill of Quantities.

The Contractor shall discuss the electrical layout with the Engineer and co-ordinate at Site with other services for exact route, location and position of the earthing system.

The Earthing system shall also comply with the General Specifications for Electrical Works Section - 16 and with other relevant provisions of the Tender Documents.

2.0 GENERAL

The earthing system consists of earth electrodes, earthing leads, earth connecting points, earth continuity conductors and all accessories necessary for the satisfactory operation of the associated electrical system.

3.0 APPLICABLE STANDARDS/CODES

The latest editions of following standards / codes shall be applicable for the materials specified within the scope of this section:

BS 951 - Earthing clamps
CP 1013 - Earthing
BS 2873 - Copper and copper alloys
BS 2874 - Copper and copper alloys - Rods and section (other than forging stock)
BS 1433 - Hard drawn bare copper conductor for earthing
BS 6346 - PVC insulated cables

4.0 MATERIAL

4.1 Earth Electrode Plate Type

The plate type earth electrode shall comprise a 600 x 600 x 3mm electrolytic copper plate. The surface of the plate shall be tinned for protection. The plate shall have four terminals for connecting the earthing leads. Nuts bolts and washers shall be either of brass or tinned copper. A 50mm dia. G.I. pipe shall be provided from inspection chamber to earth plate for watering purpose. This pipe shall have 10mm dia. holes at 500mm centre to centre all along the length.

At the ground level an inspection chamber with cast iron cover shall be constructed having dimensions as shown on the drawings. The inspection chamber shall have a cover supported on angle iron frame. The cover shall be hinged type, as approved by the Engineer and shall finish flush with the ground level.

4.2 Earth Electrode (Copper Clad Steel Rod Type)

This type of earth electrode shall comprise a 2 metre long, 20 mm dia. copper clad steel rod having flat head at drive end and pointed conical tip at the driven end. The tip shall be hardened to facilitate driving. At the top of the rod, a brass clamp for

bolted connections shall be provided suitable for connection to the down conductor or earthing lead as required.

The inspection chamber with C.I. cover shall be provided as specified for plate type earth electrode.

4.3 Earthing Lead

The earthing lead shall connect the earth electrode to earth connecting point or equipment in the building. It shall be of round hard drawn bare electrolytic copper of size shown on the drawings. The cost of earthing leads deemed to have been included in the price of earth electrode and no separate payment shall be made for it.

4.4 Earth Continuity Conductor

Earth continuity conductor (ECC) shall be hard drawn bare copper wire or single core PVC insulated copper conductor cable of sizes indicated on the drawings. All thimbles, lugs, sockets, nuts, washers & other accessories necessary for the complete installation of ECC shall be provided by the Contractor without any extra cost.

The specifications for single core PVC insulated cables used as ECC shall be same as those given in section "LT Cables" of the technical specifications. PVC insulated cables when used as ECC shall be green or green/yellow.

4.5 Earth Connecting Point

Earth connecting points shall comprise tinned copper bar, rectangular in shape, having dimensions of 300 x 50 x 6 mm. At least six terminals for connection shall be arranged on the bar, which can be increased or decreased as required by the Engineer.

The terminals shall have brass or tinned copper bolts, nuts and washers for protection against corrosion. Two holes shall be provided off centre of the copper bar for fixing to the wall by means of 10 mm dia. nut and bolt and shall be insulated by means of rubber gaskets/washers.

5.0 INSTALLATION

5.1 General

The Contractor shall install complete earthing systems as shown on the drawing. The earthing system shall give earth resistance, including the resistance of soil, earth leads and ECC equal to or less than ONE ohm.

At all connections of earth continuity conductor to HT switchboards, LT switchboards, LT distribution Boards, Neutral point of Power transformer & LT DG Set, Body of transformer and generator, communication systems and any other metallic body, proper size copper or brass sockets, thimbles or lugs shall be used to which the copper wire shall be connected by copper brazing. The soldering of copper wire at joints or terminations shall not be allowed. All tee-off connections shall be by copper brazing using suitable socket and clamps. After brazing, the jointed surface shall be protected by oxide inhibiting compound of low electrical resistance. For connections to metallic body, the surface shall be thoroughly cleaned before bolting the lug or socket.

The earth continuity conductor shall in general run in cable trench or in conduits/pipes as shown on the drawings. For under floor runs, these shall be installed in pipe/conduit of appropriate sizes. Where laid along underground cables, these shall be laid directly underground in unpaved areas and in pipes under paved areas.

5.2 Earth Electrode Plate Type

The electrode plate shall be installed at a minimum depth of 5 metres from finished ground level or 1 metre below permanent water level whichever is less. The minimum horizontal distance between earth electrodes shall be 3 metres. Proper mixture of lime and charcoal shall be made and buried alongwith the copper plate in the ground to increase the soil conductivity. The electrode shall be installed as per details shown on the drawings. The inspection chambers shall be constructed at locations approved by the Engineer.

5.3 Earth Electrode (Copper Clad Steel Rod Type)

In case the soil conditions at site permit, this type of earth electrode may be installed by hammering the electrode in soil, until the top of the rod is about 300 mm below the proposed finished ground level. If hammering down of rod is not possible due to site conditions, a pit shall be first excavated in bare ground upto the required depth and electrode shall be installed upright in the pit. The excavated pit shall be backfilled in layers of 500 mm, each layer tamped and compacted.

5.4 Earth Continuity Conductor

The earth continuity conductor of sizes shown on the drawing shall be installed all along the cable runs and connected to the earthing bar/terminals provided in equipment. The body of all switchboards shall also be connected to earth by specified size of ECC. All other metal work shall also be connected to earth by specified size of ECC.

At any joint or terminations, the ECC shall be connected using proper accessories. No connection shall be made by twisting of earth conductors.

5.5 Earth Connecting Point

The earth connecting point shall be installed at locations shown on the drawings. It shall be fixed on wall surface by means of brass screws with nuts, washers and other insulating material as instructed by the Engineer.

SECTION – 16.14: MISCELLANEOUS ITEMS

1.0 SCOPE OF WORK

The work under this section consists of supplying, installing, testing and commissioning of all material and accessories for Miscellaneous Items as specified herein and/or shown on the drawings and given in the Bill of Quantities.

The Contractor shall discuss the electrical layout with the Engineer and coordinate at site with other services for exact locations and positions of the Miscellaneous Items.

The Miscellaneous Items with accessories shall also comply with the General Specifications for Electrical Works Section - 16 and with other relevant provisions of the Tender Document.

2.0 GENERAL

The Miscellaneous Items as described in this section shall comply with other sections of these specifications as applicable. The Contractor shall ensure that all the miscellaneous items be supplied/fabricated from the reputable manufacturers, who have already supplied/fabricated similar items.

3.0 APPLICABLE STANDARDS/CODES

The latest editions of the following standards/codes shall be applicable to the material specified within the scope of this section:

BS 3871	-	Miniature & Moulded Case Circuit Breakers.
IEC 947-2	-	Low Voltage Switch Gear and Control Gear.
BS 4934	-	Safety requirements for electric fans and regulators.
BS 5060	-	Performance of circulating fans and their regulators.
BS 729	-	Hot dip galvanization
BS 5649	-	Lighting Columns

4.0 MATERIAL

4.1 MCCB / MCB Enclosed in Sheet Steel Box

The single / double pole 250 volts miniature circuit breaker (MCB) and triple pole 500 volts moulded case circuit breakers (MCCB) are used for supplying single phase and three phase power respectively to the equipment shown on the drawings and given in the Bill of Quantities.

The MCCB/MCB shall conform to the same specifications as given in section LT switchboards and LT distribution boards of these specifications. It shall be installed in a 16 SWG sheet steel box of such a size, which can easily accommodate the MCCB/MCB, and incoming/ outgoing wires or cables. Sufficient numbers of PVC connectors shall also be provided inside the sheet steel box for terminating the earth continuity conductors and neutral wires. The front plate fixed on the sheet steel box shall be of white plastic fixed with G.I. screws having an opening for operating the ON-OFF lever of MCCB / MCB.

4.2 Load Break Switch Enclosed in Sheet Steel Box

Single pole 250 volts and triple pole 500 volts load break switch are used for supplying single phase and three phase power respectively to the equipment shown on the drawings and given in the Bill of Quantities.

The load break switch shall conform to the same Specifications as given in section LT switchboard and LT distribution boards of these Specifications. It shall be housed in a, manufacturer's standard and in such a size of box which an easily accommodate the load break switch and incoming / outgoing wires alongwith the earth continuity conductor and neutral wires terminals.

4.3 Ceiling Fan

Ceiling fan shall be capacitor type, suitable for 250V AC. The air displacement shall be 12,000 cfm for 56" (1422 mm) sweep and 10,000 cfm for 48" (1219) sweep at maximum speed. The fan motor shall be capacitor type and bearing shall be groove type to give noiseless operation. The fan regulator / dimmer shall be made of low voltage electronic components, and shall be suitable for the speed control of fans. The body of the regulators shall be matching with the switching accessories, suitable for flush mounting on a sheet steel outlet box. Where the regulators are to be mounted with switches they shall match with the dimensions of switches and shall be fixed on plastic outlet by means of flat headcounter sunk galvanized screws, with the head of the screws finish flush with the surface of the plate. The complete fan with blades and canopy shall be finished in white colour, or as approved by the Engineer.

The fan hook shall be made of 16 mm diameter mild steel rod. It should be in the form of a loop about 75 mm long and about 50 mm wide. The rod should be bent to have atleast 200 mm extensions on both sides for tying to reinforcement steel of slab.

4.4 Wall Bracket Fan

Wall bracket fan shall be capacitor type, suitable for 250V AC. The fan shall be of size as mentioned in the BOQ. The fan motor shall be capacitor type and bearing shall be groove type to give noiseless operation. The fan regulator shall be made of low voltage electronic components, and shall be suitable for the speed control of fans. The regulator shall be located in the fixed portion of the fan. The complete fan with blades and cover shall be finished in white colour or as approved by the Engineer. The fan shall be provided with a rotating mechanism for swinging the fan on its vertical axis.

4.5 Exhaust Fans

Exhaust fans shall be three blade or multi blade type of metal / PVC construction as approved by the Engineer.

Fans shall be direct driven and supplied complete with electric motor, back draft dampers and anti-vermin screen.

The bearings shall be ball roller or sleeves type of permanently lubricated and sealed type.

Wheels shall be heavily and rigidly constructed and accurately balanced both statically and dynamically and be free from objectionable vibration or noises.

4.6 Cable Trays / Trunking

Where specified, the cables shall run on cable trays/trunking supported to the wall and/or ceiling. The tray shall be of appropriate dimensions to ensure minimum clearance of 50mm between the cables. Tray and trunking shall be provided with complete accessories such as straight through joint, tee, cross, internal and external bend, cover etc. complete with proper support and fixing accessories, GI nuts, bolts washer etc.

The cable tray/ trunking length shall be fabricated in sections not exceeding 3.0 metres

4.6.1 M.S. (Mild Steel) Cable Trunking

The M.S. cable trunking (with cover) shall be 16 SWG M.S. sheets. Suitable trunking design shall be provided for bends, crossings, etc., keeping in view allowable bending radius of cables.

Arrangement shall be provided to secure the cables in position on the trunking. After fabrication of each trunking and cover section, the metalwork shall be cleaned down to bore shining metal phosphated and the surface chemically prepared for powder coating. Then these shall be coated with powder of RAL colour as approved by the Engineer and then baked in oven. The thickness of powder coating shall not be less than 100 microns.

4.6.2 G.I. (Galvanized Iron) Trays

The G.I. trays shall comprise of 16 SWG perforated G.I. Sheets bend to shape and having required dimensions and all accessories shall be compatible with the tray to make a smooth medium.

Cables laid on tray or trunking shall be properly fixed or clamped, with smooth finished split pieces with bore diameter to suit the cable. Supports shall be arranged as far as practicable for easy removal of any cable without disturbing other cables.

Copper braid connections shall be provided at every joint, fixing accessories of cable tray to ensure continuity.

4.7 Handholes with CI Cover & Frame

Handholes for electric power cables or telephone cables shall be constructed in accordance with the standard Specifications of Civil works. The work shall also include making of concrete chambers and concrete benching in handholes, complete as shown on the drawings. Top of the cover shall be roughened in an approved pattern. The cover shall tightly fit in the frame and shall be watertight. The handhole shall have appropriate identification code as instructed by Engineer.

CI covers complete with frame shall be of the size specified on the drawings. The specified size means the clear opening. The cover shall be of 100 kg weight or as approved by the Engineer. Suitable locking and lifting arrangement shall also be provided. The frame shall be set in place at the time of pouring of concrete so that the cover shall tightly fit in the frame.

4.8 Uninterruptible Power Supply (UPS) System

The ON-LINE uninterruptible power supply system shall be as per EN 50091. The UPS system shall be designed to supply uninterrupted, conditioned electrical power to the electrical systems.

The system shall consist of complete UPS units, each comprising a rectifier / charger and inverter, a bypass unit with a static bypass switch, a maintenance bypass switch and battery panel.

The UPS system shall supply continuous, ON-LINE electrical power within specified tolerance limits to the connected load, upon failure or deterioration of the normal mains supply, ensuring uninterrupted clean electrical power to the load in accordance with the specified battery autonomy.

4.8.1 UPS System Operation

The UPS system shall operate in the following modes:

4.8.1.1 Normal Operation

The rectifier / charger shall draw AC power from the mains and supply DC power to the inverter while simultaneously charging the battery. The inverter shall supply clean uninterrupted AC power to the load.

4.8.1.2 Emergency Operation

On failure or deterioration of the mains supply beyond specified tolerances, the inverter shall continue to supply the load from battery source without interruption or disturbance.

4.8.1.3 Battery Recharge

When mains power is restored, the rectifier/charger shall again supply power to the inverters without interruption or disturbance to the load, at the same time recharge the battery.

4.8.1.4 Automatic Bypass Operation

The UPS unit shall include automatically operated static bypass system. In the event of overloads exceeding system capabilities or inverter shutdown for maintenance or due to internal faults, the static bypass transfer switch shall instantaneously transfer the load to the bypass source without interruption.

4.8.1.5 Manual Bypass Operation

The UPS shall include a manually operated mechanical bypass system for maintenance purposes. The system shall be designed to isolate the inverter and the static switch while maintaining load power via the bypass source. Transfer to the maintenance bypass shall take place without interruption to the load. An isolating device shall also be provided to isolate the rectifier / charger from the mains power supply.

4.8.1.6 Operation without Batteries

It shall be possible to isolate the battery from the rectifier/ charger and the inverter by means of a circuit breaker for maintenance purposes.

In such a case the UPS shall continue to supply the load except in the events of mains power outage.

4.8.2 Electrical Characteristics

4.8.2.1 Input Power

The UPS shall be designed to receive power from the mains with the following characteristics:

Voltage	=	380/400/415 volts AC + 10%/ - 15%
Wiring	=	3 phase, 4 wire + earth
Frequency	=	50 Hz ± 5%
Power Factor	=	0.8

4.8.2.2 Rectifier / Charger

a. **Starting Currents**

In order to limit inrush currents on starting a “soft start” power walk-in circuit shall be provided in the rectifier / charger input. The soft start shall be accomplished in 10 seconds.

b. **Charging Current**

The charging current shall be automatically limited by an electronic device to the maximum value as specified by the battery manufacturer. A device shall also limit the power drawn by the rectifier/charger to the rated KVA.

c. **Charging Voltage**

The DC voltage shall be set in to the charge/ floating value specified by the lead-acid battery manufacturer.

DC output voltage fluctuations shall be regulated to less than 1% irrespective of load and mains supply voltage variations.

d. **Input Filter**

The rectifier / charger shall be equipped with a filter limiting the DC ripple voltage to a value less than 1% of the DC voltage.

e. **Surge-Arrester**

A surge-arrester of adequate capacity shall be fitted at the power input. The surge arrester must be able to protect the UPS and all downstream equipment under all modes of operation.

4.8.2.3 Battery Panel

The batteries shall be lead acid type, maintenance-free, housed in matching enclosures. The battery size shall be adequate to supply power to the inverter for specified time in the event of an outage on the normal mains supply, with the UPS system operating at rated load and power factor. Battery ratings shall be based on an operating temperature range upto 40 ^{o}C. A circuit breaker shall be provided in the battery circuit. All connection cables shall be provided for battery panel.

4.8.2.4 Inverter

The inverter shall be of adequate size to ensure that the UPS system can supply rated load at rated p.f., as per the following requirements:

a. Voltage Characteristics

i. Rated voltage = 380/400/415V (pre-set on commissioning) 3 phase + neutral.
ii. Steady state voltage regulation = $\pm$ 1% for a load between 0 and 100% of full rated value irrespective of normal mains supply and DC voltage levels (within the limits specified above).
iii. Transient voltage regulation = $\pm$ 5% of rated voltage for a 100% load step change. The voltage shall return to within steady state tolerances in less than 10 milli seconds.
iv. Voltage distortion with linear load < 1%
v. Voltage distortion with 100% non-linear load < 3% phase to phase, < 5% phase to neutral.
vi. Voltage phase shift with 100% unbalanced load = $120^{o} \pm 1^{o}$
vii. Output filter: the inverter shall be provided with an output filter to limit single harmonic distortion to 3% and total harmonic distortion to less than 5% irrespective of load and normal mains supply (within the limits specified above).

b. Frequency Characteristics:

i. Rated frequency = 50 Hz
ii. The output frequency of the inverter shall be synchronised to that of the bypass power supply within the limits of $\pm$ 0.5 Hz.
iii. For mains frequency variations exceeding the above limits, the inverter shall switch over to a free-running mode, with regulation providing an output frequency to within + 0.1% of the rated value.

c. Overload Capacity

The UPS shall be able to supply 110% load for 60 minutes, 125% load for 10 minutes, 150% load for 1 minute, on 3-phase and 200% load for 30 seconds on 1-phase.

4.8.2.5 Static Bypass

The UPS system shall be provided with static bypass switch to initiate instantaneous load transfer from the inverter to the mains power supply and vice-versa without interruption.

The static bypass shall be completely independent of other components. It shall provide the load with uninterruptible supply in the following situations:

a. Overloading of inverter
b. Inverter fault
c. Short circuit in load
d. During manual switchover from inverter to bypass operation.

Synchronised transfer to bypass shall take place in zero millisecond. Unsynchronised transfer to bypass shall take place in 20 millisecond.

4.8.3 Mechanical Features

The UPS enclosure shall be of sheet steel construction, protected against corrosion, derusted, degreased, phosphated and powder coated or equivalent.

The enclosure shall be space saving modular, rigid framework construction with easily removable panels. The front panel shall be detachable and shall have a safety lock. Access to components shall be from the front or from above via removable cover. The rear panel shall be removable. The enclosure shall have height adjustable feet to ensure stable installation and levelling facilities. Each UPS system unit shall be housed in an integral enclosure. The battery shall be housed in a separate enclosure. Connection terminals shall be provided. Bus bars shall be made of electrolytic copper. Cable entry shall be from bottom/ rear. Ventilation fans with low noise generation shall be provided. Standby fans shall be provided and annunciation for fan failure shall be included.

The maximum sound level of the UPS shall be 56 db (A) at one meter. All live parts shall be adequately insulated/shielded.

4.8.4 Controls, Indications, Protection

The Control and Indicator Panel shall be mounted on the front side. It shall provide information to the operator to monitor the status and facilitate operation of the UPS system.

4.8.4.1 Controls

The following main controls shall be provided:

a. Switching from UPS operation to BYPASS operation.
b. Rectifier / Charger ON/OFF
c. Inverter ON/OFF
d. Self-test
e. Remote control and monitoring facility on remote control unit or PC.

4.8.4.2 Indications / Alarms

The following indications/alarms shall be provided:

a. Status of mains supply.
b. Status of battery.
c. Rectifier / Charger ON.
d. Load on inverter.
e. Load on bypass.

f. Charger fault.
g. Inverter overheating.
h. Fan fault.
i. Bttery autonomy.
j. Bypass defect.
k. Overload.

4.8.4.3 Protection

The UPS shall include protection against the following:

a. Input over voltage.
b. Load short circuits.
c. Over temperature.
d. Emergency stop in event of fire on receiving signal from building fire alarm control panel.
e. DC voltage low.

4.8.4.4 Metering

The following measurements shall be indicated:

a. Mains input voltage.
b. Rectifier / charger current.
c. Battery voltage.
d. Battery current (Normal / Charge).
e. Inverter output voltage.
f. Inverter output frequency.
g. Inverter output current.

4.9 Lighting Columns

Lighting columns shall be supplied in total construction heights of 12 m, 15 m, and 20 m. For illumination of the passenger parking area and roads in front of the terminal 20 m high lighting columns shall be used. These lighting columns shall be able to carry at least 4 post top/bracket mounted lanterns for ratings of 1 x 600 Watts high-pressure sodium lamps.

On top of 15 m high lighting columns there shall be either one, two or three post top/bracket mounted lanterns with suitable adapters provided. Ratings of the lanterns shall be in accordance with the ratings shown on the drawings.

On top of 12 m high lighting columns there shall be one post top/bracket mounted lantern of 1 x 250 Watts high-pressure sodium lamp provided.

All lighting columns shall be of steel (conforming to BS 5649, part 3) tubular tapered with construction heights of 12 m, 15m and 20 m above the anchor plate.

Structural design for the entire assembly of lighting column with lanterns, consideration for upto two advertisement panels (20 Kg/panel) shall be submitted by the contractor in accordance with wind & seismic loads given in the relevant Section for review and approval.

All columns and accessories such as anchor bolts, doors, adaptors, shim plates etc., shall be hot galvanized in full bath process. After galvanizing the threads of the anchor bolts shall re-cut and greased.

Lighting columns shall be welded to anchor plates by means of appropriate gusset plates. For cable access to the light pole a hole of at least 150 mm diameter shall be provided in the middle section of the anchor plate. Approximately 800 mm above the anchor plate a lockable door shall be provided. The door shall have a minimum size of 120 mm x 350 mm. Inside the door there shall be a baseboard arranged with a channel for mounting the cable termination and fuse block. An earth connection terminal screw of at least M8 mm shall be provided on the baseboard. The doors shall be fitted with tamper proof locks.

Cable connection – fuse/mcb blocks shall be provided in every light pole and shall have cable supports and terminals for at least 2 cables 5 x 16 sq.mm. Screw in fuses in sufficient number and size shall be provided. The design of the cable connection, fuse block shall be in accordance with the detailed drawing. Each light fixture on pole shall have separate fuse/ mcb.

5.0 INSTALLATION

5.1 General

The mounting heights, depths and other dimensions of all the Miscellaneous Items are stated on the drawings or in general notes. In case of any discrepancy, the instructions of the Engineer shall be obtained before fixing the item.

5.2 MCCB / MCB Enclosed in Sheet Steel Box

The triple pole moulded case circuit breakers (MCCB) single/double pole miniature circuit breakers (MCB) shall be installed on 1.63 mm (16 SWG) thick sheet steel box with screws or some suitable arrangements as approved by Engineer. White faceplate for sheet steel box shall be fixed by means of flat head galvanized screws sunk in the plastic plate so as to finish flush with the wall surface. The edges of the plate shall be champhered.

5.3 Load Break Switch enclosed in Sheet Steel Box

The load break switch shall be installed as per manufacturer's recommendation and site conditions following good engineering practice.

5.4 Ceiling Fan

Fan hook shall be installed in the RCC ceiling and to the reinforcement before pouring of concrete.

The installation of fan shall include fixing of blades, down rod, clamp, canopy, including testing and commissioning. The down rod shall be of required length having long threads and shall be provided with check nuts to secure it firmly with the clamp and with the body of the fan. A split pin shall be provided both at the fan body end and at the clamp for safety. Any scratches on the body of the fan or fan rod appearing during installation shall be cleaned and painted properly with the same quality paint as provided by the manufacturer.

Wiring between the ceiling rose and the fan terminals shall be carried out with three core 1.0 sq.mm PVC insulated PVC sheathed flexible cables.

5.5 Wall Bracket Fan

The wall bracket fan shall be installed on the wall and shall be firmly fixed by means of flat head galvanized screws.

Wiring between the ceiling rose and the fan terminals shall be three core 1.0 sq.mm PVC insulated PVC sheathed flexible cables.

5.6 Exhaust Fan

The propeller exhaust fan shall be installed in the opening already made in the wall and shall be firmly fixed by means of flat and head galvanized screws.

Wiring between the ceiling rose and the fan terminals shall be three core 1.0 sq.mm PVC insulated PVC sheathed flexible cables.

5.7 Cable Trays / Trunking

The cable trays / trunking shall be installed on supports fixed to the wall and/or ceilings. The supports shall be fixed to civil works by means of Rawl bolts. The additional hangers and other metalwork required for the installation of the trays / trunking shall be painted and finished by method as specified for the cable tray / trunking.

The distance between alternate supports (span) in straight runs shall be finalized as per loading and in no case shall exceed 1.2 metres. In addition to these, supports shall be provided near each bend or change in direction, end of trunking/ tray.

The straight jointing, bends and other accessories shall be fixed with cable tray/ trunking in such a manner that they are in one line with no sharp edges/ protruded surfaces. Rivet head nuts shall be installed on inner side of tray/ trunking.

5.8 Handholes with CI Cover & Frame

The handholes shall be constructed according to the Specifications of the Civil works and standard practice. Proper curing of the concrete shall be done for at least 15 days. Before constructing, the Contractor shall submit shop drawing of handhole showing steel reinforcement, embedded pipes, clearances, etc. for approval of the Engineer. Quality of cement used in the handhole shall be sulphate resistant.

5.9 Uninterruptible Power Supply (UPS) System

UPS installation shall be carried out by the Contractor in accordance with the recommendations/instructions of the manufacturer. The installation work shall be carried out under the supervision of Contractor's trained engineer to the satisfaction of the Owner/Consultant/Engineer, Installation work shall include all earthing to the UPS system from the existing distribution boards as per requirements and all power and control cable, conduit, trunking etc. shall be provided by the Contractor. The work shall include all cable terminations and labelling. The work shall also include angle iron supports at the base for UPS and stabilizer.

5.10 Lighting columns

Foundation blocks shall be generally in reinforced concrete, grade 25 type and in accordance with approved structural calculation. Construction of foundation blocks shall be according to the relevant drawings.

Lighting columns and necessary accessories shall be delivered free at location of use and be unloaded and set up ready for service and operation.

In addition, at least 10 pieces of setting templates for each size light poles shall be included in the scope of supply.

Expenses for auxiliary tools and equipment, such as crane and operator shall be incorporated in the tender bids.

After installation the lighting columns two coats of paint shall be applied to enhance corrosion resistance and improve aesthetics. Paint shall have inbuilt rust inhibitor, primer, undercoat and top coat in one product and shall have the ability to bond effectively with galvanized steel surface. Colour shall be of approved by the Engineer.

The cable opening and all gaps shall be filled with approved watertight material.

SECTION – 16.15: EXTERNAL COMMUNICATION CABLES NETWORK

1.0 SCOPE OF WORK

The work under this section consists of supplying, installing, testing, commissioning of all material and services of complete External Communication Cables Network as specified herein, as shown on the Tender Drawings and stated in the Bill of Quantities.

The Contractor shall discuss the electrical layout with the Engineer and co-ordinate at site with other services for exact route, location and position of the system.

The External Communication Cables Network with accessories shall also comply with the General Specifications, Section 16 and with other relevant provisions of the Tender Document.

2.0 GENERAL

The scope of work for External Communication Cables Network includes:

a. Intermediate distribution frame
b. 0.6 mm dia, 0.8 mm dia and 0.9 mm dia outdoor telephone cable
c. RG-11 coaxial outdoor cable
d. Multimode Fibre Optic outdoor cable
e. Surge Protection devices
f. 4-way outdoor micro duct for Fibre Cable

3.0 APPLICABLE STANDARDS AND CODE

The latest editions of the following standards/codes shall be applicable for the materials covered within the scope of this section:

ISO 9000-Series
Certified - Manufacturer for quality control

4.0 MATERIAL

4.1 Intermediate Distribution Frame (IDF)

IDF shall be made of 16 SWG (1.63mm) sheet steel having required dimensions to accommodate the terminal strips with adequate space available for wiring. The disconnection modules shall have provision for tag numbers. The disconnection modules shall be installed on insulated material sheet inside the sheet steel boxes. The disconnection shall provide Insulation Displacement Contact (IDC) technique for easy and quick connection for 0.9 mm. wire size. The IDC block shall have following minimum specifications:

Wire accommodation	0.4 mm - 0.9 mm
Tool accommodation	110 / LSA
Operation life	200 termination (minimum)
Cable termination	Gas tight IDC
Material	Self extinguishing plastic Component according to UL94

The steel box shall be provided with a lockable hinged door. The distribution box shall be suitable for surface mounting.

The IDF shall be of Krone make or approved equivalent.

4.2 Telephone Cable

0.6 mm, 0.8 mm and 0.9 mm dia twisted pair telephone cable for outdoor application shall have following minimum specifications.

Conductor:	Solid Plain Annealed Copper,
Insulation:	Polyethylene
Laying up:	Concentric Construction, Moisture barrier
PJ Filled Armour:	Galvanized Steel Wire
Sheath:	PVC Black

The cable manufactured to BTCW 1128D and BTCW 1198C shall be designed for use in control, signalling and telephone intercommunication application. Cable shall be suitable for direct burial. Identification marking shall be given for each cable so that it may not be confused with the various system 'T' for telephone, 'FA' for fire alarm and 'RPS' for Radio Paging System shall be used.

4.3 Coaxial Cable

Coaxial cable shall be suitable for direct burial. RG-11 type coaxial cable shall have following minimum specification.

Inner Conductor	-	Solid Copper
Dielectric	-	Foam Polyethylene
Braid	-	Copper
Jacket	-	PVC Black

4.4 Fibre Optic Cable

Fibre Optic Cable with full rodent protection shall be provided for installation in micro duct. The 50/125 Um and 62.5/125 Um multimode fibre optic cable shall have following minimum features:

a. cable construction fully dielectric for immunity against lighting
b. gel filled for protection against water
c. colour coded fibres
d. technical specification for outdoor cable shall be as follows:

Type	Attenuation	Bandwidth
50/125 micron	< = 2.7 dB/km @ 850 mm	> 500 MHz – km @ 850 mm
62.5/125 micron	< = 3.2 dB/km @ 850 mm	> 200 MHz – km @ 850 mm

4.5 Surge Protection Device (SPD)

The compact plug in single pair over voltage protection for 110 / LSA series shall have nickel plated leads for push fit and fail safe operation. Fuses shall not be used for surge protection. All cables which serve as communication link shall also have

surge protection circuits installed at each end that meet the TEEE 472 surge withstand capability test. Protector magazine for the installation into LSA modules shall be provided as required. Locate surge protection device within one metre of building entrance. Protectors for Coaxial Cable shall also be provided where the cables enter or leave the building.

4.6 Conduit and Conduit Accessories

The specifications for conduit and conduit accessories shall be same as given in section "Conduits and Pipes" of these specifications.

5.0 INSTALLATION

5.1 Intermediate Distribution Frame (IDF)

Distribution boxes for telephone cables shall be surface mounted type. All screws, nuts and bolts used for fixing the box shall be galvanized. Soft metal bushes shall be used at conduit entries in the box.

5.2 Telephone Cable

The telephone cable shall be installed as outlined in section `L.T. Cables' of these specifications. All cables shall be provided with plastic identification tags at termination which shall be clearly shown on the As-Built drawings. The complete wiring shall be checked for continuity, identification and insulation before connections are made.

5.3 Coaxial Cable and Fibre Optic Cable

Coaxial Cable and Fibre Optic Cable in micro duct shall be installed as per manufacturer’s recommendation.

5.4 Conduit

The control and communication conduit shall be installed in accordance with the instructions and details given in section “Conduit, and Pipes" of these Specifications. Control and communication conduit shall be laid 150mm away from the electrical conduits or cables, and wherever electrical conduits or cables, and control and communication conduits cross each other, they shall do so at right angles.

Identification marking shall be given at the termination or free end of conduit so that it may not be confused with the electrical conduits. The marking shall be both by colour and by attaching an approved brass tag using brass or bronze tie wire. Each tag shall be clearly stamped with ‘T’ for Telephone, ‘D’ for Data, ‘FA’ for Fire Alarm, ‘TV’ for CCTV, ‘RPS’ for Radio Paging System, ‘FIDS’ for Flight Information Display System and ‘MCS’ for Master Clock System.

SECTION – 16.16: FIRE ALARM SYSTEM

1.0 SCOPE OF WORK

The work under this section consists of supplying, installing, testing and commissioning of all material and services of complete Fire Alarm System as stated herein, as shown on Tender drawings and as given in the Bill of Quantities.

The Contractor will discuss the electrical layout with the Engineer and coordinate at site with other services for exact route, location and position of electrical lines and equipments.

The Fire Alarm System with accessories shall also comply with the general specifications for Electrical Works Section 16 and with other relevant provisions of the Tender Documents.

2.0 GENERAL

a. Fire Alarm Control Panel of each building shall be networked to the Main Fire Alarm Control Panel of FCR building. The line between individual control panel and main control panel of FCR building shall be supervised.
b. The network facility shall provide alarm reporting, coordinated evacuation and cross panel cause and effect operation. System control and graphic display computer shall be provided for the network. FCR Control Panel shall act as system master, displaying complete system status, system control and graphic display computer shall also show complete network status and allow control functions to be operated separately. Remote diagnostics facility shall be provided for both fault diagnosis and system configuration off site.
c. Relevant AHU and fire dampers shall be closed upon receiving an alarm signal from the area smoke/heat detector.
d. Automatic FM200 system, if installed shall function on dual detector principal with dual progressive alarm warning prior to flooding. Flooded rooms shall remain in the alarm state till reset at the FACP.
e. In the event of fire the lifts shall automatically remain at their position or stop at the next floor. Restarting shall only be possible from the control panel.
f. Activation of any fire alarm detector including manual call point of terminal building shall result in all alarms delay for the period of either of two programmable timers “T1” and “T2”. During this delay, only a local alarm shall be given (stage-1). If the local alarm is not acknowledged before timer “T1” expires, this shall result in all alarms being operated continuously (stage-2). If the local is acknowledged while “T1” is still running, “T1” shall reset and the general alarm is delayed for the reminder of timer “T2”, so providing time for human investigation of the alarm cause. If no reset action takes place before “T2” runs out, a general alarm (stage-2) results. In other buildings panels shall be programmed to give an immediate general alarm.
g. The power to Main Fire Alarm Control Panel, printer, mimic panel of FCR building shall be supplied by UPS which shall have an autonomy of six hours.

h. Mimic panel shall display alarm and fault indication of each fire alarm control panel.
i. In terminal building, evacuation announcements shall be made via the public address system in the passengers area. Transmission to the P.A. system shall be on the dedicated fire resistant circuit. The integrity of this line shall be supervised.

j. The FCR main fire alarm control panel shall facilitate communication with two other fighting stations so that additional help can be obtained in case of emergency.

k. A printer shall give a hard copy of all alarms, detector number, location and time. The printer pages shall be numbered and page number resetting shall be pass-word protected.
l. All outlet boxes shall be considered part of the devices installed on them and shall be supplied alongwith the devices.
m. The system shall operate on 24 VDC from a battery charger with standby batteries. The incoming supply shall be 220 VAC from emergency circuit.
n. The Addressable Fire Alarm System shall be used for early detection, warning and control function in case of fire. The system shall monitor and report the status of manual call points and automatic fire detectors.

All the Intelligent Sensors detailed above shall incorporate the following facilities:-

o. Up to 99 Sensors and 99 control modules shall be connected to each loop.
p. The Sensors shall be ceiling - mount and shall include a twist-lock base.
q. The Sensors shall provide a means of test whereby they will simulate an alarm condition and report that condition to the Control & Indicating Equipment (C.I.E.) Such a test may be initiated at the Sensor itself (by activating a magnetic switch) or initiated remotely on command from the C.I.E.
r. The Sensors shall provide address setting on the Sensor head using decimal switches. Addressable Sensors that use binary address setting methods, such as a dip switch, code cards or soft addressing are not acceptable. The Sensors shall also feature an internal identifying code that the C.I.E. shall use to identify the type of Sensor.
s. The Sensors shall provide dual LED's. Both LED's shall flash under normal conditions, indicating that the Sensor is operational and in regular communication with the C.I.E. Both LED's may be placed into steady illumination by the C.I.E., indicating that an alarm condition has been detected. If required, the flashing mode operation of the Sensor LED's shall be controlled through the system field program. An output connection shall also be provided in the base to connect an external remote alarm LED.
t. The Sensor sensitivity shall be set through the C.I.E., and shall be adjustable in the field through the field programming of the system. Sensitivity may be automatically adjusted by the C.I.E. on a time-of-day basis.
u. Using software in the C.I.E. the Sensors may automatically compensate for dust accumulation and other slow environmental changes that may affect their performance.
v. The Contractor shall provide wall chart for operation and maintenance of Fire Alarm System. The wall chart shall contain following minimum information in both English and Urdu languages.

    i. Complete layout of Fire Detection & Alarm system showing locations of all fire zones, and bells zones in two different colours.
    ii. Standby battery specification, including ampere-hour capacity Voltage per Cell, number of Cells, and the battery type.
    iii. Operating and maintenance instruction in BLACK colour.
    iv. Emergency instructions in RED colour.
    v. Name, address & telephone number of the servicing contractor.

    The characters of written instructions shall be minimum 6 mm high.

3.0 APPLICABLE STANDARDS/CODES

The following standards & codes shall be applicable for the materials covered within the scope of this section:

NFPA 72 - National Fire Alarm Code
NFPA 101 - Life Safety Code

The system shall have ability to perform satisfactory under conditions of electrical surges and transients, and shall comply fully with the requirement of the following standards as required by EN54 :

IEC 801 – 2 Electrostatic discharges
IEC 801 – 3 Radiated Electro magnetic interference
IEC 801 – 4 Voltage transients – Fast transient bursts.

Each and all items of the Fire Alarm System shall be listed as a product of a single fire alarm system manufacturer under the appropriate category by under writers laboratories (UL) & shall bear the UL label. Equivalent DIN or British standard shall also be acceptable.

4.0 MATERIAL

4.1 Analogue Addressable Fire Alarm Control Panel

The system shall be easily configured using 'plug-in' addressable loop drivers and communication modules. Further 'plug-in' modules shall be available to allow the expansion of programmable inputs and outputs.

The Power Supply shall operate on 230 VAC, 50 Hz, and shall provide all necessary power for the control panel.

In the event of a mains electrical failure, the fire alarm control panel shall have the capability of being supported in its intended state by standby batteries for 24 hours. The fire alarm control panel shall be fitted with an integral battery charger, current limited with DDP for 24 V lead acid batteries. The battery charger must be capable of being up-graded in capacity to facilitate larger systems.
The panel shall provide required number of fully programmable fire outputs each with volt-free changeover contacts rated at 24 VAC/DC, 1 Amp maximum.

The panel shall have 14 general panel status LED's. An alphanumeric liquid crystal display shall give 80 characters of information on a 2-line display. The display will be illuminated to aid viewing under dim ambient light conditions.

Zonal fire indicators (LED's) and zonal fault/test/disabled (LED's) shall be provided. It shall be possible to increase the number of zonal fire and fault/test/disabled LED's simply by "plug-in" extender cards.

An on-board alphanumeric keypad with keys shall allow the complete control and configuration of the system. Alternatively the panel shall be programmed using PC based upload/download software.

Four separate push buttons shall provide control of Sound Alarms (Evacuate), Silence/Resound, Mute/Accept and Reset, and shall be located adjacent to the main LED indication.

The panel shall have two serial communication ports. An optional “plug-in” RS485 or RS232 card will support a PC front-end graphics package or panel network connection. An RS485 peripheral bus shall support a further 126 addresses in addition to the detection loops. Peripheral bus shall support a further 126 addresses in addition to the detection loops. Peripheral devices shall include; display only and active repeater panels, remote printers, 8-way input cards and 4-way sounder & relay cards.

A dedicated RS232 port shall also be provided for both connections to a local printer and upload/download of configuration data via the manufacturer’s standard PC programming tool.

User Control Levels: -

The fire alarm control panel shall have three user control levels.

At all three levels, the LED displays shall indicate the condition of the installation, the zone LED’s shall indicate the location of any fire alarm or fault and the alphanumeric display shall provided detailed fire alarm or fault information.

Level 1 - All displays shall be functional, but the front panel controls shall be inhibited.

Level 2 - All displays and all front panel controls shall be functional. Changes to the system configuration shall not be accessible at this level. User Level 2 shall be reached by entering a unique 4 digit password from level 1.

Level 3 - All front panel controls shall be functional and full system configuration and programming shall b possible. User level 3 shall be reached by entering a unique 4 digit password from either level 1 or level 2. User level 3 shall be for use by the system installer / maintenance contractor.

A level 2 password shall not allow access to level 3 functions.

Up to 10 level 2 passwords shall be definable from level 3.
A program integrity option shall display the panel software version alongwith ROM and RAM checksums. The RAM checksum shall alter whenever the configuration is changed. For example, the checksum figure shall change when either adding or removing devices or changing text assignments. After the final configuration has been entered the program integrity shall be checked and the RAM checksum figure recorded.

Day Modes: - The fire alarm control panel shall have the ability to automatically invoke different operating modes according to the time of day. Each mode shall have adjustable start and finish times. Outside of the designated start and finishing times, the panel shall revert to normal operation. The operating modes will consist of:

Delayed mode - During the day or night the alarm signal from the detection points shall be immediately recognized and identified on the panel display, but no outputs switched on until staged timers have expired.

Sensitivity mode - Shall allow smoke and temperature detectors to use different pre-alarm and fire alarm thresholds during day and night mode.

Verification mode - Shall allow smoke detectors to tolerate transient alarms according to the programmed verification delay time during either day or night.

Control Module - Addressable Control Modules shall be provided for fan shut down and other auxiliary control functions, the control module may be set to operate as a Volt Free relay contact.

The indicating circuit may be wired for a maximum of 1 Amp (inductive) or 2 Amps of Resistive A/V Signal operation, or as a Volt Free Contact (Form C) Relay. The relay coil shall be magnetically latched to reduce wiring connection requirements, and to ensure that 100% of all auxiliary relay or indicating circuits may be energised at the same time on the same loop.

The Control Modules shall provide address setting on the module using decimal switches. The modules shall also feature an internal identifying code that the C.I.E shall use to identify the type of module.

A magnetic test switch shall be provided to test the module without opening or short line its wiring. The isolator module shall be installed on the semi flush mounted box.

Isolator Module: - Isolator Modules shall be provided to automatically isolate circuits on a loop. The Isolator Module shall limit the number of modules or detectors that may be rendered inoperative by a short circuit fault on the loop. At least one isolator module shall be provided at either side of each zone of the building.

If a wire-to-wire short occurs, the Isolator Module shall automatically open-circuit (disconnect) the affected segment of the loop. When the short circuit condition is corrected, the Isolator Module shall automatically reconnect the isolated section of the loop.

The Isolator Module shall not require any address setting, and its operations shall be totally automatic. It shall not be necessary to replace or reset an Isolator Module after its normal operation.

The Isolator Module shall be installed on the semi flush mounted box. It shall provide a single LED that shall flash to indicate that the Isolator is operational and shall illuminate steady to indicate that a short circuit condition has been detected and isolated.

Zone module shall be provided to monitor a zone of 2-wire conventional automatic and manual detectors. It shall respond to regular polls from the control panel and reports its type and status (open/normal/fire/short) of its zone circuit. A flashing LED shall indicate that the module is in communication with control panel.

Event Log: - The fire alarm control panel shall store the last 500 events. It shall be possible to se the event log to either “diagnostic” or “normal” mode. Normal is the default mode.

When in diagnostic mode the log shall record every event including single response failures from a device. The diagnostic mode shall aid the engineer to determine spurious or transient fault conditions including loop wiring and detector problems, particularly if these are intermittent.

Displayed Identification :- During normal panel operation, when the fire alarm control panel is operating correctly, the LCD display shall display a message that

identifies the system installer / maintenance company, this display shall feature up to 20 characters.

If a fault occurs on the fire alarm control panel the LCD display shall automatically show a telephone number to call for assistance, this display shall feature up to 20 characters.

Cause-and-effect programming: - The panel shall provide a flexible way of performing cause-and-effect programming. This shall include mapping individual detectors and call points to outputs as well as mapping outputs relative to zones in alarm.

In the event of a fire alarm, the indications shall be as follows:

The zone alarm LED indicators on panels shall illuminate to show the zones in alarm on the overall system.

It shall be possible to configure' or 'inspect' devices from the panel.

Upon actuation of any automatic detector and manual call point following shall occur automatically:

a. FACP LCD display shall provide information pertaining to Fire Zone, type of device and location.

b. Communicate alarm indication at the Master alarm panel of FCR building.

4.2 Manual Call Points (Conventional / addressable)

Manual Call Points shall be constructed of flame retardant plastic with clearly visible operating instructions provided on the glass or resetable plastic element. The word FIRE shall appear on the front of the Call Points.

Manual Call Points shall be suitable for semi-flush mounting as required.

The addressable Manual Call Points shall provide address-setting means using decimal switches.

4.3 Photoelectric Smoke Sensors (Conventional / addressable)

The Sensors shall use the photoelectric (light-scattering) principal to measure smoke density. Photo Electric Smoke Sensor shall have following minimum technical specifications:

a. Operating Voltage : 16 – 26 V DC
b. Monitoring type. : Open and short circuit fault, sensor removal and device
c. Area Coverage : 100 m^2

4.4 Multi Sensors (Conventional / addressable)

The multi sensors shall incorporate photo electronic optical smoke sensor and high sensitivity thermal sensor and provide early warning from all types of smoldering and thermal fires. The smoke element shall be of the light scattering type using be of the light scattering type using a pulsed internal LED light source and a photocell sensor.

The thermal element shall utilize high sensitivity, high speed thermistors optimized to measure small changes in temperature and rate of change. The detector shall be capable of protecting an area up to 100 m^2 at a height of up to 12 m.

4.5 2 Heat Sensors (Conventional / addressable)

The Sensors shall use an electronic sensor to measure thermal conditions caused by a fire. Heat sensor shall have following minimum technical specifications.

a.	Operating Voltage	:	16 – 26 V DC
b.	Monitoring device	:	Open and short circuit fault, sensor removal and type.
c.	Area Coverage	:	80 m^2

4.6 Sounder (Conventional / addressable)

Sounder shall be addressable / conventional devices and shall connect to one of the C.I.E. loops / sounder circuits. Multiple tones shall be provided with automatic tone synchronization of all sounders connected to the loop. Dual sound path shall allow a wide angle of sound distribution with a constant sound level. Self test facility shall allow all sounders to be tested from the control panel by one person. Sounder shall provide high output 90 dBA to 112 dBA at 1 m.

4.7 Audio Visual Alarm Device

Audio Visual Alarm device shall be addressable / conventional and shall connect to the C.I.E. loop/sounder circuits.

Audio Visual alarm device shall provide following minimum features:

Operating Voltage	:	24 VDC
Strobe output rating	:	110 Cd
Strobe flash rate	:	Once every two seconds
Sound output	:	75 dB @ 3 m
Housing colour	:	Red with white “FIRE” lettering Mounting Semi flesh

4.8 In-duct Smoke Sensor Housing

In-Duct Smoke Sensor Housing shall accommodate either an addressable Ionisation Sensor or a Photoelectric Sensor, to provide continuous analogue monitoring and alarm verification from the C.I.E.

When sufficient smoke is present within the sensor detection chamber, an alarm signal is initiated at the C.I.E. and appropriate action taken to change over air handling systems to help prevent the rapid distribution of toxic smoke and fire gases throughout the areas served by the duct system.

4.9 Mimic Panel

Mimic panel of terminal building shall indicate alarm of each zone, while the mimic panel of FCR building shall display the floor plans of all area covered by fire detection system. Alarms/indication shall thus be displayed call on these plans and show the actual area effected. The mimic panel shall have built-in lamp test and audible alarm

signal. The size of the panel shall be approximately 1150 x 1600 mm. The layout shall be printed onto the substrate and include the building name.

The mimic panel lights shall consist of dual LEDs. On receipt of alarm the LED concerned shall flash. On the acknowledgement of the alarm, the light shall remain steady. On receipt of an all clear signal from the operator the LED shall switch off.

4.10 Computer

The branded computer with licensed software which shall include operating system and Application Software. Back up software shall be supplied on separate CDs. Computers shall be of the latest Specifications and shall minimally comply with the following:

Processor	Latest
Hard Disk	> 80 GB
RAM	> 256 MB
Monitor	Industrial type LCD

4.11 Wiring and Cabling

Wiring and cabling of Fire and alarm system shall be carried out in conduits. Twisted pair 0.8 mm dia untinned annealed copper cable with PVC insulation and LSF sheath shall be installed for Fire Alarm System or as recommended by manufacturer for addressable detectors. However two core, 1.5 sq.mm cable meeting c,w and z categories of BS6387 shall be used for conventional detectors.

All wires and cables shall be color-coded, tagged and checked for open, short or ground faults. No transposition of colours will be permitted. All wiring shall be made on terminal blocks of proper size and type for the services involved. Cable joints shall only be allowed on the detector bases.

4.12 Conduits, Pipes and Accessories

Conduits, pipes and accessories for Fire alarm system shall have same specifications as given in section 'Conduits and Pipes' of these specifications.

5.0 INSTALLATION

5.1 Fire Alarm System Equipment

The installation of Fire Alarm system equipment shall be in strict accordance with the manufacturer's instructions/recommendations and these specifications.

The testing of Fire Alarm equipment shall be in compliance with the relevant standards and regulations. During testing of equipment, emphasis shall be laid on the following:

- Operational Safety
- Regular functioning of the system and devices
- Protection against false alarms

Various detectors like smoke, heat, manual call point etc. shall be subjected to the basic tests and sensivity tests. The automatic detectors shall be tested in various ways to check real and false alarm behaviors.

5.2 Wiring and Cabling

Wiring and cabling of fire alarm system shall be carried out as per instructions given in Section 16.9 'Low Tension Cables' of these specifications.

5.3 Conduits and Accessories

Conduits and accessories for FA system shall be installed as per instructions given in section ‘Conduits and Pipes’, of these specifications.

6.0 TRAINING

A training session shall be presented by a fully qualified, trained representative of the equipment manufacturer/supplier who is thoroughly knowledgeable of the specific installation. The training shall be given to personnel responsible for operation and maintenance of the system.

The training session shall include but not limited to the following:

6.1 Detailed explanation of wall charts as mentioned in Article 2.0 of this section.

6.2 Function of each control switch

6.3 Periodic operational testing of panel/devices.

6.4 Maintenance of fire log book supplied by manufacturer.

6.5 Actions to be taken upon receiving following signals:

6.5.1 False alarm indication

6.5.2 Trouble on any initiating or indicating zone

6.5.3 Common alarm or common trouble indication

6.5.4 Low battery voltage indication

6.6 Field modifiable programming.

SECTION 16.20: SUPERVISORY CONTROL & DATA ACQUISITION

1. GENERAL

1.1 Scope

The purpose of this Guide Form Specification is to outline some of the requirements and considerations in the selection and implementation of a monitoring and control system for a manufacturing environment. A monitoring and control system provides the infrastructure required to support the collection and sharing of data and information from the shop floor controllers to the enterprise level. The technology base that the software system is built upon is as equally important as the functionality delivered by the system. A sound technology base built upon industry accepted standards help assure a smooth transition and migration path as new technologies evolve. Since 1997, Microsoft and its technologies has become a dominant player on the factory floor and offers the greatest promise of a flexible future migration path.

A monitoring and control system makes it possible to exchange data in the form of discrete and analog values from I/O devices and/or control devices such as programmable, motion or computer numerical controllers. The system also allows information to be easily shared between computer systems and applications through an open systems design and architecture. The system also makes it possible to support modular applications such as graphical display, alarming, logical functions, analysis, data handling operations and can communicate with enterprise or external systems over a network. Sharing of data should be capable through Web based browsers as well as standard Client Viewers.

1.2 Definitions

a. HMI: Human Machine Interface. Used to provide a graphic representation of data from a process and to accept user commands to be fed back to the process.
b. Ethernet: A very high performance local area network standard providing the two lower levels of the ISO/OSI seven layer reference model, the physical layer and the data link layer.
c. TCP/IP: a protocol widely used across Ethernet networks for connecting computers and programmable controllers.
d. Web Browser: A client application that provides a user interface via the World Wide Web. Netscape and Microsoft Internet Explorer are two popular examples.
e. Thin Client: In client/server applications, a client designed to be especially small so that the bulk of the data processing occurs on the server. The term thin client refers to a client designed to be as small as possible.
f. Data Concentrator: A physical device that translates analog and digital information from attached I/O devices to a protocol that can be used with an HMI.
g. Communications Protocol: A formal set of conventions governing the control of Inputs and Outputs between the two communicating processes.
h. Network: An interconnected group of nodes, a series of devices, nodes or stations connected by communications channels.
i. Operating System: A program that controls the entire overall operation of the computer system hardware/software.

2. INDUSTRY STANDARDS

Industry standards lay the cornerstone for the technology base of a monitoring and control software system. The system should conform to and take advantage of industry standard and de-facto standards. These should include, but not be limited to:

a. ODBC
b. OLE
c. ActiveX
d. COM/DCOM
e. DDE and AdvanceDDE
f. C programming language
g. Visual Basic®
h. Microsoft Windows 98
i. Microsoft Windows NT
j. Microsoft Windows 2000
k. TCP/IP
l. OPC DE
m. OPC Alarm and Events (A&E)
n. XML

3. SYSTEM ARCHITECTURE

3.1 Overall Design

The system should be designed to pass data and information between a variety of computer platforms and operating systems. It should support industry standards, be modular in design, and provide application program interfaces to allow easy customization.

3.2 Client/Server

In order to reduce the overhead of multiple independent systems, the software system should support a distributed Client / Server architecture. This should include the support of Human Machine Interfaces, Data Servers, Viewers (clients), and Web based Thin Clients. Each of these components should work in conjunction with the others using industry standard Ethernet networks.

3.3 HMI Client/Server

The monitoring and control software system should a **true** client server HMI architecture. HMI Servers should poll and collect data from devices. This data is to be seamlessly shared among other HMI Servers and to Viewers without requiring the duplication of data values in another node. HMI Viewers should act as clients to the HMI Servers, seamlessly receiving their data.

In a true client server environment, data is to be configured once. The HMI should support one time configuration of data points. For example, points to be polled from a device should be configured once on that server and other Servers or Viewers need only reference that data item to use it for their applications.

Alarms should be configured once and served across multiple HMI Servers and Viewers.

HMI Viewers should be able to simultaneously access data from one or more HMI Servers. Data from multiple Servers may be used within the same graphic screen. Viewers should require only a valid TCP/IP connection to the Server to obtain this data. This TCP/IP link may typically be across a local area Ethernet network (LAN) although it may be across a wide area network (WAN) and make use of telephone lines, radio, and/or satellite links.

3.4 Human Machine Interface Servers

The HMI Server software should be configurable to provide for the monitoring and control of all points, loops, and systems through graphic display screens and hard copy (printer output) reports. These should include but not be limited to:

a. Parameter Displays for signal control
b. Control Loop Status Displays
c. Real Time and Historical Data Trend Displays
d. Event Displays and Log Reports
e. Alarm Displays and Log Reports
f. Equipment Diagnostic Displays and Reports

HMI Servers should be capable of operating independently but should be configurable to share data with other HMI Servers or Enterprise Server systems.

3.5 Enterprise Servers

The software system should support the use of Enterprise Servers. Enterprise Servers should be capable of consolidating data from HMI Servers without the need for reconfiguring point values. Servers should provide a broad view of information within a facility and should be capable of supporting host or database applications such as SPC and Production Tracking. In addition, Enterprise Servers should be capable of supplying data services to networked viewers.

3.6 Viewers

Viewer Systems should provide occasional system users with easy access to plant floor data using the same graphical user interface as Enterprise and HMI Servers.

Viewers should be capable of both displaying and modifying data.

3.7 Web Based Thin Client Viewers

Web based Thin Client Viewers should provide the capability of viewing the graphic screens from the software system. The user should not need to recreate screens for the Thin Clients. The software system must be able to support the display of the graphic screens without the need for the user to recreate the screens in html documents.

3.8 Computer Platforms

The computer platform for HMI servers should be a PC compatible personal computer running Windows 2000 and Windows NT operating systems. Runtime Viewers should also be supported on Windows 98 and Windows XP based systems. The HMI should be capable of running on Symmetric Multi-Processor Windows NT and Windows 2000 operating systems.

3.9 User Management

In supporting a client / server architecture, the product must be able to handle multiple users with different log ons and security. The system shall also be able to log a person off after a configured period of time without interaction with the system.

4. Technology

4.1 Microsoft Technologies

Technology is the foundation of a software system and critical to the current as well as future functionality it is capable of delivering. Choosing a system that is based on industry driven standards helps assures compatibility with existing systems as well as provides a roadmap for the future.

Microsoft has been a key player in driving the technologies used in systems on the facility floor. Since its introduction, Windows NT® has been gaining acceptance for use in facility applications at a rapid rate. Windows NT has been displacing Unix and VMS based systems with its ease of use and open standards.

Microsoft has either driven or helped sponsored the following open system standards:

a. ODBC
b. DDE
c. OLE
d. ActiveX
e. COM/DCOM
f. OPC
g. Windows Metafile
h. XML

ODBC - Open Database Connectivity is one of the fundamental standards that empower an software system. ODBC provides the means for applications to easily access and retrieve information from relational databases. Data that is collected by an software system is transformed into information that users can use. This information must be stored and retrieved from a database. ODBC provides an open systems approach to the storage and retrieval of your system information.

DDE, OLE, and ActiveX illustrate the evolutionary growth of industry standards. DDE, Dynamic Data Exchange, is a standard that was developed to allow applications to pass data in a real time fashion. This then evolved to OLE - Object Linking and Embedding. OLE allows for one application to be contained within another. A typical example of OLE is the ability to embed a Microsoft Excel chart in a Word document. Once embedded, it is easy to access the other application. In the case of the Excel chart, updates to it can be automatically reflected in the Word document. ActiveX takes the evolution one step further by providing the ability to embed a self-contained application (object) within another application. ActiveX objects are often user interface applications that receive and send data and information from the software system while allowing the user a view and interact with the information. It is therefore critical that the software system support DDE, OLE, and ActiveX as these standards provide an open systems approach allowing the user to select the best components and object to integrate the application.

OPC (OLE for Process Control) is a new standard supported by Microsoft that has gained acceptance among vendors of HMI and process automation products. OPC builds on the success and strength of the Microsoft operating systems and OLE (Object Linking and Embedding). The design of OPC was initiated in 1995, and was targeted at providing a standard for interoperability between control applications, field systems and devices, and business and office applications. OPC is endorsed by Microsoft and the OPC Foundation which developed the technical specification. The

OPC Foundation now includes over 140 members with broad representation from the process control industry.

The sign of a true open systems based monitoring and control system is its capabilities of acting as an OPC Client as well as an OPC Server. As an OPC Client, the system must be able to collect data from third party OPC data collection servers. As an OPC Server, the software system must be able to share the data and information it manages with other third party programs.

OPC Alarm and Events (A&E) provides alarm and event notifications on demand (in contrast to the continuous data flow of Data Access). These include process alarms, operator actions, informational messages, and tracking/auditing messages. That system shall be able to be act as an OPC A&E server or OPC A&E client.

COM (Component Object Model) is a Microsoft software architecture that allows applications to be built from software components. COM is the foundation behind higher-level software services, like those provided by OLE. From its original application on a single machine, COM has expanded to allow access to components on other systems. Distributed COM (DCOM), introduced in 1996, makes it possible to create networked applications built from components. DCOM is used today in applications ranging from cutting edge medical technology to traditional accounting and human resources systems. COM and DCOM provides the architecture that enables true client/server based software systems.

Windows Metafiles is a standard for vector-based graphics. Metafiles are represented as collections of lines rather than pixels, so you can manipulate them without the distortions common to bitmap (raster) graphics. Software systems that support the Metafile graphic format are capable of importing graphic objects from other packages such as AutoCAD, Visio, and PowerPoint. The support for these third party graphics can greatly reduce the time to commission a system by allowing the reuse of existing graphical design work.

XML is a standard that allows software developers to easily describe and deliver rich, structured data from any application in a standard, consistent way. XML does not replace HTML; rather, it is a complementary format. XML enables a new generation of Web-based data viewing and manipulation applications. The HMI product should provide XML server capabilities to provide data collected from the shop floor out to other applications using the XML format. In addition the HMI should provide the ability to view point and alarm reports in XML format in standard web browsers.

4.2 Object Technologies

ActiveX is a standard that defines self-registering, in-process COM components that often have a visual element either at design time or run time. It is important that the system supports ActiveX and provides an ActiveX container application. This allows native or third party ActiveX controls the ability to communicate with the software system. The use and support of ActiveX controls can greatly expand the functionality and applications the software system supports.

In addition to supporting ActiveX, the graphical interface for the system must be object oriented. It must be possible for the user to construct their own objects and incorporate point information, animation, and screen based scripts. It must be possible to create master objects that then can be linked into other screens. Any changes to the master object shall be reflected in all other screens the next time the screen is accessed. It must be possible to create and configure object classes that

outline a data structure consisting of both static attributes and variable information. For example, a user should be able to create an object for a motor that identifies attributes for information such as the manufacturer and horsepower rating as well as hold variable data for the actual speed and status of the motor. Once an object is created, the user must be able to freely instantiate several instances of the object.

4.3 Web Technologies

Internet and Web technologies are changing the way business is being conducted. It is important for the software system to have the capability of sharing and transmitting its collected and maintained information to internet users. It must be possible for the information of the software system to be shared in standard Netscape or Internet Explorer Web browsers without the need to load any additional client software on the user's PCs. Users must be able to view the information as well as with sufficient password protection, enter or modify information as well.

4.4 Wireless Technologies

The software system should support a wireless Ethernet architecture. This will allow mobile users access to the system's information on laptops or Windows CE based hand held PCs. Wireless Ethernet technologies supported should be spread spectrum frequency hopping based rather than spread spectrum direct sequence to avoid possible interference and performance problems on the manufacturing floor.

4.5 Programming and Interfaces

An open systems approach to the design and implementation of the software system is critical. The system must not only adopt open system standards such as ODBC, OLE, OPC, ActiveX, and COM/DCOM, but must also provide open APIs (Application Program Interfaces). APIs shall allow users to develop their own direct interfaces with the data and alarm information collected, managed, and maintained by the software system. Programming calls used in the APIs shall be the same as those used internally in the construction of the software system code. This common design shall permit a seamless integration of custom or third party applications with the software system.

5. REAL TIME DATA MANAGEMENT

A key capability of a monitoring and control software system is the ability to provide a real time, distributed, memory resident database of current process data values. These data ("point" or "tag") values may be from definable device points representing the value of a physical data collection item on a resource, or virtual points representing values calculated from one or more device point values used in a mathematical expression.

5.1 Data Sharing

Point values should be stored, retrieved and manipulated across one or more computers using the software system's distributed architecture. Data integrity must be automatically and continuously ensured.

Writing of custom software should not be required to provide simple data sharing among HMI Servers, Enterprise Servers and or Viewers. Viewers should simply "connect" to Servers to obtain data. Enterprise Servers should have configurable support for collecting data from HMI Servers.

The software system must provide Application Program Interfaces that are published and available to permit users to write custom software to support interfacing the HMI and Enterprise Servers to other computer systems and applications. To ensure that these "API's" provide adequate support for device data collection, it is recommended that the software system and HMI are the same vendor.

The HMI should also support data sharing using DDE. In this mode, the HMI acts as the "server" and applications such as Microsoft Excel act as the "client".

5.2 Data Collection Methods

The software system needs to support a wide range of data collection methods. Data collection methods should include scheduled polling, on-change, unsolicited, timed interval, “on demand”, triggered reads, and array support, among others. Engineering Unit conversions on collected data and reverse engineering units conversions for setpoints are required.

HMI Servers should have configurable support for obtaining data from supported plant floor devices.

The HMI should also support data collection from DDE servers using both the DDE and AdvanceDDE protocol standards. In this mode, the HMI operates as a client. This capability permits the use of third party software to extended data collection support.

The HMI should be capable of acting as an OPC Client as well as an OPC Server. As an OPC Client it should be capable of collecting data from third party OPC servers. As an OPC Server it should be capable of serving the information it is maintaining out to other third party software packages acting as OPC Clients.

5.3 Required Data Types

The software system should support the following Data Types:

a. Global
b. Floating point
c. Analog (Signed and Unsigned)
d. Discrete
e. String
f. Arrays
g. Structures

5.4 Device Communications

The software system must be capable of supporting hundreds of different models, makes, manufacturers, and protocols of programmable and industrial control devices. Support for the following should be included as a minimum:

a. GE Fanuc
b. Allen-Bradley
c. Modicon
d. Siemens/TI

To permit integration of computer numerical controllers (CNCs), the software system should preferably include a communications driver and alternately support open architecture standards and application programming interfaces to allow the development of such a driver as required.

As described earlier, the software system should also support use of DDE and OPC servers to provide device communications.

5.4.1 System Points

The system should provide a wide range of pre-defined system points that include a wide variety of topics including alarms, date and time, project, and computer information. System points should be available to be used by the standard HMI components such as graphics and scripting. The software system should accommodate for system points in a client / server architecture with the ability to access system points from the server and system points from the client viewer.

5.4.2 Real Time Data Value Display

The system should support advanced ease-of-use configuration capabilities including drag and drop. Applications that allow a user to select and display a table of points in a separate window without the need for configuring graphic screens is critical for the commissioning and maintenance of the entire system. The user should be able to add points to this table by simply dragging and dropping them from the list of points configured in the system. The values of the points should update dynamically along with a time stamp that indicates when the value changed. In addition, points that meet their alarm criteria should be displayed in a different color.

Double clicking on a displayed point should bring up configuration information on the point including its description and alarm information. Points with Read/Write capabilities should be able to be set from this table.

5.5 Point Cross Reference

The system should support the ability to cross reference where points are used within the system. The cross reference listing should include areas such as.

a. Screens
b. Point Configuration
c. Events and Actions
d. Database Logging
e. Scripts

The ability to print out the point cross reference information should be provided to assist in documenting the configuration of the system.

6. PROJECT CONFIGURATION WIZARD

The monitoring and control system should have an integrated project configuration wizard that steps the user through the initial setup and configuration of the system. The wizard should allow the user to select the communication protocols that have been installed and then be capable of detecting Ethernet based PLC devices and OPC servers. Once these devices and servers are detected the user should be able to select the ones they wish to include in the project. The wizard should then allow the user to automatically configure points for a device based on a user specified

memory range. The user interface for wizard should be HTML based to provide a simple and easy method for navigation through the configuration steps.

7. WEB CAPABILITIES

The software system should also support Thin Client technology to enable graphic screens to be sent to standard web browsers without the need for the user to create HTML pages. The resulting web based graphic viewers should be capable of viewing the graphic screens of the HMI. The web viewers should support the ability to perform setpoints back to the supporting server. Multiple levels of security must be provided including those of the operating system as well as the ability to validate users logging in to the system by user name and password. Privileges granted to web based users should be similar to standard Viewers with the addition to totally disable all set points if required.

Web Viewers should have the capability of being setup in a user mode or broadcast mode. In user mode, individual users are granted an access license when they log into the system. Once the user logs off the system, the license must be immediately available for use by another user. Broadcast mode must also be supported to allow a single license to broadcast the same screen information to an unlimited number of users. In broadcast mode the users will not be allowed to change screens or perform setpoints.

The software system should also have the capabilities of sending and receiving point based information from standard HTML pages. Point information should be capable of driving animated ActiveX graphic objects within the HTML web pages.

The HMI product should provide XML server capabilities to provide data collected from the shop floor out to other applications using the XML format. In addition the HMI should provide the ability to view point and alarm reports in XML format in standard web browsers. In addition, the XML based point and alarm reports should be integrated into a web viewer application that allows the user to view live graphic and alarm screens. Two way interaction with these screens should be provided including control actions by privileged users.

In addition to supporting graphical viewing access via the web, the monitoring and control system should allow for point data to be transferred between servers across the Internet.

8. WINDOWS TERMINAL SERVICES

HMI product should be built to take advantage of Microsoft's Terminal Services product. Microsoft Terminal Services is a product developed for Windows 2000 to deploy a "thin client" solution to deliver 32-bit Windows to a wide range of legacy desktop hardware devices. Terminal Services combines the low cost of a terminal with the benefits of a managed Windows-based environment and offers the same low cost, centrally managed environment of the traditional mainframe with terminals, but adds the familiarity, ease of use, and breadth of applications support offered by the Windows operating system platform. The HMI should support displaying its graphical screens as well as all other runtime and development applications via Windows Terminal Services. Remote diagnostics and system development should be possible through Terminal Services.

9. APPLICATIONS

The software system should provide a "base architecture" that supports one or more "option" or “application” modules.

9.1 Graphical User Interface/Status Monitoring

The Graphical User Interface should provide a set of tools for graphically representing process status. A graphic editor should be provided to enable creation of graphic screens to represent current process information.

For ease of use, the editor should include cut & paste as well as drag & drop support within a single window and among multiple windows and should include undo/redo support. It should be possible for the user to drag and drop points into a screen from the list of configured points in the system. Support for grouping and ungrouping sets of objects and for readily editing them while grouped are to be included. While editing grouped objects, properties associated with the group shall not be lost during the ungroup/edit process. Object alignment and spacing tools are required so those objects can be properly arranged on the screen.

The editor should include a utility or tool for determining which points are referenced in a screen, which objects reference them, and which points are not currently defined or known to the software. This tool should also include provision to search and replace point names - for both single objects and groups of objects.

A test animation capability should display the screen currently being developed in the runtime environment for rapid prototyping and testing.

The editor software should include the ability to Create/Edit Points from within the Editor. It should also be possible to browse the network to locate computers and projects for available points.

The editing package should include a Wizard / Symbol / Object Library to permit the inclusion of pre-developed or third party graphic objects. Objects contained in the Symbol Library should be objects native to the software solution where appropriate and not simply bitmap representations. The editing package should allow Objects/Wizards to be created with the native graphics and scripting language and added to the Library.

A procedure editor should be included to control setpoints and to perform window management. The graphic editor should include a scripting expression editor to develop application logic.

Graphic objects on these screens can be linked by name to actual device and virtual data through the distributed point database. Objects on the graphics screens can be configured with animation features, causing them to change color and/or position. Text information can be printed to the screen alerting personnel to current point status. Objects should be dynamically scalable - both horizontally and vertically.

The software should support the following dynamic attributes:

a. Annunciation, movement, blink, rotation, and fill (uni-directional and bi-directional)
b. Gradient fill
c. Object border animation
d. Object visibility

e. Blink fill and blink rate
f. Transfer tags for screen transfer or popup windows
g. Procedure tags to invoke user defined scripts/programs
h. Object and or application help screens
i. Alarm information
j. Trends charts
k. Setpoint tags for point value changes
l. Animated frames that can include other graphic objects
m. Zoom to Best Fit, Resize Window to Zoom
n. Automatic font scaling when changing window sizes
o. 1.5 Million Colors

Graphic objects should include:

a. Imported metafile objects
b. Embedded OLE, including ActiveX objects, sound, video, clip art, spreadsheets, etc.
c. SPC charts
d. Trend charts
e. Historical Data displays
f. Alarm displays
g. Arcs
h. Lines
i. Circles
j. Ellipses
k. Lines
l. Polylines
m. Polygons
n. Rectangles
o. Text strings
p. Buttons

Tag types should include:

a. constant - downloads constants to a point
b. variable - allows operator input of desired value
c. ramp - downloads values in configured increments
d. slide - increment/decrement of point values
e. toggle - sets digital points to opposite state

Graphics screens should support a Visual Basic compliant scripting language. Data items and variables can be manipulated by the screen scripting to provide additional functionality in dynamically controlling screen characteristics.

The graphical editor and viewer should be capable of being an ActiveX container. It should be capable of using ActiveX objects provided with the HMI package or third party ActiveX controls supplied by others.

The graphical user interface should support ActiveX "methods" to allow the user to interact with ActiveX control objects. Interaction may be through the association of a method to a button or object, which the operator initiates, or methods may be used by the Visual Basic compliant scripting language for advanced functionality and additional control of the ActiveX components.

The graphical interface should have historical playback and review capabilities. Through a VCR type control interface, the user should be able to select a period of time and then replay the graphical screens and watch the process parameters change on the screen in replay mode.

9.2 Alarming

The software system must support an Alarm Management module capable of alarm annunciation and routing capabilities. The alarm text associated with each alarm should be user configurable.

Alarms are to be applied as follows:

a. Digital Points - the alarm generating condition (0 or 1) should be selectable.
b. Analog Points - the alarm generating conditions should be evaluated based on alarm criteria selected:

Absolute - There should be two levels of high alarming, HI-2 and HI-1, and two levels of low alarming, LO-1 and LO-2. HI-1 and LO-1 are also known as warning alarms. For high alarming, an alarm should be generated when the point value reaches or exceeds the value specified for HI-1 or HI-2. For low alarming, an alarm should be generated when the point value reaches or falls below the value specified for LO-1 or LO-2.

Deviation - Alarm limits for deviation alarms should be given in positive values. The HI-2 and HI-1 alarms should be generated when the difference between the current point value and the Deviation Point value is positive and reaches or exceeds the specified limits. The LO-1 and LO-2 alarms should be generated when the difference between the current point value and the Deviation Point value is negative and the absolute value of the difference reaches or exceeds the specified limits.

a. Rate of Change - Rate of Change alarms should be provided to detect either a faster or slower than expected change in the value of a point.
b. Duration - The Alarm Display should include total time in alarm state.

Alarms should be configurable to be filtered and asynchronously sent to users based on user role and scope of responsibilities. Alarms should be configurable with respective priorities, divided into classes, and color-coded for display. There should be user-defined logging criteria, user-defined acknowledgment and deletion criteria, user-specific textual messages and operator help text. The alarm list can be toggled between dynamic and static display and quickly filtered to limit the current view to a particular alarm set of interest.

The system should support "alarm blocking". Users should be able to define an alarm hierarchy and block the generation of "lower level" alarms if a "higher level" alarm is present. This allows for operators to concentrate on primary causes rather than receive all the resulting secondary problems. For example, if a conveyor stops then all machines feeding it would also stop. The operator needs to determine why the conveyor stopped - the operator does not need to see the other alarms. In this example, fixing the conveyor will fix those alarms as well.

The system should provide for an automatic routing of configured alarm messages to display type pagers. The routing should be configurable as to personnel or pager ID receiving the message. It should be possible to upgrade the paging system to

support dual outputs - allowing messages to be sent to local pagers, or to a dial-up paging system.

9.3 Data Logging

Data collected by the software system should be logged via ODBC into a relational database to support historical reporting and analysis. The system should support multiple SQL compatible databases and/or formats. Configurable logging of points, alarms, and events should be supported without forcing the application developer to understanding database internals. Custom application software must not be required to log data. Configuration of the logging characteristics of a point should automatically configure the database that should store the data. A variety of database management systems should be available for use.

The system shall provide an option for integrating Microsoft SQL Server into the application as the standard data-logging database. As an integrated option, it shall have an icon as part of the configuration environment to easily launch the SQL application.

The software system shall support a high-speed data-logging rate to the Microsoft SQL Server database though a “bulk insertion” method. Bulk insertion reduces database overhead by storing information temporarily in memory and writing a larger volume of information to the database at a single time.

The software system must also support high speed / high volume logging and retrieval. This capability is often referred to as a Data Historian.

Point and alarm data is to be logged upon a "trigger" event. The following triggers for logging point and alarm data are required.

Point Data	***Alarm Data***
At Time of Day	On Generation
On Time Interval	On Reset
On Point Update	On Acknowledgment
On Event	On Deletion
Gated Based on Logical Expression	

Point attributes, which should be available for logging, include:

a. Point Value
b. Previous Value
c. Raw Value
d. Alarm State
e. Resource
f. Time Last Logged
g. Engineering units

The logging module should support the logging of multiple point attributes into a single record based on a single trigger. The logging module should also support logging multiple points and their attributes to a single record. The logging module should support the simultaneous logging of multiple tables of data consisting of combinations of single points, multiple points, alarms, and events. This supports the creation of custom database tables unique to an application.

Through configuration alone, the logging utility should support "store and forward" to selected database management products. Data should be buffered on the node collecting it and automatically forwarded to the node where it is to be logged. During a communications outage between the two nodes, the data collection node should continue to buffer data. Upon restoration of communications, the data collection node should automatically forward the buffered data to the logging node for storage.
User configurable database maintenance actions, which are executed automatically, based on database size or number of records should be supported. Examples of these actions include exporting data to a CSV file then purging the records from the database. No custom software should be required to implement this support.

Reports using the logged data may be generated using standard third party database management tools such as spreadsheets and report writers.

9.4 DDE Client and Server Interface

The software system must support a DDE interface in both client and server modes. In the server mode, DDE aware applications (clients) such as Microsoft Excel™ should be able to access data managed by the Monitoring and Control System. The DDE client interface support the use of third party applications to monitor, analyze, report, and modify point data.
Required Services for the HMI server support include:

a. Request Point Configuration Data (e.g. alarm limits, engineering units labels)
b. Request Point On-Change (DDE Peek)
c. Request Point Update (DDE Poke)

In the client mode, DDE server applications such as device communications drivers should be able to act as a source of data to the HMI, for both reading and writing of data down to factory floor devices or external systems. For maximum flexibility in selecting third party servers and for maximum software performance, the HMI must support both the DDE and AdvanceDDE protocols.

9.5 OPC Client and Server Interface

The software system must support an OPC DA and Alarm and Events interface in both client and server modes. In the server mode, OPC aware applications (clients) should be able to access data managed by the System. The OPC Client interface should support the use of third party OPC Device Communication Servers. The OPC Server interface should allow for point information collected and maintained by the software system to be sent to OPC applications requesting the data.

The OPC client should allow for browsing of available OPC servers and the published points.

9.6 Data Trending

The trending module should be capable of supporting one or more embedded trends within the runtime graphics user interface. The following types of trends should be supported:

a. Trends with Multiple Y Axes
b. Trends with Multiple X Axes
c. Trends with multiple time periods
d. Reference curves
e. XY Plots

The ability to select any numeric value or values being displayed on a graphic screen and quick trending the values should be provided. There should be no need to have pre-configured graphic screens created to display the quick trends.

The trending option should support display of an unlimited number of pens on a single trend chart. Each pen should display either dynamically updating data or provide seamless access to historical values based on user request. In addition, user should be able to compare data from different time periods.

Trending should support the creation and re-display of files with reference data from the currently displayed trend. This export capability should produce "CSV" format files so as to be compatible with standard office automation tools such as spreadsheets and databases.

Users should be able to analyze trend data by scrolling through time, changing the range for point displays, zooming into an area of the trend and selecting a new time period to display.

Printing of trend charts is required.

The trending module should support reading data from "CSV" files for the display of data collected or generated by other applications within the software system framework.

Trend layout should be highly configurable including colors, tick marks, legends, title, and fonts. The update rate for data being displayed from log files should be configurable. The data being trended should be configurable. This configuration must be modifiable at runtime without requiring a development system or license.

Trend data can be supplied from multiple sources including current point data, data from .CSV files, and data logged to a database. Data displayed by the trend manager should support time-based or on-change based sampling.

Trending should support the display of array points. Arrays can be interpreted as independent variables or as a time series of a single variable. The latter case supports buffering of data in high speed sampling applications.

Trending should support rapid retrieval of a large time span of data and be able to aggregate the display of the data into the time axis of the chart. It should also be able to handle aggregating functions such as the min, max, and average display of values over the time period as well.

9.7 Statistical Process Control

Data collected though the Monitoring and Control System should be accessible by a Statistical Process Control Module. This includes data from plant floor devices, manual data entry, custom applications, and flat files. SPC Charts/Reports should be provided as ActiveX objects which can be dropped into graphic screens. The software should support an unlimited number of quality characteristics or sub-groups. The quantity of data displayed in SPC charts should be user configurable and should be updated dynamically as new data is collected. SPC ActiveX objects should allow the user to dynamically switch between a chart and report view of the data without the need to reconfigure screens. Users should be able to scroll through data that is not initially displayed on a chart. Standard Charts/Reports should include:

a. Xbar & Range
b. Xbar & Sigma
c. X Individual
d. Histograms
e. Pareto
f. U
g. P
h. C
i. nP

Software should support the following control checks where "N" is configurable. Each may be separately enabled or disabled.

a. Any one subgroup beyond upper or lower limits
b. N subgroups on the same side of the center line
c. Trend of N consecutive subgroups in a row up or down
d. N subgroups in a row alternating up and down
e. Sets of Subgroups in a row within one, two or three standard deviation

All SPC Out of Control (OOC) conditions should be capable of being processed by the Monitoring and Control System to:

a. Change the color of a graphic object to red or flashing
b. Sounding an audio alarm
c. Logging the OOC condition to a device or file
d. Send an alarm message to a user or another process

Individual Quality Characteristics are configurable based on the following parameters:

a. Enable or disabled
b. Subgroup Size and Interval
c. Center Line, Upper and Lower Control Limits
d. Control Limit Recalculation Type (Manual, Automatic)
e. Control Checks and Alarming

Configuration information should be centralized on a server node and support SPC charts operating on viewer nodes. All nodes displaying an SPC chart must have the same control limits.

Users should be able to dynamically modify control chart configuration parameters through the user interface. In addition, they should be able to delete outliners (points that are out of reasonable range) prior to recalculation of control limits.

SPC charts may be embedded in graphic display screens as ActiveX objects to provide seamless integration among applications.

9.8 Production Tracking

The software system should support a configurable Production Tracking application that monitors point values and maintains an accurate image of work-in-process inventory. The Production Tracking module should be configurable with respect to the layout of plant conveyor systems, the type of items being tracked (serialized vs. non-serialized), and the type of plant floor inputs available for tracking. Example

inputs include radio frequency (RF) tags, bar codes, type detectors, and limit switches. The tracking system should be auto correcting based on collected data.

Each item should have a set of attributes including location, status, and user-definable fields. Attributes such “product build” options and/or inspection status should be displayable and modifiable through point values.

The Production Tracking application should support manual transactions to add, delete, modify, move, re-sequence, and scrap items.

The Production Tracking module should include a comprehensive set of routing and control functions. These functions should interface to the HMI’s data collection subsystems to exchange data with factory floor devices. The routing and control functions should be support user programming and configuration. The functions should operate based upon the work in process image maintained by the Production Tracking module.

The primary function of the tracking system is to provide tracking data to plant floor users and applications. As such the data maintained by the production tracking module should be accessible through the graphical user interfaces and through a complete set of application interfaces. Additional applications such as dynamic scheduling, material delivery, and assembly broadcast depend on tracking data.

The Production Tracking module should support operation in the distributed software system environment.

9.9 Equipment Control

The software system should support an Equipment Control module which includes the capability configure logic and schedule events based on the following criteria:

a. Time of day
b. Time Interval
c. Production event
d. Point change
e. Alarm Generation

In response to configured events, the system should invoke configurable actions that include:

a. Log Event
b. Acknowledge Alarms
c. Enable / Disable an Alarm
d. Recipe Upload / Download
e. Execute a Script
f. Set a Point Value
g. Copy a Point Value
h. Execute a Procedure

Scripts should be modular and re-usable. Scripts should be in a Visual Basic compliant language.

An event editor should be included to permits users to configure, monitor and debug applications. Users should be able to monitor the progress of control programs and

dynamically modify their operating characteristics. The event editor should at least support these debug tools:

a. Run in Single Step Mode
b. Start/Stop Scripts
c. Set Break Points
d. Step into or Over Sub-Scripts
e. Watch variables change

Control programs should have access to all of the application programming interfaces (API's) within other Monitoring and Control applications such as DDE interfaces, equipment/device interfaces, production tracking, and system alarming and logging.

9.10 Recipe Management

A module that is capable of monitoring and managing equipment recipes should be available. The Recipe module should support both batch and discrete part processing requirements. The Recipe module should support dynamic configuration of recipe information.

The Recipe management module should support the creation and management of device independent recipe data for production processes. Configuration data should be stored in recipe groups to simplify information management. Within a group, recipe parameters should only have to be entered one time to minimize duplicate data entry.

Parameter values should be supported for each recipe. The module should support the concept of device independence. This should permit the configuration of a recipe a single time yet also permit downloading that same recipe to different devices, i.e. different programmable controller models or manufacturers. This device independent support no longer requires the maintenance of separate recipes for the various pieces of production equipment in the facility.

There should be a dedicated user interface utility. The utility should support the display of recipes, parameters and the mapping of parameters to devices. Ideally, this display should support a spreadsheet-like interface for ease of use and to help minimize user training. Like a spreadsheet, the information display formatting should be user configurable. The interface should follow the Microsoft Windows look & feel and include tools such as copy/cut/paste.
Overall, the user interface should support the ability to:

a. Create and manage recipe parameters, recipes, and maps side-by-side in a spreadsheet format.
b. Import and export recipe groups from/to CSV format files.
c. Archive recipe groups.
d. Automatically reconcile recipe groups to accommodate changes in the group’s structure and layout.
e. Compare recipes.
f. Validate recipe information.
g. Manually upload recipes.
h. Manually review/modify parameters and download recipes.
i. Create recipe parameter files, to support automatic upload and download of recipes.
j. Identify a Batch ID for recipe downloads.

For maximum flexibility, the Recipe management module should also support a graphic user interface. Recipe objects should be implemented as OCX controls that may be embedded in graphic screens. These objects should let a run-time user:

a. Manually upload recipes.
b. Manually review/modify parameters then download recipes.

To support the development of sophisticated applications, the Recipe management module should support an interface to the software system's scripting capabilities. This scripting interface support should include the ability to:

a. Automatically upload and download recipes based on system events, such as point changes from a shop floor device.
b. Import and export recipe groups from/to CSV format files.

The module should support a wide range of data types including:

a. Signed integers
b. Unsigned integers
c. Digital/136oolean values
d. Real numbers
e. Text strings

9.11 Calendar Based Control

The software system should provide for calendar based control operations through a self-contained graphic users interface. The software system should allow you to dynamically create, maintain, and execute a calendar schedule of manufacturing events and corresponding actions. For example, a system should allow the user to perform such actions as turn on lights, heat, and equipment based on a schedule which they configure and maintain through simple point and click actions.

Configuration of the calendar-based control should allow the user to define different types of days – production, weekend, holidays, to conform to 4 day or 5 day work weeks, etc. Users should then be able to configure manufacturing control events they want to occur on a particular type of day and the time they should occur. Association of days on the calendar with a particular type of day should be through a point and click interface. The graphic user interface for the calendar-based control should allow the user to dynamically change or override the established schedule.

The graphics interface for the calendar-based control should be available on both Servers and Viewers.

9.12 Historical Data Display

The system should provide for tight integration of relational databases through ODBC interfaces. Once data has been logged to the database, open system tools should make the extraction and sharing of the data easy between users and applications.

9.13 Integration APIs

The software system should have a set of open interface APIs (Application Program Interfaces). The APIs should include:

a. Point Management API – Allows third party programs to be interfaced to the software system and pass point data to and from the system in real time fashion.
b. Alarm Management API – Should allow alarm information to be passed to and from the API.
c. Logon API – Should allow the user to create their own custom logon dialog boxes.
d. Device Communication Toolkit – Should allow the user to construct communication modules to third party devices with published protocols.

9.14 Marquee Driver

The Software system should have the ability to send alarm information and messages to multi-line marquee display devices. A Marquee module should be available fully configurable. No custom coding should be required to retrieve alarm or message information. It should be possible to determine which set of alarms you want to send to the actual marquee device.

Marquee configuration should include:

a. Marquee Types – All marquee devices that use the same header, footer, message wrap, empty message, and attributes belong to the same Marquee Type.
b. Marquee Ports – The PC communication port or the network communication port to which one or more serial marquee devices are connected. If more than one device is on a port, the header and/or footer information (from the Marquee Type) should indicate which device on which the message is to be displayed.
c. Marquee Devices – The ability to assign a Marquee ID, Marquee Type, Marquee Port, header, footer, empty message, and display time for each marquee device within a project should be provided. The option of associating sets of marquees into Marquee Groups should be provided.
d. Marquee Messages – For each Marquee message, it should be possible to assign a message ID, Alarm ID, alarm state, message header, message footer, message text, the marquees on which to display the message, the attributes associated with the message, and any HMI point values to be displayed with the message.

9.15 Alpha-Numeric Alarm Paging

The Software system should provide advanced communication capabilities such as the ability to send process alarms to standard alphanumeric or numeric pagers carried by a mobile workforce. The paging capabilities should be designed on a client / server architecture of to avoid duplication of configuration information. Paging capabilities should support standard IXO/TAP protocols used by common paging systems.

Paging features should include:

a. On line configuration of users and paging numbers.
b. Enable or disable users from receiving pages.
c. Escalation of pages
d. Filtering of pages based on point groupings, alarm classes, or alarm IDs.
e. Dynamic on-line configuration changes.
f. A scripting interface for automatically sending pages, changing a user's pager number, or disabling a page.
g. Customizable pager messages.

h. Configuration templates for fast setups.
i. Support of distribution lists.

9.16 Redundancy

The principle of redundancy in automated systems provides for switchover of functionality to a backup component in case of failure of a primary component. The switchover is considered automatic if no operator intervention is required. Redundancy applies to both hardware and software, and implies minimal loss of continuity during the transfer of control between primary (active) and redundant (backup) components. Redundant systems reduce single points of failure, preventing loss of functionality.

The system must support a software based redundancy solution as well as hardware dependent, high availability architectures as well.

For cell control systems, the major levels of redundancy include:

a. PLC
b. PLC LAN or serial connections to server
c. Computer networks
d. Computer

Each level of redundancy provides a failover system that allows continuous system activity with minimal loss of data. The following sections briefly describe each level.

9.16.1 PLC Redundancy

The system should support PLC redundancy. PLC redundancy lets control transfer from a primary programmable controller to a redundant one in case of failure. When the primary PLC comes back on line, control can be transferred from the redundant PLC back to the primary with minimal loss of data. The redundancy can be synchronous or independent. Synchronous systems coordinate control and handling of data between CPUs of the active and backup units, while in independent systems each PLC acts like an active unit and is not constrained by the others.

9.16.2 Cabling Redundancy

The system should support Cabling Redundancy. Cabling redundancy involves separate physical connections to the same device. The devices can be on a LAN or may require serial connections. Redundant cabling provides an alternate communication path to the device if the association with the host computer is lost due to failure of the primary path. The implementation of cable redundancy with respect to host monitoring/control systems differs with the device protocol involved.

9.16.3 Server Redundancy

The system should support Server Redundancy. Server redundancy involves a primary factory monitoring server and a redundant "Hot Standby" server. The redundant server is essentially a mirror image of the primary server, running alternate monitoring/control processes and applications. Data collection is performed via independent or shared network paths to the same devices, depending on the protocol. The characteristics of the selected communications protocol(s) determine the details of the configuration.

Upon detection of failure of the primary server, the secondary server can assume control of data collection, alarm functions, applications, and allow user access with minimal loss of continuity. When the primary server comes back on line, control can be transferred back, and the secondary server will resume its backup role.

9.16.4 Computer Network Redundancy

The system should support Computer Network Redundancy. Computer network redundancy is similar to cabling redundancy, except it covers computer to computer communications rather than computer to programmable controller. Computer network redundancy provides an alternate network path in case of failure of the primary network.

9.17 System Monitoring

The software system should provide system monitoring to allow the user to monitor the most important part of the system – the computer. System monitoring should monitor both the software system processes as well as key Windows NT and 2000 operating system and network parameters. System monitoring should be able to monitor the status of the computer the software system is running on as well as other NT or 2000 computers on the network. System monitoring should allow for key system parameters and statistics such as alarm frequency, device communications, data collection and throughput, inter-process communications, data logging, point management, and user registration to be monitored and recorded. System monitored information can be alarmed on.

9.18 CNC Ethernet Connectivity

The system shall have the capability of connecting to and collecting data from Fanuc CNC controllers over Ethernet as well as High Speed Serial Buss (HSSB) interfaces. The data which is collected shall be capable of being logged or displayed as standard point information.

9.19 VCR Screen Playback

The system should provide the capability of playing historical logged data back through the graphic screens so users can review past situations to analyze what might have caused a problem. This feature should provide a wide range of playback speeds with start and stop capabilities so the user can quickly isolate a particular period of time they are interested in.

10. CHANGE MANAGEMENT

The system shall have the ability to control and track changes to the HMI/SCADA applications that are developed.

10.1 Client/Server based

The system shall allow applications or projects to be stored on a central server.

10.2 Version Control

The system shall provide a check out, and check in mechanism so that no 2 users can modify the application files at a given time. When a check in is performed, the

system shall increment the version number of the components that have been modified.

The system shall allow the ability for users to enter comments about the changes that have been made.

The system shall provide the ability to revert to previous version of a project or component in the project.

The system should support the ability to produce version reports on the project and the components with information on the previous version including the date, time, user and comments associated to the change.

10.3 Audit Trails

The system shall keep track of changes that are made to the application including the data, time, user making the changes, what files were modified and any comments entered by the user about the changes.

The system shall allow for reports of changes to system as well as the project and its components. These reports should be in a printable format.

10.4 Security

The system shall control which users have the ability to access various projects and restrict who can and can't check out various projects.

10.5 Scheduled and manual comparisons

The system shall allow the ability to compare the running project files with the master files on the change management server, and provide a report of differences. The report should provide reports of differences at the file level or object level. This functionality should be available both on demand and on a time basis without user intervention.

10.6 Notification

The system shall allow the ability to notify administrators or assigned individuals of changes made to the project files. The system shall also provide the ability to notify administrators or individuals of differences detected between the master or server version and the running project.

11. MONITORING AND CONTROL CHECKLIST

The following list contains the key items that need to be considered when selecting an software system.

Feature	Supported – Yes / No
STANDARDS AND TECHNOLOGY	
Open System Design	
True Client / Server Architecture	
Enterprise Server Support	
Viewers (With out the need to reconfigure point databases)	

Feature	Supported – Yes / No
Web Based Thin Client Viewers – Internet Explorer and Netscape	
Web Viewer User and Broadcast mode licensing	
Operating Systems Support - Windows NT, 98, and 2000	
Microsoft Technologies Support – (ActiveX, ODBC, OPC, DDE, COM/DCOM, XML)	
Industry Standards Support – OPC, TCP/IP	
Object Technologies – ActiveX and user created	
Web Technologies – Thin client and html based	
Windows Terminal Services Support	
Wireless Technologies for Viewing and Entering Information	
Application Programming Interfaces	
Multi-threaded scripting	
REAL TIME DATA MANAGEMENT	
Data Sharing without duplicating configurations	
Required Data Types – Discrete, float, analog, string, global, arrays, structures	
Device Communications – capable of supporting hundreds of devices and protocols.	
System Points – Users, Roles, Time, Date, Alarm counts, etc.	
Real time tabular display of point values without the need to create screens.	
Point Cross Reference indicating where points are used in the system	
DIVERSE APPLICATION MODULES	
Graphical user interface with status monitoring	
Web Viewer	
Thin Client Windows CE Support	
Alarming	
Data Logging	
DDE Client & Server Interface	
OPC Client & Server Interface	
Data Trending	
Statistical Process Control	
Production Tracking	
Equipment Control	
Recipe Management	
Calendar Based Control	
Historical Data Display	
Integration Apis	
Marquee Driver	
Alpha-Numeric Alarm Paging	
Redundancy	
System Monitoring	

12. VENDOR REQUIREMENTS

12.1 Development Life Cycle

12.1.1 The vendor must have an established development life cycle that allows for traceability of features and functions throughout that life cycle.

12.1.2 The vendor must have a formal and documented set of quality assurance procedures that are applied to the engineering design, development, and documentation of the software. The presence of a formal quality assurance department shall be required.

12.1.3 The vendor must also demonstrate that its source code for the product is regularly archived both on-site and off-site in facilities suitable to withstand physical harm.

12.1.4 The vendor shall allow for on-site auditing of the development life cycle to ensure good practice.

12.2 ISO 9001 certified

12.2.1 The vendor must be able to demonstrate that it has established procedures.

12.2.2 Vendor needs to be certified under the ISO 9001-2001 guidelines.

DRAWINGS Annex 8