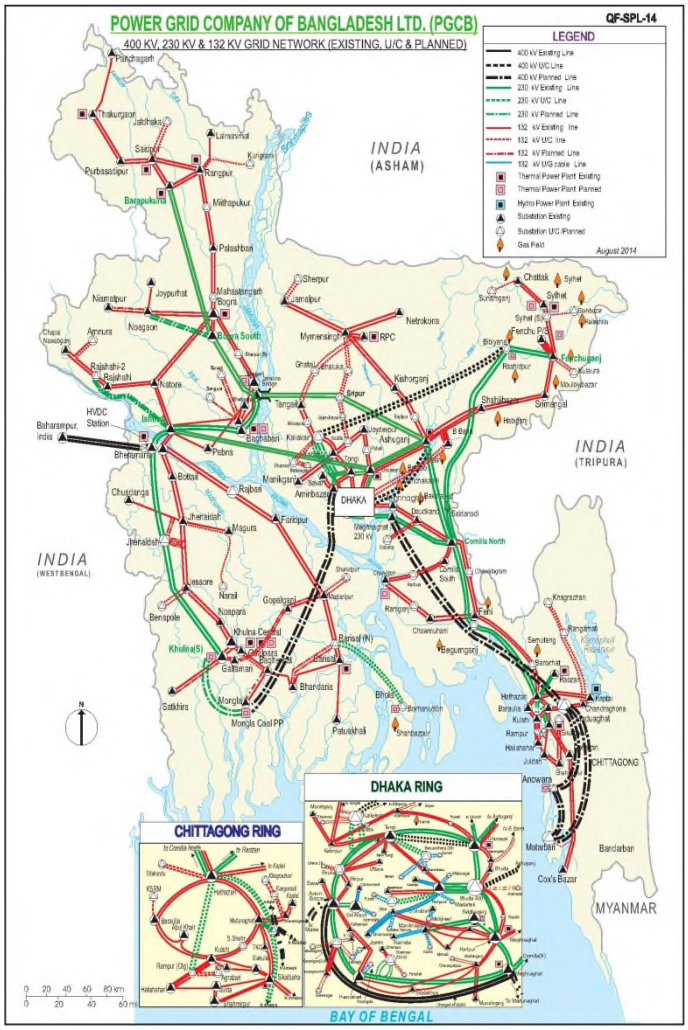
Financial Cooperation with Bangladesh

BMZ No. 2012 66 436

Transmission System Improvement Western Zone



Tender Documents for Design, Supply, Installation, Testing & Commissioning of 230/132 kV and 132/33 kV Substations, Northern Zone, on Turnkey Basis

Contract No. PGCB/KfW/2012.66.436/NZSS

Volume 2, November 2016

Employer:

Power Grid Company of Bangladesh (PGCB)
IEB Bhaban (4th Floor), IEB
Ramna, Dhaka-1000, Bangladesh

Consultant:

GOPA-International Energy Consultants GmbH
Justus-von-Liebig-Str. 1, 61352 Bad Homburg, Germany
Phone: +49 (6172) 1791-800; Fax: +49 (6172) 944 95 20
eMail: info@gopa-intec.de; www.gopa-intec.de

Contents of the Tender Documents

Volume 1

Section I. Instructions to Bidders (ITB)
Section II. Bid Data Sheet (BDS)
Section III. Evaluation and Qualification Criteria
Section IV. Bidding Forms
Section V. Eligible Countries
Section VI. Employer's Requirements
Section VII. General Conditions of Contract (GCC)
Section VIII. Special Conditions of Contract (PCC)
Section IX. Contract Forms

Volume 2

Scope of Works
Technical Specifications
Drawings forming Part of Specifications

Volume 3

Schedule A: Introduction & Preamble to the Price & Technical Schedules
Schedule B: Bid Prices & Schedules
Schedule C: Bar Chart Program of Key Activities-Delivery & Completion Time Schedule
Schedule D: Manufacturers, Places of Manufacture and Testing
Schedule E: Technical Particulars and Guarantees
Schedule F: Proposed Subcontractors

Table of Contents — Page

SCOPE OF WORKS 1

1. Scope of Works 1

1.1 Description of Overall Project 1
1.2 Description of this Package 1
1.2.1 Extension of the New 230/132 kV Substation Rajshahi 3
1.2.2 New 132/33 kV Substation Bangura 4
1.2.3 Extension of the Existing 132/33 kV Substation Baghabari 4
1.2.4 New 132/33 kV Substation Miithapukur 5
1.3 Terminal Points 5
1.3.1 Transmission Line Circuit Connections 5
1.3.2 Communication and SCADA Equipment 6
1.4 System Electrical Parameters 7
1.4.1 System Conditions 7
1.4.2 System Earthing 7
1.4.3 Minimum Substation Clearances 7
1.4.4 Low Voltage AC System 8
1.4.5 Low Voltage DC System 8
1.5 Climatic Conditions 8

TECHNICAL SPECIFICATIONS 10

2. Ancillary Mechanical and Electrical Apparatus 10

2.1 Scope 10
2.2 References 10
2.2.1 ISO Standards 10
2.2.2 IEC Standards 10
2.2.3 British Standards 12
2.2.4 BS European Standards 13
2.3 Definition of Terms 13
2.4 Statutory Regulations 13
2.5 Design Standards and Codes 13
2.5.1 General Compliance with International Standards and Codes 13
2.5.2 Standards Named in Specification 13
2.5.3 Hierarchy of Standards 13
2.5.4 Substitution of Standards and Design Codes 14
2.6 Erection Marks 14
2.7 Cleaning and Painting 14
2.7.1 General 14
2.7.2 Schedules for Indoor Surfaces Finishes 16
2.7.3 Schedules for Outdoor Surfaces Finishes 18
2.8 Rating Plates, Nameplates and Labels 21
2.8.1 General 21
2.8.2 Rating Plates 21
2.8.3 Circuit Labels 21
2.8.4 Pipe Service Identification 22
2.9 Environmental Protection & Tropicalisation 22
2.9.1 General 22
2.9.2 Tropicalisation 23

Table of Contents

		Page
2.10	Platforms, Stairways, Ladders and Hand-Railing	23
2.10.1	General	23
2.10.2	Flooring	24
2.10.3	Hand-Railing and Protective Barriers	24
2.10.4	Stairways	25
2.10.5	Fixed Access Ladders	25
2.11	Nuts, Bolts, Studs and Washers	25
2.12	Forgings	26
2.13	Castings	26
2.13.1	General	26
2.13.2	Steel Castings	27
2.13.3	Iron Castings	27
2.13.4	Aluminium Bronze Castings	28
2.14	General Welding Requirements	28
2.14.1	General	28
2.14.2	General Fabrication	28
2.14.3	Weld Procedure Documents	28
2.14.4	Weld Procedure Qualification Tests	29
2.14.5	Welder's Qualification Tests	29
2.14.6	Storage of Welding Consumables	29
2.14.7	Welding Equipment	29
2.14.8	Visual Weld Inspection	29
2.14.9	Internal Examination	30
2.14.10	Non-destructive Examination	30
2.14.11	Ultrasonic Examination	30
2.14.12	Magnetic Crack Detection	30
2.14.13	Dye Penetrant Tests	30
2.14.14	Quality Requirements for Welds	30
2.14.15	Weld Repairs	30
2.14.16	Mandatory Inspections	31
2.15	Galvanised Work	31
2.16	Chromium Plating	32
2.17	Pumps	32
2.18	Pipework	32
2.19	Valves	33
2.20	Pressure Vessels	33
2.21	Lubrication	34
2.22	Oil Level Indicators	34
2.23	Pressure Gauges	35
2.24	Thermometer Pockets	35
2.25	Gauge Cubicles and Panels	35
2.26	Locking Facilities	35
2.27	Electrical Equipment	36
2.27.1	General	36
2.27.2	Electrical Equipment Enclosures	37
2.28	Current Ratings	37
2.28.1	Normal Current Ratings	37
2.28.2	Temperature Rise	37
2.28.3	Short-Time Current Ratings	38

Table of Contents

		Page
2.29	Voltage Ratings	38
2.29.1	Normal Voltage Ratings	38
2.29.2	Short-Time Voltage Ratings	39
2.30	Electrical Insulation	39
2.31	Insulating Oil	39
2.32	Control and Selector Switches	40
2.33	Panels, Desks and Cubicles	40
2.34	Instruments & Meters	42
2.34.1	Indicating Instruments	42
2.34.2	Electrical Meters	43
2.35	Indicating Lamps and Fittings	43
2.36	Anti-Condensation Heaters	44
2.37	Control and Instrument Panel Wiring, Cable Terminations and Terminal Boards	45
2.37.1	General	45
2.37.2	Identification of Wires	46
2.37.3	Terminals and Terminal Blocks	46
2.38	Cable Boxes and Glands	47
2.38.1	General	47
2.38.2	Additional Requirements for Compound-filled Cable Boxes	48
2.38.3	Cable Glands	49
2.39	Box-Filling Compounds	49
2.40	Oil or Compound-Filled Chambers	49
2.41	Joints and Gaskets	50
2.42	Valves on Electrical Equipment Fluid Lines and Vessels	50
2.43	Junction and Marshalling Boxes	50
2.44	Conduit and Accessories	51
2.45	Trunking	51
2.46	Electric Motors	52
2.46.1	General	52
2.46.2	Type and Rating	52
2.46.3	Insulation	52
2.46.4	Conditions of Operation	52
2.46.5	Starting Performance	52
2.46.6	Bearings	53
2.46.7	Enclosures and Methods of Cooling	53
2.46.8	Anti-condensation Heaters	53
2.46.9	Terminals and Terminal Boxes	54
2.46.10	Earth Terminal	54
2.46.11	D.C. Motors	54
2.47	Motor Starters and Contactors for Separate Mounting	55
2.48	Pushbuttons and Separately Mounted Pushbutton Stations	55
2.49	Miniature Circuit Breakers, Fuses and Links	56
2.50	Earthing and Bonding	57
3.	**HV Switchgear and Neutral Earthing Equipment**	**58**
3.1	Scope	58
3.2	References	58
3.2.1	IEC Standards	58
3.2.2	British Standards	59

Table of Contents

			Page
3.3	Design Principles		60
	3.3.1	General Requirement	60
	3.3.2	Availability for Maintenance, Repair, Extensions, Testing	60
3.4	Outdoor HV Switchgear		61
	3.4.1	Switchgear - Design and Performance	61
	3.4.2	Current Ratings	61
	3.4.3	Corona	62
	3.4.4	Local, Remote and Supervisory Control	62
	3.4.5	HVAC Circuit Breakers	62
	3.4.6	HV Disconnectors	70
	3.4.7	HV Instrument Transformers	75
	3.4.8	Surge Arresters	80
	3.4.9	Post Insulators	84
4.	**Power Transformers**		**88**
	4.4.1	Magnetic Circuit	93
	4.4.2	Flux Density	93
	4.4.3	Windings	93
	4.4.4	Internal Earthing	94
4.5	Tanks and Ancillary Equipment		95
	4.5.1	Transformer Tanks	95
	4.5.2	Conservator Tanks, Breathers and Air Dryers	96
	4.5.3	Valves	96
	4.5.4	Joints and Gaskets	97
	4.5.5	Pressure Relief Device	97
	4.5.6	Earthing Terminals	97
	4.5.7	Rating, Diagram and Valve Plates	98
4.6	Cooling Plant		98
	4.6.1	Cooling Plant General	98
	4.6.2	Radiators Connected Directly to Tank	98
	4.6.3	Cooler Banks	98
	4.6.4	Forced Cooling	99
	4.6.5	Oil Pipes and Flanges	99
	4.6.6	Air Blowers	99
	4.6.7	Cooler Control	100
4.7	Voltage Control		100
	4.7.1	General	100
	4.7.2	On-Load Tap Changers	101
	4.7.3	Automatic Voltage Control	102
4.8	Supervisory Control		104
	4.8.1	Requirements	104
4.9	Terminal Bushings and Connections		105
	4.9.1	General	105
	4.9.2	Porcelain	106
	4.9.3	Marking	106
	4.9.4	Mounting of Bushings	106
4.10	Auxiliary Power and Control Cables		107
	4.10.1	Scope of Supply	107
	4.10.2	General	107

Table of Contents Page

4.11 Temperature and Alarm Devices 108
4.11.1 Temperature-Indicating Devices and Alarms 108
4.11.2 Gas and Oil-Actuated Relays 109
4.12 Shipment and Drying Out 110
4.12.1 Shipment 110
4.12.2 Drying Out 110
4.12.3 Fire Protection System 110
4.12.4 Water Spray System 115
4.12.5 Fire Wall 117
4.13 Transformer Oil and Treatment 117
4.13.1 Transformer Oil 117
4.13.2 Oil Treatment Plant 117
4.13.3 Oil Storage 117
4.14 Auto-Transformers 118
4.14.1 General 118
4.14.2 Continuous Maximum Rating 118
4.14.3 Impedance 118
4.14.4 Winding Terminations 118
4.14.5 Tap Changing 119
4.15 Earthing/Auxiliary Transformers 119
4.15.1 General 119
4.15.2 Electrical and Short Circuit Characteristics 119
4.15.3 Tanks and Fittings 119
4.15.4 Secondary Windings 120
4.15.5 Terminal Connections 120
4.16 Inspection and Testing 120
4.16.1 Factory Acceptance Tests 120
4.16.2 Site Tests 122

5. Protection, Metering and Control 123

5.4 Multi-Core Cable Diagrams 124
5.5 Test and Earthing Facilities 124
5.8.1 230 and 132 kV Transmission Line Protection 127
5.9 Busbar Protection 132
5.9.1 Busbar Protection 132
5.9.2 Conditions of Acceptance of Busbar Protection Systems Submitted on the Basis of Calculated Performance 133
5.10 Circuit Breaker Failure Protection 133
5.14.2 Restricted or Balanced Earth Fault Protection 138
5.14.3 Transformer Back-up Overcurrent Protection 138
5.14.4 Gas Pressure (Buchholz) Protection 138
5.14.5 Oil and/or Winding Temperature 139
5.14.6 Low Oil Level and Pressure Relief Devices 139
5.14.7 Tap Changer Oil Surge 139
5.14.8 Standby Earth Fault Protection 139
5.14.9 Tripping Relays 139
5.15 DC Auxiliary Voltage Operating Range 140
5.16 Teleprotection Signalling 140
5.17 Digital Fault and Disturbance Recorder (DFDR) 140

Table of Contents Page

5.18 Tripping Relays 142
5.19 Protection Settings 142
5.20 Substation Automation System 142
5.20.1 Scope of Supply 142
5.20.2 Compliance with Standards 143
5.20.3 Design and Operating Requirements 144
5.20.4 General System Design 146
5.20.5 Flexibility and Scalability 148
5.20.6 System Hardware 148
5.20.7 Software Structure 151
5.20.8 System Testing 152
5.20.9 System Functions 152
5.20.10 Availability Calculations 160
5.21 Trip Circuit and Power Supply Supervision 160
5.22 Busbar Voltage Selection 160
5.23 Synchronising 161
5.23.1 Synchronising Scheme 161
5.24 Diagrams 161
5.25 Current Transformer Calculations 161
5.26 Energy Meter (Tariff Metering) 162
5.26.1 Meter Requirements 162
5.26.2 Additional Requirements 162
5.26.3 Normal Display List 162
5.26.4 Alternate Mode Display List 163
5.26.5 Interval Date (Load Profile) 163
5.26.6 Interval Date (Instrumentation) 164

6. Auxiliary Power and Control Cables 165

6.1 Scope 165
6.2 General Description of Installation 165
6.3 Standards 165
6.4 Cable Installation 166
6.4.1 General 166
6.4.2 Installation Criteria 166
6.4.3 Reduced Fire Propagation 167
6.4.4 Type Approval 167
6.4.5 Cable Sizing and Routing 167
6.5 Cable Construction 169
6.5.1 Oversheaths 169
6.5.2 Armouring 169
6.5.3 Laying Up 169
6.5.4 Cable Drums 169
6.5.5 Sealing and Drumming 170
6.5.6 Spare Cable 170
6.5.7 Jointing Accessories 170
6.6 Types of Cable 171
6.6.1 Low Voltage Cables 171
6.6.2 Control Cables and Instrumentation Cables 171
6.7 Straight-through Joints 173

Table of Contents Page

6.8 General Methods of Cable Installation 173
6.9 Cables laid Directly in the Ground 174
6.10 Cables drawn into Ducts 174
6.11 Cables installed in Concrete Trenches 175
6.12 Cables Supported on Racks, Trays, Etc. 175
6.12.1 General 175
6.12.2 Supporting Steelwork 176
6.12.3 Cable Clamps, Cleats, Saddles and Ties 176
6.12.4 Trays and Racks 176
6.13 Cables Installed on Structural Steelwork and Brickwork or Concrete 177
6.14 Terminations 177
6.14.1 General 177
6.14.2 Power Cables 177
6.15 Terminating and Jointing Conductors 178
6.16 Core Identification 178
6.17 Cable Identification and Schedules 179
6.18 Inspection and Testing 180

7. Earthing System and Lightning Protection 181

7.1 Scope 181
7.2 References 181
7.2.1 American Standards 181
7.2.2 German Standards 181
7.2.3 British Standards 181
7.3 General 181
7.4 Extent of Work 182
7.5 Soil Survey 182
7.6 Fault Current and Duration 183
7.7 Earth Electrode System Design 183
7.7.1 Design Calculations 183
7.7.2 Earth Electrode 183
7.7.3 Mesh System 184
7.7.4 Earthing Rods 184
7.7.5 Other Conductors 184
7.7.6 Reinforcing Steel 185
7.7.7 Conductors Outside Perimeter Fence 185
7.8 Design of Earthing System 185
7.8.1 Earthing System 185
7.8.2 Connection of System Neutrals and Earth 186
7.8.3 Main Earthing Bar 186
7.8.4 Electrical Equipment and Structure Connections to Earth 186
7.8.5 Connections to Non-Electrical Structural Metalwork and Equipment 187
7.9 Materials and Installation 187
7.9.1 Earthing Conductors 187
7.9.2 Earthing Rods 188
7.9.3 Fittings 188
7.9.4 Joints 189
7.10 Lightning Protection 190
7.11 Earthing of Fences 190

7.11.1 Method 190
7.11.2 Separately Earthed Fences 190
7.11.3 Bonded Fences 190
7.11.4 Bonding of Fence Components 191
7.11.5 Gates 191
7.11.6 Potential Control Outside Fences 191
7.11.7 Conductors 192
7.12 Portable Earthing Devices 192

8. Batteries, Chargers and DC Switchgear 193

8.1 Scope 193
8.2 References 193
8.2.1 IEC Standards 193
8.2.2 British Standards 193
8.3 Design Requirements 193
8.3.1 General 193
8.4 Batteries 194
8.4.1 Type of Battery 194
8.4.2 Initial Charge and Test Discharge 194
8.4.3 Battery Duty 195
8.4.4 Location of Batteries 195
8.4.5 Battery Mounting Connections and Accessories 196
8.5 Control and Charging Equipment 196
8.6 Distribution Switchboards 200
8.7 Labelling 201
8.8 Special Tools 201
8.9 Inspection and Testing 201

9. LV AC Distribution Switchgear 202

9.1 Scope 202
9.2 References 202
9.3 Switchboard Design 202
9.3.1 General 202
9.3.2 Rating 203
9.3.3 Busbars 203
9.3.4 Busbar and Circuit Shutters 203
9.3.5 Circuit Labels 203
9.4 Circuit Breakers 204
9.5 Switch Fuses 204
9.6 Oil Filtration Socket Outlet and Plug 204
9.7 Inspection and Testing 205

10. National Load Dispatch Centre (NLDC) 206

10.1 Scope 206
10.2 Requirements 206
10.2.1 Indications 206
10.2.2 Load Flows, System Voltage and Frequency 206
10.2.3 Alarms 207
10.2.4 Controls 207

Table of Contents

Page

10.3 Interfaces 208

11. Supporting Structures for Outdoor Equipment 209

11.1 Scope 209
11.2 Structure Arrangement 209
11.3 Design 209
11.3.1 General 209
11.3.2 Assumed Loading Combinations 210
11.3.3 Line Termination Structures 212
11.3.4 Partial Load Factors 212
11.3.5 Wind Loading 213
11.3.6 Equipment and Conductor Terminations 213
11.3.7 Safety and Access Requirements 214
11.3.8 Structural Design 214
11.3.9 Design Submissions 215
11.4 Materials 215
11.5 Workmanship 216
11.6 Protective Treatment 216
11.7 Quality Control 217
11.7.1 General 217
11.7.2 Welding 217
11.7.3 Check Erection 217
11.7.4 Galvanising 217
11.7.5 Tolerances 218
11.8 Erection 218

12. Buildings and Civil Engineering Works 219

12.1 General 219
12.1.1 Scope of Work 219
12.1.2 Contractor to Satisfy himself as to all Conditions 220
12.1.3 Way Leaves, Land Purchase and Planning Permission 220
12.1.4 Site Survey Drawings 220
12.1.5 Earth Works 221
12.1.6 Engineer's and Employer's Accommodation/Surveying Equipment 221
12.1.7 Programme 221
12.1.8 Monthly Progress Certificates/Progress Reports 222
12.1.9 Temporary Facilities 222
12.1.10 Site Supervision 222
12.1.11 Designs and Drawings 222
12.2 References 223
12.2.1 General 223
12.2.2 Design and Construction Standards 223
12.3 Design 224
12.3.1 Architectural and Structural Requirements of Buildings 224
12.3.2 Ground Conditions, Foundations and Site Investigation 226
12.3.3 Drainage 230
12.3.4 Surfacing 231
12.3.5 Roads 231
12.3.6 Water Supply 232

Table of Contents Page

12.3.7 Plumbing and Sanitary Fittings 233
12.3.8 Control Building Floors 233
12.3.9 Cable Basement 234
12.3.10 Battery Room Floors 234
12.3.11 Control Room Floors 234
12.3.12 Site Clearance, Obstructions and Adjacent Structures 235
12.3.13 Guard Houses, Boundary Walls, Fences and Entrance Gates 236
12.3.14 Windows 236
12.3.15 Doors 237
12.3.16 Brickwork 237
12.3.17 Expansion Joints, Joint Fillers and Sealants 238
12.3.18 Cable Trenches in Switchyards 238
12.3.19 Cable Trenches in Buildings 239
12.3.20 Rainwater Pipes 239
12.3.21 Switchyard Foundations 239
12.3.22 Transformer Bases 240
12.3.23 Blast Walls 240
12.3.24 Paints and Painting 241
12.3.25 Furniture 241
12.3.26 Concrete 242
12.3.27 Concrete Reinforcement 242
12.3.28 External Render 243
12.3.29 Goalposts 243
12.3.30 Lifting Beams 243
12.3.31 Stairs 244
12.4 Concrete Workmanship 244
12.4.1 General 244
12.4.2 Aggregates 244
12.4.3 Sampling 245
12.4.4 Grading 245
12.4.5 Cement 245
12.4.6 Water 245
12.4.7 Reinforcing 245
12.4.8 Storage 245
12.4.9 Design Mix 246
12.4.10 Mixing and Placing of Concrete 246
12.4.11 Testing of Concrete 248
12.4.12 Formwork 249
12.4.13 Reinforcing Steel 249
12.4.14 Consolidation of Concrete 249
12.4.15 Curing of Concrete 250
12.4.16 Hot Weather Concreting 250
12.5 Workmanship of all Other Materials 250
12.6 Fire Extinguisher 251
12.6.1 Control Room / Communication Room / Battery Rooms 251
12.6.2 Cable Room / Outdoor Switchyard 251

13. Lighting, Small Power, Heating and Ventilation 252

13.1 Scope 252

Table of Contents

		Page
13.2	References	252
13.3	Defects Liability Period	253
13.4	Approvals	253
13.5	Lighting Requirements	253
13.6	Schedule of Design Requirements	254
13.7	Coding Systems	254
13.8	Distribution Boards	255
13.9	Miniature Circuit Breakers	256
13.10	Cables	256
13.11	Cable Terminations	257
13.12	Sealing and Drumming	257
13.13	Conduit	257
13.14	Cable Trunking	260
13.15	Cable Trays	261
13.16	Cable Jointing	261
13.17	Contactors	261
13.18	Switches and Pushbuttons	261
13.19	Lighting Fittings	262
13.20	Lamps	263
13.21	Socket Outlets and Fused Spur Outlets	264
13.22	Time Switches	264
13.23	Poles	264
13.24	Interior Installations	265
13.25	Exterior Installation	266
13.26	Emergency Lighting	266
13.27	Telephone System	267
13.28	Schedule of Lighting Fittings and Socket Outlets	267
13.29	Schedule of Lighting Requirements	268
13.29.1	Control Building	268
13.29.2	Outdoor Areas	269
13.30	Air Conditioning and Ventilation	269
13.30.1	Scope of Work	269
13.30.2	Heating	269
13.30.3	Air Conditioning	269
13.30.4	Mechanical Ventilation	270
13.30.5	Basis for Design	270
13.30.6	Air Cooled Condensing Units	271
13.30.7	Refrigeration Systems	272
13.30.8	Console Air Conditioning Units	273
13.30.9	Ductwork	273
13.30.10	Condensate Drains	274
13.30.11	Extract Ventilation Units	274
13.30.12	Air Filters	274
13.30.13	Grilles and Louvres	275
13.30.14	Control Equipment	275
13.30.15	Electrical Connections	275
13.30.16	Manufacturers	276
13.30.17	Standards	276
13.30.18	Approval	276

Table of Contents Page

13.30.19 Maintenance 276
13.31 Earthing and Bonding 276
13.32 Testing and Commissioning 277

14. Fibre-Optic Multiplexer Equipment for Communication and Protection 278

14.1 Scope of Specification 278
14.2 Summary of Standards 279
14.2.1 PDH Interfaces 279
14.2.2 Architecture of Optical SDH Interfaces 279
14.2.3 Synchronisation and Timing of Optical SDH Interfaces 280
14.3 Abbreviations 281
14.4 General Requirements 282
14.5 General Conditions 283
14.5.1 Channel Capacity: Digital Cross Connection 283
14.5.2 Redundant Centralised Functions 283
14.5.3 Power Supply 283
14.5.4 ITU Compliance 283
14.5.5 Electromagnetic Compatibility and Safety Regulations 283
14.5.6 Ambient Conditions 283
14.5.7 Mechanical Construction 284
14.5.8 Network Management System 284
14.5.9 1+1 Path Protection 284
14.5.10 1+1 Section Protection 284
14.5.11 Network Topology 284
14.5.12 Synchronisation 284
14.5.13 Alarms 285
14.5.14 Test Loops 285
14.5.15 Maintenance Facilities 285
14.6 Requirements for Transport Level 285
14.6.1 SDH Aggregate Units 285
14.6.2 HDSL Aggregate Units 286
14.7 Tributary Units 287
14.7.1 4-Wire Interface (VF Interface) 287
14.7.2 Analogue Subscriber Interface 287
14.7.3 Exchange Interface 288
14.7.4 Party Line Telephone System (Engineering Order Wire) 288
14.7.5 V. 24N.28 RS232 Interface 288
14.7.6 V.11/X.24 Interface 288
14.7.7 V.35 Interface 289
14.7.8 V.36 / RS 449 Interface 289
14.7.9 64 kbit/s Co-directional Interface 289
14.7.10 LAN Interface 289
14.7.11 Alarm Interface 290
14.7.12 Teleprotection Interface 290
14.7.13 Optical Protection Relays Interface 291
14.7.14 Binary Contact Interface 291
14.7.15 2NIbit/s G.703 / G.704 Interface 291
14.8 Telephone System 291

Table of Contents

		Page
14.9	Communications DC Power Supply Equipment	292
14.9.1	General	292
14.9.2	Configuration	292
14.9.3	Charger	293
14.9.4	Battery	295
14.9.5	D.C. Distribution and Instrumentation	296
14.9.6	Housing	297
14.10	Schedule of Requirements	297
15.	**Quality Assurance, Inspection, Testing, Commissioning and Warranty**	**299**
15.1	Scope of Section	299
15.2	Subcontracts	300
15.3	Guarantees	301
15.4	Quality Audit	301
15.5	Measuring and Testing Equipment	302
15.6	Inspection Plan and Procedure	302
15.7	Test Certificates	302
15.8	Material Tests	303
15.9	General Requirements for Tests at Manufacturers' Works	303
15.9.1	Testing of Plant	303
15.9.2	Rejection of Plant	304
15.10	Specific Requirements for Tests at Manufacturers' Factories	304
15.10.1	Pressure Vessels	304
15.10.2	Substation Automation System, Control, Relay Protection and Metering	304
15.10.3	Relays	307
15.10.4	Electrical Instruments and Meters	307
15.10.5	AC Switchboards	307
15.10.6	Contactors	307
15.10.7	PVC Cable	307
15.10.8	Switchgear (Other than GIS)	308
15.10.9	Disconnectors and Earth Switches	308
15.10.10	Current and Voltage Transformers	308
15.10.11	Structures of Electrical Equipment	308
15.10.12	Surge Arresters	308
15.10.13	Batteries and Battery Chargers	308
15.10.14	Control Panels	309
15.10.15	Busbars	309
15.10.16	Instruments	309
15.10.17	Neutral Earthing Resistor	309
15.10.18	Power Transformers	309
15.10.19	Outdoor Bushing Assemblies with Porcelain Insulators	311
15.10.20	Tanks	312
15.10.21	Cooling Plant	312
15.10.22	Gas and Oil-Actuated Relays	312
15.10.23	Galvanizing	312
15.10.24	Earthing Transformers	312
15.10.25	Fibre Optic Multiplexer Equipment	313

Table of Contents

	Page
15.10.26 Deleted	313
15.10.27 Telephone Equipment	313
15.10.28 Teleprotection Equipment	313
15.10.29 Transducers	313
15.11 Dismantling Prior to Shipment	313
15.12 Inspection and Testing during Site Erection	314
15.12.1 General	314
15.12.2 Mechanical Equipment	315
15.12.3 Electrical Equipment	316
15.13 Staffing	321
15.14 Taking Over	322
15.15 Defects after Taking Over	322
15.16 Final Acceptance Certificate	322
16. Power Cables and Cable Terminating Accessories	**323**
16.1 Scope	323
16.2 Standards	323
16.3 Conditions of Operation	323
16.4 Type Approval	324
16.5 Cable Lengths	324
16.6 Cable Drums	325
16.7 Spare Cable	325
16.8 Special Tools	325
16.9 Cable Jointing Instructions and Drawings	325
16.10 Cable Specification	326
16.10.1 General	326
16.10.2 Conductors	326
16.10.3 Conductor Screen	326
16.10.4 Insulation	326
16.10.5 Insulation Screen	326
16.10.6 Metallic Screen	326
16.10.7 Intermediate Layer	327
16.10.8 Corrugated Seamless Aluminium Sheath	327
16.10.9 MDPE Outer Sheath	327
16.10.10 Identification of Cable	327
16.11 Sealing and Drumming	327
16.12 Terminating Accessories	328
16.13 Installation of Cable	328
16.13.1 Cable Tunnels and Trenches with Pits, Ducts and Drains	328
16.13.2 Supports and Racks	329
16.13.3 Bonding	329
16.14 Tests	330
16.14.1 Type Tests	330
16.14.2 Routine/Sample Tests	330
16.14.3 Tests at Site	330
16.15 Earthing System	330
DRAWINGS FORMING PART OF THE SPECIFICATION	**331**
17. Bid Drawings	**331**

Table of Contents

		Page
17.1	General	331
17.2	List of Bid Drawings	331
17.3	Drawings	332

SCOPE OF WORKS

1. Scope of Works

1.1 Description of Overall Project

Providing access to affordable and reliable electricity to all citizens is a national goal of the Government of Bangladesh (GoB). In 1996, the GoB split the transmission segment and formed the Power Grid Company of Bangladesh (PGCB). PGCB is fully responsible for all transmission assets.

Bangladesh is facing chronic power shortages that could undermine its economic sustainability. Inadequate, irregular power and poor quality power supply was identified to be the major constraints for sustaining economic growth and development of the country.

PGCB launched a vast program for the improving and strengthening of its transmission system. The objective is expansion and strengthening of the 230 kV and 132 kV transmission systems of the Western Zone. The project spreads over eleven (11) regions, i.e. Ishurdi, Rajshahi, Baghabari, Bangura, Jhenaidah, Rajbari, Miithapukur, Khulna, Gopalganj, Mongla and Bagherhat.

The aim of the system expansion is to contribute to an efficient power transmission in PGCB's transmission system, to eliminate the operational bottlenecks and to provide an adequate infrastructure for future power sector development.

The GoB received from the German Government financial assistance to be used for strengthening the transmission system in the country, especially the 230 kV and 132 kV transmission facilities. KfW will provide a loan, while the remaining costs will be financed from PGCB funds.

1.2 Description of this Package

The work covered by this specification for the construction of new and the extension and renovation of existing 230/132 kV and 132/33 kV AIS substations and civil works is outlined below.

The scope of works under this turnkey contract is: **design**, **supply**, manufacture, quality assurance, inspection and testing, **delivery**, new packing for export, insurance, shipment & transport to the site, complete construction and **installation**, jointing, terminating, bonding, earthing, painting, setting to work, site **testing and commissioning**, defect liability for all equipment, including all civil works.

Especially the civil design has to incorporate countermeasures against flooding so as not to affect any substation equipment during the wet season. Given the recorded past maximum flood water level in the project area, sufficient ground level height for land formation is required at the Contractor's responsibility.

The Contractor's responsibility is to provide that all parts of the works be completed in every respect for commercial operation, to the requirements of the Engineer.

All details, accessories etc. required for the complete installation and satisfactory operation of the works not specifically mentioned in this specification are deemed included in the contract price.

The Contractor is responsible for ensuring that all and/or any item(s) of work required for the safe, efficient and satisfactory completion and functioning of the works, are included in the Bid Price whether they be described in the specification or not.

In case of extension and renovation works, not all required as-built drawings may be available for the existing plant and equipment, which required modification/renovation; the Contractor is also responsible to make drawings as required to complete the works.

The Bidder is be deemed to have visited site, inspected, gathered data and verified details of the as-built system in order to design, supply and interface their new equipment.

All necessary materials, adjustments, dismantling, remedial and tiding-up work in order to complete the work specified shall be included in the contract price.

The Contractor is responsible for ensuring that all and/or and any item(s) of work required for the safe, efficient and satisfactory completion and functioning of the works, are included in the bid price whether they be described in the specification or not.

The bid price shall include costs of witnessing of factory acceptance tests by the Employer's Engineer (three Engineers in each visit, and maximum seven days for each visit) for: autotransformers 230/132 kV, power transformers 132/33 kV, circuit breakers 230 & 132 kV, disconnectors 230 & 132 kV, instrument transformers 230 & 132 kV, substation automation system, protection relays and communication equipment;

Factory acceptance tests shall be organized separately for each equipment. In case both equipment 230 kV and 132 kV (circuit breakers, disconnectors, instrument transformers) will be manufactured at the same location, one Factory Acceptance Test shall be foreseen.

The bid price shall include costs of training at the Manufacturer's premises for four Employers' Engineer (each for a period of maximum fourteen days) for installation, testing, operation and maintenance of: OLTC, circuit breakers 230 & 132 kV, substation automation system equipment, protection equipment, DFDR and communication equipment.

The bid price shall include costs of training during and after the installation. The Contractor should provide trainer(s) (authorised by the Manufacturer) for on-site training on operation and maintenance of the works, for each new substation, for no more than 15 (fifteen) Employer's staff for minimum 1 (one) week.

The bid price shall include supply and delivery of mandatory spare parts, maintenance tools and test equipment.

The bid price shall include all other miscellaneous works required.

The "Schedule of Requirements" for equipment, materials and services and the detailed technical specifications of equipment and materials as included in Volume 3 of the bidding documents shall be read in conjunction with the scope of works described herein.

The drawings provided in the bidding documents are indicative only and hence do not reflect the entire

scope of works.

The programme of works shall be as shown in Schedule C - Times for Delivery and Completion. Within one month of acceptance of the bid, the Contractor shall submit a programme chart detailing times required for the design, supply, delivery, installation, testing and commissioning for the complete work.

The brief description of works under this contract is as follows.

Design, Supply, Installation, Testing & Commissioning of 230/132 kV and 132/33 kV Substations, Northern Zone, on Turnkey Basis (Contract No. PGCB/KfW/2012.66.436/NZSS)

This includes the following:

- Extension of the new 230/132 kV Substation Rajshahi
- New 132/33 kV Substation Bangura
- Extension of existing 132/33 kV Substation Baghabari
- New 132/33 kV Substation Miithapukur

1.2.1 Extension of the New 230/132 kV Substation Rajshahi

The scope of work under this contract includes design, supply, delivery, installation, testing & commissioning of:

- complete new 230/132/33kV air insulated switchgear (AIS) substation.
- a 230 kV double busbar system, two (2) 230 kV overhead line bays (Bheramara HVDC-1 and Bheramara HVDC-2), two (2) 230 kV transformer bays, one (1) 230 kV bus coupler bay and space for future extension for four (4) 230 kV bays
- two (2) three phase, 230/132/33 kV, 225/300 MVA autotransformers,

The 132 kV part of the substation, including two (2) 132 kV transformer bays for connection of two (2) three-phase, 230/132/33 kV, 225/300 MVA autotransformers, **is not in the scope of works** and shall be built under another project.

The scope of work furthermore includes:

- design, supply, delivery, installation, connection with existing equipment, testing & commissioning of associated substation control and monitoring system, relay protection, metering, telecommunication, AC & DC auxiliary power supply, cables, metal structure, earthing and lightning protection
- **extension of the existing substation automation/control & monitoring system**
- land development of the complete **required 230 kV switchyard area** by cutting, land filling, compacting up to a suitable level, General land development for other part of substation will be done by another project. **The approximate total area of the substation is 15 acres. The approximate required 230 kV switchyard part is 10 acres.**
- complete outdoor civil works for the **required 230 kV switchyard area**, including 230 kV gantry foundation, 230 kV and 33 kV equipment foundation, power transformer foundations, oil pit, blast wall, **part of the security boundary wall, around the required 230 kV switchyard**, internal roads, concrete culvert, surface and switchyard drainage system including outfall, cable trench including soak pit, PVC pipes etc., switchyard surface finishing and gravel surfacing,

- complete civil works and facilities for **extension of existing** control building, including finishing works like rendering, colour, floor finishing, etc.,
- the supply and delivery of mandatory spare parts, maintenance tools and test equipment.

1.2.2 New 132/33 kV Substation Bangura

The scope of work under this turnkey contract is design, supply, delivery, installation, testing & commissioning of:

- complete new 132/33kV air insulated switchgear (AIS) substation.
- 132 kV single busbar system, one (1) 132 kV overhead line bays (Baghabari), two (2) 132 kV transformer bays and space for future extension for six (6) 132 kV bays
- two (2) three phase, 132/33 kV, 50/75 MVA power transformers,
- 33 kV single busbars system, two (2) 33 kV transformer bays, two (2) 33 kV auxiliary power transformer bays, one (1) bus coupler bay and space for eight (8) 33 kV bays
- two (2) three phase, 33/0.415 kV, 200 kVA, auxiliary power transformers
- associated substation control and monitoring system, relay protection, metering, telecommunication, AC & DC auxiliary power supply, cables, metal structure, earthing and lightning protection
- land development of complete switchyard area by cutting, land filling, compacting up to a suitable level including slope protection. **The approximate total area of the substation is 5 acres.**
- complete outdoor civil works, including 132 kV and 33 kV gantry foundations, 132 kV and 33 kV equipment foundations, power transformers and auxiliary transformer foundations, oil pit, blast wall, substation main gate and guard house, security boundary wall and internal fencing, access road, internal roads and parking, concrete culvert, surface and switchyard drainage system including outfall, cable trench including soak pit, PVC pipes etc., switchyard surface finishing and gravel surfacing
- complete civil works and facilities for new two-storey control room building with cable basement, including foundation works, superstructure works, finishing works such as rendering, colour, water supply, sanitary, floor finishing, rain water drainage system, lightning protection, water supply including deep tube well for drinking water, pump house, pump, water reservoir, water pipe lines, etc., sewage facilities including septic tank, etc.
- supply and delivery of mandatory spare parts, maintenance tools and test equipment.

1.2.3 Extension of the Existing 132/33 kV Substation Baghabari

The existing 132/33 kV Substation has a 132 kV switchyard, with one and half breaker arrangement. One (1) existing, fully equipped 132 kV bay shall be used.

The scope of work under this turnkey contract is:

- re-testing & re-commissioning of a one (1) existing 132 kV overhead line bay.
- supply, delivery, installation, connection with existing equipment, **if any**, testing & commissioning of associated control and relay protection, metering, telecommunication, AC & DC auxiliary power supply, cables, metal structure, earthing and lightning protection and associated civil works.

1.2.4 New 132/33 kV Substation Miithapukur

The scope of work under this turnkey contract is design, supply, delivery, installation, testing & commissioning of:

- complete new 132/33kV air insulated switchgear (AIS) substation.
- 132 kV double busbar system, four (4) 132 kV overhead line bays (Palashbari-1, Palashbari-2, Rangur-1 and Rangur-2), two (2) 132 kV transformer bays, one (1) 132 kV bus coupler bay and space for future extension for four (4) 132 kV bays
- two (2) three phase, 132/33 kV, 50/75 MVA power transformers,
- 33 kV single busbars system, two (2) 33 kV transformer bays, two (2) 33 kV auxiliary power transformer bays, one (1) bus coupler bay and space for eight (8) 33 kV bays
- two (2) three phase, 33/0.415 kV, 200 kVA, auxiliary power transformers
- associated substation control and monitoring system, relay protection, metering, telecommunication, AC & DC auxiliary power supply, cables, metal structure, earthing and lightning protection.
- land development of complete switchyard area by cutting, land filling, compacting up to a suitable level including slope protection. **The approximate total area of the substation is 5 acres.**
- complete outdoor civil works, including 132 kV and 33 kV gantry foundation, 132 kV and 33 kV equipment foundation, power transformer and auxiliary transformer foundations, oil pit, blast wall, substation main gate and guard house, security boundary wall and internal fencing, access road, internal roads and parking, concrete culvert, surface and switchyard drainage system including outfall, cable trench including soak pit, PVC pipes etc., switchyard surface finishing and gravel surfacing
- Complete civil works and facilities for new two-storey control room building with cable basement, including foundation works, super structure works, finishing works like rendering, colour, water supply, sanitary, floor finishing, rain water drainage system, lightning protection, water supply including deep tube well for drinking water, pump house, pump, water reservoir, water pipe lines, etc., sewage facilities including septic tank, etc.
- supply and delivery of mandatory spare parts, maintenance tools and test equipment.

1.3 Terminal Points

1.3.1 Transmission Line Circuit Connections

The slack spans including overhead earth wires between the 230 kV and 132 kV overhead line terminal towers and the substation gantry structures shall be supplied and terminated by the overhead line Contractors. All required insulators and hardwires shall also be supplied by the overhead line Contractors.

Eyebolts/U-bolts or other suitable fixtures for terminating the slack spans on the switchyard gantry shall be provided under this substation contract.

The overhead line Contractor shall provide a jumper from the slack span of sufficient length to terminate on the substation entry equipment. The supply of appropriate clamps and the actual termination of the jumper to the substation equipment shall be carried out under this contract.

PLC facilities such as line trap and coupling capacitor, new or currently used in existing substations shall be carried out under this contract.

Bonding of the incoming earth wire to the station earthing screen and supply of earthing conductor and connection of the terminal tower earth electrode into the substation earth grid shall be carried out under this contract.

The overhead line Contractor shall terminate the OPGW at the substation gantry in the terminal joint boxes provided by the overhead line Contractors. The connection between OPGW joint boxes at the substation gantry and control room building via underground optical fibre cables shall be carried out under this contract; it includes supply & installation of fibre optic cable of a size similar to the OPGW.

1.3.2 Communication and SCADA Equipment

The voice communication, teleprotection signalling and main distribution frame (MDF) for optical fibre cable will be supplied and installed under this contract.

Necessary equipment for incorporating new & existing equipment system into the existing SCADA system shall also be supplied and installed under this contract:

Complete design, supply, delivery, installation, testing & commissioning of hardware and software shall be provided for the tele-control & tele-metering facilities required at the existing National Load Despatch Centre (NLDC) at Rampura for integration of the scope of the work.

In order to provide the tele-control & tele-metering facilities required at the existing NLDC, all plant supplied under this contract shall be equipped with potential free auxiliary contacts for indications and alarms. CT and VT circuits shall be fitted, where required, with the appropriate shorting and fused terminals.

All required electrical signals for signalization and control shall be transmitted to the NLDC through the Industrial Gateway of the substation automation system **or RTU**. All HV breakers, motorized disconnectors, tap changer, etc. shall be controlled form NLDC through the Gateway or RTU of the substation automation system using IEC 60870-5-104 protocol. Necessary transducer, control & interposing relays, RTUs, etc. shall be used. Necessary interfacing between the Substation Automation gateway and the communication equipment is to be carried out.

Sufficient investigations shall be made on the existing telecommunication and SCADA system for new and existing transmission lines and associated new and existing substations so that the necessary equipment shall be provided for complete telecommunication system after the new and existing transmission lines and substations are connected/reconnected.

All and complete connection between the new equipment and the existing equipment for control & protection system, SCADA, communication system, and low voltage supply system shall be provided.

In addition, to implement the complete SCADA system after completion of the project, modification of the existing software in the master and back-up computer of the national control centre, and modification / extension / renovation of hardware (installing additional printed circuit cards or other equipment, etc. if required) shall be made under this contract.

1.4 System Electrical Parameters

1.4.1 System Conditions

Equipment supplied under this contract shall be suitable for the following system conditions:

Description	Unit	Required		
Nominal system voltage between phases	kV	230	132	33
System frequency	Hz	50		
Rated voltage between phases	kV	245	145	36
Rated lightning impulse withstand voltage	kV	1050	650	170
Rated power frequency withstand voltage	kV, 1 min	460	275	70
Rated symmetrical short-circuit current	kA, 1 sec	50	40	25

1.4.2 System Earthing

The 230/138/33kV autotransformers and 132/33kV power transformers are solidly earthed.

The 230 kV system 132 kV system is solidly earthed at the power transformer 132 kV neutrals and 230/138/33 kV autotransformer neutrals but not earthed at the Grid supply points.

The 33 kV system is solidly earthed at some of the 132/33 kV grid substations and resistance earthed at some of the grid substations.

1.4.3 Minimum Substation Clearances

Air insulated connections shall have electrical clearances as listed in the following table:

Description	Unit	Required		
Nominal system voltage	kV	230	132	33
Minimum clearance between live metal parts and earth	mm	2100	1300	380
Minimum clearance between live metal	mm	2400	1500	430
Minimum safety clearance between ground and the nearest point not at earth potential of an insulator	mm	2500		
Minimum safety clearance between ground and the nearest live unscreened conductor (BS 7354: Safety Working Clearance)	mm	4270	3500	2740
Minimum insulator creepage distance (at rated voltage between phases)	mm/kV	25		

1.4.4 Low Voltage AC System

Description	Unit	Required
Rated service voltage (3 phase, 4 wire 50 Hz)	V	415 / 230
Tolerance on rated voltage	%	+15%, -15%
Switchgear symmetrical breaking capacity	kA	15 kA, 3 sec
System earthing	-	solid

1.4.5 Low Voltage DC System

For d.c. motor driven auxiliaries, relays, tripping, indicating lamps and controls.

Description	Unit	Required
Nominal DC voltage	V	110
Tolerance on rated voltage	%	+15%, -15%

For telecommunication & SCADA

Description	Unit	Required
Nominal DC voltage	V	48
Tolerance on rated voltage	%	+15%, -15%

1.5 Climatic Conditions

All plant and equipment supplied under the contract shall be entirely suitable for the climatic conditions prevailing at site.

The project area and vicinity is close to sea level and is in a tropical climate.

The ambient shade temperature variation is between 4 °C and 45 °C with periods of high humidity.

Between May and November, low-lying areas are subject to flooding. Flooding countermeasure shall be taken for the civil design, so as not to affect any substation equipment during the wet season. As per the recorded past maximum flood water levels in the project area, sufficient ground level height for land formation is required at the Contractor's responsibility. On certain sites, the flooding can be taken as an advantage in that the heavy loads may be floated on barges to close proximity of the sites.

The project area is a designated zone of moderate earthquake intensity. The seismic factor is 0.1 g. Atmospheric pollution is moderate and no special insulator design or washing is required. The area is subject to high winds of typhoon strength.

Description	Unit	Required
Maximum ambient shade temperature	°C	45
Minimum ambient shade temperature	°C	4
Maximum daily average temperature	°C	35
Maximum annual average temperature	°C	25
Maximum wind velocity	km/h	160
Minimum wind velocity for line rating purposes	km/h	3.2
Solar radiation	W/m²	1000
Rainfall	mm/year	2500
Relative humidity, maximum	%	100
Relative humidity, average	%	80
Altitude	m	< 1000
Atmospheric pollution	-	medium
Icing		no ice or snow expected
Seismic factor	g	0.1
Soil type	-	alluvial
Soil temperature (at 1.1 m)	°C	30 °C at 1.1 meter depth
Soil thermal resistivity	°Cm/W	1.5
Isokeraunic level (thunderstorm days/year)	days/year	80

The information in this clause is given solely for the general assistance of Bidders and no responsibility for it will be accepted nor will any claim based on this clause be considered.

TECHNICAL SPECIFICATIONS

2. Ancillary Mechanical and Electrical Apparatus

2.1 Scope

This section of the technical specifications describes the general requirements for mechanical and electrical designs of all the plant being supplied under the contract, electrical aspects being covered in another Section of the Specification. It shall be read in conjunction with the General Conditions, Drawings, the Schedules and other sections of these technical specifications covering particular aspects of the plant. In the event of conflict between the general and special contract requirements, the latter shall take precedence.

2.2 References

2.2.1 ISO Standards

- ISO 68 General Purpose Screw Threads
- ISO 261 General Purpose Metric Screw Threads
- ISO 262 Selected sizes for screws, bolts & nuts
- ISO 272 Fasteners-hexagon products-widths across flats
- ISO 274 Copper tubes of circular section.
- ISO 448 Gas cylinders for industrial use-marking.
- ISO 885 General purpose bolts and screws-metric series
- ISO 888 Bolts, screws and studs-nominal lengths, and thread lengths
- ISO 965 / 1, 2, 3 General purpose Metric screw threads
- ISO 4759-1 Tolerances for fasteners
- ISO 9000 Quality management and quality assurance standards
- ISO 9001 Quality management systems-Requirements

2.2.2 IEC Standards

- 60034 Rotating Electrical Machines
- 60038 IEC Standard Voltage
- 60044-1 Instrument transformers - Part 1: Current transformers
- 60044-2 Instrument transformers - Part 2: Inductive voltage transformers
- 60044-5 Instrument transformers - Part 5: Capacitor voltage transformers
- 60051 Direct acting indicating analogue electrical measuring instruments and their accessories
- 60055 Paper insulated metal sheathed cables up to 15 / 30 kV
- 60059 IEC Standard Current ratings

- 60072 Dimensions and output series for rotating electrical machines
- 60073 Coding of indicating devices and actuators by colours
- 60079 Electrical apparatus for explosive gas atmospheres
- 60085 Thermal evaluation and classification of electrical insulation
- 60137 Bushings for alternating voltages above 1000 V
- 60168 Tests on indoor and outdoor post insulators of ceramic material
- 60228 Conductors of insulated cables
- 60228 A first supplement. Guide to dimensional limits of circular conductors
- 62155 Tests on hollow insulators for use in electrical equipment
- 60269 Low voltage fuses
- 60273 Characteristics of indoor & outdoor post insulators above 1000 V
- 60282 High voltage fuses
- 60296 Specification for unused mineral insulating oils for transformers & switchgear
- 60305 Characteristics of string insulator units of the cap & pin type
- 60332 Tests on electrical cables under fire conditions
- 60364 Electrical installations of buildings
- 60376 Specification and acceptance of new sulphur hexafluoride
- 60383 Insulators for overhead lines above 1000 V
- 60417 Graphical symbols for use on equipment
- 60423 Conduits for electrical purposes
- 60433 Characteristics of string insulator units of the long rod type
- 60437 Radio interference test on high voltage insulators
- 60439 Low voltage switchgear and control gear assemblies
- 60455 Solventless polymersable resinous compounds used for electrical insulation
- 60502 Extruded solid dielectric insulated power cables from 1-30 kV
- 62052 Electricity metering equipment
- 60529 Degrees of protection provided by enclosures (IP Codes)
- 60587 Test methods for evaluating resistance to tracking
- 60614 Conduits for electrical installations-Specification
- 60621 Electrical installations for outdoor sites under heavy conditions
- 60644 Specification for high-voltage fuse links for motor circuit applications
- 60660 Tests on indoor post insulators of organic mats. between 1-300 kV
- 60672 Specification for ceramic & glass insulating mats.
- 60898 Circuit Breakers for overcurrent protection for households etc.
- 60947-1 Low-voltage switchgear and controlgear - Part 1: General rules
- 60947-2 Low-voltage switchgear and controlgear - Part 2: Circuit breakers
- 60947-3 Low-voltage switchgear and controlgear - Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units
- 60947-5-1 Low-voltage switchgear and controlgear - Part 5-1: Control circuit devices and witching elements
- 60981 Extra heavy duty steel conduits for electrical installations
- 61035 Specification for conduit fittings for electrical installations
- 61084 Cable trunking & ducting systems for electrical installations
- 62271-1 High-voltage switchgear & controlgear - Part 1: Common specifications
- 62271-100 High-voltage switchgear & controlgear - Part 100: High-voltage alternating-current circuit breakers
- 62271-102 High-voltage switchgear & controlgear - Part 102: Alternating current disconnectors and earthing switches
- 62271-105 High-voltage switchgear & controlgear - Part 105: Alternating current switch-fuse combinations
- 62271-200 AC metal-enclosed switchgear & control gear for 1 kV and above

- 62271-203 Gas-insulated metal-enclosed switchgear for rated voltages of 52 kV and above
- 62271-209 Cable connections for gas-insulated metal-enclosed switchgear for rated voltages of 52 kV and above

2.2.3 British Standards

- BS EN 10250-2 Specification for Carbon steel forgings
- BS 182 Specification for galvanised line wire for telephone & telegraphic purposes
- BS EN 10244-2 Specification for testing zinc coatings on steel wire
- BS 499 Welding terms & Symbols
- BS 709 Method & testing fusion welded joints
- BS 729 Specification for hot dip galvanised coatings on iron & steel articles
- BS 970 Specification for wrought steels for mechanical & allied Engineering
- BS EN 12540 Specification for electroplate coatings of nickel and chromium
- BS1710 Specification for identification of pipelines & services
- BS EN 837-1 Specification for Bordon tube pressure and vacuum gauges
- BS 1858 Specification for bitumen based filling compounds
- BS EN 60068-218 Environmental Testing
- BS 2569 Pt 2 Protection of iron & steel against corrosion at elevated temperature
- BS EN 1435 Radiographic examination of fusion welded butt joints in steel
- BS 2765 Specification for dimensions of temperature detecting elements
- BS 2910 Radiographic examination of fusion welded circumferential butt joints
- BS 3858 Specification for sleeves for electric cables & wires
- BS 3923 Pt 1 Methods of examination of fused welds and butt joints & Pt 2
- BS 4211 Specification for ladders for permanent access to chimneys, other high structures, silos and bins
- BS4395-1-2 Specification for High Strength Grip Bolts
- BS 4479 Recommendations for coatings. Pts 1-9
- BS EN 1412 Industrial type flooring, walkways and stair treads
- BS 4604 Pt 1-2 Spec for high strength friction bolts
- BS EN 10250-3 Spec for alloy steel forgings.
- BS 4800 Schedule of Paint Colours for building
- BS 4675 Pt 2 Mechanical vibration of rotating and reciprocating machinery
- BS 4872 Pt 1 Fusion welding of steel
- BS 5395-3 Code of Practice for the design of industrial type stairs, permanent ladders etc.
- BS 5493 Code of practice for protective coating of iron & steel structures against corrosion
- BS EN ISO 9934 Method for penetrant flaw detection
- BS EN 50262 Specification for metallic cable glands
- BS 6121-2 Specification for polymeric cable glands
- BS 6121-3 Specification for special corrosion resistant cable glands
- BS 6180 Code of Practice for barriers in and about buildings
- BS 6231 Specification for PVC insulated cables for switch & control wiring
- BS EN 571-1 Method of penetrant flaw detection.
- BS 7079 Preparation of steel substrates before application of paints

2.2.4 BS European Standards

- BS EN 287 Approval testing of welders for fusion welding-1 &-2
- BS EN 288 1-8 Specification & Approval of welding procedures

2.3 Definition of Terms

The definition of terms shall be as set out in the General Conditions of Contract.

2.4 Statutory Regulations

The Works and all equipment and materials forming part of this Contract shall comply in all respects with any relevant statutory regulations, by-laws or orders currently in force in Bangladesh.

2.5 Design Standards and Codes

2.5.1 General Compliance with International Standards and Codes

The Contract Works shall comply with the relevant standards as specified. Provided there is no conflict with the standards, and unless otherwise stated, all parts of the Works shall comply with the relevant international standards and design codes. Where suitable international standards do not exist, internationally accepted national standards or other approved standards shall apply.

2.5.2 Standards Named in Specification

Although the Works shall generally comply with international standards, any instruction in this specification that a particular aspect of the Works shall comply with a named code or standard which shall take precedence and that particular aspect of the works shall comply with the named code or standard.

2.5.3 Hierarchy of Standards

In the event of any conflict in standards, the hierarchy of standards shall be as follows, with the standards occurring first in the list taking precedence over any standards later in the list:

1. Statutory regulations of Bangladesh
2. Standards named in the specification
3. Other international standards
4. Other standards approved by the Engineer

Where equipment is specified to a particular standard, the Contractor may supply equipment of an equivalent standard, if approved by the Engineer.

2.5.4 Substitution of Standards and Design Codes

The Contractor may offer works that comply with international standards, or internationally recognised national codes or standards, which differ from those specified. However the Contractor may offer works, which comply with the different standards or codes, only if, when requested by the Engineer, he is able to demonstrate to the Engineer's satisfaction that the Works offered are equal or superior to that which would have resulted had the specified code or standard been used. This substitution of codes or standards for those specified will only be acceptable if the manufacturing organisation in question has extensive experience with the alternative code or standard offered.

Any Contractor offering contract works or part of those works to standards and codes that differ from those specified shall declare the fact to the Engineer. If requested to do so by the Engineer, the Contractor shall supply to the Engineer, at his own cost, with two copies in English of the relevant code or standard which he proposes to substitute for that specified.

2.6 Erection Marks

All members comprising multipart assemblies, e.g., towers, steel frameworks, piping installations, etc., shall be marked with distinguishing numbers and/or letters corresponding to those on the approved drawings or material lists. These erection marks, if impressed, must be completed before painting or galvanising, shall be clearly readable afterwards.

Colour banding to an approved code shall be employed to identify members of similar shape or type but of differing strengths or grades.

2.7 Cleaning and Painting

2.7.1 General

Following award of the Contract, the Contractor shall submit the name of the proposed paint supplier and applicator, together with a quality assurance programme, for approval. All paints for the outdoor equipment on the Contract shall be provided by one Manufacturer and preferably shall be manufactured in one country to ensure compatibility. All painting of outdoor equipment shall be carried out strictly in accordance with the paint system Manufacturer's recommendations and the application shall be checked and approved, in writing, by an authorised representative of the paint Manufacturer.

The painting of the plant shall be carried out in accordance with the appropriate schedule later in this section. The work is generally covered by the schedules but where particular items are not referred to specifically, they shall be treated in a manner similar to other comparable items as agreed with the Engineer.

The Contractor shall ensure that precautions are taken in packing and crating, to avoid damage to the protective treatment during transportation to the site. Any damage to paintwork that occurs during transport shall be made good at site.

The schedules indicate standards of surface preparation and painting which are intended to give a minimum life of 10 years in a severe environment, with need for only minor remedial work in that peri-

od.

Steel sections and plate shall be free from surface flaws and laminations prior to blast cleaning and shall not be in worse condition than ISO 8501-01.

Where paint coatings are proposed for the protection of surfaces of equipment exposed to corrosive conditions, such as plant items exposed to brine or sea water, or immersion in liquids or wet gases, the coatings shall be formulated to be suitably corrosion resistant and shall be high voltage spark tested at works and at Site prior to commissioning. The test procedure shall be based on the use of a high voltage direct current. The voltage used shall be 75% of the breakdown voltage of the coating. This breakdown voltage shall first be separately determined using test plates coated with the specified coating formulation and thickness. The coating on the test plate shall also be micro-sectioned by the applicator to show that it is free from vacuoles and other defects likely to invalidate the test procedure.

If the defects revealed by the above test procedure do not exceed one per 5 m² of coating surface, the coating need not be re-tested after the defects have been repaired. If the defects exceed one per 5 m² of coating surface, the repairs shall be re-tested after any curing is complete, and this procedure shall be repeated until the defects are less than one per 5 m² of coating surface. After repair of these defects, the equipment can be placed in service without further testing.

All coatings proposed for the internal protection of domestic water storage tanks and desalination plants shall be certified as suitable for use in potable water installations by an approved independent authority and shall meet the non-tainting requirements of BS 3416.

The Engineer will consider alternative paint schemes to meet the requirements of fabrication using modern automated materials handling systems, provided that the Contractor is able to demonstrate that they offer the same standards of surface protection and service life as those intended by the Schedules.

All paints shall be applied by brush or spray in accordance with the schedule, except for priming coats for steel floors, galleries and stairways where dipping will be permitted.

Where paint is to be applied by spray, the applicator shall demonstrate that the spray technique employed does not produce paint films containing vacuoles.

All planished and bright parts shall be coated with grease, oil or other approved rust preventative before dispatch and during erection and this coating shall be cleaned off and the parts polished before being handed over.

Where lapped or butted joints from part of an assembly that is assembled or part assembled prior to final painting, the jointed surfaces shall be cleaned free from all scales, loose rust, dirt and grease and given one brush-applied coat of zinc phosphate primer before assembly.

Paint shall not be applied to surfaces which are superficially or structurally damp and condensation must be absent before the application of each coat. Painting shall not be carried out under adverse weather conditions, such as low temperature (below 4°C) or above 90 % relative humidity or during rain or fog, or when the surfaces are less than 3°C above dew point, except to the approval of the Engineer or his duly appointed representative.

Priming coats of paint shall not be applied until the surfaces have been inspected and preparatory work has been approved by the Engineer or his duly appointed representative. No consecutive coats

of paints, except in the case of white, shall be of the same shade. Thinners shall not be used except with the written agreement of the Engineer.

On sheltered or unventilated horizontal surfaces on which dew may linger, more protection will be needed and to achieve this, an additional top coat of paint shall be applied.

The schedules differentiate between "Treatment at Factory" and "Treatment at Site after Completion of Erection" but the locations at which different stages of the treatments are carried out may be modified, always providing that each change is specifically agreed to by the Engineer and the painting is finished or made good at Site to the Engineer's satisfaction.

The schedules also refer to "Indoor" and "Outdoor" locations. In this context the interiors of all buildings without air conditioning, heating or forced ventilation shall be treated as "Outdoor".

All paint film thicknesses given are minima and refer to the dry film condition. All thicknesses shall be determined by the correct use of approved commercial paint film thickness measuring meters.

All outdoor painting shall be checked prior to issue of the final certificate and no visible corrosion or spotting shall be present. Slight loss of gloss may acceptable. In the event of visible corrosion being present, the Employer will retain the right to withhold such an amount from the Contractor as may be necessary to repaint the entire exterior part of the works.

The painting requirements shall be interpreted in accordance with the requirements and recommendations of the Standards and Codes of Practice referred to and the paint Manufacturer's special instructions where applicable, colours being in accordance with BS 1710 and BS 4800, or equivalent material standards.

2.7.2 Schedules for Indoor Surfaces Finishes

Treatment at Factory	Treatment at Site after Completion of Erection
General	
(a) Structural and supporting steelwork, plant items above ground, tank external surfaces. All not above 95°C (or 65°C for chlorinated rubber finishes).	
Blast clean to BS 7079 2nd quality (SA 2.5) profile amplitude 40-75 microns. Then apply within 4 hours one coat (13 microns) weldable holding primer for 12 months x match protection. After fabrication is complete dress all welds, thoroughly clean to remove corrosion products, oil, grease and dirt and apply one coat (50 microns) of two pack epoxy zinc phosphate primer followed by two coats two pack epoxy micaceous iron oxide (250 microns total).	• Thoroughly clean to remove oil, grease and dirt. • Paint coats to be touched up where necessary. • Then apply one tie coat to finish (30 microns) and one coat alkyd gloss (25 microns)
(b) Steel floors, chequer plates, galleries, stairways, treads, kick stops.	
Galvanise to BS 729	Thoroughly clean to remove oil, grease and dirt. Where galvanising is damaged, wire brush to BS 7079 3rd quality (SA2) and apply 1 coat zinc rich epoxy pri-

Treatment at Factory	Treatment at Site after Completion of Erection
	mer (50 microns). Then apply: • 1st coat of etch primer • 2nd coat epoxy zinc chromate • 3rd coat 2-pack epoxy micaceous iron oxide (50 microns). On galleries and stairways top surfaces apply: • 4th coat non-skid epoxy deck paint (30 microns).
(c) Galvanised iron and steel requiring paint finish	
Galvanise to BS 729	Thoroughly clean to remove oil, grease and dirt. Then apply: • 1st coat of etch primer • 2nd coat of zinc chromate primer (30 microns) • 3rd coat alkyd undercoat (30 microns) • 4th coat alkyd gloss (25 microns).
(d) Stainless steel, aluminium alloys and non-ferrous alloys requiring paint finish.	
Not Applicable	Thoroughly clean to remove oil, grease and dirt. Then apply: • 1st coat alkyd undercoat (30 microns) • 2nd coat alkyd gloss (25 microns).
(e) Bitumen dipped items	
Bitumen dipped.	Thoroughly clean to remove oil, grease and dirt. Then apply: • 1st coat general purpose aluminium paint (18 microns) • 2nd coat alkyd undercoat (30 microns) • 3rd coat alkyd gloss (25 microns).
Battery Rooms (open top batteries), Chlorination Plant Rooms, Electrolytic Cell Rooms	
(a) Steelwork	
Blast clean to 2nd quality BS 7079 (SA2.5) profile amplitude 40-75 microns	Thoroughly clean to remove oil, grease and dirt. Priming coat to be touched up where necessary. Then apply: • 1st coat chlorinated rubber primer to Manufacturer's instructions • 2nd coat high build chlorinated rubber (80 microns) • 3rd coat high build chlorinated rubber (80 microns).
Bright Parts	
Coat with a mixture of oil, grease or approved proprietary inhibitor.	Clean and polish

Treatment at Factory	Treatment at Site after Completion of Erection
Instrument Panels, Relay Panels, Control Panels, 400V A.C. Boards, 110V D.C. Boards, Telemetry Marshalling Kiosks, Lighting and Small Power Distribution Boxes, Battery Charger Cubicles, Metal Clad Switchgear	
Acid pickle or blast clean to 1st quality BS 7079. Then apply: • 1st coat zinc chromate primer (30 microns) Stop and fill. Then apply: • 2nd coat alkyd undercoat (30 microns). Rub down with fine abrasive paper. Then apply • 3rd coat alkyd undercoat (30 microns) Rub down with fine abrasive paper. Then apply: • 4th coat alkyd matt (25 microns) • 5th coat alkyd matt (25 microns) • 6th coat alkyd matt (25 microns) Total film thickness (125 microns).	Touch up if necessary and burnish

2.7.3 Schedules for Outdoor Surfaces Finishes

Treatment at Factory	Treatment at Site after Completion of Erection
General	
(a) Structural and supporting steelwork, plant items above ground, tank external surfaces. All not above 95°C (or 65°C for chlorinated rubber finishes).	
Blast-clean to BS 7079 2nd quality (SA2.5) profile amplitude 40-75 microns. Then apply within 4 hours one coat (13 microns) weldable holding primer for 6 months protection or (25 microns) weldable holding primer for 12 months protection. After the protection period, thoroughly clean to remove oil, grease and dirt and apply one coat (50 microns) of two pack epoxy zinc phosphate primer followed by two coats two pack epoxy micaceous iron oxide (250 microns total).	Thoroughly clean to remove oil, grease and dirt. Paint coats to be touched up where necessary. Then apply one tie coat to match finish (30 microns) and one coat alkyd gloss (25 microns)
(b) Steel floors, chequer plates, galleries, stairways, treads, kick stops	
Galvanised to BS 729	Thoroughly clean to remove oil, grease and dirt. Where galvanising is damaged, wire brush to BS 7079 3rd quality (SA2) and apply one coat zinc rich epoxy primer (50 microns). Then apply: • 1st coat epoxy etch primer • 2nd coat epoxy zinc chromate (30microns) • 3rd coat two pack epoxy micaceous iron oxide (100 microns) On galleries and stairways top surfaces apply:

Treatment at Factory	Treatment at Site after Completion of Erection
	• 4th coat non-skid epoxy deck paint (30 microns).
(c) Galvanised iron and steel requiring paint finish	
Galvanised to BS 729	Thoroughly clean to remove oil, grease and dirt. Then apply: • 1st coat etch primer • 2nd coat zinc chromate primer (30microns) • 3rd coat alkyd undercoat (30 microns) • 4th coat alkyd gloss (25 microns).
(d) Stainless steel, aluminium alloys and non-ferrous alloys requiring paint finish	
Not applicable.	Thoroughly clean to remove oil, grease and dirt. Then apply: • 1st coat alkyd undercoat (30 microns) • 2nd coat alkyd gloss (25 microns).
(e) Bitumen dipped items	
Bitumen dipped.	Thoroughly clean to remove oil, grease and dirt. Then apply: • 1st coat general purpose aluminium paint (18 microns) • 2nd coat alkyd undercoat (30 microns) • 3rd coat alkyd gloss (25 microns)
Bright Parts	
Coat with a mixture of oil, grease or approved proprietary inhibitor.	Clean and polish
Instrument Panels, Control Panels, Marshalling Kiosks, Lighting and Small Power Distribution Boxes and Junction Boxes etc.	
Blast clean, prime, undercoat and paint in accordance with the painting schedule for structural and supporting steelwork, with finish coat of paint applied at Manufacturer's works	Clean and touch up as necessary
Water and Oil Storage Tanks-Internal Surfaces	
The epoxy paint formulation shall be to the approval of the Engineer. The finished coating shall be capable of being tested with a high voltages spark tester for absence of pinholes and porosity. For oil storage tanks, solvent-free epoxy paint formulation shall be used.	
For tanks delivered to site in plate sections, the plates shall be blast cleaned to BS 7079 1st quality (SA3) profile amplitude 40-75 microns and then within 4 hours coat with a weldable holding primer dry film thickness 25 microns	Welded Construction at Site. After erection all welds shall be dressed to remove rough edges and burrs and all sharp edges shall be radiused 3 mm Prior to painting, all surfaces shall be sweep blast cleaned to a sound surface free from rust and debris.

Treatment at Factory	Treatment at Site after Completion of Erection
	Then apply within 4 hours: • 1st coat Isocyanate or amine cured epoxy primer 25 microns • 2nd coat Isocyanate or amine cured high build epoxy (125 microns) • 3rd coat Isocyanate or amine cured high build epoxy (125 microns).
Sectional Construction: Prior to assembly, all component items to be blast cleaned to BS 7079 1st quality (SA3) profile amplitude 40-75 microns. Then apply: • 1st coat Isocyanate or amine cured epoxy primer (25 microns). After assembly, clean all surfaces free from rust, grease and dirt. Priming coat to be touched up as necessary. Then apply: • 2nd coat Isocyanate or amine cured high build epoxy (125 microns) • 3rd coat Isocyanate or amine cured high build epoxy (125 microns).	Sectional Construction: Touch up damaged areas as necessary.
Radiators	
Radiators shall be thoroughly cleaned and treated externally by phosphating or other approved rust inhibiting process and given, preferably by flood painting, the same number and type of coats specified in General Sub-Clause of this Clause. Radiators that are hot dip galvanised to BS.729, Part 1, shall be artificially weathered and given one coat of zinc chromate primer followed by the same number and type of paint coatings specified in Clause. Radiators shall be painted with Munsell colour No. 5Y 7/1.	

2.8 Rating Plates, Nameplates and Labels

2.8.1 General

The Contractor shall supply and install all labels, name, rating, instruction and warning plates necessary for the identification and safe operation of the Works. Samples shall be submitted for the approval of the Engineer.

Nameplates or labels shall be of non-hygroscopic, non-deteriorating and non-warping material with engraved lettering of a contrasting colour or, in the case of indoor circuit breakers, starters, etc., white plastic material with black lettering engraved thereon.
Items of plant such as valves, mounted outdoors or subject to harsh operating conditions, shall be provided with engraved chromium plated brass or stainless steel nameplates or labels with engraving filled with black enamel.

All the above labels and plates shall be securely fixed to items of plant and equipment with stainless steel rivets, plated self-tapping screws or other approved means. The use of adhesives will not be permitted.

Individual plant items and all relevant areas within the contract works where a danger to personnel exists shall be provided with plentiful, prominent and clear warning notices.

These warning notices shall draw attention to the danger or risk with words in the language specified which attract attention and summarise the type of risk or danger. The notices shall also carry a large symbol that graphically depicts the type of risk.

All equipment within panels and desks shall be individually identified.

Items of plant, such as valves, which are subject to handling, shall be provided with nameplates with permanent inscriptions thereon.

2.8.2 Rating Plates

Each main and auxiliary item of plant shall have attached to it in a conspicuous position, a rating plate upon which shall be engraved all appropriate technical data and any identifying name, type or serial number, and the requirements of the Standard specific to the item of plant. In addition, the Engineer may require including details of the loading conditions under which the item of plant in question has been designed to operate, such as the short-time rating of switchgear.

2.8.3 Circuit Labels

Each main item of plant shall be provided with an identification plate. The inscriptions shall be approved by the Engineer.

In addition, the device number allocated by the Engineer to each item of plant shall be displayed in text height 30 mm on all operating mechanisms and 60 mm or larger in height on principal items of Plant, e.g. busbars, transformers etc. The same device number shall be displayed on control cubicles in text height 10 mm or larger as may be required by the Engineer.

2.8.4 Pipe Service Identification

A colour-banding scheme shall be used to identify pipework included within this Contract. The colours employed shall be in accordance with the painting specification herein. Colour bands shall be painted on each side of all valves and items of equipment in the piping systems. The use of adhesive-backed colour bands is not permitted.

Valve labels shall be circular and fitted under the hand-wheel captive nut. For check valves and small valves, the Contractor may provide rectangular labels fitted to the valve or secured close by the valve.

The inscription or "name" on each valve label shall summarise the duty of the valve, and the number shown on each valve label shall be the number in the unified plant valve-numbering scheme.

Where the direction of flow through a valve or other device is an important requirement for correct functioning, the body of the valve or device shall be legibly marked with a cast on or a properly secured arrow, showing the direction of flow. Pipework shall be provided with plentiful large painted arrows or other secure and durable arrow markings to allow the flows of fluids around the plant to be readily understood.

2.9 Environmental Protection & Tropicalisation

2.9.1 General

All equipment shall be designed to operate in the environmental conditions specified.

Outdoor equipment shall be designed so that water cannot collect at any point. The undersides of all tanks shall be ventilated in an approved manner to prevent corrosion.

Where applicable, equipment should tolerate the effects of freezing and air pollution.

Outdoor plant shall be rated and constructed so that its performance, operation, reliability, maintenance and or life shall meet the specified design and operating conditions.

Where personnel have to be in attendance frequently, or maintenance has to be regularly carried out, permanent means weather protection or sunshades shall be provided.

Where the performance, reliability or life of the plant would be adversely affected by solar radiation, including the effects of prolonged exposure to ultra violet light, suitable sunshades shall be provided. Such sunshades shall be constructed from materials that are able to withstand the effects of the ambient conditions on site without suffering any deterioration in material strength or effectiveness.

Sunshades need not be provided on outdoor plant or equipment provided the Manufacturer could satisfy the Engineer that the materials employed will not be adversely affected or the temperature rise due to internal heat generation plus that due to solar radiation will not exceed the equipment design temperature. However equipment requiring manual operation shall be provided with sunshades to ensure that surface temperatures will not exceed 50°C.

Sunshades shall protect plant and personnel when the sun is more than 45°C above the horizon. They shall not impede the operation or maintenance of the plant or the movement of ventilating air and shall

include adequate artificial light as necessary.

Facilities such as lighting, lifting beams and rainwater drainage shall be provided wherever necessary to the approval of the Engineer as an integral part of the sunshade structure.

2.9.2 Tropicalisation

In choosing materials and their finishes, due regard shall be given to the humid tropical conditions under which equipment shall work, and good proven practices shall be followed unless otherwise approved by the Engineer. Some relaxation of the following provisions may be permitted where equipment is hermetically sealed but it is preferred that tropical grade materials should be used wherever possible:

- Metals: Iron and steel are generally to be painted or galvanised as appropriate. Indoor parts may alternatively have chromium or copper-nickel plating or other approved protective finish. Small iron and steel parts (other than stainless steel) of all instruments and electrical equipment, the cores of electromagnets and the metal parts of relays and mechanisms shall be treated in an approved manner to prevent rusting.

- Screws, nuts, springs, etc. The use of iron and steel shall be avoided in instruments and electrical relays wherever possible. Steel screws shall be zinc, cadmium or chromium plated, or when plating is not possible owing to tolerance limitations, shall be of corrosion-resisting steel. Instrument screws (except those forming part of a magnetic circuit) shall be of brass or bronze. Springs shall be of non-rusting material, e.g., phosphor bronze or nickel silver, as far as possible.

- Rubbers: Neoprene and similar synthetic compounds, not subject to deterioration due to the climatic conditions, shall be used for gaskets, sealing rings, diaphragms, etc.

2.10 Platforms, Stairways, Ladders and Hand-Railing

2.10.1 General

The Contractor shall provide all platforms, galleries, stairways and ladders necessary to give access to the various sections of the plant being supplied under this contract. They shall provide adequate means of access for all operation, inspection and overhaul purposes and shall be of sufficient strength to support workers, tools and portions of plant that may be placed on them during overhaul and inspection periods.

Galleries, platforms and stairways shall be designed generally for a load of 7.5 kN/m² but where loads in excess of this are likely to be imposed during operation or maintenance, the Contractor shall make due allowance for the increased loads in the design. Particular care shall be given to their rigidity. All the necessary supports from the floors, buildings and foundations shall be supplied under this contract.

Galleries and platforms around plant subject to significant expansion shall be designed to allow for such expansion and to provide safe and adequate access for both hot and cold conditions.

Platforms and galleries shall have a minimum width of 850 mm clear passageway and shall be enclosed by hand railing on both sides. In cases where there is a space not exceeding 200 mm on one side of a passageway hand-railing need be supplied for one side only but an edging strip shall be provided on the side without handrail. The minimum headroom on platforms and galleries shall be 2100 mm.

Ladders will only be permitted where stairways are impractical and access is required for maintenance. All platforms, stairways, ladders and other access ways, shall comply with the requirements of BS 5395 Part 3, unless otherwise stated. As far as practical the flooring, stair treads and handrails shall conform to a uniform pattern throughout the whole of the Contract Works.

2.10.2 Flooring

The flooring of all platforms, galleries and staircase treads shall consist of an approved type of galvanised mild steel open grid flooring except in those cases where chequer plate is specified.

Toe plates extending to a height of not less than 100 mm above the platform or gallery level and of a thickness of not less than 6 mm shall be supplied. Any opening which it is necessary to cut in the open grid flooring or chequer plate shall be finished off with an edging strip similar to that on the floor panels.

The open grid flooring and stair treads shall be from an approved Manufacturer and generally in accordance with BS 4592. The pattern of open grid flooring and chequer plate shall be uniform and laid with the pattern in one direction.

Open grid floor panels shall be not less than 25 mm in depth and shall be fitted neatly between kerbs and clamped with nuts and bolts in such a manner as to permit ready removal or replacement. The design of the clamps shall be for approval and only minimal protrusion above the floor level will be permitted.

Where chequer plate is supplied it shall be galvanised mild steel to an approved design. No chequer plate shall be less than 10 mm thick and all plates shall be secured to the supporting steel by galvanised countersunk screws of not less than 10 mm nominal size.

2.10.3 Hand-Railing and Protective Barriers

Hand-railing and protective barriers shall be provided wherever necessary to protect operation or maintenance personnel from hazards, and shall comply with BS 6180.

Double hand railing shall be provided unless otherwise specified. Each length shall be joined by internal ferrules and all joints shall be neatly finished by the removal of all burrs.

The top rail shall be not less than 30 mm diameter and mounted at a height of not less than 1100 mm from the gallery or platform level. The intermediate rail shall be not less than 25 mm diameter and mounted at a height of not less than 535 mm from the gallery or platform level. Handrails for stairways shall have the top rail at a height of not less than 900 mm and lower rail at not less than 420 mm above the stairway pitch line.

Tubular or solid forged stanchions shall be provided, spaced at a maximum distance of 1750 mm, and

to which hand-railing shall be firmly attached.

The stanchions shall be firmly and directly attached to the body of the platform, gallery, stairway or ladder steelwork by bolting, and when erected shall be vertical. They shall not be attached to toe-rails.

In designing hand-railing and its supporting stanchions particular attention shall be paid to the provisions of BS 6180 relating to design loads and to permissible deflections and flexibility.

2.10.4 Stairways

Where specified, main stairways shall have a minimum stair tread width of 1100 mm; other stairways shall have a minimum width of 750 mm. Wherever possible, the angle of slope of stairways shall be standardised. Angles exceeding 42° to the horizontal shall not be used.

No flight of stairs shall have more than 16 risers. Where a stairway requires more than 16 risers, each flight shall have an approximately equal number of risers and shall be separated by a landing. Risings shall be between 190 mm and 210 mm, and goings shall be between 220 mm and 250 mm in width. Minimum headroom shall be 2.3 m.

2.10.5 Fixed Access Ladders

Ladders shall comply with BS 4211. The minimum width of ladders shall be 500 mm and inclination shall be not less than 70°, and not more than 80° to the horizontal.

2.11 Nuts, Bolts, Studs and Washers

The threads and other details of fasteners shall comply with the relevant ISO Standards for metric series fasteners. Nuts and bolts for pressure parts shall be of the best quality steel. Nuts, bolts, studs and washers shall be of materials most suitable for the service operating conditions and designed to ensure the stresses arising in normal operation shall not exceed those necessary to ensure that the specified plant life is achieved.

Nuts and bolts for incorporation in the plant are preferably to conform to ISO Metric Coarse to ISO 272. Other sizes or threads are permitted for threaded parts not to be disturbed in normal use or maintenance. Where the Contract includes nuts and bolts of different standards, then the tools to be provided in accordance with this Specification shall include spanners, taps, and dies for these nuts and bolts.

Fitted bolts shall be a driving fit in the reamed holes they occupy, and they shall have the screwed portion of a diameter such that it will not be damaged in driving and shall be marked in a conspicuous position to ensure correct assembly at site.

Stud holes in those parts of the plant that are subjected to heat in use shall be adequately vented.

The threaded portion of any bolt or stud shall not protrude more than 1.5 threads above the surface of its mating nut.

Where practicable the use of slotted head screws shall be avoided in machinery component assemblies, hexagon socketed screws being preferred.

On outdoor equipment all bolts, nuts and washers shall be of non-rusting material where they are in contact with non-ferrous parts in conductor clamps and fittings and elsewhere where specifically required by the Engineer.

All washers shall be included under this contract, including locking devices and anti-vibration arrangements, which shall be subject to the approval of the Engineer. Taper washers shall be fitted where necessary.

2.12 Forgings

The Contractor shall supply a list of all important forgings and draw up material specifications for each one. Copies of this list and specifications shall be supplied to the Engineer for his use. In each case the quality and inspection requirements shall be clearly stated.

Wherever possible steel forgings shall be in accordance with the requirements of BS Standards 29, 970 or 4670, the equivalent ISO Standards or agreed national standards.

Test blocks from which mechanical test pieces will be machined shall be cut from forgings at positions to be agreed by the Engineer. On large and important forgings several test pieces shall be taken from radial and longitudinal directions.

Forgings shall be free from cracks externally or internally, extensive non-metallic inclusions and surface defects. The Contractor shall carry out non-destructive testing of forgings during machining to verify that no unacceptable defects are present.

Repairs by welding or other means shall not be undertaken on forgings at any stage of the production cycle.

Each forging shall be suitably branded with an identification number that shall be transferred throughout all final machining stages. The identification number shall be marked on all documents and test certificates relative to the forging.

2.13 Castings

2.13.1 General

Test pieces shall be provided from medium and large castings for all necessary material and chemical tests that are to be witnessed by the Engineer. If required by the Engineer any castings for rotating or highly stressed parts are to be subjected to non-destructive testing by approved methods, including radiographic and ultrasonic, the cost of which shall be borne by the Contractor.

All castings shall be homogeneous and free of shrinkage, pipes, under-sizing, porosity or voids. "Bum-in" repairs shall not be acceptable and no welding, filling, interlocking or plugging of defective parts shall be done without the Engineer's approval in writing. All repairs shall be subjected to non-destruct-

ive examination (ultra-sonic, X-rays, gamma-rays) after heat treatment. Welding repairs to castings that will be in contact with corrosive liquids, such as seawater or brine, will only be permitted under special circumstances.

2.13.2 Steel Castings

The Contractor shall prepare material purchasing specifications for all important castings. Each document shall indicate fully the quality and inspection requirements for the component casting covered. Copies of the specifications shall be issued to the Engineer for his use.

Castings may be repaired by welding providing the approval of the Engineer be first obtained. The Contractor shall submit drawings, sketches or photographs showing the location and principal dimensions of the defect together with the proposed weld repair procedure. The maximum size of defect for which weld repair will be permitted is:

- Maximum length of defect 20 mm
- Maximum width of defect 10 mm
- Maximum depth of defect no greater than 10% of the wall thickness

Only welders who have passed an appropriate qualification test shall be employed on the repair of castings. All repairs shall be carried out by the metal arc process. Ultrasonic inspection shall be applied to all important castings to locate the extent of sub-surface defects and to check the wall thickness.

All castings shall be identified by stamped or cast-on reference marks, which shall be entered on all relevant documents and test certificates. The Engineer may require that certain castings be examined using radiographic techniques. The Contractor shall include for this eventuality and shall comply with the Engineer's instructions when issued.

2.13.3 Iron Castings

Cast iron shall not be used for any part of equipment which is in tension or which is subjected to impact, or to a working temperature exceeding 200°C, unless specifically approved by the Engineer. Nor shall it be used for chambers of oil filled apparatus.

Weldable grades of iron castings may be repaired by welding provided the approval of the Engineer is first obtained. The Contractor shall submit full details of the proposed weld repair procedure and weld procedure qualification test prior to making any weld repairs.

The maximum size of defect for which weld repair will be permitted is:

- Maximum length of defect 20 mm
- Maximum width of defect 10 mm
- Maximum depth of defect no greater than 10% of the wall thickness.

Test blocks shall be integrally cast on all medium and large castings. The Engineer may require that certain castings be checked using radiographic techniques. The Contractor shall include for this eventuality and shall comply with the Engineer's instructions when issued.

2.13.4 Aluminium Bronze Castings

The Contractor shall prepare material purchasing specifications for all important castings. Each document shall indicate fully the quality and inspection requirements for the component casting covered. Copies of the specifications shall be issued to the Engineer for his use.

The inspection and quality requirements shall include an analysis of each cast, mechanical testing of test pieces from each cast, pressure testing, penetrant flaw detection and radiographic examination of selected critical areas.

Weldable grades of aluminium bronze may be repaired by welding, provided the written approval of the Engineer is first obtained. The Contractor shall submit full details of the proposed weld repair procedure and weld procedure qualification test prior to making any weld repairs. The maximum size of defect for which weld repair will be permitted is:

- Maximum length of defect 20 mm
- Maximum width of defect 10 mm
- Maximum depth of defect no greater than 10% of the wall thickness

On completion of repairs, welded areas shall be ground smooth and carefully blended into the parent material. The repaired areas shall be examined for defects using penetrant flaw detection and radiography. Crack-like linear defects shall not be permitted.

2.14 General Welding Requirements

2.14.1 General

All welding shall conform to the relevant British Standards, or other British or National Standard Specification as agreed by the Engineer. Where there is a conflict between Codes and/or Standards the Engineer's decision will prevail.

2.14.2 General Fabrication

The Engineer shall be notified at least two days prior to commencement of any assembly or fabrication work on site. The CO_2 and flux-cored welding process will not be acceptable for site welding.

2.14.3 Weld Procedure Documents

Complete and fully detailed weld procedure documents shall be kept by the Contractor and these shall be made available to the Engineer on request. Prior to commencement of welding the Contractor shall submit to the Engineer for approval the welding procedures to be used in the fabrication of the relevant sections of work.

The weld procedure documents shall be fully detailed and each shall indicate clearly which item it is intended to cover. The procedures shall be in accordance with the requirements of BS 499 Part 1, Appendices A-G.

2.14.4 Weld Procedure Qualification Tests

Weld procedure qualification tests shall be carried out in accordance with the requirements of BS EN 288, or agreed National Standard for the item of plant under consideration. Provided that the Contractor confirms that the basic parameters of the procedure have not been changed since approval, the results of weld procedure qualification tests previously carried out under the supervision of an internationally recognised inspecting authority may be accepted by the Engineer.

The Contractor shall inform the Engineer of any proposed changes to the welding procedures before such changes are implemented. If in the opinion of the Engineer a further qualification test is required as a result of such changes, then the Contractor shall perform the required test without additional charge.

The results of all tests shall be made available, for examination by the Engineer, if required.

2.14.5 Welder's Qualification Tests

All welders and welding operators shall be qualified for the work and shall hold current welders' qualification certificates in accordance with BS EN 287, BS 4872 or agreed National Standard for the work.

All welders' tests shall be witnessed and/or approved by the Engineer before the welder or operator is permitted to work. The decision of the Engineer regarding the acceptability of any test or existing qualification tests, shall be final.

Records showing the date and results of the qualification tests performed by each welder and weld operator, together with the identification number assigned to him, shall at all times be available for scrutiny by the Engineer.

2.14.6 Storage of Welding Consumables

Welding consumables shall be stored in a manner that will protect them from all forms of deterioration prior to use and shall be properly identified. Gas cylinders for use with burning or welding equipment shall be marked in accordance with the requirements of BS 349 or IS0448. Site storage procedures for gas cylinders will require the approval of the Engineer.

2.14.7 Welding Equipment

Any welding equipment that in the opinion of the Engineer is unsuitable or unsatisfactory for the purpose for which it is being used shall be replaced by the Contractor.

2.14.8 Visual Weld Inspection

Each weld shall be subjected to a stringent visual inspection and shall be free from undercut, excessive spatter, craters, cracks, porosity and other surface imperfections. Welds shall be of regular contour, even weld ripple and indicative of good workmanship. Fillet welds shall be checked for dimensional tolerance and form using a fillet weld gauge. Fillet welds should be slightly concave in form and each leg of the weld shall have equal length.

2.14.9 Internal Examination

The internal root bead of tube butt welds shall be examined by intra-scope or other suitable optical device.

2.14.10 Non-destructive Examination

All non-destructive examinations shall be supervised by a fully qualified and experienced specialist appointed by the Contractor. Individual operators in each of the respective techniques shall be qualified and trained in the respective subject and shall have reached a standard comparable with the Certification Scheme of Weldment Inspection Personnel in the United Kingdom.

Testing shall be in accordance with the requirements of BS 709 "Methods of Testing Fusion Welded Joints and Weld Metal in Steel" or an agreed National Standard.

2.14.11 Ultrasonic Examination

Ultrasonic examination of welds shall be carried out in accordance with BS 3923 Part 1 and Part 2 and any other relevant British Standards or agreed National Standards.

2.14.12 Magnetic Crack Detection

Magnetic crack detection shall be carried out in accordance with BS 6072 or an agreed National Standard.

2.14.13 Dye Penetrant Tests

Dye penetrant tests shall be in accordance with BS 6443 or any other relevant British or agreed National Standards.

2.14.14 Quality Requirements for Welds

All welds subjected to non-destructive tests shall be entirely free from cracks or crack like defects, lack of root fusion, lack of sidewall fusion, root bum through, or tailed pores. The standard for porosity and slag inclusions will be as indicated in the agreed standards for design and welding.

2.14.15 Weld Repairs

The Engineer's approval shall be obtained prior to commencement of any repair or rectification work. Weld repairs shall be made to the same procedure as for the original weld. All tests shall be repeated after the repair has been completed and reports on radiographic and ultrasonic tests shall be marked to indicate that the report refers to a repaired weld.

2.14.16 Mandatory Inspections

All transition welds between dissimilar materials, such as high alloy steels to carbon steel, or austenitic steels or non-ferrous materials to steels, shall be subjected to 100% ultrasonic examination or crack detection wherever practicable. In addition, all butt welds between dissimilar materials shall be subjected to 100% radiographic examination.

All welds in ferritic alloy steels, e.g. having a carbon equivalent value in excess of 0.40%, and high yield-strength steels, e.g. having yield strength greater than 300 MPa, shall be subjected to 100% ultrasonic examination and crack detection wherever possible. In addition, all butt welds in these materials shall be subjected to 100% radiographic examination.

A minimum of 10% of all butt welds on all classifications of work shall be radiographically examined, unless otherwise agreed with the Engineer.

2.15 Galvanised Work

All materials to be galvanised shall be of the full dimensions shown or specified and all punching, cutting, drilling, screw tapping and the removal of burrs shall be completed before the galvanising process commences.

All galvanising shall be done by the hot dip process, not less than 98% of which must be pure zinc and in accordance with BS 729 or BS 443 as applicable. No alternative process shall be used without the approval of the Engineer. Bolts shall be completely galvanised including the threads, but the threads of nuts shall be left uncoated and shall be oiled. The zinc coating shall be uniform, clean, smooth and as free from spangle as possible.

Galvanised wire shall comply with the requirements of BS 182 and the thickness of the coating and testing thereof shall comply with BS 443. Nuts and bolts and small components shall be tested in accordance with BS 729. The Engineer may select for test as many components to be weighed after pickling and before and after galvanising as he may think fit.

Galvanised steel shall be treated after galvanising with Sodium Dichromate solution or Pretan W20 to prevent formation of white Storagstan. In addition, plastic or other non-metallic non-hygroscopic spacers shall be used between packed members to facilitate ventilation of the zinc surface during shipping.

All galvanised parts shall be protected from injury to the zinc coating due to abrasion during periods of transit, storage and erection. If, in the opinion of the Engineer, the extent of the damage found on Site to a galvanised part appears to be capable of repair the Contractor may, after receiving such agreement, attempt to affect a repair by approved methods. The agreement to attempt the repair shall not bind the Engineer to accept the repaired part when this is re-offered for inspection.

Should an emergency arise on Site necessitating drilling, cutting or any other process likely to damage the protective zinc surface, this will be permitted only in extreme circumstances and with the Engineer's express authority. In such a case, the bared metal will be coated with an approved zinc rich paint of not less than 92 percent zinc content.

2.16 Chromium Plating

The chromium plating of those components of the Plant where specified and where offered by the Contractor shall comply with the requirements of BS 1224.

2.17 Pumps

Pumps should be of the centrifugal type unless strong technical or economic reasons dictate that a positive displacement pump, either rotary or reciprocating, is more appropriate.

Preventive and routine maintenance time should be minimised by the selection of appropriate designs of pump, preferably those that leave casing to piping joints intact, i.e. horizontal split-casing types for large centrifugal pumps and horizontal, back pull-out types for smaller units. Where a significant saving in floor space or improvement of layout can be shown, a vertical pump may be acceptable.

Pumps shall be capable of continuous operation with minimum maintenance.

2.18 Pipework

During the contract Engineering, the Contractor shall supply to the Engineer schedules of the pipework provided under this contract. These schedules shall state, for each pipework system or part of a pipework system, the design and operating pressures and temperatures, the fluid transmitted, the piping and valve materials, the types of valves, any corrosion allowance, the pipework design code, insulation proposals, pipe supports and any other data relevant to the mechanical design of the pipework system or part of a pipework system.

All piping shall be routed to provide a neat and economical layout requiring the minimum number of fittings. Piping shall be arranged so that full access is provided for the operation and maintenance of equipment and so that removal or replacement of equipment can be achieved with the minimum dismantling of piping.

The Contractor is to be responsible for ensuring that the internal surface of each pipe line is thoroughly clean both during erection and before the pipe line is placed in commission.

The procedure for internal cleaning of pipes adopted by the Contractor is to include the following:

- Thorough cleaning of all internal surfaces prior to erection to remove accumulations of dirt, rust, scale etc., and welding slag due to site welding before erection.
- Thorough cleaning of all pipework after erection by blowing through to atmosphere to ensure that no extraneous matter is left in the system.

The Contractor is to provide all necessary facilities for carrying out these requirements.

Pipework shall be supported and anchored in an appropriate manner in accordance with the provisions of US Standard ANSI B31.1 or the Standard to which the pipework is designed. The whole of the

pipework and accessories included in this Contract are to be supported and mounted in an approved manner. All necessary slings, saddles, structural steelwork, foundation bolts, fixing bolts and all other attachments are to be supplied. The number and positions of all supports and the maximum weight carried by a support is to be subject to the approval of the Engineer.

2.19 Valves

All valves shall be suitable for the service conditions under which they are required to operate. The design, construction and choice of materials shall take into account all operational deviations including pressure surge and thermal shock.

All valve hand operating mechanisms shall be easily operable by one man. The mechanisms shall be such that the total force at the rim of the hand-wheel or other point of application of manual action shall not need to exceed 400 N (normally 200 N pull plus 200 N push) to exercise any valve. Special attention shall be given to the operating mechanism for large size valves with a view to ensuring that a minimum of maintenance is required and to obtaining quick and easy operation.

All valves shall be closed by rotating the hand-wheels in a clockwise direction when looking at the face of the hand-wheel. In cases where the hand-wheel is not directly attached to the valve spindle suitable gearing shall be introduced to ensure clockwise closing. The face of each hand-wheel shall be clearly marked "open" and "shut" or "closed" with arrows indicating the direction of rotation to which they refer.

Plastic valve hand-wheels will not be acceptable, except where such hand-wheels are in the Employer's best interests. All valve spindles shall be fitted with indicators so that the valve opening can be readily determined. In the case of valves fitted with extended spindles, indicators shall be fitted both to the extended spindles and to the valve spindles.

Valves of 50 mm nominal bore and over are to be provided with indicators showing when the valve is open or closed.

All valve hand wheels are to be fitted with nameplates complying with this Specification.

Suitable means are to be provided to protect the operating mechanisms of all valves against mechanical damage and dust or dirt.

Valves that it will be necessary to lock in the open or closed position are to be provided with a non-detachable locking arrangement.

2.20 Pressure Vessels

All vessels shall be designed, constructed and otherwise comply with appropriate international or national pressure vessel design codes, unless the vessel in question falls into one of the following groups:

- vessels with a water containment capacity of less than 454 litres for the containment of water under pressure, including those containing air, the compression of which serves only as a cushion.

- hot water storage vessels heated by steam or any other indirect means when none of the following limitations is exceeded:
  - a heat input of 58kW
  - a water temperature of 93°C
  - a nominal water containment capacity of 454 litres.
- vessels having an internal or external design pressure not exceeding 1.03 bar gauge, this design pressure being not less than the maximum expected difference that may exist between the inside and outside of the vessel at any time.
- vessels having an internal diameter not exceeding 150 mm.
- vessels and equipment covered more appropriately by boiler or pipework design codes.

Should any difficulty arise in the decision as to whether a particular vessel shall comply with a pressure vessel code, the vessel shall be "coded" unless specifically excluded in clause U- 1 of the US ASME Boiler and Pressure Code, Section VIII, division 1, dealing with the scope of that code.

Notwithstanding the foregoing exclusions, if it is stated elsewhere in the Specification that a particular vessel shall comply with a pressure vessel design code, then a vessel complying with a suitable design code shall be provided.

In respect of the design codes to which "coded" vessels shall comply, attention is drawn to the provisions of this Specification relating to design codes and standards.

2.21 Lubrication

The Contract is to include for the supply of flushing oil for each lubrication system when the item of plant is ready for preliminary tests and the first filling of approved lubricants for the commercial operation of the plant.

A schedule of the oils and other lubricants recommended for all components of the Contract Works is to be submitted to the Engineer for approval. The number of different types of lubricants is to be kept to a minimum. Copies of this schedule shall be included in both the draft and final copies of the operating and maintenance instructions. In the case of grease lubricated roller type bearings for electric motors a lithium based grease is preferred.

The Contractor shall supply at least one grease gun equipment for each type of nipple provided. Where more than one special grease is required, a grease gun for each special type shall be supplied and permanently labelled.

2.22 Oil Level Indicators

Oil level indicators of approved design are to be fitted to all oil containers such as transformer tanks etc. The indicators are to show the level at all temperatures likely to be experienced in service, are to be marked with the normal level at 20°C clearly visible from normal access levels and are to be easily dismantled for cleaning. In addition, the normal filling level of all removable containers is to be marked on the inside.

2.23 Pressure Gauges

Pressure gauges are to comply with the requirements of BS 1780.

All pressure gauges are to be fitted with stop cocks immediately adjacent to each gauge and all pressure gauge piping is to be fitted with an isolating valve at each point of connection to the main system. Where pressure gauges are mounted on panels, the stop cocks are to be suitable for the connection of a test gauge.

Gauges shall be calibrated to read pressure at the tapping point and a sealed pressure transmitting system shall be used. All pressure gauges are to be clearly identified by means of labels of approved type and lettering. All pressure gauge piping is to be of corrosion resistant steel or copper tube.

2.24 Thermometer Pockets

Thermometer pockets and instrument connections of an approved pattern are to be fitted in such positions as may be determined to suit the operation and testing of the plant to the approval of the Engineer. A thermometer pocket is to be fitted adjacent to each point of connection for distant remote temperature indication unless specifically stated to the contrary. Where necessary, the pocket is to be of approved alloy material suitable for the required service.

All thermometer pockets are to comply with the requirements of BS 2765.

2.25 Gauge Cubicles and Panels

Gauges and instruments are to be grouped whenever possible and housed in suitable cubicles. Where circumstances do not justify cubicle accommodation, they may be secured to flat back panels but in such cases the approval of the Engineer is first to be obtained.

Cubicles are to be sheet metal having a thickness of 3 mm. The construction shall employ folding technique with the use of standard rolled sections or other reinforcement where necessary. The stiffness shall be such as to prevent mal-operation of relays or other apparatus by impact. The front of the panel is to have a smooth well finished surface and, if of the "desk" type, the desk is not to protrude so far as to hinder the easy reading of instruments and the operation of the controls.

2.26 Locking Facilities

Locking facilities including padlocks shall be provided under this contract for:

- Control position selector switches in all positions provided, except where other electrical or mechanical interlocking is approved.
- Marshalling, operating and terminal kiosks or cubicle access doors and panels.
- Isolating valves in open or closed positions.

Locking facilities shall be of an approved dead latch type. Three keys shall be supplied for each lock and all locks and keys shall be non-interchangeable. Where a set of locks is provided under a particular section of the Plant, a group master key shall be supplied in addition.

A schedule of locks and keys shall be submitted to the Engineer for approval.
All locks and padlocks shall be of brass and where they are fitted to switchboards or similar cubicles shall have the visible parts chromium plated.

Where a group of locks is supplied under any part of the Contract, a rack or cabinet of approved design shall be supplied for the accommodation of all padlocks and/or keys while not in use. The padlocks and keys shall be engraved with an agreed identifying code or inscription and this shall be repeated on the racks or cabinets on engraved labels.

Where a mechanism is to be locked in a specific position, provision shall be made at that part of the mechanism where the operating power is applied and not to remote or ancillary linkages.

Provision for locks shall be designed, constructed and located on the equipment so that locks will remain serviceable in the climatic conditions specified without operation or maintenance for continuous periods of up to two years and with suitable maintenance shall be fit for indefinite service.

2.27 Electrical Equipment

2.27.1 General

The works shall be designed to ensure continuity of operation under all working conditions obtaining at the Site as the first consideration and to facilitate inspection, maintenance and repairs. All reasonable precautions shall be taken in the design of equipment and of the works, to ensure the safety of personnel concerned with the operation and maintenance of the works.

Outdoor equipment shall be designed so that water cannot collect at any point. The undersides of all tanks shall be ventilated in an approved manner to prevent corrosion.

Mechanisms shall be constructed to prevent sticking due to rust and corrosion, and the bearings of exposed operating shafts shall be designed so as to prevent moisture seeping along shafts into the interior of equipment.

Corresponding parts of similar equipment, and equipment liable to renewal, shall be fully interchangeable and the Contractor will be required to demonstrate this feature to the Engineer's and Employer's satisfaction.

All equipment shall operate without undue vibration and with the least practical amount of noise.

All equipment shall be designed to minimise corona or other electrical discharges, to comply with local electromagnetic compatibility (EMC) standards and in accordance with IEC standard 61000.

All electrical components shall be adequately rated for their most onerous duty and the specified ambient temperature. When equipment is mounted in panels, cubicles etc., due account shall be taken of any heat generated by the equipment therein and the components shall be appropriately selected, rated or de-rated as necessary to suit the most onerous operating temperatures within the enclosure.

Except where a different meaning is stated in an equipment standard, the term "low voltage" (LV) shall refer to voltages up to and including 1 kV, and "high voltage" (HV) shall refer to all voltages exceeding 1 kV.

Fuses, circuit breakers and other electrical switchgear components shall comply with the relevant clauses, for low voltage ac switchgear.

2.27.2 Electrical Equipment Enclosures

Equipment enclosures for electrical equipment shall comply with IEC 60079, IEC 60529 and IEC 60947-1 as applicable. Equipment enclosures for use in hazardous areas other than explosive gas atmosphere shall comply with National and Local Regulations relating to this application. Unless otherwise specified, minimum equipment enclosure classifications for non-rotating electrical equipment shall be as follows:

- Indoors only in totally enclosed rooms with provision for limiting ingress of dust: IP 31
- Indoors, except as noted otherwise: IP 54
- Outdoors, and indoors in areas subject to water spray, or heavy condensation: IP 55W

The enclosure classification of main and auxiliary cable boxes with the cable(s) terminated shall not be less than that of the associated equipment, subject to a minimum classification of IP54.

2.28 Current Ratings

2.28.1 Normal Current Ratings

Current ratings in accordance with IEC 60059 shall be adopted, unless otherwise agreed with the Engineer.

Every current carrying part of the equipment shall be capable of carrying its site rated current continuously under the site ambient conditions as specified and shall not be rated on the basis of air conditioned rooms even when these are specified. In no conditions shall the specified maximum temperature be exceeded.

The current ratings specified are the continuous current ratings required at the Site, under the specified maximum temperature conditions.

2.28.2 Temperature Rise

Full provision shall be made for solar heat gain on all outdoor apparatus and any differential temperatures attained as a result of the impingement of solar heat.

The allowable temperature rise shall be in accordance with the relevant Standard, except where the ambient temperature exceeds the maximum permitted in that Standard, when the permitted temperature rise shall be reduced by one degree Celsius for every degree Celsius the maximum ambient temperature exceeds the maximum permitted in the Standard.

To allow for high ambient site temperatures, the allowable temperature rise for transformers shall be reduced by a maximum of 10°C from the standard value in IEC60076.

In such cases where the Contractor is unable to guarantee the permitted maximum temperature reached under site conditions, taking account of solar heating, then sunshades shall be provided to the Engineer's approval.

The maximum temperature attained by components under the most onerous service conditions shall not cause damage or deterioration to the equipment or to any associated or adjacent components. The Contractor shall submit his calculations to the Engineer to prove that all plant has been sufficiently de-rated to suit the site conditions and any changes required by the Engineer shall be made at no extra cost.

2.28.3 Short-Time Current Ratings

Electrical equipment shall be adequately supported and braced to withstand the forces associated with the maximum short-circuit currents specified or pertaining, whichever is the greater, and assuming that the inception of the short-circuit is at such a time that gives maximum peak currents. No provision for current decrement shall be made unless specifically permitted by the appropriate Standard, or elsewhere in this Specification.

Equipment shall be so constructed as to withstand the specified maximum short-circuit currents for the time specified in the Schedules without the temperature exceeding the specified maximum short-time temperature or value stated in the relevant standard, under these conditions. The equipment shall be considered as being operated at the maximum permitted continuous temperature prior to inception of the short circuit.

The final temperature attained as a result of the passage of short-circuit current shall not cause permanent damage, or deterioration sufficient to reduce the normal operating characteristics below the specified or most onerous operating requirements, whichever is the highest.

2.29 Voltage Ratings

2.29.1 Normal Voltage Ratings

Unless otherwise specifically stated, any reference to voltage rating shall be deemed to refer to the nominal rated voltage or voltages of electrical equipment. Standard voltage levels in accordance with IEC 60038 shall be adopted, unless otherwise specified by or agreed with the Engineer.

All electrical equipment shall, except where otherwise specified, be capable of continuous operation at a voltage in the range of ±10% of the nominal voltage and at a frequency in the range of 47 to 51 Hz coincidentally without deterioration.

The temperature rise of electrical equipment continuously operating at the specified extreme voltage and frequency shall not exceed the temperature rise when operating at nominal voltage and frequency by more than 5°C

2.29.2 Short-Time Voltage Ratings

All electrical equipment shall be so designed such as to withstand abnormal system voltages as required by the applicable BS, IEC or acceptable International Standard.

2.30 Electrical Insulation

Insulating materials shall be suitably finished so as to prevent deterioration of their qualities under the specified working conditions. Account shall be taken of the IEC 60085 recommendations.

Ebonite, synthetic resin-bonded laminated material and bituminised asbestos cement-bonded panels shall be of suitable quality selected from the grades or types in the appropriate IEC, or approved National Standard.

The insulation of all machine windings, solenoids, etc. other than those immersed in oil or compound, shall be of Class F materials, unless otherwise specified elsewhere.

All cut or machined surfaces and edges of resin-bonded laminated materials shall be cleaned and then sealed with an approved varnish as soon as possible after cutting.

Linseed oil and untreated materials of fibre, leatheroid, presspahn, asbestos or other similar hygroscopic types of materials shall not be used for insulation purposes. Untreated leatheroid and presspahn may be used for mechanical protection of winding insulation.

The use of asbestos is not permitted without the permission of the Engineer.

Wherever practicable, instrument, apparatus and machine coil windings, including wire wound resistors, with the exception of those immersed in oil or compound, shall be thoroughly dried in a vacuum or by other approved means and shall then be immediately impregnated through to the core with an approved insulating varnish. Varnish with a linseed oil base shall not be used.

No material of a hygroscopic nature shall be used for covering coils. Where inter-leaving between windings in coils is necessary, only the best manila paper, thoroughly dried, which permits penetration by the insulating varnish or wax, shall be used.

Polychlorinated Biphenyl (PCB) type materials shall not be used anywhere in the equipment or in any component.

2.31 Insulating Oil

Insulating oil shall comply with the requirements of IEC 60296. Insulating oil shall be provided by the Contractor for all oil-filled apparatus and 10% excess shall be provided for topping up purposes in sealed drums. The Contractor shall provide at no additional cost any oil treatment facilities he may require for his own use in order to ensure that insulating oil meets the requirements of the specification.

2.32 Control and Selector Switches

Control switches shall be of the three-position type with a spring return action to a central neutral position and without a locking feature. Circuit breakers shall have control switches which shall be labelled open/N/close or (0/N/I) and arranged to operate clockwise when closing the circuit breakers and anti-clockwise when opening them.

Control switches of the discrepancy type shall be provided where specified. Such discrepancy control switches shall be arranged in the lines of the mimic diagram. Such switches shall include lamps and be of the manually operated pattern, spring loaded such that it is necessary to push and twist the switch past its indicating position for operation.

The lamp shall be incorporated in the switch base and shall flash whenever the position of the controlled device is at variance with the position indicated by the control switch. Hand dressing of the control switch to the correct position shall cause the lamp to extinguish.

Pushbutton test switches shall be provided along the control panel that will illuminate all indicating discrepancy lamps as well as spare lamps on the control panels. The scheme shall be complete with all necessary diodes and other equipment required for satisfactory operation.

Switches for other apparatus shall be operated by pushbuttons, shrouded or well recessed in their housings in such a way as to minimise the risk of inadvertent operation.

Multi-position selector switches shall have a lockable stayput action. Each position of the selector switches shall be suitably labelled to signify the functions in accordance with the approved wiring diagrams. The switch handle shall be of the pistol grip spade type to the approval of the Engineer.

It shall not be possible at any time to close any switching device from more than one location simultaneously, and suitable lockable selector switches shall be provided to meet this requirement. Tripping signals from all locations shall function at all times.

Particular variations of the above requirements may be agreed with the Engineer for special instrument or control equipment, viz. main control room desks and panels, and electrical equipment cubicles.

The contacts of all control and selector switches shall be shrouded to minimise the ingress of dust and accidental contact, and shall be amply rated for voltage and current for the circuits in which they are used.

2.33 Panels, Desks and Cubicles

Unless otherwise specified, panels, desks and cubicles, shall be of floor-mounted and free-standing construction and be in accordance with the enclosure classification specified elsewhere. All control and instrumentation panels in any one location shall be identical in appearance and construction. Where new panels are supplied for existing substations, these shall match existing panels in appearance, arrangement and devices and colour finishes.

Panels shall be rigidly constructed from folded sheet steel of 3mm minimum thickness to support the equipment mounted thereon, above a channel base frame to provide a toe recess.

Overall height, excluding cable boxes, shall not exceed 2.5m. Operating handles and locking devices shall be located within the operating limits of 0.95m and 1.8m above floor level. The minimum height for indicating instruments and meters shall be 1.5m unless otherwise approved by the Engineer.

Panels shall be mounted on an approved form of anti-vibration mounting whenever necessary.

All panels, desks and cubicles shall be vermin-proof. All cable entries to equipment shall be sealed against vermin as soon as possible after installation and connecting-up of the cables to the approval of the Engineer.

All cubicles, desks and panels shall be provided with a natural air circulation ventilation system. All control equipment shall be designed to operate without forced ventilation.

For outdoor equipment, metal to metal joints shall not be permitted and all external bolts or screws shall be provided with blind tapped holes where a through hole would permit the ingress of moisture. For harsh environments, all nuts, bolts and washers shall be tropicalized as appropriate.

Door sealing materials shall be provided suitable for the specified site conditions. Doors shall be fitted with handles and locks. Where walk-in type panels are supplied the door shall be capable of being opened from inside the panel without the aid of a key after they have been locked from the outside. Hinges shall be of the lift-off type, and shall permit the doors when open, to lie back flat so as not to restrict access. Means shall be provided for securing the doors in the open position.

Cubicles and cubicle doors shall be rigidly constructed such that, for example, door mounted emergency trip contacts can be set so that mal-operation will not be possible due to any vibrations or impacts as may reasonably be expected under normal working conditions.

The bottom and/or top of all panels shall be sealed by means of removable gasketted steel gland plates. Gland plates for bottom entry shall be at least 250mm above the floor of the cubicle.

Panels shall be suitably designed to permit future extension wherever appropriate or specified.

Each panel shall include rear access doors internal power sockets and door-operated internal lighting, and be clearly labelled with the circuit title at front and rear, with an additional label inside the panel. Panel sections accommodating equipment at voltages higher than 125V (nominal) shall be partitioned off and the voltage clearly labelled. Each relay and electronic card within panels shall be identified by labels permanently attached to the panel and adjacent to the equipment concerned. Where instruments are terminated in a plug and socket type connection both the plug and the socket shall have permanently attached identifying labels.

Instrument and control devices shall be easily accessible and capable of being removed from the panels for maintenance purposes.

Terminations, wiring and cabling shall be in accordance with the requirements of this section of the specification.

For suites of panels inter-panel bus-wiring shall be routed through apertures in the sides of panels and not via external multicore cabling looped between the panels.

All panels, whether individually mounted or forming part of a suite, shall incorporate a common internal copper earthing bar onto which all panel earth connections shall be made.

Suitable studs or holes to the Engineer's approval shall be left at each end of the bar for connection to the main station earthing system and possible future extension.

Earth connection between adjacent panels shall be achieved by extending the bar through the panel sides and not by interconnecting external cabling.

Where intrinsically safe circuitry is routed from a hazardous area to a safe area instrument panel, it shall be connected through Zener Barriers located in the safe area (instrument panel) of suitable rating and mounted on an insulated earthing busbar having facilities for connection of a separate dedicated outgoing cable to a "clean earth" system.

Control supplies in desks, panels and cubicles shall be derived from a duplicate standby/UPS system, except if specified otherwise in this specification. The following alarms shall be provided to monitor the systems: voltage high, voltage low, no volts and earth fault. The alarms shall be signalled to the Control Room.

Instruments having pressure pipe connections containing oil, water, steam or flammable or toxic fluids shall be excluded from the Control Room.

All cubicles, desks and panels shall be painted externally with a high gloss paint of Munsell 5Y7/1 colour. The interiors of all cubicles, desks and panels shall be painted matt white.

All cubicles, or panels mounted external to control and apparatus rooms shall be fitted with thermostat controlled anti-condensation heaters.

2.34 Instruments & Meters

2.34.1 Indicating Instruments

All indicating instruments shall be of the flush mounted pattern with dust and moisture proof cases complying with BS 2011, Classification 00/50/04, and shall comply with IEC 60051-1.

Unless otherwise specified, all indicating instruments shall have 96 mm or 144 mm square cases to DIN standard or equivalent circular cases.

Instrument dials in general should be white with black markings and should preferably be reversible where double scale instruments are specified.

Scales shall be of such material that no peeling or discolouration will take place with age under humid tropical conditions.

The movements of all instruments shall be of the dead beat type. Wherever possible, instruments shall be provided with a readily accessible zero adjustment.

2.34.2 Electrical Meters

All electrical meters shall comply with IEC 62053 and other relevant IEC standards and, unless otherwise specified, shall be of accuracy Class 1, except Class 0.2 for energy meters. Three-phase power measuring instruments shall be of the three-phase unbalanced load pattern wherever the current and voltage references permit.

Where precision grade metering is specified meters shall be calibrated to precision grade accuracy to IEC standards.

Due allowance shall be made for the errors of current and voltage transformers with which they shall work and whose accuracy class shall be Class 0.2.

Where commercial grade metering is specified the meters shall be calibrated to commercial grade accuracy to IEC standards.

Meters shall be single directional and shall be fitted where required with suitable devices for the transmission of impulses to a summator. Var-hour meters shall be complete with phase shifting transformers as necessary.

Front of panel test terminal blocks shall be provided for all meters.

Summators shall be equipped to summate the circuits specified and shall be equipped where required with suitable contacts for the re-transmission of impulses to a printometer. They shall register in kilowatts the value of the impulses received from each kilowatt-hour meter. Printometers shall be of an approved type having the specified demand interval.

Each 230 kV and 132 kV feeder shall be provided with Main 1 and Main 2 energy meters.

The energy meter shall be 3-element, 4-wire arrangement of programmable digital type and shall have proven performance and shall consist of different types, either from the same Manufacturer or different Manufacturers. The accuracy class of the energy meter shall be 0.2.

2.35 Indicating Lamps and Fittings

All indicating lamps shall be adequately ventilated and as far as practicable, lamps of a common type and manufacture shall be used throughout the Contract.

Lamps shall be easily removed and replaced where possible from the front of the panel by manual means preferably not requiring the use of extractors.

Where specified every circuit breaker panel shall be equipped with one red and one green indicating lamp, indicating respectively circuit closed and circuit open and an amber lamp for indicating 'auto-trip'. Where specified for in the lines of mimic diagrams, indicating lamps may be of the three-lamp single-aspect type.

The variety of indicating lamps provided shall be rationalised to reduce maintenance and spares requirements.

The lamps shall be clear and shall fit into a lamp holder. The rated lamp voltage shall be at least 20% in excess of nominal supply voltage, whether a.c. or d.c. The lamps shall have an operating life of at least 10,000 hours, under site conditions. In the event that other indicating devices, such as light emitting diodes, are used in place of lamps then these shall have the same life expectancy and performance capability as the lamps they replace.

The lamp glasses shall comply with IEC 60073 and be in the standard colours, red, green, blue, white and amber. The colour shall be in the glass and not an applied coating. Transparent synthetic materials may be used instead of glass subject to the approval of the Engineer.

Where illuminated pushbuttons are used for control purposes, the illuminated pushbuttons shall be engraved with a clear instruction such as 'push to open' or 'push to close', and the lamp shall illuminate in accordance with the above colour code after the instruction has been carried out and the device has operated.

Unless otherwise agreed with the Engineer all lamp colours shall conform to the following practice:

- Red energised or operative position
- Green de-energised or inoperative position
- Amber fault or abnormal condition
- White healthy or normal condition
- Blue other purposes, to be used with descriptive label

Lamp test facilities shall be provided for all switchboards, control panels etc. to enable all lamps to be tested whilst the equipment is in service. Operation of the lamp test facility shall not cause any other device to operate. Indication circuits shall be fused.

2.36 Anti-Condensation Heaters

All switchboards, panels, cubicles and the like shall incorporate thermostat controlled electric heaters capable of providing movement of sufficient heated air to avoid condensation. The apparatus so protected shall be designed so that the maximum permitted rise in temperature is not exceeded if the heaters are energised while the apparatus is in operation.

The switchboard anti-condensation heaters shall be fed from an LV single phase and neutral supply, manually switched by a two-pole switch with red lamp, mounted on the back of the board, panel or cubicle and bus-wired through the board. Labels shall be provided on the switch stating "Heater Supply". Heater terminals shall be shrouded and labelled "Heater".

Motor anti-condensation heaters where fitted shall be fed from an LV single phase and neutral supply bus-wired through the board. The supplies shall be individually fused and will be switched by auxiliary contacts on the contactor and isolated by auxiliary contacts on the contactor isolator.

2.37 Control and Instrument Panel Wiring, Cable Terminations and Terminal Boards

2.37.1 General

All electrical equipment mounted in or on switchgear, panels and desks, shall have readily accessible connections and shall be wired to terminal blocks for the reception of external cabling.

The wiring shall comply with BS 6231 and shall be capable of withstanding without deterioration the conditions at Site, due allowance being made for such temperature conditions as may arise within any enclosure. The insulating material shall be flame retardant in accordance with IEC 60332.

All wiring shall be of adequate cross-sectional area to carry prospective short-circuit currents without risk of damage to conductors, insulation or joints.

The following classes of copper conductor, as defined in IEC 60228, shall be used for panel wiring:

- Class 1: conductors up to a maximum of 0.9 mm diameter where necessary for wire-wrapped terminations and similar techniques,
- Class 2: conductors except where specified otherwise,
- Class 5 and Class 6: conductors between points subject to relative movement.

The following minimum conductor sizes shall be used:

- 1.5 mm² except where specified otherwise,
- 2.5 mm² for current transformer secondary circuits with a rated secondary current of not exceeding 1A.
- 4 mm² for current transformer secondary circuits with a rated secondary current exceeding 1A.

Where an overall screen is used, this shall be a metallic screen or low resistance tape, with a drain wire as above.

Wiring shall be supported using an insulated system that allows easy access for fault finding and facilitates the installation of additional wiring.

Small wiring passing between compartments that may be separated for transport shall be taken to terminal blocks mounted separately from those for external cable connections.

Connections to apparatus mounted on doors or between points subject to relative movement shall be arranged so that they are subjected to torsion rather than bending.

Ribbon cables or similar preformed cables with plug and socket connectors may be used for light current wiring. Plug and socket connectors shall be polarised so that they can only be inserted into one another in the correct manner.

If so required, the Contractor shall submit for the Engineer's approval samples of the types of wire, numbered ferrules, and terminal washers or lugs as appropriate which he propose to use.

2.37.2 Identification of Wires

All wiring and cores in control and instrument cables shall be identified in accordance with the associated schematic and/or wiring diagrams either by means of discrete wire numbers or wire colours, except when an automatic or proprietary system of wiring is used, e.g. point-to-point wiring on a mother board.

When a wire numbering system is used, it should be in accordance with IEC standards or with a functional marking system. Both ends of every wire and core in control and instrument cables shall be fitted with interlocking ring ferrules of white insulating material indelibly marked with black characters, complying with BS 3858. Heat shrink marking sleeves may be used, but adhesive markers are not acceptable.

When plug and socket connectors are used, they shall be uniquely identified as mating pairs and each connector pin shall be numbered. Wiring which is permanently connected to plugs or sockets need not be identified.

Each core of multi-pair wiring shall be identified by colour and terminal block identification together with an identification tracer per bundle.

Permanent identification of all terminals, wires and terminal blocks shall be provided.

A consistent system of wiring numbering shall be used throughout the plant, and it shall be agreed with the Engineer at the start of the Contract.

2.37.3 Terminals and Terminal Blocks

Terminal blocks shall have separate terminals for internal and external connections, and not more than one wire shall be connected to each terminal.

Adjacent terminals to which wires of different voltage, polarity or phase are connected shall be separated by a protruding insulating barrier. This requirement also applies to terminals carrying wires of the same voltage but originating from different sources.

Trip circuit wiring and instrument transformer secondary wiring shall be connected using hook type crimped terminations in screw clamp, spring loaded insertion type terminals.

Where clamp type terminals are used, Class 1 and Class 2 conductors may be terminated without lugs. Crimp lugs shall be used for Class 5 and Class 6 conductors. Means shall be provided for retaining the identifying ferrules of the wire end when it is disconnected.

Pinch screw type terminals shall not be permitted.

Subject to approval of the Engineer, "wire-wrap", "termi-point" or equivalent methods of terminations of single strand conductors may be used.

Wires shall be grouped on the terminal boards according to their functions.

All terminal blocks shall provide a degree of protection of not less than IP2X when correctly installed, either inherently or by provision of insulating covers.

Terminal boards shall be mounted vertically, not less than 150 mm above the gland plates, and spaced not less than 100 mm apart, on the side of the enclosure and set obliquely towards the rear doors.

Sufficient terminals shall be provided to permit all cores on multicore cables to be terminated. Terminals for spare cores shall be numbered and be located at such position as will provide the maximum length of spare core. At least 10% spare terminals shall in all cases remain after commissioning.

The tails of multicore cables shall be bound and routed so that each tail may be traced without difficulty to its associated cable. All spare cores shall be made off to terminals.

When two lengths of screened cable are to be connected at a terminal block (i.e. junction box) a separate terminal shall be provided to maintain screen continuity.

In the main and local control and equipment rooms, means shall be provided on the terminal blocks of panels, desks, cubicles, etc., for testing all the instrument circuits without the need to remove the internal or external wiring from the block.

The Contractor shall submit full details and specification of the proposed means of termination where wire wrapping, soldering and similar methods are used. The adopted methods shall be to the Engineer's approval.

The Contractor shall identify all special tools, such as wire wrapping tools required for termination, and shall make provision for their supply in sufficient numbers.

The use of pre-formed factory tested cable connections to field mounted marshalling boxes shall be to the Engineer's approval.

2.38 Cable Boxes and Glands

2.38.1 General

Electrical equipment shall be provided with all necessary cable boxes, which shall be complete with all required fittings. All cable boxes shall be of adequate size to allow for the correct termination of the cable sizes required or specified, taking into account the crossing of cores to achieve the correct phasing, and to accommodate all cable fittings, including stress cones or other means of cable insulation grading, if required. All cable boxes shall be designed in such a manner that they can be opened for inspection without disturbing the gland plate or incoming cable.

All main cable boxes shall be air insulated for the termination of all types of cable at voltages up to and including 33 kV nominal system voltage, unless otherwise specified elsewhere in this Specification. Compound-filled cable boxes may only be used for paper insulated cables, where specified elsewhere.

The enclosure classification of main and auxiliary cable boxes on motors with the cable(s) terminated shall not be less than that of the associated motor, subject to a minimum classification of IP54.

Clearance and creepage distances shall be adequate to withstand the specified alternating current voltages and impulse voltages for service under the prevailing site conditions.

Means shall be provided for preventing accumulation of dirt, dust, moisture, vermin or insects such as to maintain the anticipated life of the equipment.

The terminals for 3 phase cables shall be clearly marked with the specified phase designations to enable the cables to be terminated in the correct sequence.

Flexible connections shall be provided between cable lugs and bushings for all cables of 300 mm² section and greater.

There shall be no possibility of oil entering the cable box from an associated oil filled compartment.

Inner sheaths shall be arranged to project at least 25 mm above the gland plate to avoid moisture collecting in the crutch.

All cable boxes shall be designed to withstand the high voltage d.c. cable tests prescribed in IEC 60055, IEC 60502 or other applicable standard.

Cable lugs and terminations for the receipt of all power, control and instrumentation cable cores shall be provided.

Where air insulated terminations are used, the cable crutch within a cable box or equipment panel shall be protected by the use of a heat-shrink plastic trifurcating sleeve or equivalent placed over the cores and crutch.

The Contractor shall provide full information and instruction for his proposed method of terminating HV cables.

Removable gasketted steel gland plates shall be provided for multicore cables. The cable entry into the cable box shall be arranged so that there is adequate space to manipulate the cable for glanding and termination.

When single core cables are used, particularly for currents in excess of 500 A, adequate steps must be taken to minimise the effects of eddy currents in the gland and bushing-mounted plate.

Gland plates for externally mounted marshalling boxes shall be in the form of removable gasketted steel plates, forming part of the underside of the box. Indoor marshalling boxes may be fitted with gland plates on all four sides.

2.38.2 Additional Requirements for Compound-filled Cable Boxes

Cable boxes for paper insulated cables shall be complete with universal tapered brass glands, insulated from the box in an approved manner and including an island layer for testing purposes, together with removable shorting links.

Filling and venting plugs, where required, shall be positioned so as to avoid the possibility of air being trapped internally and adequate arrangements shall be made for expansion of compound, etc.

Compound-filled chambers shall be clean and dry and at such a temperature before filling that the compound does not solidify during the filling process. Filling orifices shall be sufficiently large to permit easy and rapid filling.

2.38.3 Cable Glands

Cable glands for extruded solid dielectric insulated cables (PVC, EPR, XLPE) shall be of the compression type and as specified in BS 6121 Part 1.

All glands shall be provided with an earthing tag or equal facility. For cables having conductors not larger than 4 mm² serrated washers may be used in place of earthing tags to provide earth continuity.

Glands for armoured or screened cables greater than or equal to 240 mm² and all insulated glands for power cables shall be provided with an integral earthing lug. On cable glands up to and including 40 mm nominal size, the earthing connection shall have a short circuit rating of at least 25 kA for 1 second and of at least 40 kA for 1 second on larger sizes.

Insulated glands shall be provided with removable connections for bonding across the gland insulation. The gland insulation shall withstand a wet insulation voltage withstand test of at least 2 kV a.c. for 1 minute.

Under conditions of severe corrosion, corrosion-resistant cable glands complying with BS 6121 Part 3 may be used, or the Contractor may use an alternative solution with the approval of the Engineer.

Polymeric cable glands complying with BS 6121 Part 2 may be used, but only when terminating unarmoured cables.

Glands for MICS cables shall be to the approval of the Engineer.

2.39 Box-Filling Compounds

The type of compound shall be to the approval of the Engineer, who shall be supplied with sufficient information by the Contractor. The Contractor shall supply all compound required together with an additional quantity of not less than 10% of normal requirements.

Where hot-pouring compounds are employed the pouring temperature shall be verified by use of thermometers or similar instruments and the metallic case of all joints and terminal boxes shall be adequately pre-warmed to drive off moisture.

The Contractor shall take particular care to adhere to the recommended topping-up procedures and to ensure that no leakage or migration of the filling compound occurs.

Should leakages occur during the maintenance period the Engineer will require the joint to be re-made at the Contractor's expense.

2.40 Oil or Compound-Filled Chambers

All joints of oil- or compound-filled fabricated chambers, other than those that have to be broken, shall be welded and care shall be taken to ensure that the chambers are oil-tight. Defective welded joints shall not be repaired but maybe re-welded subject to the written approval of the Engineer.

Insulating compound shall comply with BS 1858.

The correct oil or compound filling level shall be indicated on the inside and outside of chambers.

2.41 Joints and Gaskets

All joint faces are to be flat and parallel to the approval of the Engineer and arranged to prevent the ingress of water or leakage of oil with a minimum of gasket surface exposed to the action of oil or air. Oil-resisting synthetic rubber gaskets are not permissible, unless the degree of compression is accurately controlled. For gaskets of cork or similar, oil resisting synthetic rubber may be used as a bonding medium.

2.42 Valves on Electrical Equipment Fluid Lines and Vessels

Valves shall comply with the requirements of Clause 2.19. All drain and filter valves shall be provided with gun metal adaptors suitable for connecting a flexible hose having a screwed coupling of approved size. Captive-screwed caps shall be provided for all such adaptors.

2.43 Junction and Marshalling Boxes

Junction and marshalling boxes for use in non-hazardous areas shall be of substantial sheet aluminium anodised coating construction to prevent corrosion, having an enclosure classification in accordance with the requirements of clause 2.27.2. They shall be fitted with external fixing lugs and finished in accordance with the requirements of the specification for cleaning, painting and finishing. The boxes shall allow ample room for wiring, with particular regard to the routing of wires from the point of entry. Boxes made from aluminium shall be subject to agreement with the Engineer.

Outdoor boxes shall have an anti-condensation finish and all boxes shall be designed such that any condensed water cannot affect the insulation of the terminal boards or cables. No cables shall be terminated into the top of outdoor boxes unless specifically approved by the Engineer.

All outdoor kiosks, cubicles and panels shall be provided with sun/rain shades. All kiosks, cubicles and panels not in air-conditioned rooms shall be provided with thermostat controlled anti-condensation heaters. All kiosks, and cubicles shall be fitted with door operated internal illumination lamps. All necessary gland plates shall be provided undrilled.

Boxes shall be complete with suitably inscribed identification labels. Boxes for use in hazardous areas shall have all entries factory pre-drilled. Every unused screwed entry shall be sealed by means of a tamperproof screwed plug in accordance with IEC 60079. Hazardous area boxes with bolted or screwed lids shall require the use of special keys or spanners, for lid removal, protected against the ingress of moisture, by an approved means, compliant with local standards.

All box covers are to be arranged for padlocking and padlocks with keys shall be supplied.

All boxes shall be provided with adequate earthing bars and terminals.

2.44 Conduit and Accessories

Conduit installations shall comply with IEC standards 60364, 60621, 60981 and 61035. Installations shall also be compliant with local regulations, unless otherwise approved by the Engineer.

All conduit and conduit fittings shall comply with IEC 60423 and IEC 60614. Unless otherwise approved, all conduit and conduit fittings shall be threadable steel conduit with minimum enclosure classification IP55, heavy mechanical protection and high resistance to corrosion inside and outside.

No conduit smaller than 20mm diameter shall be used.

Standard circular boxes or machined face heavy duty steel adaptable boxes with machined heavy type lids shall be used throughout. For outdoor mounting all boxes shall be galvanised, weatherproof and fitted with external fixing lugs.

Where conduit is terminated so that the bare end of the conduit is exposed the conduit end shall be fitted with a brass bush.

The use of running threads, solid elbows and solid tees will not be permitted.

Conduit ends shall be carefully reamed to remove burrs. Draw-in boxes shall be provided at intervals not exceeding 10 m in straight-through runs.

Conduit runs shall be in either the vertical or horizontal direction, unless otherwise approved, and shall be arranged to minimise accumulation of moisture. Provision for drainage shall be made at the lowest points of each run.

Conduits shall be supported on heavy galvanised spacer saddles so as to stand off at least 6mm from the fixing surface.

All conduits run in any circuit are to be completed before any cables are pulled in.

Flexible metallic conduit shall be used where relative movement is required between the conduit and connected apparatus, and a separate earth continuity conductor shall be provided.

2.45 Trunking

Steel trunking may be used for running numbers of insulated cables or wires in certain positions to the approval of the Engineer. The trunking thickness shall not be less than 1.2 mm. Connection of conduit to trunking shall be with socket and male bush. All trunking shall be manufactured from hot-dip zinc coated steel sheet and conform to IEC 61084.

2.46 Electric Motors

2.46.1 General

Motors shall comply with the requirements of IEC 60034 and IEC 60072 as amended and supplemented by this specification.

2.46.2 Type and Rating

Except where specified otherwise or economically justified, all a.c. motors shall be of the constant speed, cage induction type with windings adequately braced for direct-on-line starting at the rated voltage. They shall be suitable for control by either circuit breaker or fused contactor.

Motors shall be continuously rated, Duty Type S1. Exceptions shall be permitted only when the intermittent or short time duty cycle can be accurately defined by the Contractor.

Three phase a.c. motors shall be rated for the voltages specified elsewhere in the Specification. The minimum rated output of HV motors shall comply with IEC 60034-1. The maximum rated output of LV motors shall not exceed 150 kW, except where approved by the Engineer.

2.46.3 Insulation

Motors shall be insulated with materials complying with IEC 60085. All motors shall have Class F insulation but the temperature rise shall not exceed the limits applicable to Class B.

2.46.4 Conditions of Operation

A.C. motors shall be capable of continuous operation under the service conditions within the Zone A voltage and frequency variations specified in IEC 60034-1 Figure 13 or as covered in Clause 4.1 whichever is the most onerous. Unless otherwise specified, the motors shall be capable of continued operation at 75% rated voltage and rated frequency for a period of 5 minutes without injurious heating. In the event of loss of supply, all motors shall be suitable for restarting against the full residual voltage in the motor winding during motor run-down.

2.46.5 Starting Performance

Unless otherwise specified or required, cage induction motors up to and including 40 kW shall have a starting performance better than or equal to Design N in accordance with IEC 60034 (External inertias for 50 and 60 Hz motors shall be in accordance with BS 4999 Part 112). Cage induction motors above 40 kW shall have a starting performance better or equal to Design D in accordance with BS 4999 Part 112. The starting current at full voltage shall not exceed 6 times full load current.

The starting torque at 80% voltage shall be adequate for starting the driven load under the most arduous conditions, such as open fan vane or open pump discharge valve. The accelerating torque at any speed and 80% rated voltage shall be not less than 10% of motor rated torque. In any event the motor starting torque at 100% rated voltage, and at all speeds between standstill and the speed at which

breakdown torque occurs, shall be not less than 1.7 times the torque obtained from a load curve which varies as the square of the speed and is equal to 100% motor rated torque at rated speed.

The margins between the torques of the motors and driven plant shall include suitable allowances for impeller wear, fouling etc. during the life of the plant.

Electric motors shall be suitable for two successive starts with the motor already at full load working temperature, subject to the motor being permitted to decelerate to rest under operating conditions between successive starts. After a cooling period of 30 minutes at rest another starting sequence of two successive starts shall be permissible.

2.46.6 Bearings

The type of bearings used in the motor shall be fully compatible with those used in the driven equipment. The type of bearing, bearing numbers and regressing interval shall be stamped on each motor rating plate. Bearings shall comply with the applicable ISO standards. Bearings shall be designed to exclude the ingress of dust and water and sealed to prevent leakage of lubricant along the shaft.

2.46.7 Enclosures and Methods of Cooling

The degree of enclosure protection for motors shall be as follows unless otherwise specifically approved by the Engineer:

- IP54 for indoor locations not subject to hosing.
- Not less than IP 55W for outdoor locations, and indoor locations subject to hosing.
- Where motors are exposed to solar radiation, sunshades shall be fitted, if required by the Manufacturer to meet his guarantees.

The cooling classification for motors shall be as follows unless otherwise specifically approved by the Engineer:

- IC4AlA1 or IC5AIA1 for LV motors, or IC4AIAO for small power LV motors.
- IC4AlAl, IC5AlAI, IC6A1A1 or IC7AlW7 for HV motors.
- Ferrous metals should be used for the frames and end shields of all ratings of motors.

Aluminium and its alloys shall only be used when the Manufacturer can demonstrate that such materials are entirely suitable for the particular application at its installation location. Fans of identical motors shall be interchangeable without affecting motor balance.

2.46.8 Anti-condensation Heaters

To minimise condensation in all outdoor 400V and intermittently used 400 V motors when out of service, heaters of an approved type and rating, suitable for operation from a 230 V a.c. single phase supply, shall be fitted inside the lower half of the stator frame.

The control of anti-condensation heaters shall be so arranged that they are normally energised when the motor is not running.

2.46.9 Terminals and Terminal Boxes

Winding terminations shall generally comply with BS 4999 Part 145. Separate non-compound filled, terminal boxes shall be provided for each of the following, as applicable:

- Main (line) connections.
- Star point connections.
- Anti-condensation heater connections.
- Instrumentation and alarm devices.

All terminal boxes with the cables terminated shall have an enclosure classification not less than that of the motor itself. All terminal boxes shall be of an adequate size for the satisfactory termination of the cable(s) required or specified, including all applicable termination components. All HV terminal boxes shall be provided with a desiccant indicator, externally sealed.

Terminals and terminal leads shall be to approval and shall be substantially designed for connection to a system having the symmetrical short circuit rating of the source switchboard, as limited by fuses, where applicable. The clearances and creepage distances shall apply also to insulated terminals and connectors. Porcelain terminal bushings and insulators shall not be used.

Main and star point terminal boxes of HV motors shall be of steel. Cast iron may only be used for LV motor terminal boxes and auxiliary terminal boxes. Star point terminal boxes shall only be provided where required to accommodate neutral end current transformers and shall be positioned opposite the main terminal box.

Main HV terminal boxes at voltages exceeding 7.2 kV (Um) shall be of a type that restricts internal faults to earth faults only. Where pressure relief terminal boxes are used, they shall be designed to relieve the products of an internal fault safely to the outside, and not into the interior of the motor.

Provision shall be made for earthing the cable armour and the cable insulation screens, where applicable, in accordance with the cable termination method being used. In auxiliary cable boxes either stud terminals or clamp terminals shall be provided. The anti-condensation heater terminal box shall have a warning label adjacent to it, stating "motor heater-terminals live".

2.46.10 Earth Terminal

All motors shall be provided with a means of earthing the frame, which shall be to the approval of the Engineer.

2.46.11 D.C. Motors

D.C. motors that are to operate from batteries shall be capable of operating under the service conditions at any voltage in the range of 80% to 110% of the nominal value.

Motors of the constant speed type shall be designed to operate with a permanent series resistor of suitable rating and with a contactor such that starters with tagged resistors are not required.

All d.c. motors shall be provided with brush-gear that does not require to be moved to suit load conditions.

Motors connected to rectifier equipment shall meet the conditions of supply voltage and frequency specified for a.c. motors. Where necessary, rectifier equipment shall be fitted with a current limiting device.

2.47 Motor Starters and Contactors for Separate Mounting

In special cases for motors below 30 kW, and non-essential non-plant auxiliaries, such as roller shutter doors, and where approved by the Engineer, separately mounted starters for motors may be provided. Each such motor starter shall be equipped with two or three pole control gear, as appropriate, for direct-on-line starting and shall be complete with a fully shrouded lockable isolating switch, mechanically interlocked with the means of access. All starters shall be supplied by one Manufacturer, except where otherwise approved by the Engineer.

Contactors shall be of robust design and shall comply with IEC 60947. All contactors and their associated apparatus for minor motors shall be capable of operating without overheating for all specified motor operating conditions, and including for a period of five minutes at normal frequency if the supply voltage falls to 80% of nominal voltage.

For motors up to 30 kW rating motor starters shall be provided with direct connected thermal overload and phase failure industrial pattern protection tripping devices, integral with the motor contactor. Phase failure protection shall operate with out-of-balance currents not exceeding 85% of motor full load current. Separate contacts for a remote trip alarm shall be provided, and connected up if required.

For motors above 30 kW starters shall not be wall mounted but included in a switchboard. For such circuits motor protection relays with a more accurate and easily adjustable overload setting shall be used, which are sensitive to out-of-balance currents not exceeding 20% of full load, and shall include instantaneous earth fault elements. Alternatively, instantaneous earth fault protection may be incorporated in the motor circuit breaker. The earth fault protection shall not operate for unbalanced current surges during motor starting.

2.48 Pushbuttons and Separately Mounted Pushbutton Stations

Pushbuttons, which may be of the illuminated or non-illuminated type, shall be shrouded or well recessed in their housings in such a way as to minimise the risk of inadvertent operation. In instances where "enable" pushbuttons are required they shall be electrically interlocked with the normal control such that deliberate operation of the "enable" push-button is required before the normal control can take place.

The colour of pushbuttons shall be as follows:

- When mounted on pushbutton stations adjacent to running plant:
  - the stop button shall be coloured red and
  - the start button coloured green.
- When mounted on the front of the contactor panel:
  - the stop button shall be coloured red and
  - the start button coloured green.

- When mounted on panels or desks with adjacent indication lights, unless required otherwise by the Engineer:
  - both buttons shall be coloured black

Loose pushbutton stations, unless supplied as weatherproof free standing enclosures, shall be of the metalclad weatherproof type suitable for wall or bracket mounting with a minimum enclosure classification of IP55.

All outdoor mounted pushbutton stations shall incorporate a protective cover or guard (e.g. toughened glass door) to prevent inadvertent operation.

Control stations shall be clearly labelled showing the duty or drive to which they are applicable. Location of ammeters shall be agreed with the Engineer.

Any necessary pushbuttons used on covered desks, panels etc. have to be of special types (e.g. miniature, illuminated). The specifications and requirements for these special pushbuttons shall be agreed with the Engineer.

Emergency stop pushbuttons shall be provided adjacent to all motors and machinery with exposed moving parts, couplings etc. to prevent danger, and on main and local control panels. These pushbuttons shall have a large "mushroom" head, be coloured red and incorporate a protective cover or guard to avoid accidental operation. These buttons shall automatically lock in the depressed position, requiring twist or key resetting. Contacts shall be provided to cause tripping of the associated circuit, prevent restart of the circuit and bring up an alarm in the Central Control Room.

Stop pushbuttons mounted local to motors shall trip the associated circuit breaker or contactor regardless of the control position selected.

The contacts of all pushbuttons shall be shrouded to minimise the ingress of dust, and accidental contact, and shall be amply rated for voltage and current for the circuits in which they are used.

2.49 Miniature Circuit Breakers, Fuses and Links

Facilities shall be provided for protection and isolation of circuits associated with protection, control and instruments. They shall be of approved type and grouped, as far as possible, according to their functions. They shall be clearly labelled, both on the panels and the associated wiring diagrams.

Facilities shall be provided to enable the control circuits for any circuit breaker to be individually isolated for maintenance purposes.

Facilities for protection and isolation of control and tripping circuits are preferably to be mounted on the outside of control panels in approved positions.

All fuses shall incorporate HRC cartridges to BS 88 or IEC 60269.

Fuse holders shall be designed to lock the cartridges firmly into position without the use of screw clamping devices.

Miniature circuit breakers (MCB's) shall comply with IEC 60898.

Where MCB's are used on control, protection and alarm supplies, tripping shall cause an alarm to be displayed.

2.50 Earthing and Bonding

The main earthing conductors for connection to all electrical equipment, cables, motors, panels, etc., shall be provided for connection to the main earthing system.

All non-current carrying metal parts of electrical equipment shall be bonded to an earth terminal or terminals mounted on the equipment and readily accessible.

All equipment terminals provided for an external earth connection shall be identified by indelible means unless such terminals are directly and visibly mounted on metallic equipment frames or earth bars, when such marking may be omitted.

Identification marks for earth terminals shall comprise the colours green/yellow in combination or a reproduction of the symbol no. 5019 in IEC 60417.

Assemblies containing electrical equipment, including switchboards, control boards and control desks, shall be provided with a separate copper earth bar running the length of the assembly. All metal parts and the earth terminal or terminals shall be bonded to this earth bar. Earthing connections shall not depend upon the bolting of steel/steel joints between adjacent panels or cubicles.

Earth bars shall be of adequate size and suitably supported and braced to carry the rated short circuit current for the associated electrical circuits for the rated short-circuit current duration, without damage or excessive heating likely to damage joints, associated or adjacent components.

Switchgear and control gear assemblies shall be provided with two or more earth terminals unless otherwise specified. The copper earth bar shall be sized to withstand the maximum system earth fault current for three seconds without deterioration.

The size of the copper earth bar in control panels, control desks or similar enclosures containing low voltage apparatus shall be such as to comply with the specified requirements for withstanding prospective short-circuit currents. The size of this bar shall be a minimum of 100 mm² cross-sectional area, providing that sufficient mechanical integrity is provided by adequate supports and terminals, and also providing this size is not less than the size of the largest incoming power supply conductor.

The metal cases of all instruments, relays and the like shall be connected to the panel earth bars by copper conductors of not less than 1.5 mm² cross-sectional area, or by other means to the approval of the Engineer.

If the plant contains electronic equipment that is vulnerable to possible conductive interference, or if the equipment generates electrical noise, which could interfere with other plant or equipment, then separate earths may be supplied and the actual means of interconnecting with the station earth system shall be agreed with the Engineer.

3. HV Switchgear and Neutral Earthing Equipment

3.1 Scope

These clauses describe the general technical requirements for the new 230 kV, 132 kV and 33 kV Air Insulated Switchgear (AIS) and Gas Insulated Switchgear (GIS), and shall be read in conjunction with the project requirements, schedules and drawings in the specification.

The Contractor shall demonstrate that the switchgear has been designed, built and installed in accordance with the relevant international standards and the specification. It shall also operate and perform on a site in accordance with the requirements of the specification and in the environment defined therein.

The design shall be proven by the submission of test certificates at the time of bidding covering all specified tests deemed to be pertinent to the plant and to the conditions in which it will operate.

The requirement for switchgear spares, tools and appliances, including test, maintenance and handling equipment shall be as stated in the Bid document. All devices necessary for operation and earthing shall be provided within the contract price.

Installation, testing and commissioning of all switchgears shall be done by the switchgear engineer(s) of the switchgear(s) manufacturer(s).

3.2 References

3.2.1 IEC Standards

Except where modified by this specification, the switchgear and/or accessories shall be designed, manufactured and tested in accordance with the latest IEC Standards and other publications quoted in these Standards.

- IEC 60044 Instrument transformers
- IEC 60060 High voltage test techniques
- IEC 60071 Insulation coordination
- IEC 60099 Surge arresters
- IEC 60137 Bushings for alternating voltages
- IEC 60265-1 High-voltage switches - Part 1: Switches for rated voltages above 1 kV and less than 52 kV
- IEC 60265-2 High-voltage switches. Part 2: High-voltage switches for rated voltages of 52 kV and above
- IEC 60269 Low voltage fuses
- IEC 60273 Characteristics of indoor and outdoor post insulators for systems with nominal voltages greater than 1000V
- IEC 60282 High voltage fuses.

- IEC 60305 Insulators for overhead lines with a nominal voltage above 1000V - Ceramic or glass insulator units for ac systems - Characteristics of insulator units of the cap and pin type.
- IEC 60358 Coupling capacitors and capacitor dividers
- IEC 60364 Electrical installation of buildings
- IEC 60376 Specification of technical grade sulphur hexafluoride (SF6) for use in electrical equipment
- IEC 60383 Insulators for overhead lines with a nominal voltage above 1000V
- IEC 60815 Guide for the selection of insulators in respect of polluted conditions
- IEC 60865-1 Short-circuit currents - Calculation of effects
- IEC 61639 Direct connection between power transformers and gas insulated metal enclosed switchgear for rated voltages of 72.5 kV and above
- IEC 62155 Hollow pressurized and unpressurized ceramic and glass insulators for use in electrical equipment with rated voltages greater than 1000 V
- IEC 62271-1 HV switchgear and controlgear - part 1: common specifications
- IEC 62271-100 HV switchgear and controlgear - part 100: AC circuit breakers
- IEC 62271-103 Switches for rated voltage above 1 kV and less than 52 kV
- IEC 62271-104 Switches for rated voltage of 52 kV and above
- IEC 62271-102 HV switchgear and controlgear - part 102: AC disconnectors and earthing switches
- IEC 62271-200 HV switchgear and controlgear - part 200: A.C. metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV
- IEC 62271-203 HV switchgear and controlgear - part 203: Gas insulated metal-enclosed switchgear for rated voltages 52 kV and above
- IEC 62271-209 HV switchgear and controlgear - part 209: Cable connections for gas insulated metal-enclosed switchgear for rated voltages of 52 kV and above

3.2.2 British Standards

- BS 7884 Specifications for hard-drawn copper and copper cadmium conductors for overhead power transmission purposes
- BS EN 60383-2 Insulators for overhead lines with voltage greater than 1000V.
- BS 159 Specifications for HV busbars and busbar connections
- BS 215S Specifications for aluminium conductors for overhead transmission
- BS EN 13600 Specifications for high conductivity copper tubes for electrical purposes
- BS 2898 Specifications for wrought aluminium for electrical purposes. Strip with drawn or rolled edges.
- BS 3288 Insulator and conductor fittings for overhead power lines.
- BS 3938 Current Transformers
- BS 6651 Lightning Protection
- BS 7354 Code of practice for design of HV open terminal stations.

3.3 Design Principles

3.3.1 General Requirement

The normal operations will be effected from the National Load Dispatching Centre (NLDC) at Rampura. The Bidder shall take into consideration the unmanned operation of the substation in his design (No operators are necessary in the new substation control rooms).

Control facilities shall be simple and clearly designated with the respective function and instructions on operation and maintenance shall be unambiguous.

The following provisions shall be made for control and indications:

- Local control cubicle to equipment - control of circuit breakers, disconnectors and earthing switches where power operated, complete with electrical indications, mimic diagram, gauges and alarm annunciator.
- Remote control panel in the control room on each substation site - control of circuit breakers, disconnectors and earthing switches where power operated, complete with electrical position indications, mimic diagram in each instance.
- Supervisory control from NLDC - provision of control of circuit breakers and disconnectors switches where power operated, with position indication in each instance.

All necessary local/remote and remote/supervisory control relays, interposing relays and selector switches are to be provided as part of this Contract.

Circuit identifying labels shall be fitted at the front and rear of each individual circuit assembly and on the local control cubicle. In case of labels not visible when standing on the floor, additional name plate shall be fixed at a suitable location.

A single line diagram shall be marked along each bay showing the location of all items of switchgear.

In the event of leakage of SF_6 gas from any compartment, equipment shall withstand rated voltage with SF_6 at atmospheric pressure.

The insulation levels shall be able to withstand test voltages in accordance with the relevant standards for Synchronising Operation for Breakers.

Busbar connections and enclosures shall be designed to absorb the effects of thermal expansion without application of stress to the supporting structure.

3.3.2 Availability for Maintenance, Repair, Extensions, Testing

Maintenance, repair or extension (MRE) and HV testing on one busbar with directly connected apparatuses shall be possible with the other busbar in normal operation.

MRE testing on one switchgear bay shall be possible with all other switchgear bays in normal operation on one busbar.

MRE testing on/of bus coupler bay shall be possible with one busbar at the time in normal operation

and all switchgear bays in normal operation.

Maintenance access to each module shall be possible without necessitating the outage of adjacent modules.

3.4 Outdoor HV Switchgear

3.4.1 Switchgear - Design and Performance

The switchgear shall be suitable for outdoor installation and capable of continuous operation under the climatic conditions existing on site.

It shall be designed to comply with this Specification and relevant IEC and British Standards where applicable. Deviations from these Specifications and Standards shall be stated in Schedule F of Departures in Volume 3.

In all cases the ancillary plant necessary to complete installation of the equipment shall be included in the Contract.

The disposition of plant in any substation is to be such that the operation of any item of plant under the specified service conditions, shall in no way create a condition that could adversely affect the performance of adjacent circuit breakers or any associated equipment.

The Contractor is to ensure that the complete substation installation will satisfy the requirements of this Specification and the appropriate Standards in respect of insulation, fault levels, mechanical stress etc., and any additional equipment found to be necessary to meet these requirements shall be deemed to have been included in the Contract Price.

The layout and design of plant and equipment on substation sites shall make provision for the future extensions shown on the layout drawings and shall provide for ready access for operation, maintenance and extension whilst the remaining sections of equipment are alive.

Electrical clearances provided between isolated equipment and nearest live metal work shall not be less than the distance data as mentioned in sub-clause 1.2.3 of Section 1 of this specification.

Insulation creepage distances shall not be less than 25 mm per kV of rated voltage between phases.

The Contractor shall be responsible for ensuring that insulation co-ordination in accordance with recommendation of IEC 60071 is achieved.

Dynamic and temporary over voltages shall be assumed to be in accordance with normally accepted IEC levels and subject to approval of the Engineer.

3.4.2 Current Ratings

Every current-carrying part of the switchgear including circuit breakers, disconnectors, current transformers, busbars, connections, contacts and joints shall be capable of carrying its specified rated current at rated frequency continuously, and in no part shall its temperature rise exceed that specified in

relevant standards.

Every part of the switchgear shall also withstand, without mechanical or thermal damage, the rated instantaneous peak currents and rated short time current.

3.4.3 Corona

Equipment shall be designed so as to minimise corona or other electrical discharge and radio interference. The Contractor is to confirm and ensure adequacy of design in terms of corona performance. Tests for corona and radio interference shall be carried out by the Contractor as per relevant IEC standard.

3.4.4 Local, Remote and Supervisory Control

Circuit breakers and motorised disconnectors shall be electrically controlled locally, remotely and by supervisory telecontrol.

Position indication of these devices shall be provided on their operating mechanisms and the Contractor shall include the supply and fitting of the necessary auxiliary switches for remote position indication.

For supervisory telecontrol, the interface between the telecontrol control equipment and the control equipment being provided under this contract shall be as specified in Section 10.

3.4.5 HVAC Circuit Breakers

This specification of technical conditions and technical requirements for Circuit Breakers covers the ratings, design, equipment requirements, inspection and testing of the equipment.

Here are stated only those general aspects that are meant to ensure minimum requirements with respect of quality and performance.

Other details and specific data are contained in the Technical Data Schedules.

Properties, testing and ratings of the equipment shall at least conform to the latest edition of the relevant IEC and British standards.

The Contractor is obliged to provide complete equipment, even if the details are not mentioned specifically in the following specifications.

General Design

Circuit breaker shall be, for outdoor installation. The circuit breaker shall be with SF6 gas as the arc-quenching and insulating medium. The circuit breakers shall comply with the requirements of IEC 60273, IEC 60694, IEC 60815, IEC 62271-100.

Beside the rated short circuit breaking current, the circuit breakers shall be capable of making and

breaking the excitation all currents, without restricting and generating harmful over-voltage.

Circuit breakers with two breaking chambers shall be constructed to provide voltage distribution per breaking unit not above 55 % of the total voltage, at any circumstances.

The Contractor shall provide and deliver suitable horizontal and vertical supporting structure that shall be galvanized

Operating Mechanism

The operating mechanism shall be of motor wound-spring charged type. Other type operating mechanism is not allowed. Operating mechanism shall be of maintenance free type.

Operating mechanisms housing shall be made of aluminium or stainless steel. Anticorrosion protection is not anticipated.

It shall be possible to charge the operating springs with the circuit breaker in either the open or closed positions.

In normal operation, recharging of the operating springs shall commence immediately and automatically upon completion of the closing operation.

While a spring charging operation is in progress, closure shall be prevented.

Release of the springs shall not be possible until they are fully charged.

Manual spring release shall be provided.

The operating mechanism shall have hand and electrically charging.

The operating mechanism shall have hand charging facility and it shall be possible to discharge the operating springs, at site, from a charged condition without difficulty.

The state of charge of the operating springs shall be indicated by a mechanical device which shows "spring charged" when operation is permissible and "uncharged" when operation is not possible.

A provision shall be made for remote indication of "spring charge fail" conditions. Therefore, a spare spring-drive limit switch contacts and necessary time delay relays shall be provided.

The charging motor shall be connected to the a.c. supply.

The control circuits shall be connected to the d.c. supply.

The state of charge of the operating springs shall be indicated by a mechanical device which shows "spring charged" when operation is permissible and "uncharged" when operation is not possible.

At the bottom of each operating mechanism cabinets provide the option of earthing together with the earthing rails, by using the copper wire Cu from the outer side. Connection of Cu earthing rail shall be adopted to Al material of operating mechanism using appropriate material (electrolytically between Cu and Al).

Detachable plates for cable insertion rings shall be provided at the bottom of each operating mechanisms cabinet.

Mechanically endurance of circuit breaker shall correspond to class M2.

High Speed Reclosing

The circuit breakers shall be constructed for high speed reclosure of the three poles simultaneously or of a single pole at a time, as per the Technical Schedules.

Reclosing applies only to the circuit breakers used for transmission line feeders.

The operating mechanism shall be suitable for auto-reclosing (cycle 0 - 0.3 s - CO - 3 min - CO).

After loss of power supply the operating mechanism shall be capable of performing a complete cycle.

Control Circuits

Circuit breaker shall be equipped with one closing coil per phase. The closing coil shall be supplied with anti-pumping devices. Circuit breaker shall be equipped with two electrically independent trip coils per phase. The trip coils shall be suitable for application of trip circuit supervision relays.

Means shall be provided to prevent the mechanism from responding to a closing signal when the trip coils is energized.

Circuit breaker shall be designed and equipped with, at least, the following control devices that should be situated in each central control panels:

- Open and close push buttons.
- Local/remote selector with possibility to be locked in "neutral" position. In neutral position provide appropriate signal.

The control circuits shall be designed to operate under the following conditions:

- Remotely, from a National Load Control Centre,
- Remotely, from a substation control building,
- Automatically, by the protective relays,
- Locally, by electrical push buttons,
- Locally, by mechanical arrangement.

Each pole of the HV line feeder circuit breakers shall have, its own distinct operating mechanism with the controls grouped in a central control cabinet.

The circuit breaker shall be designed taking into consideration the following points:

- The circuit assigned to the closing coil and the first tripping coil shall be separate from the circuit assigned to the second tripping coil. This means that there are two different d.c. supplies.
- Power supply for the motor operated mechanism shall be protected by moulded circuit breakers. It is not allowed to cut-of neutral conductor.

- Provide enough number of contacts of densimeter to fulfil previous preconditions.
- Protective tripping of the circuit breaker shall not be blocked by the selector switch "Local/Remote".
- A "Manual/Local/Remote" selector switch shall be provided in the central control cabinet.
- A manual operating crank for each circuit breaker mechanism shall be provided.
- Close-Trip" push buttons shall be provided in the central control panel.
- Housing protection shall be at least of IP54.
- A anti-condensation element, shall be provided in each operating mechanism housing and central control panel.
- Provide anti-pumping devices.
- A time delayed adjustable alarm contact for "phase discrepancy" condition shall be provided.

Auxiliary Contacts

The Manufacturer shall provide, for each mechanism, the sufficient number of normal close and normal open mechanically operated auxiliary switches, but at least 20 percent spare and not below amount specified in the Technical Schedules.

Position Indicator

A visual, mechanical, circuit breaker "Open-Closed" position indicator clearly visible from the ground level and without the opening of any access door, shall be provided. It shall be positively driven (cord drives excluded) directly from the mechanism.

Operating Counter

Each operating mechanism is to be equipped with an operation counter.

SF_6 Gas

The circuit breaker shall use SF_6 gas as the arc-quenching and insulating medium. Depending on the design, each pole or complete circuit breaker shall have at least:

- Temperature compensated densimeter. Densimeter should be so designed to allow easy check correctness contacts of densimeter. Pressure device must be temperature compensated.
- Device must so designed to allow easy reading of a gas density, for each pole or complete circuit breaker, without need for opening of operating mechanism housing or control panel housing.
- Sufficient quantity of SF6 gas should be delivered for the first filling and additionally 20 % for eventually refilling.
- One gas leakage alarm signal (S1) and one interlock signal (S2).

High-voltage Terminals

High-voltage terminals shall be:

- horizontal,
- flat,

- for aluminium conductor,
- minimum area of 100 x 100 mm.
- with minimum four holes 14 mm diameter, at 50 mm distance between each other.

Cables

The Contractor must deliver factory-prepared-and-tested all necessary equipment (cables, connectors and similar) for mutual connection all operating mechanisms of circuit breakers and central control panel of a circuit breaker (if exist). Cables must be only for connection between operating mechanisms and central control panel. Cables should be for outdoor installation, equipped with appropriate connectors for fast and reliable erection of circuit breaker.

Terminals for connection of cables within operating mechanism and central control panel must be equivalent to PHENIX type UK6N and UK10N.

Provide a sufficient space for cables entrance inside operating mechanism and central control panel.

Support Metal Structure

Circuit breaker must be delivered with factory-prepared horizontal and vertical supporting structure necessary for erection. Metal structures shall be galvanized.

Final design of construction will be subject of later agreement. Metal structures shall be galvanized with minimum 70µm zinc layer.

Environmental Protection

Design of circuit breakers shall be designed to take maximum care of environment.

Insulators

Insulators shall be made of brown porcelain, according to technical specifications. Any connection between porcelain and flange shall be made with Portland cement. The connection itself shall be handled with such manner so as to prevent retaining or intrusion of moisture. During Acceptance tests Manufacturer shall present a type and routine test report of porcelains.

Minimum creepage distance is 25 mm/kV.

Nameplates

Nameplates should have data written in English language:

- Manufacturer name
- Country of origin
- Applicable standard
- Type of circuit breaker

- Type of operating mechanism
- Rated voltage
- Rated lighting impulse withstand voltage
- Rated switching impulse withstand voltage
- Rated frequency
- Rated current
- Rated duration of short circuit
- Rated short time withstand current
- Rated short time withstand current of a no-load OHL
- Average making time
- Rated operating sequence
- Rated gas pressure on 20°C
- Mass of a SF_6 gases
- Weight of a circuit breaker
- Year of production
- Factory number
- Factory number (numbers) of operating mechanisms

Special Equipment and Tools

The Contractor is obliged to deliver all equipment and tools required for installation, dismantling, testing and maintenance of equipment. Special equipment and tools shall be of the highest quality and suitable for field work.

- A handle for manual winding shall be found in all operating mechanisms.
- SF_6 gas cylinder with valve and instruments for refilling and
- SF_6 leakage detector

All materials to be used shall be new. A list of a special equipment and tools shall be delivered with a bid. The Employer reserves the right to request any other special equipment or tools during training or testing, which he finds necessary, free of charge, although such equipment or tools were not on the list of special equipment and.

Spare Parts

Contractor is obliged to enclose with the bid a list of recommended spares required for operation and maintenance necessary for 10 years period.

Packing, Shipment and Transportation

The Contractor is obliged to arrange preparation, packing and transport of the equipment.

Each circuit breaker shall be separately packed. It is not allowed to pack parts for more circuit breakers in single package.

The equipment shall be packed and ready to be stored for a longer period. All operating mechanisms shall be provided and packed so as the heater can be connected. For this purpose provide a suitable cable with a plug.

Sufficient quantity of SF_6 gas must be delivered for the first gas filling and eventually refilling.

Inspection and Tests

Tests shall be carried out in order to determine whether the material and equipment comply with the required properties. All tests on the materials and equipment shall be made in accordance with IEC standards. Testing shall not impair the properties and reliability of a test object or reduce its lifetime.

- Type tests shall be performed on each type and rating of the specified equipment with the purpose of proving its properties. Detailed list of type tests shall be attached to the bid along with the copies of the Type tests certificates.
- Routine tests shall be performed on each piece of equipment to be supplied, for the purpose of revealing faults in material or construction.
- Acceptance test shall be conducted in the Manufacturer's laboratory in a presence of three representatives of the Employer, before delivery. All costs including visa fee, health insurance, transport, accommodation, food, daily allowance as well as costs for the tests shall be borne by the Contractor and included in the contract price. Acceptance test will be conducted in accordance with the program of routine tests.

Type Tests

The following type tests shall be conducted on each type and class of the specified equipment for the purpose of proving its properties:

- Dielectric tests
  - Power frequency withstand voltage test (wet and dry)
  - Lightning impulse voltage tests
- Test on auxiliary and control circuit
- Radio interference voltage (r.i.v.) test
- Measurement of the resistance of the main circuit
- Temperature rise test
- Short time withstand current and peak withstand current test
- Verification of the degree of protection
- Tightness test
- Electromagnetic compatibility (EMC) tests
- Mechanical operation test at ambient air temperature
- Static terminal load test
- Short circuit current making and breaking tests, including short line fault tests
- Capacitive current switching tests
- Magnetizing and small inductive current switching tests

Routine Tests

The following type tests shall be conducted on each piece the equipment to be supplied for the purpose of revealing faults in material or construction:

- Dielectric test on the main circuit including partial discharge measurement
- Dielectric test on auxiliary and control circuits

- Measurements of the resistance of the main circuit
- Design and visual checks
- Mechanical operating tests
- Tightness test
- Measurement of gas condition

Training for Installation, Testing and Maintenance and Training Plan

Theoretical and practical (hands-on) training and issuance of certificates for the following works shall be performed:

- circuit breaker installation
- pre-commissioning circuit breaker test
- commissioning
- maintenance of circuit breaker in a service

Training shall be on English language.

Training shall be provided in the Manufacturer's training centre for 4 (four) Employer's Engineers, prior to acceptance test and prior to delivery. All costs including visa fee, health insurance, transport, accommodation, food, daily allowance as well as costs for the training shall be borne by the Contractor and included in the contract price.

Documentation

Documentation attached to the bid shall include minimum the following:

- Manufacturer's Authorization
- Manufacturer's Quality control certificate
- Detailed list of type test for each type and class of the specified equipment
- Copies of type test reports
- Equipment-related catalogues
- Reference list for previous five years
- Drawings, schematic diagrams and similar
- List of special equipment and tools
- List of recommended spare parts
- Training plan

For each circuit breaker, in one of the operating mechanisms the following documentation shall be delivered:

- Drawings
- Schematic diagrams
- Instruction manuals for installation, testing and maintenance
- Test protocol of acceptance testing

All documents, tables and rating plates attached to the equipment shall be in English language.

3.4.6 HV Disconnectors

This chapter covers the ratings, design, equipment requirements, inspection and testing of the equipment. It states only those general aspects that are meant to ensure minimum requirements with respect of quality and performance. Other details and specific data are contained in the technical data schedules.
Properties, testing and ratings of the equipment shall at least conform to the latest edition of the relevant IEC and British standards. The Contractor is obliged to provide complete equipment, even if the details are not mentioned specifically in the following specifications.

General Design

Disconnectors shall be for outdoor installation, double column, centre break. Disconnectors shall comply with the requirements of IEC 60129, IEC 60265, IEC 60273, IEC 60694, IEC 60815, IEC 62271. Insulators shall be porcelain, brown colour and follow the dimensions ad characteristics defined in the technical specifications.

Operating Mechanism

Disconnectors without earthing blade shall have one operating mechanisms, compliant to the technical specifications.

Disconnectors with earthing blade shall have two separate operating mechanisms, compliant to the technical specifications. It is not allowed that drive mechanisms of main and earthing blades be located in the same housing.

Operating mechanisms housing shall be made of aluminium or stainless steel. Anticorrosion protection is not anticipated. Operating mechanism shall be easily accessible constructed for exchange needs.

All operating mechanisms shall be motor driven, providing the option of manual operation, too. Motor shall be maintenance-free unit. Motor shall be AC, single phase, designed for 230 V, 50 Hz. Motor protection shall be provided with miniature circuit breaker (MCB) having alarm (signalling) contact. Alarm for MCB outage shall be provided. If three-phase MCB is used, the circuit shall be made through all three contacts. Neutral phase shall not be interrupted. After the MCB, the motor circuit shall be positioned with the voltage presence controller (voltage detector relay). Control voltage for electric controls of the disconnector shall be conditioned by the presence of voltage for the motor supply.

Alarm (signalling) and control voltage shall be 220V, DC. Control over disconnectors shall be two-pole, i.e. both polarities shall be interrupted in control circuits. Selection switch for local/neutral (manual)/ remote controls shall be provided in each operating mechanism. Suitable push buttons shall be provided on all control operating mechanisms.

Option of mechanical blocking and locking of disconnector at both work positions shall be provided.

Blockings shall have latches (bolts) for prevention of electric operation in case of manual manipulation, when crank of manual unit is put in work position.

Provide that the crank for manual operation cannot be inserted if the selection switch has not been put in manual position. When the crank is inserted, the electric control over disconnector shall not be pos-

sible regardless to the position of selection switch.

All operating mechanisms shall be equipped with heater to prevent condensation.

All operating mechanisms shall have lighting, with automatic switch located at the door of the operating mechanism.
Heater and lighting shall be for 230 V AC, 50 Hz.

The circuits for supply of heater and lighting and socket shall be independent from the circuits for motor supply.

All operating mechanisms shall be equipped with manual control regardless to the type of operating mechanism.

A crank for manual control shall be found in each operating mechanisms.

Secondary connections must be made on terminal connections. Terminal connections shall be made of best material. For AC circuits it shall be for 16 mm2 conductors and for other circuits it shall be for 6 mm2 conductors.

All operating mechanisms shall have copper latches at the bottom of the cabinet for earthing of the cable sheath.

Detachable plates for cable glands shall be provided at the bottom of each operating mechanisms cabinet.

Housing protection shall be at least IP 54. Operating mechanism housing shall have electric scheme on inner side of the door.

Control Circuits

Disconnector shall be designed and equipped with at least the following control units to be found at all operating mechanisms:

- Buttons for manual closing/opening
- Control switch for operation mode local / neutral (manual) / remote, with an option of electric blocking in "neutral" position,

Control circuits shall be designed to operate under the following conditions:

- Remotely
- Locally, via electric buttons in operating mechanism
- Locally, using crank for manual operation.

Blocking

Mechanical and electrical blockings shall ensure to avoid minimum the following conditions:

- Concurrent use of closing and opening Contractors

- Use of electric motor in the course of manual operation
- Electric operation when the crank for manual operation has been inserted.
- Activation of main blades when earthing blades are activated and vice versa
- Mechanical blocking of the main blades when earthing blades are activated and vice versa

Auxiliary Contacts

Manufacturer shall for each mechanism provide sufficient number of mechanical auxiliary contacts for normal closing and normal opening, number specified in the Technical Data Schedules. The auxiliary contacts shall be Class 1 and shall offer the option of time adjustment.

High-Voltage Terminals

High-voltage terminals shall be:

- horizontal,
- flat,
- for aluminium conductor,
- minimum area of 100 x 100 mm.
- with minimum four holes 14 mm diameter, at 50 mm distance between each other.

Metal Structure

The Contractor shall provide and deliver suitable horizontal supporting structure. The horizontal supporting structure as well as all other pertinent metal components shall be galvanized with minimum 70µm zinc layer.

Environmental Protection

Design of Disconnectors shall be designed to take maximum care of environment.

Insulators

Insulators shall be made of brown porcelain, according to technical specifications. Any connection between porcelain and flange shall be made with Portland cement. The connection itself shall be handled with such manner so as to prevent retaining or intrusion of moisture. Metal parts shall be galvanized with minimum 70 µm zinc layer.

Minimum creepage distance is 25 mm/kV.

Special Equipment AND Tools

The Contractor is obliged to deliver all equipment and tools required for installation, testing and maintenance of disconnectors. Special equipment and tools shall be of the highest quality and suitable for field work. All materials to be used shall be new.

Special equipment and tools list shall be defined by the Technical data Schedule. Special equipment and tools shall be supplied in a number defined by the Technical data Schedule.

The Employer reserves the right to request any other special equipment or tools during training or testing, which he finds necessary, free of charge, although such equipment or tools were not on the list of special equipment.

Spare Parts

Contractor is obliged to enclose with the bid a list of recommended spares required for operation and maintenance of disconnectors.

Packing, Shipment and Transportation

Each disconnector shall be separately packed. It is not allowed to pack parts for more disconnectors in one package. The equipment shall be packed and ready to be stored for a longer period. All operating mechanisms shall be provided and packed so as the heater can be connected. For this purpose provide a suitable cable with a plug.

Inspection and Tests

Tests shall be carried out in order to determine whether the material and equipment comply with the required properties. All tests on the materials and equipment shall be made in accordance with IEC standards. Testing shall not impair the properties and reliability of a test object or reduce its lifetime.

- Type tests shall be performed on each type and rating of the specified equipment with the purpose of proving its properties. Detailed list of type tests shall be attached to the bid along with the copies of the Type tests certificates.
- Routine tests shall be performed on each piece of equipment to be supplied, for the purpose of revealing faults in material or construction.
- Acceptance test shall be conducted in the Manufacturer's laboratory in a presence of three representatives of the Employer, before delivery. All costs including visa fee, health insurance, transport, accommodation, food, daily allowance as well as costs for the tests shall be borne by the Contractor and included in the contract price.

Acceptance test will be conducted in accordance with the program of Routine tests.

Type Tests

The following type tests shall be conducted on each type and class of the specified equipment for the purpose of proving its properties:

- Dielectric tests
  - Power frequency withstand voltage test (wet and dry)
  - Lightning impulse voltage tests
- Artificial contamination test
- Auxiliary and control circuits test

- Radio interference voltage test (r.i.v.)
- Main circuit resistance test
- Temperature rise test
- Short circuit withstand current test and impulse withstand current tests
- Earthing blade operation performance test
- Operation and mechanical endurance tests
- Busbar breaking currents test

A detailed list of type tests shall be attached to the bid.

Routine Test

The following type tests shall be conducted on each piece the equipment to be supplied for the purpose of revealing faults in material or construction:

- Main circuit dielectric test
- Auxiliary circuits and control circuits dielectric test
- Main circuit resistance measurement
- Visual inspection
- Functionality check and mechanical operation test

Documentation

Documentation attached to the bid shall include minimum the following:

- Manufacturer's authorization
- Manufacturer's quality control certificate
- Detailed list of type test for each type and class of the specified equipment
- Copies of type test reports
- Equipment-related catalogues
- Reference list for previous five years
- Drawings, schematic diagrams and similar
- List of special equipment and tools
- List of recommended spare parts
- Training plan

For each disconnector, in one of the operating mechanisms the following documentation shall be delivered:

- Drawings
- Schematic diagrams
- Instruction manuals for installation, testing and maintenance
- Test protocol of acceptance testing

All documents, tables and rating plates attached to the equipment shall be in English language.

3.4.7 HV Instrument Transformers

This chapter covers the ratings, design, equipment requirements, inspection and testing of the equipment. It states only those general aspects that are meant to ensure minimum requirements with respect of quality and performance.

Other details and specific data are contained in the Technical Data Schedules.

Properties, testing and ratings of the equipment shall at least conform to the latest edition of the relevant IEC and British standards.

The Contractor is obliged to provide complete equipment, even if the details are not mentioned specifically in the following specifications.

Current transformers in the existing substations shall be carefully chosen. Final characteristics may be different from the characteristics in the single line diagram and/or in the technical schedules. They shall be defined during the design stage and shall be appropriate for busbar protection in the existing substation.

General Design - Current Transformers

The current transformers shall be for outdoor installation, single phase, head type, hermetically sealed, oil-paper immersed. SF6 gas is not allowed. They shall be multi core with appropriate characteristics. They shall be designed to allow secondary reconnection. Primary reconnection is not allowed.

The current transformers shall be supported by a porcelain insulator. They shall comply with IEC 60044 and shall be equipped with:

- Expansion chamber/and internal metal bellows type oil gauge diaphragm.
- Device for determining insulating medium level.
- Oil drain cock and sampling device.
- tgδ measuring connection
- Low voltage terminal box
- Enable sealing after accuracy class checks (sealing possibilities).
- Overpressure device
- Adequate earth terminal connection

General Design - Voltage Transformers

The voltage transformers shall be for outdoor installation, single phase, hermetically sealed.

Capacitive voltage transformers as insulation medium shall be oil-paper immersed or impregnate-mixed dielectric. Inductive voltage transformers as insulation medium shall be oil-paper immersed, only. SF_6 gas is not allowed.

The tgδ for capacitive divider of capacitive voltage transformers shall not be greater than 0.1%. For efficient suppression of the ferro-resonance feature, working induction of intermediate transformer of capacitive voltage transformer should be ≤ 0.5 T.

The voltage transformers shall have multi secondary windings appropriate characteristics. Capacitive voltage transformers should be used as capacitor for HF connection. They shall be supported by porcelain insulator.

The voltage transformers shall comply with IEC 60044. They shall be equipped with:

- Expansion chamber/and internal metal bellows type oil gauge diaphragm.
- Device for determining insulating medium level
- Oil drain cock and sampling device
- tgδ measuring connection
- Low voltage terminal box
- Adequate earth terminal connection
- Enable sealing after accuracy class checks (sealing possibilities)
- terminal connection for anti-ferro-resonance control for capacitive voltage transformers
- HF connection terminal for capacitive voltage transformers
- Overpressure device

High-Voltage Terminals

High-voltage terminals shall be:

- horizontal (or vertical, for voltage transformers only),
- flat,
- for aluminium conductor,
- minimum area of 100 x 100 mm, with four holes, 14 mm diameter, at 50 mm distance between each other

Permissible Partial Discharges Level

Instrument transformers should be so designed to have a neglect level of partial discharges. Contractor shall guarantee a partial discharge level lower or equal to maximum allowed according to the IEC standards. It is desirable that partial discharge level should be as lower as it is possible.

Outdoor Insulation

Outdoor insulation of instrument transformers shall consist of porcelain insulator element.

Insulators shall be made of brown porcelain, according to technical specifications. Any connection between porcelain and flange shall be made with Portland cement. The connection itself shall be handled with such manner so as to prevent retaining or intrusion of moisture. Metal parts shall be made of aluminium, stainless steel or shall be galvanized with minimum 70 µm zinc layer.

Minimum creepage distance is 25 mm/kV.

Environmental Protection

Design of Instrument transformers shall be designed to take maximum care of environment.

Mechanical Terminal Loads

Instrument transformers shall fulfil at least mechanical requirements of Class II.

Mechanical Protection

Design of instrument transformers shall provide hermetically sealing of active parts. Secondary terminal box shall be mechanical protection level min. IP54.

Anticorrosion Protection

All outdoor metal parts shall be made of aluminium, stainless steel or shall be galvanized with minimum 70 µm zinc layer. All screws and other connecting material must be made of stainless steel.

It is not allowed to use material with anticorrosion protection, except metal support structure, which shall be galvanized with minimum 70 µm zinc layer.

Packing, Shipment and Transport

The Contractor is obliged to arrange for preparation, packing and transport of the equipment. Each instrument transformer shall be separately packed. Copy of a routine test report shall be submitted together with each piece of instrument transformer.

Inspection and Tests

Tests shall be carried out in order to determine whether the material and equipment comply with the required properties. All tests on the materials and equipment shall be made in accordance with IEC standards. Testing shall not impair the properties and reliability of a test object or reduce its lifetime.

- Type tests shall be performed on each type and rating of the specified equipment with the purpose of proving its properties. Detailed list of type tests shall be attached to the bid along with the copies of the Type tests certificates.
- Routine tests shall be performed on each piece of equipment to be supplied, for the purpose of revealing faults in material or construction.
- Special tests shall be performed on each piece of equipment before delivery, during the acceptance test
- Acceptance test shall be conducted in the Manufacturer's laboratory in a presence of three representatives of the Employer, before delivery. All costs including visa fee, health insurance, transport, accommodation, food, daily allowance as well as costs for the tests shall be borne by the Contractor and included in the contract price.

Acceptance test will be conducted in accordance with the program of routine tests.

Type Tests of Current Transformers

The following type tests shall be conducted on each type and class of the specified equipment for the purpose of proving its properties:

- Short-circuit withstand capability test
- Short-duration current test
- Temperature rise test
- Lighting impulse tests
- Switching impulse test
- Wet test
- Determination of errors
- Test of secondary winding resistance for PR and TPY class
- Determination induce characteristic of a secondary winding for TPY class
- Determination of remanence factor for PR and TRY class
- Determination of a secondary loop time constant for PR and TPY class
- Accuracy class test for TPY class
- Determination construction factor for TPY class
- Radio interference voltage measurement test (RIV)
- Seismic test
- Wind pressure test.

Type Tests of Capacitive Voltage Transformers

The following type tests shall be conducted on each type and class of the specified equipment for the purpose of proving its properties:

- Accuracy class test
- Temperature rise test
- Measurement of capacitance and dielectric dissipation factor
- Chopped impulse tests
- Radio interference voltage measurement test (RIV)
- Short-circuit withstand capability test
- Lighting impulse tests
- Switching impulse test wet
- Transient response test
- Ferro-resonance test
- Tightness test of liquid-filed electromagnetic unit
- Voltage and phase accuracy test

Type Test of Inductive Voltage Transformers

The following type tests shall be conducted on each type and class of the specified equipment for the purpose of proving its properties:

- Temperature rise test
- Short-circuit withstand capability test
- Lighting impulse tests
- Switching impulse test

- Power frequency voltage wet test
- Determination of voltage and phase errors
- Radio interference voltage measurement test (RIV)
- Seismic test
- Wind pressure test
- Measurement of capacitance and dielectric dissipation factor
- Chopped impulse tests
- Transient response test
- Ferro-resonance test
- Tightness test of liquid-filed electromagnetic unit

Routine Tests

The following type tests shall be conducted on each piece the equipment to be supplied for the purpose of revealing faults in material or construction:

Routine Tests - Current Transformers

- Verification of terminal markings
- Power frequency withstand tests on primary windings
- Partial discharge measurement
- Measurement of capacitance
- Measurement of dielectric dissipation factor (tgδ)
- Power frequency withstand tests on secondary windings
- Power frequency withstand tests between sections
- Inter-turn overvoltage test
- Insulation resistant test
- Instrument security factor test
- Security factor test
- Accuracy class test
- Galvanizing test

Routine Tests - Capacitive Voltage Transformers

- On capacitive divider of capacitive voltage transformers:
  - Measurement of capacitance
  - Measurement of dissipation factor (tgδ)
  - Power frequency withstand tests
  - Partial discharge measurement
  - Measurement of capacitance (again)
  - Measurement of dissipation factor (tgδ)(again)
  - Measurement of capacitance separately C1 and C2
  - Power frequency withstand tests on low voltage terminals of capacitive divider.
- On electromagnetic unit of capacitive voltage transformer:
  - Power frequency withstand tests
  - Power frequency withstand tests on low voltage terminals of capacitive divider
  - Power frequency withstand tests on secondary windings
- On complete of capacitive voltage transformer:
  - Verification of terminal markings
  - Ferro-resonance test
  - Accuracy class test
  - Galvanizing test

Routine Tests - Inductive Voltage Transformers

- Verification of terminal markings
- Partial discharge measurement
- Measurement of capacitance
- Measurement of dissipation factor (tgδ) 2 kV
- Power frequency withstand tests on low voltage terminals.
- Power frequency withstand tests on secondary windings.
- Accuracy class test
- Galvanizing test

Special Tests - Inductive Voltage Transformers

The following type tests shall be conducted on each piece the equipment to be supplied for the purpose of revealing faults in material or construction:

- High frequency transient voltage test
- Over pressure device test

Documentation

Documentation attached to the bid shall include minimum the following:

- Manufacturer's Authorization
- Manufacturer's Quality control certificate
- Detailed list of type test for each type and class of the specified equipment
- Copies of type test reports
- Equipment-related catalogues
- Reference list for previous five years
- Drawings, schematic diagrams and similar
- List of special equipment and tools, if any
- List of recommended spare parts, if any

For each instrument transformer, the following documentation shall be delivered:

- Drawings
- Schematic diagrams
- Instruction manuals for installation, testing and maintenance
- Test protocol of acceptance testing

All documents, tables and rating plates attached to the equipment shall be in English language.

3.4.8 Surge Arresters

This section covers the ratings, design, equipment requirements, inspection and testing of the equipment. It states only those general aspects that are meant to ensure minimum requirements with respect of quality and performance. Other details and specific data are contained in the Technical Data Schedules.

Properties, testing and ratings of the equipment shall at least conform to the latest edition of the relevant IEC and British standards.

The Contractor is obliged to provide complete equipment, even if the details are not mentioned specifically in the following specifications.

General Design

Surge arresters will be metal-oxide, gapless, outdoor. Design shall comply with the requirements of IEC 60099 and other relevant standards, if it is not requested in different manner in this specification. Surge arresters be shall be hermetically sealed type, composite housing, on insulating basement and with counter. Insulating basement shall be delivered together with the Surge arresters.
The metal-oxide blocks shall be manufactured by manufacturers of European countries, Korea and Japan.

High-Voltage Terminals

High-voltage terminals shall be as it is defined in a technical schedule:

- Vertical,
- Flat,
- For aluminium conductor,
- Minimum area of 100 x 100 mm
- With at least four holes 14 mm diameter, at 50 mm distance between each other

Insulating Basement

Surge arresters shall be equipped with appropriate insulating basement that is part of delivery. They shall be fixed and electrically connected to insulating basement. Earthing shall be fixed and electrically connected to surge arrester directly.

Earthing

Surge arresters will be equipped with appropriate earthing connector.

Surge Arresters Housing

Housing shall be made from silicon and/or composite material in accordance with Technical specification. The connection itself shall be handled with such manner so as to prevent retaining or intrusion of moisture. Minimum creepage distance is 25 mm/kV.

Environmental Protection

Design of surge arresters shall be designed to take maximum care of environment.

Nameplates

Nameplates should have data written in a English language:

- Manufacturer name
- Type of surge arrester
- Rated voltage of surge arrester Ur
- Continuous operating voltage of surge arrester Uc
- Nominal discharge current of an arrester (8/20 µs)
- Rated short circuit current
- Rated frequency
- Line discharge class
- Number of a unit position in a set (for multi units surge arrester)
- Mass of surge arrester
- Year of production
- Serial number

Special Equipment, Tools and Drawings

The Contractor is obliged to deliver all equipment and tools required for installation, dismantling, testing and maintenance of equipment. Special equipment and tools shall be of the highest quality and suitable for field work. All materials to be used shall be new. A list of special equipment and tools shall be delivered with the bid. The Employer reserves the right to request any other special equipment or tools during training or testing, which he finds necessary, free of charge, although such equipment or tools were not on the list of special equipment.

Spare Parts

The Contractor is obliged to enclose with the bid a list of recommended spares required for operation and maintenance necessary for 10 years period. All spare parts to be used shall be new. A list of spare parts shall be delivered with a bid.

Packing, Shipment and Transportation

The Contractor is obliged to arrange for preparation, packing and transport of the equipment to the destination point. The equipment shall be packed and ready to be stored for a longer period.

Inspection and Tests

Tests shall be carried out in order to determine whether the material and equipment comply with the required properties. All tests on the materials and equipment shall be made in accordance with IEC standards. Testing shall not impair the properties and reliability of a test object or reduce its lifetime.

- Type tests shall be performed on each type and rating of the specified equipment with the purpose of proving its properties. Detailed list of type tests shall be attached to the bid along with the copies of the Type tests certificates.

- Routine tests shall be performed on each piece of equipment to be supplied, for the purpose of revealing faults in material or construction.
- Special tests shall be performed on each piece of equipment before delivery, during the acceptance test

Type Tests

The following type tests shall be conducted on each type and class of the specified equipment for the purpose of proving its properties:

- Dielectric tests
  - Power frequency withstand voltage test of arrester housing
  - Lightning impulse voltage tests
  - Power frequency voltage wet and dry test
- Residual voltage test
  - Steep current
  - Lightning impulse
  - Switching impulse
- Test to verify long term stability under continuous operating voltage
- Repetitive change behaviour verification
- Operating duty tests
- Power frequency voltage versus time
- Short circuit test
- Weather aging test

Short circuit test shall be conducted by the STL – Short Circuit Testing Liaison and Short circuit test report shall be certified from STL – Short Circuit Testing Liaison authority.

Routine Tests

The following type tests shall be conducted on each piece the equipment to be supplied for the purpose of revealing faults in material or construction:

- Measurement of reference voltage
- Residual voltage test
- Partial discharge and contact noise tests
- Seal leakage test

Documentation

Documentation attached to the bid shall include minimum the following:

- Manufacturer's Authorization
- Manufacturer's Quality control certificate
- Detailed list of type test for each type and class of the specified equipment
- Copies of type test reports
- Equipment-related catalogues
- Reference list for previous five years
- Drawings

For each surge arrester, the following documentation shall be delivered:

- Drawings
- Instruction manuals for installation, testing and maintenance
- Test protocol of acceptance testing

All documents, tables and rating plates attached to the equipment shall be in English language.

3.4.9 Post Insulators

This Section covers the ratings, design, equipment requirements, inspection and testing of the equipment. It states only those general aspects that are meant to ensure minimum requirements with respect of quality and performance. Other details and specific data are contained in the Technical Data Schedules.

Properties, testing and ratings of the equipment shall at least conform to the latest edition of the relevant IEC and British standards.

The Contractor is obliged to provide complete equipment, even if the details are not mentioned specifically in the following specifications.

General Design

Post insulators should be solid core type post insulators, made of porcelain, for outdoor installation in the three phase AC system. The post insulators shall comply with the requirements of following standards: IEC 60273, IEC 60437, 60815, 60672, IEC 60168, EN1562, EN1563, EN ISO 1461 and other relevant standards if it is not required in this Specification.

Post insulators should satisfy the best level of development for this kind of equipment in a field of design, construction and material.

Insulator Material

Insulators should be made of high quality aluminium oxide porcelain. Porcelain material shall fulfil requirements of a class C130, which confirms to the standard IEC 60672. Insulators shall be cylindrical with a hard core and metal base. Glazing shall be in brown colour.

RIV

The RIV performance of post insulator styles shall be tested in accordance with the standard IEC60437. If corona rings are necessary to reach a certain RIV level for a single insulator column, the appropriate ones shall be delivered with the insulator column.

Fittings

Fittings shall be made in malleable cast iron according to standard EN1562 or spheroidal graphite cast iron according to standard EN1563. All fittings shall be hot dip galvanized according to standard EN ISO 1461 with a zinc weight of min. 600 g/m2 (min. 85 µm) as average value. Connection method of Support insulators shall be in accordance with standard IEC 60273. Connection holes shall be equally arrange on a circle meaning concentric with eight insulators. Holes in upper and lower part of connection equipment should be in line and so arranged to allow usage of standard screws with six-angle heads.

Cementing

Any connection between porcelain and flange shall be made with Portland cement. The connection itself shall be handled with such manner so as to prevent retaining or intrusion of moisture by a silicone or any other manner.

Insulation Level

Post insulators should be designed for standard value of lightning impulses voltage according IEC 60071-1. Minimal value for the height depend of lightning impulses voltage in dry, power frequency voltage in wet and switching withstand voltage in wet where it is in accordance with relevant requirement from coordination insulation point.

Dimensions

Rated dimensions of insulator shall be in accordance with values defined in the Technical Data Schedules, with appropriate tolerances referring to parallelism, eccentric and angle deviation, in accordance with standard IEC 60272. Minimum creepage distance is 25 mm/kV.

Packing, Shipment and Transportation

The Contractor is obliged to arrange for preparation, packing and transport of the equipment to the destination point. The equipment shall be packed and ready to be stored for a longer period.

Inspection and Tests

Tests shall be carried out in order to determine whether the material and equipment comply with the required properties. All tests on the materials and equipment shall be made in accordance with IEC standards. Testing shall not impair the properties and reliability of a test object or reduce its lifetime.

- Type and special tests shall be performed on each type and rating of the specified equipment with the purpose of proving its properties. Detailed list of type tests shall be attached to the bid along with the copies of the Type tests certificates.
- Routine tests shall be performed on each piece of equipment to be supplied, for the purpose of revealing faults in material or construction.

Type Tests

The following type tests shall be conducted on each type and class of the specified equipment for the purpose of proving its properties:

- Dielectric tests
  - Lightning impulse voltage tests
  - Power frequency voltage wet and dry test
  - Power frequency withstand voltage test of arrester housing
    Residual voltage test
    Mechanical failing load test+

Special Tests

The following type tests shall be conducted on each type and class of the specified equipment for the purpose of proving its properties:

- Radio interference voltage measurement test (RIV)
- Test for deflection under load

Routine Tests

The following type tests shall be conducted on each piece the equipment to be supplied for the purpose of revealing faults in material or construction:

- Routine thermal shock test
- Routine visual examination
- Routine electrical test
- Routine mechanical test

Acceptance Tests

The following tests shall be conducted:

- Verification of dimensions
- Temperature cycle test
- Dimension tests
- Mechanical test
- Puncture test
- Porosity test
- Galvanizing test

Documentation

Documentation attached to the bid shall include minimum the following:

- Manufacturer's Authorization

- Manufacturer's Quality control certificate
- Detailed list of type test for each type and class of the specified equipment
- Copies of type test reports
- Equipment-related catalogues
- Reference list for previous five years
- Drawings

Following documentation shall be delivered together with the equipment:

- Drawings
- Instruction manuals for installation, testing and maintenance
- Test protocol of acceptance testing

All documents, tables and rating plates attached to the equipment shall be in English language.

4. Power Transformers

4.1 Scope

These clauses describe the general technical requirements for power transformers and shall be read in conjunction with the schedule of requirements.

Installation, testing and commissioning of power transformers shall be done by the Manufacturer(s)' Engineer(s).

4.2 References

4.2.1 IEC Standards

IEC 60076	Power transformers
IEC 60137	Insulated bushings for ac voltages above 1000V
IEC 60044-2	Voltage transformers
IEC 60044-5	- ditto -
IEC 60214-1	On load tap changers
IEC 60228	Conductors of insulated cables
IEC 62155	Tests on hollow insulators for use in electrical equipment
IEC 60289	Reactors and Earthing Transformers
IEC 60296	Specification for unused mineral insulating oils for transformers and switchgear
IEC 60354	Loading guide for oil immersed power transformers
IEC 60422	Supervision and maintenance guide for mineral insulating oils in electrical equipment
IEC 60529	Degrees of protection provided by enclosures
IEC 60551	Determination of transformer and reactor sound levels

4.2.2 British Standards

BS61	Specification for threads for light gauge copper tubes and fittings
BS EN 10220	Specification for dimensions and masses per unit length of welded and seamless steel pipes and tubes for pressure purposes
BS EN 1092	Circular flanges for pipes, valves and fittings (PN designated)
BS 6121	Mechanical cable glands
BS 6346	Specification for PVC insulated cables for electricity supply
BS 6435	Specification for unfilled enclosures for the dry termination of HV cables for transformers and reactors
BS 7354	Code of practice for design of HV open terminal stations
BS EN 10137	Specification for hot rolled quenched and tempered weldable plates

4.2.3 BS European Standards

BS EN 10029 Specification for tolerances on dimensions, shape and mass for hot rolled steel plates 3mm thick and above

4.3 Power Transformers

4.3.1 Types of Transformers and Operating Conditions

General

The transformers shall be oil immersed and suitable for outdoor installation and shall comply with IEC 60076, Parts 1 to 5 inclusive.

Electrical clearances shall not be less than those in the appropriate sections of BS 7354, or as stated in the System Electrical Parameters in Section-1 of Volume 2 of 3, whichever is the greater.

Cooling

The types of cooling shall be as stated in the Schedule A of Requirements, Appendix A2 in Schedule A of Volume 1 of 3 and the letters relating to the method of cooling used in this Specification and Schedules shall be in accordance with IEC 60076.

Where a combination of two methods of cooling is applied to one transformer, as for ONAN/ONAF units, the transformer shall be capable of operating under the ONAN condition up to half full load or more as stated in the Schedule of Requirements, after which the cooling equipment is to come into operation and the Transformer will operate as an ONAF unit.

Transformers shall be fitted with at least two coolers or two banks of radiators each capable of dissipating 50 per cent of the losses at continuous maximum rating. They shall be capable of remaining in operation at full load for 20 minutes in the event of failure of blowers associated with one half of coolers or radiators, without the calculated winding hot spot temperature exceeding 140˚C.

Failure of one fan in each group of blowers shall not reduce the continuous maximum rating of the transformer.

Parallel Operation

Transformers supplied against each item shall be designed to operate satisfactorily, one with the other, when operating on the same tap position.

Handling on Site

For installation purposes and to permit the moving of any three phase unit, the transformers are to be equipped with castors (rail wheels). A permanent rail transfer track system shall be provided, integrat-

ed with the transformer foundations. The castors should be able to swivel in both the longitudinal and transverse directions.

A system of wedges shall be included to stop any unwanted movement of the transformer during its operating life. The distance between rails must be compatible with the transformer dimensions and also the rail gauge prevailing at existing substation sites.

4.3.2 Continuous Maximum Rating

Transformers shall have the rating stated in the Schedule of Requirements and shall comply with the requirements as regards temperature rise and overloads on all tapings, irrespective of the direction of power flow and with the voltage of the lower voltage winding at the normal voltage stated in the Schedule of Requirements. To allow for high atmospheric temperatures, the allowable temperature rises shall be reduced in accordance with IEC 60076-Part 2.

The overload capability shall be in accordance with IEC 60354.

4.3.3 Electrical Connections

Transformer windings shall be connected in accordance with the IEC 60076 group symbol specified in the Schedule of Requirements.

All electrical connections within windings shall be brazed, subject to approval, mechanically crimped joints may be used for round stranded conductors on tapping, bushing or earthing connections and on bundle conductors where design has been proved by type test and application is subject to rigorous quality control.

4.3.4 Ability to Withstand Short Circuit

General

All transformers shall be capable of withstanding, on any tappings and without damage, the thermal and dynamic effects of external short circuits under the conditions stated in IEC 60076 Part 5. For this purpose the design short circuit level for each system voltage is stated in the Schedule of Requirements.

Calculations and Tests

Evidence shall be submitted with the Bid as to the extent to which the Manufacturer has proved, or is able to prove, either by calculation or test, the ability of the specified Transformers to withstand short circuit.

The Bidder shall provide with his bid a brief description of those transformers, or parts thereof, which have been subjected to short circuit test or for which short circuit calculations are available. It is preferred that this information relates to designs comparable with the transformers offered, but, in the event this is not so, the Engineer reserves the fight to require calculations to prove that the design of transformers offered will satisfactorily comply with this clause.

4.3.5 Stabilizing Windings

Unless otherwise specified in the Schedule of Requirements, the product of the number of turns of the stabilizing windings and the cross- sectional area of one such turn must not be less than 33 per- cent of the corresponding product for the untapped main winding.

When required by the Schedule of Requirements, the stabilizing winding shall be capable of carrying continuously the load specified therein.

4.3.6 Losses and Evaluation of Losses

Guaranteed values for component losses of the total loss of the transformers shall be as low as is consistent with transport restrictions, reliability and economic use of materials, shall be as stated in the Schedule B of Particulars and Guarantees.

For the evaluation of the bid as per section 3 (Evaluation and qualification criteria) capitalization cost (Evaluated price of transformer losses) due to transformer guaranteed losses shall be added with the bid price. The evaluated price of the Power Transformer shall be the sum of the quoted bid price of the transformer plus evaluated price of the transformer losses. The evaluated price of transformer loss shall be:

For each unit of the three-phase transformers,

Evaluated price of transformer loss = N * a + L * b + M * c

Where

N = No-load loss (core-loss) at rated voltage in kW
L = Load loss (copper-loss) at 75 °C, 50 Hz maximum continuous rating in kW
M = Total load of transformer cooling fans at transformer maximum continuous rating in kW (when all the cooling fans are in operation)
a = Cost/kW of no load loss (core-loss) valued at EUR 7,000
b = Cost/kW of load loss (copper-loss) valued at EUR 3,500
c = Cost/kW of auxiliary power valued at EUR 3,500

The acceptance of transformers (after Factory Acceptance Test) yielding component losses higher than the guaranteed values shall be governed by either of the following:

(a) Component losses in excess of guaranteed values but within the tolerance permitted under IEC 60076 Part 1.
Transformers shall be acceptable subject to full compliance with all technical particulars, including temperature rises at CMR and subject to the Bidder accepting deduction from the contract Price of charges for each kW or part thereof of component losses in excess of the guaranteed values, at the above evaluation rates.

(b) Component losses in excess of guaranteed values and exceeding the tolerance permitted under IEC 60076 Part 1.

The acceptance of transformers shall be entirely at the discretion of the Employer and subject to the Bidder accepting the deduction from the contract Price of charges for each kW or part thereof of component losses in excess of the guaranteed values, at the above loss evaluation rates.

In the event of transformers yielding component and total losses that are either equal to or below the guaranteed values, the Bidder will not be entitled to any premium in respect of reduction in losses below the guaranteed values.

4.3.7 Impedance

The value of impedance measured on normal and extreme tappings shall be as stated in the Schedule and minimum and maximum values where stated in the Schedule A of Requirements shall not be subject to tolerance.

4.3.8 Noise

The transformer noise levels shall be measured as a type test and in accordance with IEC 60551. The acceptance level of the transformers shall be as stated in the Schedule of Requirements.

Where the bottom plate of the transformer tank will be in direct contact with the surface of the foundation, anti-vibration pads shall be provided under the contract for insertion between the transformer and its foundation.

The anti-vibration mountings shall be of an oil and weather resisting rubber or other approved material, capable of operation at temperatures from minus 10'C to plus 80'C. Due regard shall be given to irregularities in the tank underbase and the plinth surface. Anti-vibration mountings for separately mounted coolers, pumps, etc. are not required.

The total unloaded depth of anti-vibration material (excluding load spreading plates) in the mountings shall not exceed 40mm.

When loaded to the same pressure as in service, the anti-vibration mountings shall give, at normal room temperature, a vibration attenuation at 100Hz of not less than 32dB (assuming an infinite ground impedance value).

Representative samples of anti-vibration material for the mountings shall be subjected to sample tests.

4.3.9 Harmonic Suppression

Transformers shall be designed with particular attention to the suppression of harmonic voltages, especially the third, fifth and seventh harmonics, and to minimise the detrimental effects resulting therefrom.

4.4 Magnetic Circuit and Windings

4.4.1 Magnetic Circuit

The design of the magnetic circuit shall be such as to avoid static discharges, development of short circuit paths internally or to the earthed clamping structure, and the production of flux components normal to the plane of the laminations. Each lamination shall be insulated with a material stable under the action of pressure and hot oil.

The winding structure and major insulation shall be designed to permit an unobstructed flow of cooling oil through core cooling ducts to ensure efficient core cooling.

With the earthing link removed, the magnetic circuit shall be insulated from all structural parts, and shall be capable of withstanding a test voltage to core bolts and to the frame of 2,000 volts RMS for one minute.

4.4.2 Flux Density

Cores shall be constructed from cold rolled grain oriented steel sheets. Design shall be such that there will be no adverse effects due to core or stray flux heating with the quality of steel employed, and that when operating under the most onerous conditions envisaged in IEC 60076 and IEC 60354, flux density in any part of the magnetic circuit does not exceed 1.9 Tesla.

4.4.3 Windings

Transformer 235kV and 132kV star connected windings shall have graded insulation as defined in IEC 60076. For 33kV and below they shall have uniform insulation as defined in IEC 60076. All neutral points shall be insulated to withstand the applied test voltage specified in the Schedule of Requirements.

The windings shall be located in a manner that will ensure that they remain electromagnetically balanced and that their magnetic centres remain coincident under all conditions of operation.

The windings shall also be thoroughly dried and shrunk by the application of axial pressure for such length of time as will ensure that further shrinkage will not occur in service.

The windings and leads of all transformers shall be braced to withstand the shocks that may occur through rough handling and vibration during transport, switching and other transient service conditions including external short circuit.

If the winding is built up of sections or of disc coils separated by spacers, the clamping arrangements shall ensure that equal pressures are applied to all columns of spacers.

4.4.4 Internal Earthing

General

All metal parts of the transformer, with the exception of the individual core laminations, core bolts and associated individual clamping plates, shall be maintained at some fixed potential.

Earthing of Core Clamping Structure

The top main core clamping structure shall be connected to the tank body by a copper strap. The bottom main core clamping structure shall be earthed by one or more of the following methods:

(a) by connection through vertical tie rods to the top structure;
(b) by direct metal-to-metal contact with the tank base maintained by the weight of the ore and windings;
(c) by connection to the top structure on the same side of the core as the main earth connection to the tank.

Earthing of Magnetic Circuits

The magnetic circuit shall be earthed to the clamping structure at one point only through a removable link placed in an accessible position just beneath an inspection opening in the tank cover and which, by disconnection, will enable the insulation between the core and clamping plates, etc., to be tested at voltages up to 2 kV. The link shall have no detachable components and the connection to the link shall be on the same side of the core as the main earth connection. These requirements are compulsory.

All insulating barriers within magnetic circuits shall be bridged by means of aluminium or tinned copper strips, so inserted as to maintain electrical continuity.

Earthing of Coil Clamping Rings

Where coil clamping rings are of metal at earth potential, each ring shall be connected to the adjacent core clamping structure on the same side of the Transformer as the main earth connection.

Size of Earthing Connections

Main earthing connections shall have a cross-sectional area of not less than 80 sq.mm but connections inserted between laminations may have cross-sectional areas reduced to 20 sq.mm when in close thermal contact with the core.

4.5 Tanks and Ancillary Equipment

4.5.1 Transformer Tanks

Each transformer shall be enclosed in a suitably stiffened welded steel tank such that the transformer can be lifted and transported without permanent deformation or oil leakage. The construction shall employ weldable structural steel of an approved grade to BS 7613 and BS EN 10029. The final coat colour of transformers shall be to Munsell notation N5Y-7/1.

Lifting lugs shall be provided, suitable for the weight of the transformer, including core and windings, fittings, and with the tank filled with oil. Each tank shall be provided with at least four jacking lugs, and where required, with lugs suitably positioned for transport on a beam transporter. Haulage lugs should also be provided to enable a cable to be used safely for haulage in any direction.

The base of each tank shall be so designed that it is possible to move the complete transformer unit in any direction without injury when using rollers, plates, or rails.

Transformers shall have wheel bases, unless otherwise specifically approved by the Engineer.

All joints, other than those that may have to be broken, shall be welded.

The tank and cover shall be designed in such a manner as to leave no external pockets in which water can lodge, no internal pockets in which oil can remain when draining the tank or in which air can be trapped when filling the tank, and to provide easy access to all external surfaces for painting.

Where cooling tubes are used, each tube shall be of heavy gauge steel welded into the tank sides, top and bottom.

Each tank cover shall be of adequate strength, must not distort when lifted and shall be provided with suitable flanges having sufficient and properly spaced bolts. Inspection openings shall be provided to give access to the internal connections of bushings, winding connections and earthing links. Each opening shall be correctly located and must be of ample size for the purpose for which it is intended. All inspection covers shall be provided with lifting handles.

It must be possible to remove any bushing without removing the tank cover.

Pockets shall be provided for a stem type thermometer and for the bulbs of temperature indicators where specified. These pockets shall be located in the position of maximum oil temperature and it must be possible to remove any bulb without lowering the oil level in the tank. Captive screwed caps shall be provided to prevent the ingress of water to the thermometer pockets when they are not in use.

Where called for in the Schedule A of Requirements, accommodation shall be provided for outdoor weatherproof neutral current transformers.

A ladder shall be provided on one side of the tank as a means for inspection and access to the top of the transformer. The lower section of the ladder shall be equipped with a barrier complete with provision for locking with a padlock.

4.5.2 Conservator Tanks, Breathers and Air Dryers

Each transformer shall be provided with an overhead conservator tank formed of substantial steel plates and arranged above the highest point of the oil circulating system (see also Clause 4.6. 1). Connections into the main tank shall be at the highest point to prevent the trapping of air or gas under the main tank cover.

The capacity of each conservator tank shall be adequate for the expansion and contraction of oil in the whole system under the specified operating conditions. Conservator tanks shall also be provided with a cleaning door, filling cap, drain valve with captive cap and an oil level indicator with minimum and maximum levels indicated. The normal level at an oil temperature of 25˚C shall be indicated and the minimum and maximum levels shall also be correlated with oil temperature markings. The temperature markings shall preferably be integral with the level indicating device.

The location of the conservator tank shall be so arranged that it does not obstruct the passage of high voltage conductors immediately above the transformer.

The pipework between the conservator and the transformer tank shall comply with the requirements of Clause 4.6.1 and a valve shall be provided at the conservator to cut off the oil supply to the tank.

Each conservator shall be fitted with an air cell that shall be connected to a silica gel breather of a type that permits the silica gel content to be removed for drying. Due to the climatic conditions at site, this breather shall be larger than would be fitted for use in a temperate climate. All breathers shall be mounted at a height of approximately 1400 mm above ground level.

4.5.3 Valves

Each transformer shall be fitted with the following valves as a minimum requirement:

Main Tank

(A) One 50mm bore filter valve located near to the top of the tank.

(B) One 50 mm bore filter valve located near to the bottom of the tank and diagonally opposite to the filter valve required against (A). Where design permits, this valve may be combined with item (C).

(C) One 50mm drain valve with such arrangements as may be necessary inside the tank to ensure that the tank can be completely drained of oil as far as practicable. This valve shall also be provided with an approved oil sampling device.

(D) One valve between the main tank and gas actuated relay, complete with bypass facility to facilitate removal of relay and maintain oil flow.

Conservator

(E) One valve between the conservator and gas actuated relay for the main tank and, where appropriate, for the tap change diverter switch tank complete with bypass pipework for Buchholz relay to facilitate maintenance of the relay.

(F) One drain valve for oil conservator tank so arranged that the tank can be completely drained of all oil.

Tap Changer

(G) 50mm filter and 50mm drain valve where selector switches are contained in a separate tank.

Diverter Switch

(H) One drain valve to be fitted to each tank.

Radiators and Cooler Banks

(I) Valves at each point of connection to the tank and in accordance with Clauses 4.6.2 and 4.6.3.

The two valves (D) and (E) arrangement across the gas-actuated relay are to be connected with an oil pipework bypass facility to facilitate removal of the relay, due to failure etc., and still maintain the oil flow system between the conservator and main tank.

Blank flanges, plates or captive screw caps shall be fitted to all valves and pipe ends not normally connected in service.

The omission of any, or the provision of alternative arrangements to the above requirements, will not be accepted unless approved in writing by the Engineer before manufacture.

4.5.4 Joints and Gaskets

All joint faces shall be arranged to prevent the ingress of water or leakage of oil with a minimum of gasket surface exposed to the action of oil or air.

Oil resisting synthetic rubber gaskets are not permissible except where the synthetic rubber is used as a bonding medium for cork, or similar material, or where metal inserts are provided to limit compression.

Gaskets shall be as thin as possible consistent with the provision of a good seal and full details of all gasket sealing arrangements shall be shown on the Plant drawings.

4.5.5 Pressure Relief Device

An approved pressure relief device of sufficient size for the rapid release of over pressure that may be generated in the tank, and designed to operate at a static pressure lower than the hydraulic test pressure called for in Section 15, shall be provided. It shall be of the spring operated valve type ("Qualitrol" or equivalent) and shall be provided with one set of normally open signalling contacts that will be used for trip alarm purposes.

The relief device is to be mounted on the tank cover and is to be provided with a skirt to project at least 25mm into the tank to prevent gas accumulation. Discharge of oil shall be directed away from the transformer top cover and clear of any operating position. Means shall be provided to direct the oil discharge to the oil collecting pit.

4.5.6 Earthing Terminals

Two substantial steel flag type terminals each having two 14mm diameter holes on 55mm centres shall be located one on either side and near to the bottom of the transformer to facilitate connection to the local earthing system.

4.5.7 Rating, Diagram and Valve Plates

The following plates, or an approved combined plate, shall be fixed to each transformer tank at an average height of 1500mm above the ground level:-

(A) A rating plate bearing the data specified in IEC 60076 Part 1. This plate shall also include the short-circuit current rating and time-factor for each winding.
(B) A diagram plate showing in an approved manner the internal connections and the voltage vector relationship of the several windings, in accordance with IEC 60076 Part I with the transformer voltage ratio for each tap and, in addition, a plan view of the transformer giving the correct physical relationship of the terminals.
(C) A plate showing the location and function of all valves and air release cocks or plugs. This plate shall also if necessary warn operators to refer to the Maintenance Instructions before applying vacuum.

Plates are to be of stainless steel or other approved material capable of withstanding the rigours; of continuous outdoor service at site.

4.6 Cooling Plant

4.6.1 Cooling Plant General

Radiators and coolers shall be hot-dip galvanised, designed so that all painted surfaces can be thoroughly cleaned and easily painted in situ with brush or spray gun. The design shall also avoid pockets in which water can collect and shall be capable of withstanding the pressure tests specified in Section 15 for the transformer main tank.

The clearance between any oil or other pipework and live parts shall be not less than the minimum clearances stated in the Schedule of Requirements.

4.6.2 Radiators Connected Directly to Tank

Where built-on radiators are used, each radiator shall be connected to the main tank through flanged valves. Plugs shall be fitted at the top of each radiator for air release and at the bottom for draining.

A valve shall be provided on the tank at each point of connection to the tank.

4.6.3 Cooler Banks

Each cooler bank shall be provided with:

(A) A valve at each point of connection to the tank.
(B) A valve at each point of connection of radiators.
(C) Loose blanking plates for blanking off the main oil connections.
(D) A 50mm filter valve at the top of each cooler bank.
(E) A 50mm drain valve at the lowest point of each interconnecting oil pipe.
(F) A thermometer pocket, fitted with captive screw cap, in the inlet and in the outlet oil pipes.

(G) Air release and drain plugs on each radiator.

The omission of any, or the provision of alternative, arrangements to the above requirements will not be accepted unless approved in writing by the Engineer before manufacture.

4.6.4 Forced Cooling

The type of forced cooling shall be as stated in the Schedule of Requirements.

Forced cooling equipment for transformers of similar rating and design shall be completely inter-changeable, one with the other, without modification on site.

4.6.5 Oil Pipes and Flanges

All oil piping necessary for the connecting of each transformer to its conservator, cooler banks etc. shall be supplied and erected under this contract.

The oil piping shall be of approved material with machined flanged joints. Copper pipework is to comply with BS 61.

Dimensions of steel pipes shall be in accordance with BS 3600 and the drilling of all pipe flanges shall comply with BS EN 1092.

An approved expansion piece shall be provided in each oil pipe connection between the transformer and each oil cooler bank.

All necessary pipe supports, foundation bolts and other attachments are to be provided.

It shall be possible to drain any section of pipework independently of the rest and drain valves or plugs shall be provided as necessary to meet this requirement.

4.6.6 Air Blowers

Air blowers for forced air cooling shall be of approved make and design and be suitable for continuous operation out-of-doors. They shall also be capable of withstanding the stresses imposed when brought up to speed by the direct application of full line voltage to the motor.

To reduce noise to the practical minimum, motors shall be mounted independently from the coolers or, alternatively, an approved form of anti-vibration mounting shall be provided.

It shall be possible to remove the blower, complete with motor, without disturbing or dismantling the cooler structure framework.

Blades shall be of material subject to approval.

Blower casings shall be made of galvanised steel of thickness not less than 2.6mm (14 S.W.G.) and shall be suitably stiffened by angles or tees.

Galvanised wire guards with mesh not exceeding 12.5mm shall be provided to prevent accidental contact with the blades. Guards shall also be provided over all moving parts. Guards shall be designed such that blades and other moving parts cannot be touched by test fingers to IEC 60529.

4.6.7 Cooler Control

Where forced cooling using multiple small single-phase motors is employed, the motors in each cooling bank shall be grouped so as to form a balanced three-phase load.

Each motor or group of motors shall be provided with a three-pole electrically operated contactor and with control gear of approved design for starting and stopping manually.

Where forced cooling is used on transformers, provision shall be included under this contract for automatic starting and stopping from contacts on the winding temperature indicating devices as specified. The control equipment shall be provided with a short time delay device to prevent the starting of more than one motor, or group of motors in the case of multiple cooling, at a time.

Where motors are operated in groups, the group protection shall be arranged so that it will operate satisfactorily in the event of a fault occurring in a single motor.

The control arrangements are to be designed to prevent the starting of motors totalling more than 15kW simultaneously, either manually or automatically. Phase failure relays are to be provided in the main cooler supply circuit.

All contacts and other parts that may require periodic renewal, adjustment or inspection shall be readily accessible.

All wiring for the control gear accommodated in the marshalling kiosk, together with all necessary cable boxes and terminations and all wiring between the marshalling kiosk and the motors, shall be included in the contract.

An alarm of indicating "Transformer Cooling Fault" is to be provided and initiated in the event of any ventilation/cooling motor trip, or failure of either main or control supplies.

4.7 Voltage Control

4.7.1 General

Transformers shall be provided with tap changers for varying the effective transformation ratio. Control schemes shall utilise voltage derived from the 400V, 3 phase, 4 wire system. Phase failure relays shall be provided to ensure a secure supply.

Winding taps as called for in the Schedule A of Requirements shall be provided on the high voltage winding.

All terminals shall be clearly and permanently marked with numbers corresponding to the cables connected thereto.

Tap positions shall be numbered consecutively, ranging from one upwards. The tap positions shall be numbered so that by raising the tap position the LV voltage is increased.

4.7.2 On-Load Tap Changers

General

On-load tap changers shall be from **MR Germany** or **ABB Sweden** make, oil immersed or vacuum type, and comply with IEC 60214-1 and shall be suitable for power flow in both directions. Only designs that have been type-tested in accordance with these standards will be accepted. Tap changers in auto-transformers shall be located between the HV and LV windings.

The OLTC shall be installed inside the main tank.

Current making and breaking switches associated with the tap selectors or otherwise where combined with tap selectors shall be contained in a tank in which the head of oil is maintained by means completely independent of that on the transformer itself. Details of maintaining oil separation, oil levels, detection of oil surges and provision of alarm or trip contacts will be dependent on the design of tap-changer and be to the approval of the Engineer.

Mechanisms

The tap change mechanism shall be designed such that when a tap change has been initiated, it will be completed independently of the operation of the control relays and switches. If a failure of the auxiliary supply during tap change or any other contingency would result in that movement not being completed an approved means shall be provided to safeguard the transformer and its auxiliary equipment.

The driving motor shall be rated 400/230V ac and shall be equipped with thermal and over load protection located in the motor drive cubicle. Proper working of the drive motor shall be ensured up to 25% below the rated voltage.

Limit switches shall be provided to prevent over-running of the tap changing mechanism. These shall be directly connected in the operating motor circuit. In addition, mechanical stops shall be fitted to prevent over-running of the mechanism under any conditions. For on-load tap change equipment these stops shall withstand the full torque of the driving mechanism without damage to the tap change equipment.

Thermal devices or other approved means shall be provided to protect the motor and control circuit.

A permanently legible lubrication chart shall be provided and fitted inside the tap change mechanism chamber.

Local and Remote Control

Equipment for local manual and electrical operation shall be provided in an outdoor cubicle complying with Section 2. A thermostat controlled anti-condensation heater is to be provided in the cubicle. Electrical remote control equipment shall also be supplied as specified in the Schedule A - Schedule of Requirements.

The following operating conditions are to apply to the on-load tap changer controls:

(A) It must not be possible to operate the electric drive when the manual operating gear is in use.
(B) It must not be possible for two electric control points to be in operation at the same time.
(C) Operation from the local or remote control switch shall cause one tap movement only, unless the control switch is returned to the off position between successive operations.
(D) It must not be possible for any transformer operating in parallel with one or more transformers in a group to be out of step with the other transformers in the group. Any deviation in the position of tap changers has to stop further function of the AVR. (Out of step protection)
(E) All electrical control switches and local manual operating gear shall be clearly labelled in an approved manner to indicate the direction of tap changing, i.e. raise and lower tap number.
(F) Emergency stop push-button at local and remote control positions.

Indications

Apparatus of an approved type shall be provided on each transformer:

(A) To give indication mechanically at the transformer and electrically at the remote control point of the number of the tapping in use.
(B) To give electrical indication, separate from that specified above, of tap position at the remote supervisory point.
(C) To give indication at the remote control point and at the supervisory control point that a tap change is in progress; this indication to continue until the tap change is completed.
(D) To give indication at the remote control point and at the supervisory control point when the transformers operating in parallel are operating out of step.
(E) To indicate at the tap change mechanism the number of operations completed by the equipment.

Oil Treatment

Each tap changer is to be equipped with a stationary on-line oil filter facility, complete with time switch control in case of oil type switches used.

4.7.3 Automatic Voltage Control

Automatic control shall be suitable for control of transformers in parallel. In addition to the methods of control covered by Clause 4.7.2, the following methods shall also be provided.

(A) Automatic Independent - It shall be possible to select automatic independent control for each transformer irrespective of the method of control selected for any other of the associated transformers.
(B) Automatic parallel - It shall be possible to select any transformer for master or follower control.

It must not be possible to operate any tap changer by supervisory, remote or local electrical hand control while the equipment is switched for automatic operation.

4.7.4 Voltage Regulating Relays

Automatic voltage control shall be initiated by a voltage regulating relay of an approved type and suitable for flush mounting. The relay shall operate from the nominal reference voltage stated in the Schedule of Requirements derived from a circuit mounted LV voltage transformer having Class 1.0 or 0.5 accuracy to IEC 60044-5 (for capacitive) IEC 60044-2 (for inductive) and the relay voltage reference balance point shall be adjustable.

The relay bandwidth shall preferably be adjustable to any value between 1.5 times and 2.5 times the transformer tap step percentage, the nominal setting being twice the transformer tap step percentage.

The relay shall be insensitive to frequency variation between the limits of 47Hz and 51Hz. The relay shall be complete with a time delay element adjustable between 10 and 120 seconds. The relay shall also incorporate an under voltage blocking facility which renders the control inoperative if the reference voltage falls below 80 percent of the nominal value with automatic restoration of control when the reference voltage rises to 85 percent of nominal value.

On each transformer the voltage transformer supply to the voltage regulating relay shall be monitored for partial or complete failure. The specified indicating lamp and alarm will be inoperative when the circuit breaker controlling the lower voltage side of the transformer is open and also that when the tap changer is on control other than automatic control.

4.7.5 Remote Control Panels

The remote control panels specified in the Schedule A of Requirements shall be floor mounted sheet steel cubicles of approved type, layout and colour to Munsell notation 5Y-7/1 and shall be provided for each transformer. Each shall form a complete enclosure with lockable rear doors and shall be fitted with interior lamp, door switch, heaters, cable gland plates for bottom entry of cables and all other equipment to provide the features specified, the standard requirements (which may be varied to suit Manufacturer's design) being as follows:

- Instruments:
  - Voltmeter (voltage at the low voltage terminals of the transformer)
  - Tap position indicator with integral or separate scale to indicate the no-load (LV) Voltage in kV appropriate to each winding tap.
- Relays:
  - Automatic voltage control
- Controls:
  - Automatic/Non-automatic voltage control selector switch
  - Remote/Supervisory tap change control selector switch
  - Pistol grip selector switch with centre zero
  - Independent/Master/Follower selector switch
  - AVR voltage reference adjuster
- Indications and Alarms:
  - Tap change in progress - white lamp
  - Tap change out of step - amber lamp
  - Tap change incomplete - amber
  - Tap change control on "local"
  - Tap change control on auto/manual
  - Group 1 Air forced cooling equipment running - white

- Group 1 Air forced cooling overcurrent alarm - amber
- Group 2 Air forced cooling equipment running - white
- Group 2 Air forced cooling overcurrent alarm - amber
- Forced cooling failure-amber lamp
- VT Fail alarm - amber
- Supply voltage to OLTC failure - amber lamp

Remote control schemes shall be entirely suitable for operation with the distance between the transformer and remote control panels as shown on the Specification drawings.

4.7.6 Off-Load Tap Changers

The off-circuit tappings as specified in the Schedule of Requirements shall be provided on the higher voltage windings for a variation of no-load primary voltage as specified.

Off-load tap-changing shall be carried out by means of an external hand-operated tapping switch mounted on the side of the tank. All phases of the tapping switch must be operated by one hand wheel.

The tapping switch shall have a spring-loaded captive bolt or other approved means on the moving part that positively locates the switch correctly at each tapping position. This bolt must be lockable at each tapping position and shall be provided with a suitable padlock and keys. Moving the switch from one tapping position to another shall require that the bolt be withdrawn by hand from its locating socket on the transformer tank against the spring pressure.

Tap-position numbers corresponding to the tapping switch bolt-locating sockets shall be cast or engraved in a metal indication plate fixed to the tank and a keyed metal pointer on the tapping switch operating handle shall show clearly at which tapping number the transformer is operating.

All tap-position indicators shall be marked with one integer for each tap position, beginning at number 1. Adjacent taps shall be numbered consecutively in such a manner that when moving a tap to a new tapping position that has a higher number, the no-load output voltage of the untapped winding increases.

4.8 Supervisory Control

4.8.1 Requirements

Transformer tap change control will be effected from the substation control room with facilities for remote control from the Load Despatch Centre. All necessary connections, indications, auxiliary switches, relays and changeover switches to meet supervisory control requirements shall be provided and connected under this contract to terminal blocks in the remote control panels. The supply and installation of the multicore control cables between the remote control panels and the plant/telecontrol interface cubicle shall be provided under the contract.

The following supervisory facilities are required:

Controls:

i) Supervisory selection of auto/non-auto voltage control.
ii) Tap change raise/lower by direct operation of tap changer.
iii) Tap change blocking on/off.
iv) Remote/supervisory selection "override".
v) Parallel/independent control.

Indications and Alarms:

i) Tap position indication by means of transducer with 4-20 mA d.c. output range proportional to step increment.
ii) Tap change out of step alarm.
iii) Buchholz and winding temperature non-trip alarm.
iv) Tap change control on Local/Supervisory.
v) Parallel/independent, master/follower.
vi) Tap change blocking on/off.
vii) Tap change control on automatic/manual.

All contacts for supervisory alarms and indications shall be potential free.

4.9 Terminal Bushings and Connections

4.9.1 General

Where stated in the Schedule of Requirements, transformers are to be provided with outdoor type bushing insulators.

All bushings shall comply with IEC 60137 and the minimum creepage distance for outdoor bushings shall not be less than 25mm per kV of rated voltage between phases.

Outdoor bushing insulators shall be provided with adjustable arcing horns and for rated voltages of 33kV and lower these shall be of the duplex gap type.

Bushings shall be of sealed construction suitable for service under the very humid conditions at Site and, addition, for the very rapid cooling of equipment exposed to direct sunlight when this is followed by sudden heavy rainstorms.

Typical sections of bushing insulators showing the internal construction, method of securing the top cap and methods of sealing shall be included in the Bid.

The 230kV and 132kV outdoor bushings shall be oil impregnated paper insulated condenser type and have no communication with the oil in the transformer. An oil gauge shall be provided to indicate that the correct level is maintained. 33kV bushings shall be oil filled or solid type.

Completely immersed bushings and lower voltage outdoor immersed bushings may be of other type of construction, subject to the approval of the Engineer but bushings of resin bonded paper construction are not permitted.

On all condenser bushings a tapping shall be brought out to a separate terminal for testing purposes on site.

Special precautions shall be taken to exclude moisture from paper insulation during manufacture, assembly, transport and erection.

4.9.2 Porcelain

Hollow porcelain shall meet the test requirements of IEC 60233 and shall be sound, free from defects and thoroughly verified. Designs based on jointed porcelains will not be acceptable. The glaze must not be depended upon for insulation. The glaze shall be smooth, hard, of a uniform shade of brown and shall cover completely all exposed parts of the insulator. Outdoor insulators and fittings shall be unaffected by atmospheric conditions producing weathering, acids, alkalis, dust and rapid changes in temperature that may be experienced under working conditions.

The porcelain must not engage directly with hard metal and, where necessary, gaskets shall be interposed between the porcelain and the fittings. All porcelain clamping surfaces in contact with gaskets shall be accurately ground and free from glaze.

All fixing material used shall be of suitable quality and properly applied and must not enter into chemical action with the metal parts or cause fracture by expansion in service. Cement thicknesses are to be as small and even as possible and proper care is to be taken to centre and locate the individual parts correctly during cementing.

All porcelain insulators shall be designed to facilitate cleaning.

4.9.3 Marking

Each porcelain insulator shall have marked upon it the Manufacturer's name or identification mark and year of manufacture. These marks shall be clearly legible after assembly of fittings and shall be imprinted before firing, not impressed.

When a batch of insulators bearing a certain identification mark has been rejected, no further insulators bearing this mark shall be submitted and the Contractor shall satisfy the Engineer that adequate steps will be taken to mark or segregate the insulators constituting the rejected batch in such a way that there can be no possibility of the insulators being re-submitted for the test or supplied for the use of the Employer.

Each complete bushing shall be marked with the Manufacturer's name or identification mark, year of manufacture, serial number, electrical and mechanical characteristics in accordance with IEC 60137:1973.

4.9.4 Mounting of Bushings

Bushing insulators shall be mounted on the tank in a manner such that the external connections can be taken away clear of all obstacles. Neutral bushings shall be mounted in a position from which a connection can be taken to a neutral current transformer mounted on a bracket secured to the trans-

former tank. The current transformer will be supplied by the switchgear Manufacturer but provision shall be made on the tank for mounting to the Engineer's requirements.

The clearances from phase to earth must not be less than those stated in the Schedule A of Requirements.

A flexible pull-through lead suitably sweated to the end of the winding copper shall be provided for the bushings and is to be continuous to the connector that is housed in the helmet of the bushings.
When bushings with an under-oil end of a re-entrant type are used the associated flexible pull-through lead is to be fitted with a suitably designed gas bubble deflector.

The bushing flanges must not be of re-entrant shape that may trap air.

Clamps and fittings made of steel or malleable iron shall be galvanised and all bolt threads are to be greased before erection.

4.10 Auxiliary Power and Control Cables

4.10.1 Scope of Supply

This Contract includes the supply, installation and termination of the necessary auxiliary power and control cables within items of plant supplied under the contract.

The Contractor shall produce, during the currency of the contract and in any case, before shipment of plant commences, detailed cable core schedules for each transformer.

4.10.2 General

Auxiliary power and control cables shall have copper conductors, PVC insulated, armoured and PVC sheathed overall. The cable design shall generally be in accordance with BS 6346 and Section 6 of this Specification.

All cables installed under the contract shall utilise compression glands of type El to BS.6121 or otherwise designed to secure armour wires and bond them to earthed metal and to provide seals between sheath and gland and between inner sheath and threaded fixing component.

The Contractor shall supply and fit the compression gland and make off individual cores on to the terminal boards, including the supply and fitting of numbered markers on each core.

4.11 Temperature and Alarm Devices

4.11.1 Temperature-Indicating Devices and Alarms

The transformers shall be provided with approved devices of Kilhstrom or equivalent for indicating the top oil temperature and hottest spot winding temperatures. The devices shall have a dial type indicator and, in addition, a pointer to register the highest temperature reached. Each winding temperature device shall have four separate contacts fitted, two of which shall be used to control the two groups of cooling plant motors (i.e. AF1 and AF2), one to give an alarm and one to trip the associated circuit breakers.

To simulate indication of the hottest spot temperature of the winding the device shall comprise a current transformer associated with one phase only and a heating device designed to operate continuously at 130 percent of transformer CMR current and for 30 minutes at 150 percent of CMR current, associated with a sensing bulb installed in an oil tight pocket in the transformer top oil.
The winding temperature indicators (WTI) shall be housed in the marshalling cubicle. The tripping contacts of the winding temperature indicators shall be adjustable to close between 80˚C and 150˚C and to re-open when the temperature has fallen by not more than 5˚C.

The alarm contacts and the contacts used to control the cooling plant motors on the above devices shall be adjustable to close between 50˚C and 100˚C and to re-open when the temperature has fallen by a desired amount between 5˚C and 10˚C.

All contacts shall be adjustable to a scale and must be accessible on removal of the relay cover. Alarm and trip circuit contacts shall be suitable for making or breaking 150 VA between the limits of 30 volts and 250 volts AC or DC and of making 500 VA between the limits of 110 and 250V DC. Cooler motor control contacts shall be suitable for operating the cooler contactors direct or, if necessary, through an interposing relay.

The temperature indicators in the marshalling kiosk shall be so designed that it is possible to move the pointers by hand for the purpose of checking the operation of the contacts and associated equipment.

The working parts of the instrument shall be made visible by the provision of cut-away dials and glass-fronted covers and all setting and error adjustment devices shall be easily accessible.

Connections shall be brought from the device to terminal boards placed inside the marshalling cubicle.

Terminals, links and a moving iron ammeter shall be provided in the marshalling kiosk for each WTI for:

(A) Checking the output of the current transformer.
(B) Testing the current transformer and thermal image characteristics.
(C) Disconnecting the bulb heaters from the current transformer secondary circuit to enable the instrument to be used as an oil temperature indicator. Links shall be provided as shown on the drawing enclosed with this Specification.

4.11.2 Gas and Oil-Actuated Relays

Each transformer shall be fitted with gas and oil-actuated relay equipment having alarm contacts that close on collection of gas or low oil level, and tripping contacts which close following oil surge conditions.

Each gas and oil-actuated relay shall be provided with a test cock to take a flexible pipe connection for checking the operation of the relay.

Each relay shall be fitted with a calibrated glass window for indication of gas volume.

To allow gas to be collected at ground level, a small bore pipe shall be connected to the gas release cock of the gas and oil-actuated relay and brought down to a point approximately 1400MM above ground level, where it shall be terminated by a cock which shall have provision for locking to prevent unauthorised operation.

The design of the relay mounting arrangements, the associated pipework and the cooling plant shall be such that mal-operation of the relay will not take place under normal service conditions, including starting or stopping of oil circulating pumps, whether by manual or automatic control under all operating temperatures.

The pipework shall be so arranged that all gas arising from the transformer will pass into the gas and oil-actuated relay. The oil circuit through the relay must not form a delivery path in parallel with any circulating oil pipe, nor is it to be teed into or connected through the pressure relief vent. Sharp bends in the pipework shall be avoided.

When a transformer is provided with two conservators, the gas and oil-actuated relays shall be arranged as follows:

a) If the two conservators are connected to the transformer by a common oil pipe, one relay shall be installed in the common pipe.
b) If the two conservators are piped separately to the transformer, two relays shall be installed, one in each pipe connection.

The clearance between oil pipework and live metal shall be not less than the minimum clearances stated in the Project Requirements of Section 1.

4.12 Shipment and Drying Out

4.12.1 Shipment

Each transformer, when prepared for shipment, shall be fitted with a shock indicator or recorder which shall remain in situ until the transformer is delivered to site. In the event that the transformer is found to have been subjected to excessive shock in transit, such examination as is necessary shall be made in the presence of the Engineer.

Where practicable, transformers shall be shipped with oil filling to cover core and windings but, when shipped under pressure of gas, shall be fitted for the duration of delivery to Site and for such time thereafter as is necessary, with a gauge and gas cylinder adequate to maintain internal pressure above atmospheric.

All earthing transformers shall be shipped full of oil.

4.12.2 Drying Out

All transformers shall be dried out by an approved method at the Manufacturer's works and so arranged that they might be put into service without further drying out on site.

Clear instructions shall be included in the Maintenance Instructions regarding any special precautionary measures (e.g. strutting of tap changer barriers or tank cover) which must be taken before the specified vacuum treatment can be carried out. Any special equipment necessary to enable the transformer to withstand the treatment shall be provided with each transformer.

4.12.3 Fire Protection System

4.12.3.1 General

The new 230/132/33kV,225/300MVA, ONAN/ONAF autotransformers shall be provided with Nitrogen Injection Fire Protection System (NIFPS). General description, design and performance requirements of the NIFPS is given below. It is not intended to completely specify all details of design and construction. Nevertheless, the system design and equipment shall conform in all respects to high standard of engineering, design and workmanship.

The system design shall also conform to TAC / NFPA norms. The offered system shall comply with the relevant international standards. Reference standards are listed below. Relevant international standards other than BS standards shall be subject to approval by the Employer:

4.12.3.2 BS Standards

BS 381 C	Colours for Identification, Coding & Special Purpose
BS 7629-1	Specification for 300/500 V fire resistant electric cables having low emission of smoke and corrosive gases when affected by fire.
BS 8434-1	Methods of test for assessment for power integrity of electric cables

BS 5839-1	Code of practice system design, installation, commissioning and maintenance for fire detection and fire alarm system
BS EN50267-2-1	Common Test Methods for Cables Under Fire Conditions

The fire protection system shall have been in successful operation in for at least last three years for protection of transformers of 230/132/33 kV and higher voltage class. The reference list along with performance certificate from end users of the system shall be submitted with the bid.

The system shall be reliable without making any mal operation. Even if undesirable nitrogen gas injection is made into the transformer tank under normal transformer condition without the internal faults, restoration of transformer by vacuum oil purification up to re-energizing shall complete as soon as possible after the undesired gas injection.

In case of an event of the control power failure, the system shall be able to be operated manually. Various equipment to perform the required fire protection shall be provided under this contract.

4.12.3.3 Nitrogen Fire Fighting System

The Contractor has to make necessary provisions (in consultation with the Supplier of the NIFPS) for the satisfactory operation of the nitrogen fire-fighting system without affecting the overall performance of the transformer. Oil filled autotransformers shall be provided with an appropriate NIFPS for the following ratings: 230/132/33 kV, 225/300 MVA, ONAN/ONAF.

The fire protective system shall prevent the explosion of the transformer oil tank and a possible fire in case of internal faults. In the event of fire by external causes such as bushing fire, OLTC fires, fire from surrounding equipment etc., it shall act as a fast and effective fire fighter. It shall accomplish its role as fire preventer and extinguisher without employing water and/or carbon dioxide.

Fire shall be extinguished within 3 minutes (maximum) of system activation and within 30 seconds (maximum) of commencement of nitrogen injection.

Activation of the Fire Protective System

Mal-functioning of fire prevention / extinguishing system could lead to an interruption in power supply. The Bidder shall ensure that the probability of malfunctioning of the fire protective system is practically zero. To achieve this objective, the Bidder shall plan out his scheme of activating signals which should not be too complicated to make the fire protective system inoperative in case of actual need. The system shall be provided with automatic control for fire prevention and fire extinction. Besides automatic control, remote electrical push button control at the control box and local manual control in the fire extinguishing cubicle shall also be provided. The following electrical signals are required for activating the fire protective system under prevention mode / fire extinguishing mode:

Auto Mode

- For prevention of fire:
  - differential relay operation
  - Buchholz relay paralleled with pressure relief valve or RPRR (rapid pressure rise relay)
  - tripping of all circuit breakers (on HV & LV/IV side) associated with transformer is the pre-requisite for activation of system
- For extinguishing fire
  - fire detector

- Buchholz relay paralleled with pressure relief valve or RPRR (rapid pressure rise relay)
- tripping of all circuit breakers (on HV &LV/IV side) associated with transformer is the pre-requisite for activation of system.

Manual Mode (Local / Remote)

- Tripping of all circuit breakers (on HV & LV/IV side) associated with transformer is the pre-requisite for activation of system

Manual Mode (Mechanical)

- The system shall be designed to be operated manually in case of failure of the power supply to the fire protection system

Description

The nitrogen injection fire protection system should be a dedicated system for each oil-immersed transformer. It should have a fire extinguishing cubicle (FEC) placed on a plinth at a distance of 5-10 m from transformer / reactor or placed next to the fire wall (if a fire-fighting wall exists).

The FEC shall be connected to the top of the transformer/reactor oil tank for depressurization of the tank and to the oil pit (capacity is approximately equal to 10% of the total volume of the oil in the transformer / reactor tank) from its bottom through oil pipes.

The fire extinguishing cubicle should house a pressurized nitrogen cylinder(s) which is connected at to the bottom of the transformer oil tank. The transformer conservator isolation valve (TCIV) is fitted between the conservator tank and the Buchholz relay. Cable connections are to be provided from the signal box to the control box in the control room, from the control box to the fire extinguishing cubicle and from the TCIV to the signal box. Fire detectors placed on the top of the transformer/reactor tank are to be connected in parallel to the signal box by fire-survival cables. The control box is also to be connected to the relay panel in the control room for receiving system activation signals.

Operation

On receipt of all activating signals, the system shall drain a pre-determined volume of hot oil from the top of the tank (i.e. top oil layer) through an outlet valve to reduce the tank's pressure by removing top oil and should simultaneously inject nitrogen gas at high pressure for stirring the oil at a pre-set rate, thus bringing down the temperature of the top oil layer.

The transformer conservator isolation valve blocks the flow of oil from the conservator tank in case of tank rupture / explosion or bushing bursting. Nitrogen occupies the space created by the drained out oil and acts as an insulating layer over the oil in the tank, thus preventing an aggravation of the fire.

System Components

The nitrogen injection fire protection system shall broadly consist of the components mentioned below. However, all other components which are necessary for fast, reliable and effective operation of the fire protection system are deemed to be included in the scope of supply.

- Fire Extinguishing Cubicle (FEC)
  The FEC shall be made of CRCA sheets of a minimum thickness of 3 mm, complete with the base frame, painted inside and outside with post office red colour (shade to be in line with BS: 381 C: 1988 - Colours for Identification, Coding and Special Purposes). It shall have hugged split doors fitted with high-quality tamper proof lock. The degree of protection shall be IP55. The following items shall be provided in the FEC.
  - a nitrogen gas cylinder with regulator and falling pressure electrical contact manometer
  - oil drain pipe with mechanical quick drain valve
  - electro-mechanical control equipment for draining of a pre-set volume of oil and for injecting a regulated volume of nitrogen gas
  - a pressure monitoring switch for back-up protection for nitrogen release
  - limit switches for monitoring of the system
  - a butterfly valve with flanges on the top of the panel for connecting the oil drain pipe and the nitrogen injection pipes for transformers
  - panel lighting (CFL type)
  - oil drain pipe extensions of suitable sizes for connecting the pipes to the oil pit
  - space heater
  - other items, if necessary

- Control box
  The control box shall be placed in the control room for monitoring system operation, automatic control and remote operation. The following alarms, indications, switches, push buttons, audio signal etc. shall be provided.
  - system on
  - TCIV open
  - oil drain valve closed
  - gas inlet valve closed
  - TCIV closed*
  - fire detector trip *
  - Buchholz relay trip
  - oil drain valve open*
  - extinction in progress *
  - cylinder pressure low *
  - differential relay trip
  - PRV / RPRR trip
  - transformer/reactor trip
  - system out of service *
  - fault in cable connecting fault fire detector
  - fault in cable connecting differential relay
  - fault in cable connecting Buchholz relay
  - fault in cable connecting PRV / RPRR
  - fault in cable connecting transformer /reactor trip
  - fault in cable connecting TCIV
  - auto / manual / off
  - extinction release on / off
  - lamp test
  - visual / audio alarm*
  - visual / audio alarm for DC supply fail *
  - space heater
  - others, if necessary

Suitable provisions shall be made in the control box for monitoring of the system from a remote substation using the substation automation system.

- Transformer Conservator Isolation Valve
  A transformer conservator isolation valve (TCIV) shall be fitted in the conservator pipeline, between the conservator and the Buchholz relay. It shall isolate the conservator during abnormal flow of oil due to rupture / explosion of tank or bursting of bushing. The valve shall not isolate the conservator during normal flow of oil during filtration or filling or refilling. Locking plates shall be provided with handle for pad locking. It shall have a proximity switch for remote alarm; indication shall be with visual position indicator.

- Fire Detectors
  The system shall be complete with an adequate number of fire detectors (quartz bulb) fitted on the top cover of the transformer / reactor oil tank.

- Signal Box
  The signal box shall be mounted away from the transformer's main tank, preferably near the transformer marshalling box, for terminating cable connections from TCIV & fire detectors and for further connecting them to the control box. The degree of protection shall be IP55.

- Cables
  Fire-survival cables (capable to withstand 750 °C) of 4 core x 1.5 mm² size for parallel connection of the fire detectors shall be used. They shall conform to BS 7629-1, BS 8434-1 and BS 5839-1, BS EN 50267-2-1 or relevant International standards.
  Fire-retardant low smoke (FRLS) cables of 12 core x 1.5 mm² size shall be used for connection of the signal box / marshalling box near the transformer and the FEC mounted near the transformer with the control box mounted in the control room. Such cables shall also be used for the connection between the control box and the DC and AC supply source, the fire extinguishing cubicle and the AC supply source, the signal box / marshalling box and the transformer conservator isolation valve connection on the transformer.

- Pipes
  Pipes complete with connections, flanges, bends and tees etc. shall be supplied along with the system.

- Other items
  - Oil drain and nitrogen injection openings with gate valves on transformer tank at suitable locations.
  - Flanges with dummy piece in conservator pipe between Buchholz relay and conservator tank for fixing TCIV.
  - Fire detector brackets on transformer / reactor tank top cover.
  - Spare potential free contacts for activating the system i.e. in differential relay, Buchholz relay, Pressure Relief Device / RPRR, Circuit Breaker of transformer/reactor
  - Pipe connections between transformer / reactor and FEC and between FEC and oil pit required for collecting top oil.
  - Cabling for fire detectors mounted on transformer /reactor top cover
  - Inter cabling between signal box, control box and Fire Extinguishing Cubicle (FEC).
  - Butterfly valves /Gate valves on oil drain pipe and nitrogen injection pipe which should be able to withstand full vacuum.
  - Supports, signal box etc. which are to be painted with enamelled paint.

Technical Particulars

- Fire extinction period from commencement of nitrogen injection: 30 s. (max.)
- Total duration from activation of fire protection system to complete cooling: 30 minutes (max.)
- Fire detectors' heat sensing temperature: 141 °C
- Heat sensing area per detector: Up to R = 800 mm
- Transformer Conservator Isolation valve setting (minimum): 60 litre / min
- Capacity of nitrogen cylinder (minimum water capacity): 68 litre
- Capacity of nitrogen cylinder (minimum gas capacity, at 150 kg/cm² pressure: 10 m³
- Power supply, for control box and for fire extinguishing cubicle for lighting: 110 V DC / 240 V AC

Mandatory Spare Parts - Per Substation

- Cylinder filled with nitrogen of required capacity per substation: 1 piece
- Fire detectors: 3 pieces
- Regulator assembly: 1 piece

Tests

Reports of all type tests conducted as per relevant IEC standards including test reports for the degree of protection for FEC / control box / signal box shall be submitted with the bid.

The performance test of the complete system shall be carried out after installation of the system on site. Detailed layout drawings, equipment drawing along with 4 sets of the operation and maintenance manual along with soft copies (on CDs) shall be submitted by the Contractor.

4.12.4 Water Spray System

The new power transformers 132/33 kV are to be equipped with the arrangements specified below:

One transformer water spray system.

To the water spray system is to be allowed one valve station including necessary control and monitoring cabinet, to be designed for manual, automatic and electrical remote operation and must be provided in free-standing and self-supporting design, with the following basic equipment:

- the required number of triggering and fire extinguishing nozzles, with galvanized pipes and mountings,
- the necessary galvanized connecting lines from the appropriate valve station to the nozzles pipe network,
- the necessary drainage valve, struts, diaphragms, sleeve valve, single chamber valve stations with all fittings and connections, pressure sensitive switches for signalling and air pressure drop with the possibility of extension by three transformer,
- the necessary tank feed pump,
- pressurizing air vessel for maintaining a reserve of fire-fighting water,

The pressurizing air vessel is to be designed for a minimum spraying time of 5 minutes and is to be fully equipped with all necessary fittings and connecting pipes, pressure controllers, low water level alarm, reducing valves and all other equipment essential for trouble-free operation.

The pressurizing air vessel is to be installed above ground.

Two air pressure units, rated pressure 10 bar, each provided with the following main equipment:

- 1 air compressor
- 1 400/230 V three-phase motor
- 1 flexible coupling
- 1 oil and water separator
- 1 non-return valve
- 1 vent and drain valve
- 1 pressure gauge

install complete on a sturdy base frame with all necessary anti-vibration mounts and fixing material.

One compressed air container, 1000 1, vertical type, welded with manhole, rated pressure matched to the water spray system including the following main fittings:

- 1 contact type pressure gauge
- 1 relief valve
- 1 pressure switch
- 1 drain valve

assembled completely and ready for operation, the volume of air being matched to the time sequence of the transformer extinguishing operation.

The necessary control cabinet, enclosure type IP 55, completely equipped with the following main items:

- 2 motor-protection switches, 400/230 V, 50 Hz coil voltage 230 V 50 Hz, auxiliary contactors and relays for optional operation of compressors 1 and 2 with switch controlling operation.

Positions

Manual 1- manual 2-0-auto 2

With terminal board and cable entry glands as well as the necessary local fault and indicator lamps and spare contacts for remove monitoring and the necessary interlock criteria.

One complete compressed air distribution system with the necessary signalling pressure gauges, contact pressure gauges, pressure relief valves, pressure gauge valves, drain valves, pressure reducing valves, hand-operated shut-off valves and copper piping in the diameters required for the compressed air distribution.

4.12.5 Fire Wall

A fire wall of suitable height shall be installed between the transformers to prevent transformers from the spread fire. The wall shall be made of reinforced concrete.

4.13 Transformer Oil and Treatment

4.13.1 Transformer Oil

The transformer oil shall be new, inhibited, naphthenic based mineral oil, free from additives. It shall be acid-refined and pre-treated and shall have properties complying with IEC 60296-class II. The Contractor shall supply the first filling of all insulating oil required for the operation of the Plant and, after treatment, a test shall be made in the Engineer's presence to prove that the breakdown voltage is at least 50kV at 2.5mm electrode gap.

4.13.2 Oil Treatment Plant

The Contractor shall supply oil treatment plant for the treatment of insulating oil for the initial filling of transformers at Site and handed over the same to Employer at the end of work.

The oil treatment plant is to be mounted on a steerable trailer equipped with pneumatic types, over-run and parking brakes and weatherproof canopy. The plant shall be capable of treatment of oil to IEC 60296 and IEC 60422, shall be of the replaceable paper filter type and shall have the following facilities:

(A) Oil treatment rate not less than 6000 litres per hour.
(B) Water extraction capability down to 5 ppm.
(C) Reduction of dissolved gas content to 1% by volume or less.
(D) Filtration level less than 1 micron.
(E) Oil transfer, vacuum pumps and heaters suitable for 40OV, 3 phase 50Hz, 4 wire, supply.
(F) Vacuum capability approximately 1 Torr.
(G) Facility to apply vacuum to transformer tank during oil filling.
(H) Two 15m lengths of wire reinforced hose coloured differently for clean and dirty oil.
(I) Facility for "closed loop" operation.
(J) One 20m length of power supply cable with plug and socket at the filter end only.

4.13.3 Oil Storage

As required by Clause 4.13. 1, the Contractor shall supply the first filling of transformer oil. It is envisaged that the oil will be supplied to site in 200kg drums and filtered by use of the plant described in the preceding paragraph into a storage tank prior to transfer again via filter plant into the transformer.

Storage tanks shall be painted internally and externally and shall be equipped with:

- 50mm top inlet and bottom outlets with blank flanges.
- 50mm drain valve.
- Oil level indicator.

- Manhole.
- Silica gel breather.

4.14 Auto-Transformers

4.14.1 General

Auto-transformers for interconnection between the 230kV and 132kV system shall comply with the general requirements of the Specification and the particular requirements of this Section.

The auto-transformers will be star connected and the system will be solidly earthed at each auto transformer neutral.

A delta connected stabilising winding shall be provided.

4.14.2 Continuous Maximum Rating

The auto-transformers shall have the continuous maximum rating stated in the Schedule A of Requirements and be provided with a delta connected tertiary winding capable of supplying the load stated in the Schedule of Requirements. No compensation shall be made to the rating of the series or common windings of the auto-transformer for any limitation in output consequent on the tertiary load but Schedule E shall be completed showing any restriction in 132 kV output, for conditions of input from the 235 kV system, with the tertiary power factors of their respective loads down to 0.8 lagging.

4.14.3 Impedance

Auto-transformers shall have an impedance between 235kV and 132kV windings as stated in the Schedule E of Particulars and Guarantees. The impedance on other tappings and between other windings shall be stated in the Schedule E of Particulars and Guarantees.

It is preferred that the equivalent zero sequence impedance of the auto-transformer, when viewed from the 235kV terminals and feeding a fault at the 132kV terminals, is not less than the positive sequence impedance between 235kV and 132kV terminals at normal ratio and normal rating. The value shall be stated in the Schedule of Particulars and Guarantees on the basis of system short circuit levels stated in the Schedule of Requirements.

4.14.4 Winding Terminations

Terminations of stabilising windings and neutral ends of windings shall be as follows:

i) Neutral ends of the three phase windings shall be connected at a point accessible from a hand hole in the cover and brought out via one bushing insulator.
ii) Stabilising winding terminations shall be brought out via oil/air bushings for connections in delta formation by means of busbar arrangement mounted on firewalls between transformers.

4.14.5 Tap Changing

Tap-changers are required between the 235 kV and 132 kV transformer windings. Tap-changers shall comply with Clause 4.7.2.

4.15 Earthing/Auxiliary Transformers

4.15.1 General

Earthing transformers shall comply with IEC 60289 and shall be of the oil immersed ONAN type suitable for outdoor installation. They are to have a main interconnected star winding brought out via oil/air terminal bushings, which will be directly connected to the lower voltage terminals of the associated system transformer.

The neutral point of the interconnected star winding shall be brought out of the tank through a bushing insulator. This point maybe isolated or connected to earth directly or through a resistance in order to provide an earthing point for the neutral of the system.

The earthing transformers shall have a secondary winding to supply the substation auxiliary load. The voltage ratio shall be 33/0.415kV. The star-connected secondary windings shall be arranged to give a three-phase, four wire supply with the star point solidly earthed. The secondary winding shall have a continuous rating of 200kVA as stated in the Schedule of Requirements and shall conform to IEC 60076.

4.15.2 Electrical and Short Circuit Characteristics

Earthing transformers will normally have their neutral points connected to earth via a resistance which limits earth fault current to the full load current at the associated power transformer. However, provision is made for solidly earthing the neutral points and, under this condition, the earthing transformers shall be capable of withstanding, both thermally and mechanically without damage, for a period of 2 seconds the application of normal three phase line voltage to the terminals of the interconnected star winding with one line terminal earthed. The current density of the winding under this condition shall not exceed 50A/mm².

In addition, the interconnected star winding of each earthing transformer, when at its maximum temperature due to continuous full load on the auxiliary winding, shall be designed to carry for 10 seconds without injurious heating an earth fault current in the neutral connection as specified. The current density under such conditions shall not exceed 23A/mm².

4.15.3 Tanks and Fittings

Earthing transformers shall be provided with the following fittings:

(A) Conservator vessel with removable end cover and prismatic oil gauge.
(B) Buchholz relay.
(C) One thermometer pocket with captive screw cap.
(D) Silica gel breather of the oil seal type with a minimum capacity of 1 kg.

(E) Pressure relief device.
(F) Filter valve and combined filter and drain valves.
(G) Oil sampling device.
(H) Rating plate.
(1) Tank earth terminals.
(J) Lifting lugs.

4.15.4 Secondary Windings

The three-phase, four-wire secondary windings shall be terminated at a three-pole MCCB unit with bolted neutral link and gland entry for a four-core solid dielectric cable. This shall be accommodated in a lockable, fully weatherproof compartment together with a neutral earthing link. The purpose of the neutral earthing link is to connect the 400V system neutral to earth. It shall be connected between the transformer winding end and a suitably located earthing terminal to which the system earth can be connected.

The windings shall be fitted with off-load tap changer to vary the voltage ±5 percent of the nominal open circuit value in 2.5 percent steps.

4.15.5 Terminal Connections

The 33 kV side of the earthing transformers shall be fitted with oil/air terminal bushings. The earth point connection to the neutral earthing resistor shall be via a 33 kV conductor.

4.16 Inspection and Testing

Tests shall be carried out in order to determine whether the material and equipment complies with the required properties. All tests on materials and equipment shall be made in accordance with IEC standards. Testing shall not impair the properties and reliability of a test object or reduce its lifetime. Test shall be performed at all power transformers.

4.16.1 Factory Acceptance Tests

Factory acceptance tests shall be carried out at the Manufacturer's laboratory, following a mutually agreed programme, in presence of Employer's authorized representatives.

Type Tests

The following type tests shall be conducted on the first power transformer of each type:

- Temperature rise test.
  The temperature rise test must be carried out in a manner that the highest losses are generated (tap changer in the highest loss position) and the reserve cooling unit is not in operation.

Routine Tests

Routine tests will be performed to detect defects in material or construction. They shall not impair the properties and reliability of any part being tested or reduce its lifetime. The following routine tests shall be performed:

- Visual inspection and dimension verification
- Power transformer tank oil leakage test
- Corrosion protection check
- Autotransformer tank vibration test
- Jacking pad test - checking of tank by lifting of power transformer
- Welding check after jacking pad test
- Oil dielectric strength
- Winding resistance measurement
- Transformation ratio measurements and winding connection verification
- Measurement of winding insulation resistance (before and after dielectric tests)
- Core insulation measurement (before and after dielectric tests)
- Switching impulse withstand voltage (SI)
- Impulse voltage test; primary voltage, secondary voltage, tertiary, including neutral point (LI)
- Impulse chopped voltage (LIC)
- Power frequency withstand voltage test, 50 Hz , 1 min (winding, core and secondary equipment)
- Short-duration induced AC withstand voltage test (ACSD) with monitoring of partial discharges.
- Long-duration induced AC withstand voltage test (ACLD) with measurement of partial discharges.
- Measurement of no load losses and no-load current at rated frequency before and after impulse test.
- Dissolved gas-in-oil analysis by chromatography prior to dielectric tests, after completion of dielectric tests and prior and after the temperature rise tests.
- Tap changer test for no load and short circuit conditions.
- Functional tests of protection devices and related equipment.

Special Tests

Within the factory acceptance test, the following special tests shall be performed:

- Noise level measurements, in line with the specifications of NEMA TR-1.
- Measurement of zero-sequence impedance.
- Measurement of no-load current harmonics.
- Measurement of magnetizing current.
- Measurement of power consumption for cooling system.
- Measurement of capacitance (C), factor of dielectric losses (tgδ), (before and after dielectric testing).
- Measurement of the mutual inductance of the winding.
- Sweep frequency response analysis (SFRA).
- Measurement of transferred overvoltages.

Note: The transformer's capability to withstand thermal and dynamic effects of short circuit without any damage should be presented by design analysis and calculation.

4.16.2 Site Tests

Tests During Installation

The following tests shall be performed during and after installation on the entire equipment in order to ensure correct assembly of the equipment as well as to prove that the equipment has been correctly installed:

- Verification of proper and complete erection
- Verification of the proper condition of porcelains, sealing and external surfaces
- Verification of proper connection to the earthing system
- Verification of transformer bolted connections by torque spanner
- Voltage tests of all electrical LV circuits
- Verification of the proper cabling and operation of all electrical LV equipment
- Verification of control and protection circuits and wiring.

Commissioning Tests

Main objective of the commissioning tests is to check proper and safe operation of the equipment, and in particular to verify and confirm the factory acceptance test results.

The following commissioning tests will be performed before putting the transformers into operation:

- Measurements of insulation resistances of windings and magnetic core.
- Capacitance (C), dielectric losses (tgδ) and winding inductance.
- Measurement of winding resistance at all tap changer positions.
- Measurement of voltage ratio at all tap changer positions and check of winding connection.
- Operation test of all protection units, measuring and alarm (signalling) units, Buchholz relay, contact thermometer, thermal image unit, etc.
- Operation test of cooling-system controls and alarms.
- Operation test of tap changer controls and alarms.
- Oil dielectric strength.
- Physical, chemical and electrical characteristics of oil.

5. Protection, Metering and Control

5.1 General

The protection and control facilities shall be suitable for the power system arrangement as shown on the bid drawings.

For standardisation of operating performance, facilities and spare requirements, the protection relays and control systems, together with complete panels to be supplied under this project shall be manufactured by Siemens (Germany), ABB (Switzerland/Sweden) or Alstom (France / UK).

The protection shall be sufficiently sensitive to cater for the minimum fault level condition. This will be advised later. The protection shall also be suitable for a system fault level equal to the switchgear rating of 50kA for 230 kV system and 40kA for 132 kV system. All current transformer design shall be based on these fault levels.

All relays shall operate correctly within system frequency limits of 47Hz to 51Hz.

Installation, testing and Commissioning of Control, protection and metering system shall be done by the Manufacturer(s) Engineer(s)

5.2 Fault Clearance Times

230 kV, 132 kV and 33 kV systems overall fault clearance times (i.e. from fault initiation to arc extinction) shall not exceed the following:

Type of Fault	**Maximum Fault Clearance Time**			
Nominal system voltage between phases	kV	230	132	33
Substation and transformer fault	msec.	100	120	160
Line faults:				
Up to 72% of the line length (i.e. 90% of a distance relay zone 1 reach setting of 80% of the line impedance)	msec.	100	120	160
72% of 100% of the line length where (@) plus protection signalling time	msec.	130	150	190

These requirements must be fulfilled under all system conditions including maximum dc current offset and any time delay. Clearance within these times shall be achieved for all types of faults except high resistance earth faults detected by DEF protection or under circuit breaker failure conditions.

5.3 Arrangement of Facilities

Control and relay equipment shall be mounted on panels and cubicles as specified and shall be installed in permanent buildings on the substation sites. The order of the panels shall follow the sequence shown on the drawings.

Panels provided as extensions or for erection in the same room as existing panels shall be of similar design and appearance to those existing. Equipment, meters, etc., mounted on such panels shall likewise be of style and scaling similar to the existing equipment. Characteristics of relays, etc., and all connections of equipment to be associated with existing equipment shall be such that they are fully compatible with and can operate satisfactorily in conjunction with the existing equipment. The characteristics and appearance of all such equipment shall be to the approval of the Engineer.

Backup Control panels shall incorporate all necessary control and indication facilities for the operation of the plant and equipment at the associated substation even in the case of failure of Substation Automation System. In addition, the plant may be remotely controlled and supervised from the National Load Despatch Centre (NLDC) in Dhaka.

The Gateway system for communication to the NLDC shall be supplied under this contract including all necessary items like auxiliary switches, relays and changeover switches etc. All circuits provided under this contract whether or not they are subject to the system control requirements at the present time, shall be designed and constructed so that the standard facilities specified can be readily provided as required in the future.

The Contractor shall be responsible for ensuring the correct operation of the protective equipment and shall submit for approval recommended relay settings supported by design calculations for all protective equipment being supplied. The Engineer reserves the right to ask the Contractor to get the design calculations approved by the Manufacturer of the Protection equipment and/or get the confirmation for the suitability of the particular protective relay for the proposed application. In case the proposed Protective relay is not suitable for the proposed application the Contractor shall change to a suitable relay as recommended by the Manufacturer without any cost implications to the Engineer.

5.4 Multi-Core Cable Diagrams

Diagrams of communication arrangements will be made available to the Contractor who will be required to coordinate the provision of necessary multi-core cabling. This contract includes the preparation of cabling schematic diagrams, showing the approved routing of cores in the various cables, and detailed cable schedules and connection diagrams for all the cables associated with each item of equipment.

5.5 Test and Earthing Facilities

Each control or relay panels shall be provided with a copper earth bar of not less than 150 sq.mm Cross-section and arranged so that the bars of adjacent panels can be joined together to form a common bus.

The common earthing busbar of control and relay panels shall be connected to the main station earthing system via a copper earthing connection of not less than 150 mm².

Software for testing the protection & control devices shall be included in the scope of supply. In addition, for secondary injection testing of the protection & control devices, provision shall be made in the panel for current & voltage injection using standard test set and disconnecting type terminal blocks with facility for short circuiting of current transformer secondary circuit etc. by means of movement of links from their normal operating position, or any other testing arrangement approved by the Engineer.

5.6 Protection Devices

Simplified arrangements of the main connections and protection for the various items of plant are shown in Bid Drawing.

Protection equipment shall be designed and applied to provide maximum discrimination between faulty and healthy circuits. All equipment is to remain inoperative during transient phenomena which may arise during switching or other disturbances to the system.

Current transformers, where possible, are to be located so as to include the associated circuit breaker within the protected zone and shall be located generally as indicated on the schematic drawings included in this Specification.

Transformer Buchholz, winding temperature and tap changer protective devices are to be supplied under this contract, and all necessary interposing relays, tripping relays and cabling associated with these devices shall be supplied and mounted under this contract.

5.7 Relays

5.7.1 General

Relays shall be of approved types complying with IEC 60255 or British Standard 142 and 5992, Parts 1,2 and 3 as appropriate, fully tropicalized, and shall have approved characteristics. **Relays designed identical to relays with a minimum of five years proven field experience will only be accepted**. Supply record of proposed relays shall be furnished for the last five years. The Engineer will reject any design he considers unsatisfactory or having insufficient field experience. All the **protective relays shall be numerical type only**. Numerical relays shall be configured in such a way that at least 2 nos. relays shall be provided for each feeder.

The protection relays, shall be located in conventional panels and shall be flush mounted in dust and moisture proof cases and of the draw out type with rear connections.

Relays shall be of approved construction and shall be arranged so that adjustments, testing and replacement can be effected with the minimum of time and labour. Relays of the hand reset type shall be capable of being reset without opening the case.

Electrically reset tripping relays shall be provided where necessitated by the system of control, such as for those circuits subject to remote supervisory control.

Relay contacts shall be suitable for making and breaking the maximum currents which they may be required to control in normal service but where contacts of the protective relays are unable to deal directly with the tripping currents, approved auxiliary contacts, relays or auxiliary switches shall be provided. In such cases the number of auxiliary contacts or tripping relays operating in tandem shall be kept to the minimum in order to achieve fast fault clearance times. Separate contacts shall be provided for alarm and tripping functions. Relay contacts shall make firmly without bounce and the whole of the relay mechanisms shall be as far as possible unaffected by vibration or external magnetic fields.

Relays, where appropriate, shall be provided with LED or flag indicators, phase coloured where applicable. LED or Flag indicators shall be of the hand reset pattern and shall be capable of being reset without opening the case. Where two or more phase elements are included in one case, separate indicators shall be provided for each element.

All Relay settings shall be visible and readable without having to remove the relay front cover. It shall not be possible to amend relay settings with the front cover in place; other than over a serial link.

If a connector for local use is provided this shall be accessible only after removing the front cover. Where a port is provided for permanent connection to a modem or other peripheral equipment, remote access shall be password protected.

Relays which rely for their operation on an external DC supply shall utilise for this purpose the trip supply of the associated circuit breaker trip coil. This supply shall be monitored and an alarm provided in the event of failure.

Any auxiliary supplies needed shall be drawn from the main station batteries and not from separate internal batteries in the protection equipment.

Relays, whether mounted in panels or not, shall be provided with clearly inscribed labels describing their function and designation in addition to the general purpose labels.

Attention is practically drawn to the tropical climate and relay designs should be entirely suitable for duty under full tropical conditions.

To minimise the effect of electrolysis, relay coils operating on DC shall be so connected that the coils are not continuously energised from the positive pole of the battery.

Relay shall be suitable for operation on 110 V nominal, 121 V float DC systems without the use of voltage dropping resistors or diodes

Numerical protection shall be designed in such a way that in case of a failure of DC auxiliary infeed, the full information need to be maintained at least 24 hrs. After a recovery of DC auxiliary infeed the last information and alarms will be displayed and the alarm "failure of DC auxiliary infeed" released. The relay reset shall not erase the relay memory.

The Numerical protection functions shall be in the form of software such that additional or different functions, application specific logic etc. can be readily implemented without changes to the existing hardware. It shall be possible to programme/ parameterize by a portable computer (PC) all the numerical protective relays and the entire relay operating and configuring software and the portable computers and other accessory equipment needed to communicate with the relays shall be provided.

All numerical relays shall be adequately protected against damage from incoming surge and shall meet relevant IEC, BS and ANSI SWC test standards. Relays shall utilise a DC-DC converter type regulated power supply to provide transient surge isolation between the station battery and protection equipment. Each DC supply shall be designed to protect it from high voltage and surge and provide electrically isolated contacts for annunciation.

In addition, to all equipment and components, the Contractor shall supply documents and calculations to prove the correct functioning of the equipment and he shall ensure and demonstrate that the setting range of relays and the operating limits of all equipment is suitable for the intended applications.

5.7.2 Electromagnetic Compatibility

In certain cases, e.g. distance protection, current differential etc., electronic relays, or devices utilising microprocessors are specified and electromagnetic devices will not be accepted.

Where such devices are required, they and the ancillary circuits connected to them, such as power supplies, current and voltage transformer secondaries, status or tripping or alarm circuits shall be designed to ensure that they are compatible for use in the hostile electrical environment found in an EHV substation.

Adequate steps, by means of suitable design, shall be taken to prevent Electromagnetic Interference (EMI) (generated by sources such as circuit breakers, disconnectors, lightning, radio or radar emissions, switching contactors in dc circuits etc.) or Electrostatic Discharges (ESD) from affecting relay performance or causing damage to components.

All relays offered must therefore have been type tested to meet the current requirements of IEC 60255 with respect to High Frequency disturbance, Fast Transients, Electrostatic Discharge, Radio Frequency Interference testing etc.

5.8 Overhead Line Protection

5.8.1 230 and 132 kV Transmission Line Protection

Protective devices for Main 1 and Main 2 overhead line protection are shown on Bid Drawing. These devices shall comply with the following.

Main 1 and Main 2 protection of 230 kV line shall be of distance protection with directional overcurrent to earth fault protection as a backup. The Main 1 & Main 2 protection of 132 kV line shall be distance and Directional overcurrent & Earth fault protection. Both main protections and directional earth fault protection operating in conjunction with tele-protection channels over optical fibre permissive underreach scheme of distance protection.

Each set of protection will be energised from separate current transformers and shall have facilities for independently tripping duplicated circuit breaker tripping coils and initiating auto-reclosing, breaker failure protection, inter-tripping, alarms, fault location equipment, disturbance recorders etc. The Contractor shall ensure that the relay contacts used for initiation of auto reclosing shall have the same dwell time as the main tripping contacts to avoid any problems arising from contact racing with the auto reclose relay.

Two sets of protection shall consist of different types of relays either from the same Manufacturer or from different Manufacturers. Separate elements shall be provided for phase and earth fault measurement. Separate elements shall also be provided for each zone. Phase and earth fault compensation features shall be incorporated to ensure accurate distance measurement for all types of fault and to allow for variation in the path of earth faults on the system.

Main Protection (Distance)

The main protection (Main-1 & Main-2 for 132 kV and Main-1 for 132 kV) shall be of numerical type and shall be provided by distance relays for use with a signalling channel.

The relay scheme offered shall be suitable for use in the permissive under-reaching, permissive over-reaching, blocking and unblocking modes. All these options shall be contained and selectable in the standard relay scheme. The relay should be applicable to all neutral ground possibilities and should be suitable for the protection of long or short overhead lines or cables, double circuit lines, heavily loaded lines, lines with weak infeeds etc.

The permissive overreach scheme shall operate in a permissive underreach/overreach transfer tripping mode with underreaching zone I elements and overreaching zone 2 elements and suitable logic to achieve fast tripping at the sending end in the event of a weak infeed at the receiving end. The weak infeed logic shall comprise a zone 3 element set to look in the reverse direction, which "echoes" back the received signal to the sending end if the reversed zone 3 comparator does not operate.

To provide high speed tripping when a line terminal is open a 'signal echo feature' shall be provided, which is initiated when either the feeder disconnector is open, or when the associated circuit breakers are open.

The Zone 1 elements will normally be set to approximately 80 per cent of the line impedance. They shall trip the local line circuit breaker.

The Zone 2 elements will be set to overreach the remote substation and in the case of permissive over-reaching mode operate in conjunction with teleprotection signalling channels to form a permissive over-reaching scheme. They shall also act as a back-up time delayed zone which trips the local circuit breaker. In the case of permissive under-reaching mode protection the overreaching Zone 2 unit will be used as the permissive element to permit instantaneous tripping of the local circuit.

The Zone 3 elements shall provide a further time delayed back-up zone.

Distance protection back-up zones shall also trip the remote end circuit breaker(s) via a direct inter-tripping channel.

Partially cross polarised mho or polygonal impedance characteristics relays are preferred for Zones 1 and 2 for 3-phase and 2-phase faults but other characteristics will be considered. Quadrilateral characteristics with adaptive reactance measurement to avoid overreach or underreach for resistive faults with pre fault load are preferred for earth faults. The relays shall operate for faults in the direction of the protected line only. Under no circumstances shall they operate for reverse faults even when the voltage supplied to the relay falls to zero on all three phases nor shall they operate due to the transient response of the capacitive voltage transformers following reverse close-up faults. Details of methods used for polarising the relays to deal with faults close to the relaying point shall be provided. Zone 3 shall be capable of being set as either directional or non-directional and shall be capable of being in-

dependently off set in both directions.

The reach of each zone and reverse element shall be individually adjustable by means of a multi-tap voltage transformer or other approved method. The characteristic angle shall be adjustable between approximately 40 and 80 degrees.

Where used in a permissive overreach transfer tripping scheme with weak infeed tripping the zone 3 unit may be set looking in the reverse direction. The reverse looking impedance/directional elements shall detect all reverse faults capable of being detected by the Zone 2 relay at the remote substation. Bidders shall explain how this is achieved.

Single pole tripping and auto-reclosing are being employed and the auto-reclosing scheme requirements are given in Section 5.11. The distance protection shall be suitable for such a scheme and the Contractor shall substantiate by calculation or other means that phase selective tripping will be achieved under the system conditions anticipated in the daily operation.

The Contractor may request whatever information he requires for carrying out the necessary calculations.

Auto reclosing shall be capable of being blocked for

i) any three phase fault
ii) any Zone 2 or Zone 3 time delayed trip
iii) carrier channel out of service
iv) DEF aided trip
v) DEF back up time delayed trip
vi) Switch on to fault.

The necessary circuitry shall be incorporated to inhibit the Zone 1 and Zone 2 phase fault elements when necessary during single phase to earth faults and during the single phase autoreclose dead time. These features shall be selectable by links or switches. Provision shall also be made to ensure that the earth fault elements reset during the single phase dead time.

The protection sensitivity shall be shown to be adequate for the minimum fault level conditions. These will be advised to the Contractor at a later stage.

Where fault resistance may be significant, the Contractor shall illustrate that the distance protection can cover such values taking fault current distribution and load conditions into account.

The operating time of each distance protection zone shall be substantially independent of fault current magnitude. The operating times shall be stated in the Schedule of Particulars and, in addition, curves shall be provided showing the effect of line and source impedance, fault position and operating current.

Under no circumstances shall any line protection operate because of normal system switching including de-energisation of the line.

A feature shall be incorporated to ensure instantaneous tripping in the event that the circuit breaker is closed onto a fault on a previously de-energised line.

Distance protection back-up Zone 2 and Zone 3 time delay setting ranges shall be 0.2 to 1.0 seconds and 0.5 to 3.0 seconds respectively.

A carrier receive signal extension timer with a delay on reset of 100 msec. shall be provided to ensure that relays at both ends of a parallel feeder circuit have sufficient time to trip for faults occurring in the end zones of the protected line.

A monitoring system shall be provided to supervise the voltage transformer supply to each set of distance protection. In the event of loss of one, two or three phases, the monitoring system shall inhibit relay operation and initiate an alarm. The VT supervision unit associated with the distance relay shall also inhibit the DEF protection in the event of VT fuse failure.

All relays shall incorporate indicators to show the relay tripped, zone indication and the phase or phases faulted. Indication must not be lost in the event of a supply failure.

Directional earth fault protection operating in a permissive overreach scheme shall be provided to cater for high resistance faults which cannot be detected by the distance protection. The same teleprotection signalling channel shall be used for the directional earth fault scheme and the distance protection scheme. An echo feature shall be included with the DEF Scheme and shall be subject to approval by the Engineer.

The directional relays shall be dual polarised i.e. polarised with zero sequence voltage and current. The relay sensitivity shall be adjustable between approximately 5 and 10% of rated current. A relay characteristic angle of 60 degrees is preferred but alternative angles will be considered. It is appreciated that because the 230 kV system zero sequence source is an auto transformer with a delta tertiary winding, that current polarising of a dual polarised relay is unreliable without careful analysis. The Contractor shall be responsible for determining whether such a current signal can be taken from the auto transformer neutral and safely used for polarising the relay within three months of being advised of all transformer impedance parameters.

The directional earth fault protection shall initiate three pole tripping. It must therefore include a short time delay to permit single pole tripping by the distance protection. Initiation of three pole reclosing following operation of a DEF aided trip shall be selectable by means of a switch.

Directional earth fault relays shall incorporate a back-up stage in addition to the aided tripping unit. The time delay range shall be 0.2 to 5.0 seconds or inverse time delayed with a characteristic to IEC 60255.

Neither the distance protection scheme nor the directional earth fault scheme shall mal-operate due to fault current reversal during sequential clearance of a fault on the parallel circuit.

The effect of zero sequence mutual coupling between the double circuit lines on the protection shall be described, together with any measures considered necessary to overcome this effect.

The distance protection time delayed back-up Zones 2 and 3 and the directional earth fault back-up stage shall intertrip the remote station circuit breakers over direct intertripping channels.

Auto reclosing shall not be initiated on receipt of direct intertripping signal. Direct intertripping shall also be initiated in the event of a 3 phase fault in any zone, or following a switch on to fault trip.

Distance relays shall be supplemented by power swing blocking relays. Power swing blocking relays shall be compatible with their appropriate distance relays, and for distance relays having offset mho zone 3 characteristics or starters shall comprise an offset mho characteristic which encompasses and is concentric with the distance relay impedance starter or zone 3 characteristic. Similarly where it is possible to shape the zone 3 or starter characteristic the power swing blocking relay characteristic shall also be capable of similar shaping. Where zone 3 is set reverse looking the power swing blocking characteristic shall be set such that it encompasses the forward looking zone 2 characteristic.

Facilities shall be provided to block zones 1, 2 and 3 of the distance relay from the power swing blocking logic as required.

Blocking logic shall be derived by determining the time taken for the apparent impedance of the power swing locus to pass from the characteristic of the power swing relay to the appropriate distance relay characteristic. Blocking shall not take place until the apparent impedance has passed through the two power swing characteristics and the set time delay has expired.

The associated time delay relay shall have a setting range of 50-250 ms.

Relays shall be of numerical or static design. Electromechanical relays will not be accepted. The Numerical relays shall be design with 16 bit Analogue to Digital converters, powerful Digital signal processors, CPU etc. The relay should have continuous self-supervision and diagnosis. A local display unit shall be provided on the front of the relay for measure and display, Distance to fault indication, diagnostics, etc. and also for acknowledging and resetting of latched outputs. The required software for setting and configuring the relay shall be provided with the relay and this man machine communication (MMC) shall be user friendly and should not require any special programming knowledge. It should be possible to do the settings off line and load the settings on to the relay with a standard portable PC with a fibre optic connection. A separate communication port shall be provided so that the distance relays can in future communicate with the Station monitoring system as well as easily be integrated into Station Control Systems. A PC with a man machine communication (MMC) software for setting of the relay shall be included in the scope of supply.

Reset times shall be low to ensure the associated distance relay reverts to its normal role as soon as possible following a power swing.

Power swing blocking shall be inhibited during the single pole dead time of an auto reclose cycle so that if a power swing develops during this period the distance protection can give an immediate three phase trip. The Bidder shall advise whether it is possible to extend the inhibition of the power swing blocking to cover a period immediately following auto reclosing so that if a power swing develops on reclosing onto a permanent fault a 3-phase trip would be permitted. The Bidder shall also advise whether power swing blocking can be inhibited if an earth fault occurs during a power swing.

If the associated VT supplies are lost due to VT fuse failure the power swing blocking relay shall not operate.

Where protection is supplied from multi-ratio current transformers, the lowest ratio will be used for the initial system configuration, when fault levels are low. The working ratio will be increased when the system expands and the fault levels and load transfers increase.

5.9 Busbar Protection

5.9.1 Busbar Protection

The busbar protection for 230 kV and 132 kV shall be low impedance type numerical relay capable of detecting all types of phase and earth faults under all system generation conditions. The protection shall be extensible to cover the final substation arrangements and Bidders shall state what extra material is required.

The busbar protection shall have the following features:

(a) Two independent measurement & tripping criteria. One based on stabilized current differential algorithm and the other on directional current comparison and shall be capable of detecting three phase, phase-phase and phase to earth faults, under all system generation plant conditions. They shall meet the fault clearance time of 100ms under all conditions.
(b) Two independent hand or electrically reset busbar protection trip relays shall be associated with each circuit breaker. These trip relays may also be employed for circuit breaker failure. Operation of either of these relays shall block closing of the associated circuit breaker.
(c) Each trip relay shall trip the circuit breaker via both trip coils. Both relays on the 132 kV transformer circuits shall trip the associated circuit breakers.
(d) The operating time of the measuring relays shall not exceed 30 msecs at five times the relay current setting.

The busbar protection will be supplied from multi-ratio current transformers. The working ratio will be selected on the basis of maximum load transfer in the same manner as the line current transformer ratios.

The overall fault setting shall be between 10% and 30% of the minimum fault current available for any type of fault, unless otherwise specified. The minimum fault current for 230 kV busbar faults will be advised at a later stage.

The rated stability limit of the protection shall not be less than the switchgear short circuit rating.

Automatic and continuous supervision of current transformer circuits shall be provided to give an alarm when the out-of-balance current reaches an undesirable value. Operation of current transformer supervision equipment should take the defective protection zone out-of-service.

The Contract shall include for all necessary current transformers, relay panels, marshalling boxes, isolating and shorting links, etc. A lockable busbar protection ON/OFF switch shall be provided.

Current transformer secondary bus wiring should be suitably dimensioned to reduce current transformer burdens to a minimum.

Suitable voltage limiting devices shall be provided as necessary, including across the unused part of the CT secondary when tappings are employed.

Full details of the scheme offered, together with performance figures for stability and sensitivity, shall be provided in accordance with Clause 5.9.2.

The numerical busbar protection shall be multi-processor in structure, with extensive self-supervision, 16 bit analogue to digital converters, together with appropriate algorithms to provide phase segregated measuring principles and multi criteria evaluations before initialisation of trip commands. The busbar protection shall be of decentralised, with redundant DC/DC supplies type and the bay units shall be fixed as close to the CTs as possible reducing the copper wiring to a bare minimum and thereby also reducing the CT burden and CT dimension.

If the intercommunication between the bay unit and central unit by fibre optic cables, the required fibre optic cable and all necessary items shall be supplied, connected and commissioned by the Contractor.

Extension of existing busbar protection: The scope of work under this contract is to extend the existing busbar protection for new bays with the same equipment.

5.9.2 Conditions of Acceptance of Busbar Protection Systems Submitted on the Basis of Calculated Performance

The Contractor shall prepare for approval calculated performance data for differential busbar protection systems in lieu of heavy current tests, subject to the following:

i) The rated stability limit shall be no less than the three phase symmetrical breaking capacity of the associated switchgear.
ii) The overall fault setting for any type of fault shall be between 10% and 30% of the minimum fault current available. The minimum fault current available for a busbar fault will be advised later.
iii) Current transformer knee point voltages shall not be less than twice the relay circuit setting voltage.
iv) The maximum peak voltage across current transformer secondary wiring shall not exceed 3 kV under maximum internal fault conditions.
v) Associated current transformers shall be Class X or 5P, low reactance type. Split core type current transformers will not be accepted.
vi) The Contractor shall submit for the Engineers approval a design report detailing the protected equipment, design parameters of associated current transformers, details of connections and burdens between current transformers and relays, details of the relay circuits and performance calculations.

5.10 Circuit Breaker Failure Protection

Breaker failure protection shall be fitted to all 245 kV and 145 kV circuit breakers of the substation. The breaker failure protection on a circuit breaker shall be initiated by all the other protection devices which normally initiate tripping of that breaker including the receipt of a direct intertripping signal from a remote line end. In the event of the circuit breaker failing to open within a pre-selected time, the breaker failure protection shall initiate tripping of all adjacent circuit breakers. It shall also incorporate provision for initiating tripping of any remote infeeds, via direct intertripping channels over optical fibre communication link or power line carrier circuits.

In the case of 245 kV and 145 kV circuit breaker failure protection, the position of each circuit breaker shall be monitored by a current check relays fed from the protection current transformers as shown on the drawings. The relay outputs shall be connected in series in a "two out of two" arrangement. The re-

lays shall have an operating time of approximately 10 msec. and a consistent reset time of less than 15 msec. The relays shall be capable of remaining in the operated position continuously and of carrying twice the circuit rated current continuously.

The scheme provided shall be suitable for use in a single pole and three pole tripping and auto reclosing schemes as appropriate.

The operating time from initiation to back tripping output shall be selected by means of duplicated timers with a setting range of 50-500 msec. The two timers per circuit breaker in the case of the 230 kV scheme shall be connected in series in a two-out-two basis and shall energise both trip coils of all adjacent circuit breakers via two back tripping circuits from separate d.c. supplies. In the case of the 132 kV scheme the two timers shall also be connected in series in a two-out-two basis and energise both trip coils of all adjacent circuit breakers but via a single trip relay.

The timers shall be of a modern design to minimise overtravel. With the approval of the Engineer the busbar protection trip circuits may be employed for circuit breaker fail back tripping.

In the event that a circuit breaker is unable to trip due to low gas pressure, low hydraulic oil pressure etc. the associated alarm shall be arranged to by-pass the breaker fail time delay. The breaker fail relay/scheme shall be designed to accept this input.

Operation of the breaker fail protection shall block manual and automatic reclosure of the associated circuit breaker. Breaker failure protections inbuilt in distance / transformer relays will not be accepted.

5.11 Auto-Reclosing Scheme

Three pole and/or single pole, single shot repetitive auto-reclosing equipment, shall be provided for the overhead line circuit breakers.

Reclosure shall be initiated following tripping by either main protection operating in Zone 1 or in conjunction with a teleprotection receive signal. Selection facilities shall also be provided to enable or block three pole delayed auto-reclosing following operation of the directional earth fault protection aided trip output. Reclosure shall not be initiated in the event of a three phase fault, nor any type of fault in the second or third back-up zones, nor when a direct intertripping signal is received, nor when the circuit breaker is closed onto a fault on a previously de-energised line, nor when the DEF back-up protection operates nor if the carrier channel is out of service.

The following modes of operation shall be selectable by means of a switch or switches or programmable.

(a) Single pole, high speed, auto-reclose: Auto-reclosure shall only be initiated in the event of a single phase to earth fault. All other types of faults shall result in three phase tripping without auto-reclosing.
(b) Three pole delayed reclosing: Delaying reclosing shall only be initiated in the event of a single phase or two phase fault. Three phase faults shall result in tripping without auto-reclosing.
(c) Single pole, high speed and/or three phase delayed, auto-reclosing as appropriate.
Single pole, high speed auto-reclosing shall be initiated only in the event of a single phase-earth fault and delayed reclosing initiated in the event of a two phase fault. Three phase tripping without re-closing shall take place for three phase faults.

(d) No auto reclosing: Three phase tripping without auto-reclose shall take place for any type of fault.

If a second earth fault occurs during the single pole auto-reclose dead time, and the selector switch is in the single and/or three pole reclosing mode three phase tripping with subsequent delayed three pole auto-reclose shall take place. If the auto-reclose selector switch is in the single pole reclose mode, three phase tripping with lockout should follow. Any auxiliary relays required to meet this logic shall be deemed to be included.

The high speed and delayed reclosing dead times have to be coordinated with the equipment being provided at the remote substation. Tentative ranges are, as follows:

- High speed single pole reclose dead time: 0.3 to 3 seconds.
- Delayed three pole reclose dead time: 3 to 30 seconds.

Bidders shall state available ranges.

The reclaim time i.e. the time period following the automatic reclosing of the circuit breaker, during which any further fault results in three phase tripping and lockout, shall be chosen to match the duty cycle of the circuit breakers, assuming the shortest available dead time is chosen. The reclaim time shall, however, not be less than five seconds, and the reclaim timer range shall extend to 180 seconds. (The reclaim time commences at the instant the reclose command is given to the circuit breaker and, therefore, includes the circuit breaker closing time).

The closing command shall be limited to two seconds, after which time the reclosing equipment shall be automatically reset without resetting the reclaim timer. The reclosing equipment shall also reset if dead line check or synchronism check conditions are not satisfied within a predetermined time of the check relays being energised.

A counter shall be provided to record the number of reclosures and lockout after a pre-selected number of reclosures has been reached.

The rated duty cycle of the circuit breaker as defined in IEC 60056 (and subsequent amendments) states that following an initial trip and auto reclosure a further reclosure is not permitted for a further 3 mins.

Reclosing schemes shall include voltage monitoring and check synchronising relays as appropriate.

Dead line check relays shall monitor the condition of the line and busbar and permit three pole reclosing only when the line is de-energised and the busbar is energised. The line is considered to be de-energised when the voltage is less than twenty percent of rated voltage, and the busbar is considered to be energised when the voltage is greater than eighty percent of rated voltage.

(A signal shall be provided from the dead line check relays for interlocking of the line earth switches to prevent the switches being closed onto a live line).

When a voltage is present on both sides of a circuit breaker, the synchronism check relay shall monitor the magnitudes of the two voltages across the open circuit breaker, and the phase angle and slip frequency between these voltages. Closing shall only be permitted when these are within prescribed limits.

Check synchronising relays shall comply with the requirements of Clause 5.24. 1. The same relays may be used as for manual closing.

5.12 Overcurrent and Earth Fault Protection

The overcurrent and earth fault relays shall be fully Numerical and have multi characteristics (inverse, very inverse, extremely inverse) to IEC 60255.

Overcurrent relays shall have a current setting range from at least 50% - 200% in 25% setting steps.

Earth fault relays shall have a current setting range from at least 20% - 80% in 10% setting steps.

Time multiplier settings shall be continuously adjustable from 0 to 1 or, as an alternative in steps of 0.025 from 0.05 to 1.0.

In the case of transformer circuits relays shall be provided with high set instantaneous units which can be set to 1.25 times the fault current in the HV winding for a fault on the LV terminals computed using the transformer minimum impedance and assuming negligible source impedance. The instantaneous unit shall have a low transient overreach (less than 5% for system X/R ratio of 10) and an operating time of less than 40 msec. at two times the current setting.

In the case of underground line circuits relays should have a reset ratio greater than 95% to enable settings to be made which are close to the circuit emergency rating. The relay contacts must close at a current equivalent to 110% of the setting and relay overshoot must not exceed 50 msec.

Overcurrent and earth fault relays shall trip via the CB duplicate trip coils and initiate duplicated direct intertripping to the remote line end CB.

Relays shall be thermally rated such that the operating time of the relay at the highest practical current levels on any combination of current and time multiplier settings shall not exceed the thermal withstand time of the relay. The Contractor shall provide copies of type test reports to show that this requirement has been met.

Directional back up overcurrent and earth fault relays shall be provided for underground Cable feeders and the directional elements shall be voltage polarised.

Directional units for directional overcurrent protection shall be quadrature connected with a relay characteristic angle setting of 30° or 45° current leading voltage.

Directional units for directional earth fault back up protection shall employ residual voltage quantities and the relay characteristic angle be variable 0°, 45° and 60°, current lag.

The nominal operating boundary shall be ±90° from the relay characteristic angle and the operating time of the directional unit shall not exceed 20 ms at the relay characteristic angle.

The relay shall be capable of operating correctly when both the operating current and polarising voltage quantities are 1% of rated values at an angle equal to the relay characteristic angle.

The residual polarising voltage for earth faults may reach 190.5 volts and therefore it should withstand this value continuously. The continuous withstand current should be no less than twice rated current.

5.13 Coupling Bay Protection

The Coupler bay shall be provided with overcurrent instantaneous trip relay protection (50 BF) and overcurrent time delay relay protection (51, 51N). Relays shall comply with the requirements of clause 5.12.

All trip-signal of OHL and transformer feeder protection shall be transferred to the coupling breaker in case the feeder breaker is bypassed and the feeder is protected by the coupling-bay circuit breaker. This shall be provided by auxiliary relay, not by auxiliary contacts of the circuit breaker by-pass isolator.

5.14 Transformer Protection

5.14.1 Biased Differential Protection

The transformer differential protection shall be fully numerical design with 16 bit Analogue to Digital converters, powerful Digital signal processors, CPU etc. The relay should have continuous self-supervision and diagnosis. A local display unit shall be provided on the front of the relay for measure and display, Trip indications, diagnostics, etc. and also for acknowledging and resetting of latched outputs. The required software for setting and configuring the relay shall be provided with the relay and this Human Machine Interface (HMI) shall be user friendly and should not require any special programming knowledge. It should be possible to do the settings off line and load the settings on to the relay with a standard portable PC with a fibre optic connection.

Overall differential protection shall be of the biased differential type and capable of detecting phase and earth faults.

Separate facilities shall be provided to enable bias and operating settings to be adjusted. The minimum operating setting shall not be greater than 20 per cent of the rated full load current of the transformer.

The protection shall be designed to ensure stability on any transformer tap position under maximum through fault conditions with maximum d.c. offset. An infinite source is to be assumed and the through fault current calculated using the transformer impedance only.

Correction for matching transformer vector groups and main CT ratio's for Transformer Differential protection shall be performed within the relay without the use of external interposing-transformer.

The relays shall have magnetising inrush current restraint of the second harmonic or other approved means. All necessary interposing current transformers shall be provided under the contract.

5.14.2 Restricted or Balanced Earth Fault Protection

Where specified, or shown on drawings, transformer windings and connections shall be protected by restricted earth fault protection. Delta connected windings shall be protected by balanced earth fault protection. Relays shall be of identical numerical design as the main protection and of the high impedance type with necessary protection against over voltages. For reliability reasons the restricted earth fault relay shall be separate from the transformer differential relay.

Relays shall have maximum sensitivity and minimum operating times consistent with stability for faults outside the protected zone and on magnetising inrush surges.

The rated stability limit shall not be less than the maximum current available for an external fault. This shall be taken as 16 times the rated current of the protected winding of the power transformer, or any other value agreed by the Engineer.

For the purpose of calculations it shall be assumed that any neutral earthing impedance is short circuited.

The Contractor shall prepare for approval calculated performance for instantaneous high impedance restricted earth fault protection in lieu of heavy current tests, subject to the conditions in Clause 5.9.2 except:

i) The rated stability limit shall be as specified above.
ii) The fault setting shall be as specified below.
   (a) When the transformer winding is connected to a solidly earthed power system, the fault setting shall be between 10% and 60% of the rated current of the winding. When the transformer winding has more than one rating, the setting shall be based on the lower rating.
   (b) When the protected transformer is not connected to a solidly earthed power system the fault setting shall be between 10% and 25% of the minimum current available for an earth fault at the transformer terminals.

5.14.3 Transformer Back-up Overcurrent Protection

Three-pole inverse time back up overcurrent and earth fault protection shall be provided as shown on the drawings. This shall comply generally with Clause 5.12 but in addition the overcurrent elements shall also be a two stage device. Stage 1 will comprise the inverse time unit and stage 2 will comprise an additional definite time unit with a setting range of 50 msec. - 5 secs.

5.14.4 Gas Pressure (Buchholz) Protection

Power transformers and earthing transformers shall be fitted with Buchholz devices under this contract. The Buchholz device will be of the two element type giving operation under gassing and under surge conditions.

All necessary flag indication, tripping relays and alarm relays associated with this protection shall be provided, mounted and connected under this contract.

5.14.5 Oil and/or Winding Temperature

Transformers will be provided with oil and/or winding temperature protection under this contract. These will be of the two stage type with adjustable settings giving alarm and trip facilities.

All necessary flag indication, tripping relays and alarm relays associated with this protection shall be supplied and connected under this contract.

5.14.6 Low Oil Level and Pressure Relief Devices

Transformers shall be provided with low oil level with contacts for the purpose of providing remote alarm. Transformers shall also be provided with a pressure relief device with contacts for purposes of remote alarm and trip function.

The alarm relays associated with these devices shall be supplied and connected under this contract.

5.14.7 Tap Changer Oil Surge

Transformers will be provided with an oil surge or pressure operated device having contacts for purposes of remote alarm and trip.

A relay associated with this device shall be supplied and connected under this contract.

All necessary flag indication, tripping and alarm relays associated with tap change oil surge shall be provided.

5.14.8 Standby Earth Fault Protection

Standby earth fault protection shall be provided for all earthing transformers/resistors, fed from a current transformer in the transformer/resistor neutral connection.

The operating current shall be adjustable between 10 and 40 per cent of the resistor value. The time delay shall be adjustable between 1 and 10 secs. As an alternative to a definite time relay, a long inverse time relay may be offered.

5.14.9 Tripping Relays

All tripping relays, where specified shall be of the heavy duty type suitable for panel mounting. The trip relays of the offered numerical protections shall be directly capable of tripping the breaker coils. It shall not be required to add additional trip relays

Trip relay contacts shall be suitably rated to satisfactorily perform their required duty and relay operating time shall not exceed 10 ms. from initiation of trip relay operating coil to contact close.

Where specified latching type relays shall have hand or electrically reset contacts and hand reset flag indicators. Resetting of the flag indicator and the contacts shall be possible without having to open the relay case.

Tripping relays shall operate when the supply voltage is reduced to not higher than 30% of nominal battery voltage. It shall not operate for wiring leakage currents and discharge of wiring capacitance

230 kV and 132 kV circuit breakers are equipped with two trip coils. One tripping relay shall initiate tripping via one trip coil and the other tripping relay via the second trip coil.

5.15 DC Auxiliary Voltage Operating Range

DC operated relays, coils, elements, etc. will be operated from a 110V rated dc. battery, which under float charging conditions operates at about 125V. DC operated relays coils elements etc. shall be suitable for operation over a voltage range of 66V to 143V. i-e. 110 - 40% + 20%.

5.16 Teleprotection Signalling

Details of protection initiation and various permissive and direct intertripping signals are as specified in Section-14, of Vol. 2 of 3.

5.17 Digital Fault and Disturbance Recorder (DFDR)

The DFDR shall be delivered only for new 230/132 kV substations.

The DFDR in PGCB's system are manufactured by Qualitrol, Belgium, BEN 6000/5000.

For the purpose of standardization, the DFDR to be supplied under this project shall be from Qualitrol (Belgium), SIEMENS (Germany) or SEL (USA).

Installation, testing & commissioning of the DFDR shall be done by the DFDR Engineer(s) of the DFDR Manufacturer(s).

The DFDR shall have the following features:

a) The equipment shall be an independent stand-alone system to monitor analogue and digital signals from all 230 kV & 132 kV feeders, including transformer and bus coupler bays that require to be monitored.
b) The Manufacturer shall prove the system's reliability and good site performances by providing substantial evidence of the systems already installed and commissioned for at least a duration of 5 years, accompanied by the customer's recommendations and type test reports from internationally acclaimed laboratories.
c) The DFDR system shall be modular in design for easy expansion, upgrade and maintenance.
d) The acquisition system or its storage unit shall not be based on a PC platform.
e) The independent DFDR system shall be equipped with a minimum of 40 digital and 8 analogue signals per bay and shall be suitable for AC/DC measurement without any hardware changes.
f) The system shall be equipped to monitor, detect and record simultaneously fast transient faults (short-term) and slow phenomena disturbances (long.term) like power swing, frequency variation, voltage drop, etc., covering all the required feeders.

g) All input signals shall be able to scan and record simultaneously at least 2 or 3 user-programmable sampling rates from 500 Hz to 6 kHz for fast (short-term) transient monitoring and from 1 Hz to 500 Hz for slow phenomena (long-term) monitoring in order to detect and record fast (short-term) and slow phenomena (long-term) events.

h) At least 25 sec. of memory for transient fault data recording (at 6 kHz sampling rate) and over 1000 sec. for slow (at 30 Hz) phenomena recording shall be provided in addition to the auto-maintained, inbuilt hard disk unit which shall be installed for data storage. The inbuilt hard disk unit shall be managed and operated by the identical industrially proven operating system of the DFDR.

i) The graphical data should be recorded for all feeders simultaneously (snap shot image).The recording should contain the data prior to the event and after the event, including the dynamic length of the event / fault without any alterations.

j) The system should possess a library of sensors (triggering criteria), which should be selected by the user and shall be able to detect and record various type of incidents. The system shall be able to detect incidents by the selected starting criteria and should be able to produce a record.

k) The recordings shall contain the graphical data of physical inputs (voltage, currents, digitals) and virtual inputs (e.g. frequency, dp/dt, dq/dt (3 phases / single phase), RMS values etc.).

l) The DFDR shall be able to communicate with local and / or remote master stations, using master communication and analysis software. This software should permit the user either locally or remotely to download the recorded data, to ascertain the system's operational status, to change parameters, etc.

m) Master communication should be able to communicate via RS 232 (direct connection), through modem (dial-up telephone line) and LAN (Ethernet (TCP / IP) - IEEE 802.3) networking.

n) The DFR shall perform the following functions:
- fault location (including impedances and report),
- graphical display of data,
- phase measurement & display,
- transient fault recording,
- dynamic swing recording,
- harmonics' measurement & display,
- integrated SER function,
- calculated channels etc.

o) The system shall be able to calibrate at site, and the required menu-driven software and other required accessories shall be supplied along with a notebook computer, colour printer etc.

p) The system shall be equipped for time synchronization by the external GPS clock receiver for real time synchronizing (including antenna).

q) Local printing facility shall be provided with the system.

r) The master station (a latest version of PC) and the relevant software shall be supplied with the equipment for analysis and communication.

s) Power quality monitoring or continuous monitoring (periodical recording) shall be made available for at least 4 feeders.

Extension of the existing DFDR: The scope of work under this contract is to extend the existing DFDR system for new bays. All necessary input and output (both digital & analogue) shall be provided as per the existing bays.

5.18 Tripping Relays

All tripping relays, where specified, shall be of high-speed (less than 10 ms.), high-burden, heavy-duty (larger than 150 W) type and shall be suitable for panel mounting. Relays shall comply with the requirements of Clause 5.13.9.

5.19 Protection Settings

Relay settings with calculation for all unit-type protective schemes and shall be submitted to the Engineer and Employer prior to commissioning of any plant for approval. Settings shall also be provided for those relays and other equipment provided under this section of the contract which do not require an intimate knowledge of existing relay settings e.g. circuit breaker fail relays. Detailed calculations shall be provided supporting all recommended settings.

Any additional information needed by Contractors should be requested.

5.20 Substation Automation System

5.20.1 Scope of Supply

This specification covers the design, manufacture, inspection, testing at the Manufacturer's works, erection and commissioning of a substation automation system, as shown in drawing of this technical specifications & described in the following sections, to control and operate the 230 kV & 132 kV grid substation.

This describes the facilities required to provide the control of plant and system within a substation and outlines the facilities to be provided on site, interface requirements and performance criteria.

The substation automation system (SAS) shall comprise full station and bay protection as well as control, monitoring and communication functions; it shall provide all functions required for the safe and reliable operation based on IEC 61850 standards. It shall enable local station control via PC by means of a human machine interface (HMI) and control software package, and shall perform the necessary system control and data acquisition functions. It shall include communication gateway to NLDC, inter-bay bus, intelligent electronic devices (IED) for bay control and protection as shown in the enclosed general system architecture drawing.

The communication gateway shall secure control from and information flow to remote network control centres. The inter-bay bus shall provide independent station-to-bay and bay-to-bay data exchange. The bay level intelligent electronic devices (IED) for protection and control shall be directly connected to the instrument transformer and trip/close coils in the switchgear without any interposing equipment and perform control, protection, and monitoring functions subject to a detail proposal approved by the Employer.

The Contractor will have the option to choose different types of communication networks for the bay level and the process level based on IEC 61850. However, network topology and access mode shall

be clearly indicated. The availability shall be maintained with suitable topology of ring, star or bus. The physical medium of those shall be glass fibre optics.

The IEDs for protection and control functions shall maintain high availability and reliability together with bay independence through extensive self-supervision and state-of-the-art technology. All IEDs shall be directly connected to the IEC 61850 bus and shall use only the IEC 61850 protocol for communication. No proprietary protocols shall be used.

The system shall be capable of having its computing power increased in the future through the addition of additional computing systems.

The system design life shall be not less than 20 years.

The capacity of the SA system shall be sufficient for the ultimate development of the substation as set out in the project requirements.

The SA Supplier shall demonstrate that the proposed system has been designed, installed and commissioned in accordance with the IEC 61850 standard and shall provide evidence of satisfactory service experience during the past 5 years.

Extension of existing SAS: The scope of work under this contract is to extend the existing SAS system for new bays. All necessary input and output shall be provided as per existing bays.

5.20.2 Compliance with Standards

For design and type-testing of the protection and control equipment, the following standards shall apply:

5.20.2.1 General List of Specifications

- IEC 60255: Electrical Relays
- IEC 60038: IEC Standard voltages
- IEC 68068: Environmental testing
- IEC 60664: Insulation co-ordination for equipment within low-voltage systems
- IEC 61850: Standard for Substation integrated protection and control data communication

5.20.2.2 Detailed List of Specifications

- IEC 60068-2-3: Test Ca: Damp heat steady state
- IEC 60068-2-30: Test Db and guidance; Damp heat, cyclic
- IEC 60255-11: Measuring relays and protection equipment
- IEC 60255-22: Electrical disturbance tests for measuring relays and protection equipment:
- IEC 60255-22-1: 1 MHz burst disturbance test
- IEC 60255-22-2: Electrostatic discharge test
- IEC 60255-22-3: Radiated electromagnetic field disturbance test
- IEC 60255-22-4: Fast transient disturbance test
- IEC 60255-11: Interruptions to and alternating component (ripple) in D.C. auxiliary energis-

ing quantity to measuring relays
- IEC 60255-6: Measuring relays and protection equipment
- IEC 60255-21: Vibration, shock, bump and seismic tests on measuring relays and protection equipment:
- IEC 60255-21-1: Vibration tests(sinusoidal)
- IEC 60255-21-2: Shock and bump tests
- IEC 60255-21-3: Seismic tests
- IEC 60255-0-20: Contact performance of electrical relays
- IEC 60870-3 class 2: Digital I/O, Analogue I/O dielectric tests
- IEC 60801-5/class 3: digital I/O Surge withstand test
- IEC 60870-3/class2: Radio interference test
- IEC 60801-4/4: Transient fast burst test
- IEC 60801-2/4: Static discharge
- IEC 60801-3/3: Electromagnetic fields

5.20.3 Design and Operating Requirements

5.20.3.1 General

The SAS shall be suitable for operation and monitoring of the complete substation including future extensions. The offered products shall be suitable for efficient and reliable operation and maintenance support of the substations.

The SAS system shall have state-of-the art design, suitable for operation in a high voltage substation environment, follow the latest engineering practice; it shall ensure long-term compatibility requirements, continuity of equipment supply and the safety of the operating staff.

As shown in the SAS structure, protection is an integral part of the SAS, and protective relays shall be directly connected to the inter-bay bus in order to provide unrestricted access to all data and information stored in the relays and for changing protection parameters from the remote control location.

Failure behaviour of the hardware and software functions shall be addressed, and related diagnostic and rectification working instructions shall be provided. The system's performance in case of failure of communication to NLDC, main and redundant computer base workstations, central functions, data model, control and protection IEDs, station and bay level communication shall also be clearly addressed (shall be provided by the Manufacturer).

Both, the 230 kV and 132 kV substation, can also be controlled from the control panel installed in the control room. The following modes of operation shall be possible:

a. Emergency operation of breaker, disconnector, earthing switch etc. from the control panel.
b. Emergency operation of breaker, disconnector, earthing switch etc. from the backup mimic panel located in the new control room. Both, bay controller-guided and unguided operation shall be possible from this panel.
c. Normal operation of breaker, disconnector, earthing switch etc. from the station automation system's HMI located in the new control room.

5.20.3.2 Modes of Operation

The operator stations and specified remote users shall have the following operational modes, each password protected.

Monitoring	Ability to select graphic displays and lists for display only. No capability to acknowledge alarms, complete controls or select items for inclusion in program functions.
Control	Selection of graphic display and lists. Able to acknowledge station and SAS alarms, complete controls, dressing etc. associated with normal real time of the control of the substation.
SAS Engineering	To provide all SAS monitoring functions, together with online facilities for program / database / format modifications and checking without the possibility of executing power system controls.
System Manager	To provide access to all system functions, including assignment of passwords and system maintenance activities.

In addition, a facility to provide access to the numerical protection relays, change / modify relay settings & AVR parameters and fault recorder data shall be provided.

A series of passwords shall be personally assigned to operators in each of the above categories.

Substation operators shall have the possibility to log on to either substation workstation and to be allocated the appropriate mode of operation relevant to the password. SAS engineering work and access to the protection relay and disturbance reorder information shall generally be carried out at the engineering workstation or the remote master station.

All workstations and the system database shall function as a system. It shall not be necessary for example to acknowledge an alarm at more than one workstation.

Similarly, an operator's manual entry applied at one workstation shall be immediately displayed at other workstations where this data is presented.

5.20.3.3 Project Specifications

Specific functions required and boundary conditions of the SAS are detailed elsewhere in this specification. The following project-specific drawings are attached:

- Overall single line diagram
- General system architecture
- Location of substation buildings
- Control and operation principles
- Protection schemes

5.20.3.4 Vendor's Experience and Local Support

Only experienced and technically capable Manufacturers with minimum 5 years' experience in design and supply of control and protection systems for electricity transmission and distribution applications will be accepted. Preferred Manufacturers will be those who have experience in deliveries of the full

scope of station automation systems and services. This experience has to be substantiated by means of reference installations being in service under similar environmental conditions for at least 5 years. In order to assess the Vendor's experience with similar projects, the Vendor is required to submit the following with his bid:

- Technical design specifications and description of SAS
- Catalogues and brochures of equipment and devices offered
- Reference list

The Vendor shall assure long-term maintenance and availability of spares. Moreover, a guarantee shall be submitted for the availability of spares during the lifetime of the SAS equipment (not less than 10 years).

5.20.3.5 Quality Assurance and Inspection

Quality assurance of design and development, production, installation and servicing of material and workmanship shall be governed by ISO 9001. Supporting documents to prove ISO 9001 third party approvals shall be provided with the offer.

The SAS shall be pre-assembled and tested at the Vendor's workshop before shipment.

5.20.4 General System Design

The system shall be so designed that personnel without any background in microprocessor-based technology can operate the system easily after having received some basic training.

System control from the substation control room will be done by means of an industrial computer (PC) operated by a mouse. The following HMI (Human Machine Interface) functions shall be provided:

1) Acquisition and plausibility check of switchgear status
2) Control of switchgear
3) Remote checking of device parameters and activation of alternative parameter sets in the connected protective relays
4) Display of actual measured values (U, I, P, Q, f)
5) Display of events
6) Display of alarms
7) Display of trends
8) Sequence control functions
9) Disturbance records and fault location
10) System self-supervision
11) Hard copy printing
12) Dynamic busbar colouring

The offered SAS shall support remote control and monitoring from the NLDC via an industrial grade gateway with redundant CPU as well as redundant DC/DC converters. PC-based gateways which contain moving parts will not be accepted. The gateway should be designed for a life of at least 20 years. The gateway shall provide for communication to/from remote control centres via the IEC 60870-5-101 protocol. Even if the station PC is not available, it shall be possible to control the station from the NLDC as well as from the backup control panel in the individual bays with all interlocks. Interlocking in

case of emergency (i.e. if the bay controller fails) should be waived locally by means of a switch with key lock by the Maintenance Engineer for all the switchgear.

Maintenance, modification or extension of components shall not require a shutdown of the whole station automation system. Self-monitoring of single components, modules and communication shall be incorporated to increase the availability of the equipment while minimising maintenance time to repair.

As shown in the system drawing, the SAS shall be structured in two levels - station level and bay level. The data exchange between the electronic devices on both levels shall take place via an inter-bay bus using IEC 61850 standards. The entire station shall be controlled and supervised from the station level PC. It shall also be possible to control, monitor and protect each individual bay from the respective bay level equipment for maintenance purposes or if the communication to a particular bay fails. Clear control priorities shall prevent initiation of operation of a single switch at the same time from more than one of the various control levels viz. NLDC, station level, bay level or switchgear (apparatus) level. The priority shall always be with the lowest enabled control level.

Bay control and protection units shall be independent of each other and their functioning shall not be affected by any fault occurring in any of the other bay control and protection units of the station.

The SAS shall contain the following main functional parts:

1) Human Machine Interface (HMI) with process database
2) Gateway function for remote control via an industrial grade hardware
3) Dial-in facility / laptop workstation for protection relay parameterisation, disturbance analysis and SAS fault analysis.
4) Data exchange between the different system components via high speed bus
5) Bay level devices for control, monitoring and protection
6) Bay-oriented local control and protection panels with mimic inserts
7) Facility for emergency operation of all the switchgear, if the bay controller fails (key / master key system).

The main process information of the station shall be stored in distributed databases. The system shall be based on a decentralised concept with bay-oriented distributed intelligence for safety and availability reasons. Functions shall be decentralised, object-oriented and located as close as possible to the process.

The substation monitoring/protection system shall supply data for maintenance, repair and remote parameter setting of protection and control devices in the switchyard.

In the event of a fault in the electrical network, the substation monitoring shall provide a quick means for collecting the relevant and critical data of the fault.

The monitoring system shall be suitable for the supervision and monitoring of all the secondary (IED) and primary devices in a substation including future extensions.

Maintenance, modification or extension of components shall not cause a shut-off of the whole station monitoring system. Self-monitoring of single components, modules and communication shall be incorporated to increase the availability and the reliability of the equipment and to minimise maintenance.

It shall be possible to access all protection and control devices for reading the terminal parameters (settings). The setting of parameters or activation of parameter sets shall be restricted by password to the Protection Engineer.

One remote computer should be provided with access to the SMS and with different access levels. The required SMS software and application-specific firmware (for relay parameterisation) shall be provided with associated tools and equipment. The required engineering tools and analysing software shall also be provided/installed both in the station PC and the remote master analysis station. A back-up copy of all the software shall be provided on CDs.

The SMS shall be capable of communicating with the remote master analysis station at the protection development branch through a modem over a dedicated or dial-up voice grade telephone line or microwave channel.

5.20.5 Flexibility and Scalability

The offered SAS concept shall be flexible and shall permit future extensions to be implemented easily. Preference will be given to those Suppliers who are in a position to provide protection and control devices that can be freely adapted to the required application functions.

5.20.6 System Hardware

5.20.6.1 Operator Station

The main operator station shall be based on an industrial PC hardware and high-resolution full-graphics screen with the Manufacturer's standard type-tested software operating under Windows NT environment. An event printer and a hard copy printer shall be connected via a printer server and LAN to the operator station.

Dual station computers shall control the SAS and drive the work stations and other peripherals. One of the station computers shall operate the system in the "online" state while the other acts as a "redundant hot standby". The standby computer shall be continuously updated and shall immediately take over the SAS duties without interruption or transfer mechanism should the online operator workstation fail.

Disturbance records shall be analysed using the installed disturbance record analysis programmes. The disturbance records will be collected, over the inter-bay bus, from the connected IEDs by the system software. All necessary facilities shall be provided to allow the system to perform spontaneous upload of disturbance data or their upload in a pre-programmed manner. The event printer shall print events spontaneously as they arrive in the main operator station.

Each uploaded data report file shall be reported on one line that shall contain:

1) The event date and time
2) The name of the event object
3) A descriptive text
4) The state or value of the object

The information fields above shall be structured in columns for maximum readability.

The hard copy printer shall permit printing of any picture (or part thereof) from the station level PCs using easily accessible commands from the window menus.

The main station PCs shall be supplied by the station DC battery and a UPS system with a supply duration of not less than 30 minutes to supply the monitor and the printers.

A 16-window annunciator unit shall be directly connected to the main station PCs to monitor the same and also to annunciate common station abnormal/fault conditions.

5.20.6.2 Station Inter-bay Bus

The LAN connecting the industrial computer-based operator workstations and printers shall be Ethernet 802.3 LAN, protocol TCP/IP (10 Mbit./ sec or higher), and the physical medium shall be thin Ethernet or fibre optic bus, provided this LAN is kept within the confines of the control room.

The bay control and protection units shall be connected via glass fibre optic cables to a station inter-bay bus using industrial grade Ethernet switches. The station bus according to IEC 61850-8 is today mapped to MSS / Ethernet (with priority tagging and with 100 MS/s). The standard is not making any provision on the Ethernet communication infrastructure. To at least ensure a certain level of quality, performance and availability, the Ethernet switches and topology shall fulfil at least the criteria described below.

- Industrial-grade Ethernet switches that fulfil the hardened requirements concerning temperature, EMC and power supply (110 V DC from the station battery) suitable to be installed in substations shall be provided, i.e. the same data as common for numerical protection.
- The use of Ethernet hubs is not permitted as they do not provide collision-free transmission.
- The switches shall support priority tagging and open standards for ring management like fast spanning tree to ensure that e.g. for later system extension the utility has not to rely on one switch supplier only.
- External switches shall be supplied as they have the advantage that there is no interruption or reconfiguration of the Ethernet ring, if one or several bay devices are taken out of service.
- To increase reliability, the Ethernet switches shall have redundant power supply & shall be powered from two different station batteries.

5.20.6.3 Protection and Control IEDs and Local Back-up Control Mimic on 230 kV Level

The bay control IEDs, based on microprocessor technology, shall use numerical techniques for the calculation and evaluation of externally input analogue signals. They shall incorporate select-before-operate control principles as safety measure for operation via the HMI. They shall perform all bay-related functions such as protection, commands, bay interlocking, data acquisition, data storage, event and disturbance recording, and shall provide inputs for status indication and outputs for commands. They shall be directly connected to the switchgear without any need for separate interposing equipment or transducers.

The numerical bay control IED shall be provided with a minimum of nine (9) configurable (current or voltage) analogue input channels and an adequate number of binary input & output channels which are galvanically isolated from the SAS. The channels shall also be individually separated from each

other. HV switchgear and instrument transformers shall be directly connected to the bay level IED without any interposing equipment.

The devices shall meet the requirements for withstanding electromagnetic interference according to relevant parts of IEC 60255 to conform to the high requirements for operation on the secondary system of HV switchgear.

The 230 kV bay control & protection IED shall have the following features:

1) a minimum of 9 configurable analogue channels
2) at least 32 binary inputs, 24 signal relays and 2 command relays
3) 16 LEDs on the front of the unit for indication
4) auto-reclose function
5) synchrocheck function
6) power function which can be configured to measure forward or reverse, active or reactive power
7) four (4) independently settable parameter setting groups, settable/selectable locally or remotely via the HMI programme
8) 4 line local display units (LDU or front HMI) on the front of the relay which can display both input as well as measured quantities: frequency, phase currents, phase voltages, active power, reactive power, etc.
9) high-speed bus serial communication port as per IEC 61850 standards.
10) a sequence of events recorder with a buffer for 256 events and a resolution of 1 msec. The events to be recorded should be freely programmable. These could be alarm/trip signals, external signals connected to opto-coupler inputs, internal signals, etc. Once events are defined, they are recorded in chronological order as they occur.
11) disturbance recorder function which can record 9 analogue values, 16 binary signals and 12 analogue channels for internal measurement values. It shall be possible to trigger the disturbance recorder function by any internal or external binary signal or internal protective function.
12) comprehensive self-supervision
13) battery-free memory back-up of event and disturbance records
14) logic functions (AND, OR, bistable flip flop, etc.)
15) delay/integrator function

The numerical bay control IEDs shall be mounted together with all the relevant bay protective relays in cubicles of protection class IP54 or better. Distributed back-up control mimics with associated switches meters and Indicating LEDs shall also be provided on these cubicles. These cubicles shall be installed in an air-conditioned room in the substation.

The distributed backup mimic for local control shall be installed next to the bay controller IED, which can be used in case of maintenance or emergency or if bay control IED fails. Local bay control via the back-up control mimic on the control & protection cubicles shall incorporate the same user safety measures e.g. bay interlocking, synchrocheck, interlock override user guidance etc. as the station HMI. Local bay control shall be key-locked, and the control either from remote control panel (in the new control room), the station HMI or from remote shall be disabled if the local/remote selector switch on the back-up control mimic is in the "local" position.

The electronic system has to be provided with functions for self-supervision and testing. Each circuit board shall contain circuits for automatic testing of its own function.

Faults in the bay control IED shall be indicated on a front HMI, and a message shall be sent to the station-level HMI. The time for fault tracing and replacement of a faulty unit shall be reduced to a mini-

mum. The supervision shall also cover the power supply system, the internal system bus and the ability of the central processing module to communicate with different printed circuit boards.

Failure of any single component within the equipment shall neither cause unwanted operation nor lead to a complete system breakdown. The n-1 criterion must be maintained in worst case scenarios, also. Further, a single failure must not have any effect on the primary system, which is monitored and controlled.

Only the backup protection can be incorporated in the bay control unit and not the main protections. Main protection shall be provided separately.

All IEDs shall have at least 5 years of successful proven experience in HV applications, and the MTBF for the offered units shall be provided.

5.20.7 Software Structure

The software package shall be structured according to the SAS architecture and shall be strictly divided into various levels. It shall be possible to extend the station with minimum possible effort. Maintenance, modification or extension of components of any feeder may not force a shutdown of the parts of the system which are not affected by the system adaptation.

Confirmation that the software programs will be supported for a minimum of 20 years is required to be submitted with the bid.

It shall be the responsibility of the Contractor to obtain any license required for the operation software. The Contractor shall indemnify the Client against all claims of infringement of any patent, registered design, copyright, trademark or trade name or other intellectual property right.

5.20.7.1 Station Level Software

(a) Human Machine Interface (HMI)

The base HMI software package for the operator station shall include the main SAS functions and shall be independent of project specific hardware version and operating system. It shall further include tools for picture editing, engineering and system configuration. The system shall be easy to use, to maintain, and to adapt according to specific user requirements. The system shall contain a library with standard functions and applications.

(b) Operating System

A Windows NT workstation operating system shall be used for the operator station as it supports several standard system features, e.g. support for several Windows office applications, multitasking, security levels, data exchange mechanisms (DDE, OLE), open data base communication standards (ODBC) and a standardised, user-friendly look & feel HMI.

5.20.7.2 Bay Level Software

(a) System Software

The system software shall be structured in various levels. This software shall be placed in a non-volatile memory. Its lowest level shall assure system performance and contain basic func-

tions, which shall not be accessible by the Application and Maintenance Engineer for modification. The system shall support the generation of typical control macros and a process database for user-specific data storage.

(b) Application Software

In order to ensure robust quality and reliable software functions, the main part of the application software shall consist of standard software modules built as functional block elements. The functional blocks shall be documented and thoroughly tested. They shall form part of a library. The application software within the control/protective devices shall be programmed in a functional block language.

5.20.8 System Testing

The Supplier shall submit a test specification for factory acceptance test (FAT) and commissioning tests of the station automation system for approval. For the individual bay level IEDs, applicable type test certificates shall be submitted.

The manufacturing phase of the SAS shall be concluded by a FAT. The purpose is to ensure that the Contractor has interpreted the specified requirements correctly. The general philosophy shall be to deliver a system to site only after it has been thoroughly tested and its specified performance has been verified with site conditions simulated to the extent possible in a test lab. If the FAT involves only a certain portion of the system for practical reasons, it has to be assured that this test configuration contains at least one unit of each and every type of equipment incorporated in the delivered system.

If the complete system consists of parts from various suppliers or some parts are already installed at site, the FAT shall be limited to sub-system tests. In such cases, the complete system test shall be performed at site together with the site acceptance test (SAT).

5.20.9 System Functions

5.20.9.1 Control Unit Functions

(a) Control

The different high voltage apparatuses in the station shall either be operated manually by the operator or automatically by programmed switching sequences.

The control function shall comprise:

1) Commands from different operator places, e.g. from the associated control centre (NLDC), station HMI, or the control panel (in control room) according to the operating principle
2) Select-before-execute commands
3) Operation from only one operator place at a time.
4) Operation depending on conditions from other functions, such as interlocking, synchrocheck, operator mode, or external status conditions.

The control function shall also include:

1) Prevention of double operation

2) Command supervision
3) Selection of operator place
4) Block/de-block of operation
5) Block/de-block of updating of position indications
6) Manual setting of position indications
7) Overriding of the interlocking function (Second key switch.)
8) Switchgear run time supervision

(b) Status Supervision

The position of each switchgear, e.g. circuit breaker, isolator, earthing switch, etc., shall be permanently supervised. Every detected change of position shall be immediately visible on the screen in the single-line diagram, be recorded in the event list, and a hard copy printout shall be produced. Alarms shall be initiated in case spontaneous position changes took place.

Each position of an apparatus shall be indicated using two binary auxiliary normally closed (NC) and normally open (NO) contacts. An alarm shall be initiated if these position indications are inconsistent or indicate an excessive running time of the operating mechanism to change position.

(c) Interlocking

The interlocking function prevents unsafe operation of apparatuses such as isolators and earthing switches within a bay or station-wide. The operation of the switchgear shall only be possible when certain conditions are fulfilled. The interlocking function is required to be decentralised so that it does not depend on a central control device. Communication between the various bays for the station interlocking shall take place via bay communication system.

An override function shall be provided, which can be enabled to by-pass the interlocking function via a key/password, in cases of maintenance or emergency situations.

(d) Measurements

Analogue inputs for voltage and current measurements shall be connected directly to the voltage transformers (VT) and the current transformers (CT) without intermediate transducers. The correlated values of active power (W), reactive power (VAr), frequency (Hz), and the rms values for voltage (U) and current (I) shall be calculated.

(e) Event and Alarm Handling

Events and alarms shall be generated either by the switchgear, by the control devices or by the station level unit. They shall be recorded in an event list in the station HMI. Alarms shall be recorded in a separate alarm list and shall appear on the screen. All or a freely selectable group of events and alarms shall also be printed out on an event printer. The alarms and events shall be time-tagged with a time resolution of 1 ms. The time tagging shall be done at the lowest level where the event occurs, and the information shall be distributed with the time tagging.

(f) Time Synchronisation

The time within the SAS shall be set via a GPS clock receiver connected directly to the bay level LAN. The time shall then be distributed to the control/protective devices via the high speed optic fibre bus. An accuracy of ±1 ms within the station is required.

(g) Synchronism and Energising Check

The synchronism and energising check functions shall be distributed to the control and/or protective devices and shall have the following features:

1) Adjustable voltage, phase angle, and frequency difference.
2) Energising for dead line - live bus, or live line - dead bus.
3) Settings for manual close command and auto-reclose command shall be adaptable to the operating times of the specific switchgear.

(h) Voltage Selection

The voltages, which are relevant for the synchrocheck functions, depend on the station topology i.e. on the positions of the circuit breakers and/or the isolators. The correct voltage for synchronising and energising is derived from the auxiliary switches of the circuit breakers, isolator, and earthing switch and shall be selected automatically by the control and protection IED.

5.20.9.2 HMI Functions

(a) General

The operator station HMI shall provide basic functions for supervision and control of the substation. The operator shall give commands to the switchgear via the station monitor with the help of mouse clicks on soft-keys.

The HMI shall provide the operator with access to alarms and events displayed on the screen. Besides these lists on the screen, there shall be a print out of hard copies of alarms or events in an event log. The alarm list shall indicate persisting and fleeting alarms separately.

An acoustic alarm shall indicate abnormalities and all unacknowledged alarms shall be accessible from any screen selected by the operator.

The following standard pictures shall be available from the HMI:

1) single-line diagram showing the switching status and measured values
2) control dialogues
3) measurement dialogues
4) blocking dialogues
5) alarm list, station / bay oriented
6) event list, station / bay oriented
7) system status
8) checking of parameter setting

(b) HMI Design Principles

Consistent design principles shall be provided with the HMI concerning labels, colours, dialogues and fonts. Non-valid selections shall be dimmed out.

The object status shall be indicated using different status colours for:

1) selected object under command
2) selected on the screen
3) not updated, obsolete value, not in use or not sampled
4) alarm or faulty state
5) warning or blocked
6) update blocked or manually updated
7) control blocked
8) normal state
9) busbar colouring to show live & dead bus.

(c) Process Status Displays and Command Procedures

The process status of the substation in terms of actual values of currents, voltages, frequency, active and reactive power as well as the positions of circuit breakers, isolators and transformer tap changers are displayed in the station single-line diagram.

In order to ensure a high degree of security against unwanted operation, a special "select-before-execute" command procedure shall be provided. After the "selection" of a switch, the operator shall be able to recognise the selected device on the screen and all other switchgear shall be blocked. After the "execution" of the command, the operated switch symbol shall blink until the switch has reached its final new position.

The system shall permit the operator to execute a command only if the selected object is not blocked and if no interlocking condition is going to be violated The interlocking conditions shall be checked by the interlocking scheme which is implemented on bay level.

After command execution, the operator shall receive a confirmation that the new switching position is reached or an indication that the switching procedure was unsuccessful with the indication of the reason for non-functioning.

(d) System Supervision Display

The SAS shall feature comprehensive self-supervision such that faults are immediately indicated to the operator before they possibly develop into serious situations. Such faults are recorded as faulty status in a system supervision display. This display shall cover the status of the entire substation including all switchgear, IEDs, communication links, and printers at the station level etc.

(e) Reports

The SAS shall generate reports that provide time-related information on measured values and calculated values. The data displayed shall comprise:

Trend reports:
1) day (mean, peak)
2) month (mean, peak)
3) semi-annual (mean, peak)
4) year (mean, peak)

Historical reports:
1) day
2) week

3) month
4) year

It shall be possible to select the displayed values from the database online in the process display. Scrolling between e.g. days shall be possible. Unsure values shall be indicated. It shall be possible to select the time period for which the specific data are kept in the memory.

This report shall be printed automatically at pre-selected times. It shall also be possible to print this report on request.

(f) Trend Display (Historical Data)

A trend is a time-related follow-up of process data. The analogue channels of all connected bay level devices on the 132 kV level shall be illustrated as trends. The trends shall be displayed in graphical form as columns or curve diagrams with 10 trends per screen as maximum.

It shall be possible to change the type of value logging (direct, mean, sum, or difference) online in the window. It shall also be possible to change the update intervals online in the picture as well as the selection of threshold values for alarming purposes.

(g) Event List

The event list shall contain events, which are important for the control and monitoring of the substation. The time has to be displayed for each event.

The operator shall be able to call up the chronological event list on the monitor at any time for the whole substation or sections of it.

A printout of each display shall be possible on the hard copy printer.

The events shall be registered in a chronological event list in which the type of event and its time of occurrence are specified. It shall be possible to store all events in the computer. The information shall be obtainable also from printed event log.

The chronological event list shall contain:

1) position changes of circuit breakers, isolators and earthing devices
2) indication of protective relay operations
3) fault signals from the switchgear
4) violation of upper and lower limits of analogue measured value
5) loss of communication

Filters for selection of a certain type or group of events shall be available. The filters shall be designed to enable viewing of events grouped per:

1) date and time
2) bay
3) device
4) function
5) alarm class

(h) Alarm List

Faults and errors occurring in the substation shall be listed in an alarm list and shall be immediately transmitted to the control centre. The alarm list shall substitute a conventional alarm tableau and shall constitute an evaluation of all station alarms. It shall contain unacknowledged alarms and persisting faults. Date and time of occurrence shall be indicated.

The alarm list consists of a summary display of the present alarm situation. Each alarm shall be reported on one line that contains:

1) The alarm date and time
2) The name of the alarming object
3) A descriptive text
4) The acknowledgement state

The operator shall be able to acknowledge alarms, which shall be either audible or only displayed on the monitor. Acknowledged alarms shall be marked at the list.

Faults that appear and disappear without being acknowledged shall be specially presented in a separate list for fleeting alarms. For example due to bad contacts or intermittent operation.

Filters for selection of a certain type or group of alarms shall be available as for events.

(i) Object Picture

When selecting an object such as a circuit breaker or isolator in the single line diagram, first the associated bay picture shall be presented. In the selected object picture, all attributes such as

1) type of blocking,
2) authority
3) local / remote control
4) NLDC/SAS control
5) errors,
6) etc.,

shall be displayed.

(j) Control Dialogues

The operator shall give commands to the system by means of soft keys located on the single line diagram. It shall also be possible to use the keyboard for soft key activation. Data entry is performed with the keyboard.

(k) User Authority Levels

It shall be possible to restrict the activation of the process pictures of each object (bays, apparatus, etc.) to a certain user authorisation group. Each user shall then be given access rights to each group of objects, e.g.:

1) Display only
2) Normal operation (e.g. open/close apparatus)

3) Restricted operation (e.g. by-passed interlock)
4) System administrator

For maintenance and Engineering purposes of the station HMI, the following authorisation levels shall be available:

1) No Engineering allowed
2) Engineering/configuration allowed
3) Entire system management allowed

The access rights shall be defined by passwords assigned during the log-in procedure. Only the system administrator shall be able to add/remove users and change access rights.

5.20.9.3 System Performance

The refresh/update times on the operator station PC under normal and calm conditions in the substation shall be according to the levels specified below:

Function	Typical values
Exchange of display (first reaction)	< 1 s
Presentation of a binary change in the process display	< 0.5 s
Presentation of an analogue change in the process display	< 1 s
From order to process output	< 0.5 s
From order to update of display	< 1.5 s

5.20.9.4 System Reliability

The SAS system shall be designed to satisfy very high demands for reliability and availability concerning:

1) Solid mechanical and electrical design
2) Security against electrical interference (EMI)
3) High quality components and boards
4) Modular, well-tested hardware
5) Thoroughly developed and tested modular software
6) Easy-to-understand programming language for application programming
7) Detailed graphical documentation, according to IEC 61131-3, of the application software
8) Built-in supervision and diagnostic functions
9) After sales service
10) Security
11) Experience of security requirements
12) Process know-how
13) Select before execute at operation
14) Process status representation as double indications
15) Distributed solution
16) Independent units connected to the local area network
17) Back-up functions

18) Panel design appropriate to the harsh electrical environment and ambient conditions
20) Panel grounding to provide immunity against transient ground potential rise

5.20.9.5 Configuration Tools

The configuration of the station HMI shall be made using the operator station working in Windows NT environment. The various functions shall be customised by easy to use interactive configuration tools. Configuration shall include the visual presentation of the object, adaptations needed in process data-base and adaptations of the communication configuration data.
A portable personal computer (PC) as a service unit shall be foreseen for on-site modifications of the control and protection devices. The service unit shall be used for documentation, test and commissioning.

The PC based service & support system shall be used for the following purposes:

1) System configuration
2) System testing
3) Help functions
4) Program documentation
5) Down- and up-loading of programs
6) System commissioning
7) Data base management
8) Changing peripheral parameters

The service & support system shall be able to monitor data in the running substation control system and to present changing variables on the display screen in graphic representation.

5.20.9.6 Documentation

The following documentation shall be provided for the system during the course of the project and they shall be consistent, CAD supported, and of similar look/feel:

1) List of drawings
2) Control room layout
3) Assembly drawing
4) Single line diagram
5) Block diagram
6) Circuit diagram
7) List of apparatus
8) List of labels
9) Functional design specification (FDS)
10) Test specification for factory acceptance test (FAT)
11) Logic diagram
12) List of signals
13) Operator's manual
14) Product manuals
15) Calculation for uninterrupted power supply (UPS) dimensioning
16) High-quality SCD file.

(Please refer to chapter 5.20.6.3 which specifies the requirements of the local back-up control mimic. This back-up control shall be used during emergency conditions, or bay control IED is out of service or when control from HMI workstation or from remote NCC has been lost.)

5.20.9.7 Indicating Meters in Local Back-up Control Panels

Each circuit shall be equipped with Indicating meter for measurement of three phase currents, voltages, frequency, power factor, active and reactive power. Repeat pulse outputs are to be provided from all energy meters, where specified.

5.20.10 Availability Calculations

The Contractor shall submit availability calculations for the offered substation automation system.

5.21 Trip Circuit and Power Supply Supervision

Trip circuit supervision relays shall be provided to monitor each of the trip circuits of circuit breakers in the relay panel and each relay shall have sufficient contacts for visual/audible alarm and indication purposes.

The trip circuit supervision scheme shall provide continuous supervision of the trip circuits of the circuit breaker in either the open or closed position and independent of Local or Remote selection at the local operating position.

The trip circuit supervision scheme shall operate satisfactorily and correctly under such conditions.

Relay elements shall be delayed on drop-off to prevent false alarms during faults on dc wiring on adjacent circuits, or due to operation of a trip relay contact.

Series resistances shall be provided in trip circuit supervision circuits to prevent mal-tripping of a circuit breaker if a relay element is short circuited.

Relay alarm elements should be equipped with self-resetting flag indicators.

Where specified, time delayed power supply supervision relays shall be provided to monitor the duplicated d.c. power supplies for tripping, closing, CB fail, Busbar protection etc. within a relay panel. An alarm shall be given if either supply voltage falls below 70% of nominal voltage for a period in excess of 3 secs. The relay shall be equipped with a self-resetting flag indicator, and shall be suitable for continuous operation at 125% of nominal d.c. voltage.

5.22 Busbar Voltage Selection

Where required, selected voltage references, one for each busbar, shall be employed for all indications, metering, protection and synchronizing where appropriate. The correct voltage selection for the

requirements of each circuit according to the busbar to which it is connected shall be obtained by direct use of auxiliary contacts on busbar selector switches.

5.23 Synchronising

5.23.1 Synchronising Scheme

Synchrocheck facilities are required at all circuit breakers controlling feeder circuits and bus coupler circuits, and LV circuit breakers controlling transformers. Interlocking is not required between the HV and LV circuit breaker on the transformer circuit since the transformer could be energised from either network.

The system provided under the Contract is to be to the approval of the Engineer and is to be such that the synchronising circuit must be established before the circuit breaker can be closed. Check synchronising relays to prevent circuit breaker closing under adverse conditions are to be included where specified.

Synchrocheck relays shall check the phase and magnitude and slip frequency of the voltage difference across the open circuit breaker with contacts connected to prevent inadvertent manual closing outside acceptable limits.

It shall be possible when closing via HMI Workstation or remote NCC to close a circuit breaker when both the line side and the busbar side of the circuit are dead by bypassing the check synchronising relay. The dead line/dead busbar check shall be made by means of 3 phase undervoltage devices. The primary circuit shall be deemed to be dead if the voltage of all three phases is less than 20% of nominal voltage.

It shall only be possible to operate on one circuit at a time.

5.24 Diagrams

The Contractor shall submit schematic diagrams for consideration of the Engineer within six months of the contract commencement date. Prior to preparation of schematic diagrams, the Contractor shall provide single line, block and logic diagrams in order to agree the circuit schemes and operating modes.

The Contractor will be provided with a set of drawings for Substations as soon as possible after award of Contract. As part of the contract documentation, the Contractor shall provide integrated sets of complete drawings (schematic and wiring diagrams and cable schedules etc.) for protection and substation automation. The detail list of documentation is given under clause 5.19.9.6.

5.25 Current Transformer Calculations

The Contractor shall submit to the Engineer detailed calculations substantiating the parameters of the current transformers he proposes to provide. They shall be presented within six weeks of the contract

commencement date.

5.26 Energy Meter (Tariff Metering)

5.26.1 Meter Requirements

1. Programmable meter
2. Adjustable different tariff
3. 110-400V flexible input voltage setting
4. 1(10) A current rating
5. Accuracy class to be ±0.2 for kWh and ±0.5 for kVARh
6. RS232/485 port for modem interface
7. Standard metering protocol for remote interface
8. Data storage of 16 channel@30min interval and of 90 days
9. Optical head and software to upload and download of meter data
10. Password protection for programming and for configuration
11. Configurable display, including meter ID, power quadrant display etc.
12. Provision for quick reading scroll, reset etc. (programmable)

5.26.2 Additional Requirements

1. Online test facility of meter (with TTB) and with security sealing provision
2. TTBs should be at the suitable accessible panel front location with meter
3. Meter cabinet should be exclusively for tariff metering only and have sufficient security sealing provision, provided with 220 V, 5 A, two-pin socket outlet for modem power, auxiliary bias power, testing equipment power, etc.
4. All main metering CTs and VTs should be directly terminated to the metering panel including star point (4 wire)
5. The backup metering circuit may be shared for other purpose
6. The VT MCBs (both main and backup) should be located in the metering panel; downstream VT MCB rating should be less than that of upstream
7. All CT & VT terminals should have security sealing provisions.

5.26.3 Normal Display List

Scroll Order	Display Item Name
1	Complete LCD test
2	Present date
3	Present time
4	Current billing total kWh-Del
5	Current billing total kWh-Rec
6	Current billing total kVARh-(Q1+Q4)
7	Current billing total kVARh-(Q2+Q3)
8	Current billing maximum kW-Del
9	Current billing maximum kW-Del Date
10	Current billing maximum kW-Del Time

Scroll Order	Display Item Name
11	Current billing cumulative kW-Del
12	Current billing maximum-Rec
13	Current billing maximum kW-Rec Date
14	Current billing maximum kW-Rec Time
15	Current billing cumulative kW-Rec
16	Phase A Voltage
17	Phase B Voltage
18	Phase C Voltage
19	Phase A Current
20	Phase B Current
21	Phase C Current
22	Phase A voltage angle
23	Phase B voltage angle
24	Phase C voltage angle
25	Phase A current angle
26	Phase B current angle
27	Phase C current angle
28	System PF-arithmetic
29	Line frequency

5.26.4 Alternate Mode Display List

Scroll Order	Display Item Name
1	Complete LCD test
2	Present date
3	Present time
4	Current billing total kWh-Del
5	Current billing total kWh-Rec
6	Current billing total kVARh-(Q1+Q4)
7	Current billing total kVARh-(Q2+Q3)
8	System PF-arithmetic
9	Line frequency

Load profile (cumulative meter reading) and Instrumentation profile data in the following format should be stored in intervals of 30 min for at least 100 days:

5.26.5 Interval Date (Load Profile)

Interval Data Mode: Cumulative Engineering Units

Time	kWh-Del	kWh-Rec	KVARh-(Q1+Q4)	kVARh-(Q2+Q3)
Date: 1/31/2015				
00:00	0	0	0	0

Time	kWh-Del	kWh-Rec	KVARh-(Q1+Q4)	kVARh-(Q2+Q3)
00:30	0	0	0	0
01:00	0	0	0	0
01:30	0	0	0	0

5.26.6 Interval Date (Instrumentation)

Set-1

Time	End Phase A Voltage	End Phase A Voltage	End Phase A Voltage	Average System kW
Date: 1/31/2015				
13:45	61.0544	61.1424	61.072	0

Set-2

Time	End Phase A Current	End Phase A Current	End Phase A Current	Average System PF-Arithmetic
Date: 1/31/2015				
13:45	0.0008	0.0004	0.0004	-0.7002

Self-read feature for at least 12 months' billing history.

6. Auxiliary Power and Control Cables

6.1 Scope

A complete cabling system for the substation auxiliary power requirements and the control and protection multicore cabling shall be designed, provided, installed and commissioned by the Contractor as specified in the Project Requirements and schedules. All ducts, cable racking and supports are to be supplied under the Contract. The Contractor shall, furnish satisfactory evidence as to the competence of the electricians and jointers, he proposes to employ on the cable installation and jointing works.

6.2 General Description of Installation

The complete cabling installation, including that associated with control and instrumentation, shall be managed by the Contractor, who shall be responsible for design, procurement, installation and works/site testing of the whole installation.

The Contractor shall employ a cabling computer program to facilitate the above and the Bidder shall describe in his Tender the cabling management procedures he will adopt. A cable scheduling system will be imposed by the Engineer.

The Contractor shall provide an installation in accordance with the best modem practice and complete in every detail for continuous operation.

Cabling areas will include those which have natural ventilation. Cabling shall therefore be designed for the maximum ambient temperatures expected.

To cater for future requirements, adequate provision shall be made for the associated cables in respect of trench sizes, space for future racks or trays and numbers of cables permitted in areas or spaces required for future equipment.

The Contractor shall submit to the Engineer drawings for approval showing the proposed cable routes, cross-sections of the trenches and arrangements of the cable racks and trays.

The Contractor shall prepare and provide all necessary cable schedules. The cable numbering system to be used shall be advised to the Contractor and this system shall be followed.

The Contractor shall provide all necessary power, multicore and communications cables required as required and specified in the Project Requirements.

6.3 Standards

The cables shall comply with British Standards or IEC standards and recommendations, or any other Internationally recognised standards, subject to the approval and acceptance of the Engineer.

6.4 Cable Installation

6.4.1 General

The cabling system shall be designed to incorporate maximum practical security, to ensure that an incident such as fire causing loss of cable circuits in any one route would at worst result in the interruption in operation of one unit only. Cables with reduced fire propagation characteristics shall be provided.

Cables shall be satisfactory for operation under the atmospheric and climatic conditions prevailing at the site and under such variations of current, voltage and frequency as may be met under fault and surge conditions on the system.

Cables shall be derated to allow for the likely number of cables following a given route.

The methods of installation shall be as follows:

(a) directly buried
(b) in concrete trenches (on racks or trays)
(c) in ducts
(d) in air

Control and instrumentation cables shall be screened/shielded to minimise interference, where necessary.

6.4.2 Installation Criteria

Specific requirements shall be as detailed in the project requirements.

System security shall be achieved by ensuring that cables are segregated or separated from each other as appropriate. Segregation shall be achieved by laying cables associated with any one high voltage circuit of a pair on separate trays or racks at least 600 mm apart from the cables of the other of the pair with an airspace, but not necessarily a physical barrier, between them.

In general, to minimise interference, control cables and instrumentation cables shall be separated from power cables.

The following group classifications will be allocated for each cable:

- Group A: Single core power cables,
- Group B: Multicore power cables,
- Group C: Multicore control cables and protection cables,
- Group D: Multi-pair control and instrumentation or indication cables.

In general, single core (Group A) and multicore (Group B) power cables shall be allocated to separate racks. In a similar manner, multicore control (Group C) and multi-pair (Group D) instrumentation cables shall generally be allocated to separate trays.

There shall generally be a minimum separation of 600 mm between instrumentation cables (Group D) and power cables (Groups A and B), and a minimum separation of 300 mm between control cables (Group C) and power cables (Groups A and B). However, both these separation distances may be reduced where the two types of cable only run in parallel for a limited distance, provided the Contractor demonstrates that the level of interference resulting will not be detrimental to the operation of the equipment concerned.

6.4.3 Reduced Fire Propagation

A cable installation with reduced fire propagation characteristics shall be provided, utilising cables with organic compounds which are capable of extinguishing or considerably reducing the spread of flame along the cable.

Consideration shall also be given to ensuring that the minimum toxic or corrosive products are given off on combustion of any organic component used in cable construction.

6.4.4 Type Approval

Cables and accessories for use at all voltages shall have satisfactorily passed type approval tests equal to those required by the International Electro technical Commission or equivalent, and details for the cable designs offered shall be given in Schedule E of Particulars and Guarantees.

The Contractor is to certify that the cables and/or accessories offered will be identical in all essential particulars in respect of design, materials and workmanship with the cables and/or accessories for which type approval certificates are offered in support of his tender. The Contractor shall also ensure that all materials used will be subjected to and shall have satisfactorily withstood such tests as are customary in the manufacture of the types of cables specified. Records of such tests shall be available for inspection, if required by the Engineer.

6.4.5 Cable Sizing and Routing

The Contractor shall be responsible for all cable sizing and routing design, procurement, installation and testing.

Proposals for the following aspects of cable design shall be submitted for approval:

- Routing cables along the shortest route compatible with segregation/separation and capacity limitations
- Sizing cables in accordance with length grouping, ambient temperature and current rating
- Recording estimated lengths and later measured lengths for each cable
- Progressing the cable installation
- Producing and progressing cable schedules, cable termination schedules, and support steelwork schedules and drawings

All necessary de-rating factors shall be applied when sizing cables, to allow for maximum ambient temperatures, soil temperatures, values of thermal resistivity of soil, and grouping as necessary.
Due allowance shall be made for the method of installation, depth of laying, spacing and grouping factors.

All power cables shall be adequately rated to withstand the thermal and magnetic effects of short-circuit fault currents equivalent to the short circuit fault rating of the associated switchgear, except when advantage can be taken of the peak current limiting effects of MCCB's and fuses. Screens and / or outer sheaths shall be designed to carry the full ground fault current.

The short-time rating of all transformer and interconnector feeders shall correspond to the maximum short-circuit conditions and be based on the previous maximum continuous rating operating temperature, followed by the initial asymmetric peak current, followed by the thermal steady state r.m.s. fault current for the total duration required for the associated main and back-up protection to operate and isolate the circuit. When protected by a circuit breaker which is not of the current limiting type, the cable shall withstand the maximum fault current, including asymmetric peak, for at least 3 seconds without damage.

For 400V motor supply cables the rating shall be based upon the duration of the let-through current of the associated main circuit breaker or fuse protection. The fault currents considered shall not include for the reduction due to the impedance of the cables concerned.

Maximum conductor temperatures permissible during the passage of short-circuit current shall be in accordance with cable Manufacturer's recommendations and joints and terminations shall be designed to match the cable characteristics.

For all alarm, control, indication, instrumentation, metering and protection cables, the Contractor shall determine the impedances, load burdens and other requirements of the cabling and associated equipment and shall provide cabling for satisfactory operation. Particular attention shall be given to protection circuits and the Contractor shall ensure that satisfactory operation will be achieved under overload or short circuit conditions on the system.

The Contractor shall furnish copies of calculations and other details to show how the ratings and cross-section areas of all cables have been obtained and the de-rating factors for which allowance has been made. Where a cable is routed through differing types of installation conditions, the condition giving the lowest cable rating shall determine the cable size.

The sizes of all cables shall be submitted to the Engineer for approval and the Engineer may require the Contractor to increase the cross-sectional area of the conductor to ensure that the required current carrying capacity and performance is obtained. All such changes shall be made by the Contractor without extra cost.

6.5 Cable Construction

6.5.1 Oversheaths

All cables shall have a black flame retardant low smoke PVC oversheath material, to meet the fire retardant characteristics of BS 4066 and IEC 60332.

PVC sheathing shall comply with IEC 60540 and shall have flame retardant properties such that the Oxygen Index is not less than 30 when tested in accordance with A.S.T.M. D2863-77. Test certificates stating measurement values for sample drum lengths of cable shall be provided.

The external surface of the oversheath shall be embossed along two or more lines approximately equally spaced around the circumference with the words "ELECTRIC CABLE" in English. Figures for the relevant voltage grade, together with Manufacturer's name, shall be embossed on the oversheath.

The letters and figures shall be raised and shall consist of upright block characters. The maximum size of the character shall be 13 mm and the minimum size 15% of the approximate overall diameter of the cable. The gap between the end of one set of embossed characters and the beginning of the next shall not be greater than 150mm.

The minimum thickness of oversheath shall not fall below the Manufacturer's stated value by more than 0.2mm plus 20 percent.

A means of identifying the Manufacturer shall be provided throughout the length of the cable.

6.5.2 Armouring

All multicore cables shall be provided with galvanised steel wire armour. Single-core cables shall have copper or aluminium wire or tape armouring.

The armour shall be protected by an overall PVC or plastic sheath.

6.5.3 Laying Up

The cores of multicore cables shall be laid up with a right hand direction of lay. Where necessary, non-hygroscopic fillers, which may be applied integrally with the bedding, shall be used to form a compact and circular cable.

6.5.4 Cable Drums

Cable drums shall be non-returnable and shall be made of timber, pressure impregnated against fungal and insect attack, or made of steel suitably protected against corrosion. They shall be lagged with closely fitting battens.

Each cable drum shall bear a distinguishing number on the outside of one flange. Particulars of the cable, i.e. voltage, conductor size and material, number of cores, type, length, gross and net weights shall also be clearly shown on one flange. The direction of rolling shall be indicated by an arrow on

both flanges. The method of drum marking shall be to the Engineer's approval.

Cable spare lengths shall be wound on to steel drums before they are handed over to the Employer's stores.

6.5.5 Sealing and Drumming

Immediately after the Works tests, both ends of each cable length shall be sealed by means of a shrinkable cap and the end projecting from the drum shall be adequately protected against mechanical damage during handling. The ends of each drum length of multicore cables shall be masked red and green in accordance with BS 6346 or BS 5467.

6.5.6 Spare Cable

Spare cable and accessories, as detailed in the schedules, are required to be included in the Contract.

6.5.7 Jointing Accessories

Cables shall be installed in continuous lengths and straight through jointing between shorter lengths will not be permitted.

Jointing accessories shall include all necessary internal and external fittings, insulating materials, soldering metal, glands, filling and drain plugs, armour clamps, earth bonding terminals and filling compounds as appropriate.

Mechanical glands for the termination of elastomeric or thermoplastic insulated cables into straight-through joints and termination accessories shall meet the requirements of BS 6121 and shall be correctly designed for the termination of the armouring. The gland shall not only adequately secure the armour to provide efficient electrical continuity but shall also provide a watertight seal between the oversheath and the inner extruded or taped bedding to prevent the ingress of moisture. All glands shall be fitted with a substantial earth bond terminal.

The armour clamping device shall be capable of clamping the cable armour so that the clamp withstands any short circuit current from the armour wires, through the gland body to the integral bonding connector.

Sealing end porcelains shall be free from defects and thoroughly vitrified so that the glaze is not depended upon for insulation. The glaze shall be smooth and hard, completely cover all exposed parts of the porcelain and for outdoor types shall be a uniform shade of brown.

Porcelains must not engage directly with hard metals and, where necessary, gaskets shall be interposed between the porcelain and the fittings. All porcelain clamping surfaces in contact with gaskets shall be accurately ground and free from glaze.

Outdoor sealing ends and fittings shall be unaffected by atmospheric conditions, proximity to the coast, fumes, ozone, acids, alkalis, dust or rapid changes of air temperature between 15˚C and 65˚C under working conditions.

6.6 Types of Cable

6.6.1 Low Voltage Cables

These cables shall be in accordance with IEC 60502 with a voltage rating of 0.6 / 1 kV. They cables shall have stranded copper conductors. Insulation shall be XLPE with an operating temperature of 90˚C.

6.6.2 Control Cables and Instrumentation Cables

6.6.2.1 General

Two types of cable shall be provided for the control and instrumentation cabling.

The first is multicore cable with stranded (7/0.67mm wires) copper conductors of min 2.5sq.mm which is suitable for voltages up to 300V to ground a.c. or d.c. and currents up to 5A. These cables shall be used where a low impedance is essential i.e. the secondary wiring of current or voltage transformers and for circuit breaker or contactor controls.

The second type designated "SIGNAL CABLE" is defined as those cables carrying milliamp, analogue or digital signals at low voltage levels (110 V d.c. maximum) used on instrument and Logic Transmission Systems. These cables shall be multiple twisted pairs, screened and PVC covered with conductors sized 1.5 mm² minimum. The use of cable cores shall be such that each plant analogue signal is transmitted in a twisted pair. Under no circumstances shall the signal positive be in a different twisted pair to the negative. 20% spare capacity shall be included in all multiple twisted pair cables. The combinations of multiple twisted pair cables used throughout the plant shall be restricted to 2, 5, 10, 20, 30, 50 and 100 pairs.

Inductive interference between primary and secondary cables due to load, switching or unbalanced fault conditions associated with the primary circuit shall be avoided. The more sensitive telephone, communication, analogue and digital circuit cables shall be spaced at least 600mm from power cables.

6.6.2.2 Multicore Control Cables

Cables shall comply with the construction here above and shall have cross-linked polyethylene (XLPE) insulation.

All cables shall be provided with a low smoke PVC oversheath.

Multicore control cables shall be generally in accordance with IEC 60502 with a voltage rating of 0.6/1 kV, except that 2.5 mm² copper conductors shall be stranded (7 / 0.67 mm wires). Standard designs shall be for cables with 2, 3, 4, 8, 12, 16, 24 and 36 cores, and single strand conductors will be accepted at 1.5 mm².

All these cables shall have galvanised steel wire armouring.

These cables shall be used where a low impedance is essential, e.g. for the secondary wiring of current and voltage transformers and for circuit breaker and contactor control circuits.

6.6.2.3 Multi-Pair Instrumentation Cables

Multi-pair instrumentation cables shall be provided in accordance with industry standards. These cables shall have solid copper conductors, typically of 0.9 mm diameter laid in twisted pairs, triplets or quads. The cables shall be polyethylene or XLPE insulated. They shall have galvanised steel wire armouring.

Cables shall be provided with either an overall metallic tape screen or individual tape screens round each conductor bundle to reduce interference from adjacent circuits.

These cables shall be used for circuits with a voltage rating not exceeding 125 V to earth and a current rating not exceeding 20 mA, where considerations of interference and cross-talk are of great importance. Typical applications include communications, computer signals, transducer circuits and alarms.

6.6.2.4 Oversheaths

All the cable types above shall have a black flame-retardant low smoke PVC oversheath. In normally manned locations, especially the control building, cables shall have a low smoke, zero halogen oversheath, so as to minimise the generation of smoke and corrosive acid gases in the event of a fire.

6.6.2.5 Telephone Type Cables (TWPVC)

Construction
Multi-pair cables with 1/0.9mm tinned copper conductors complying with IEC 60228, PVC insulation, individual twisted pairs, PVC bedding, single wire armoured and low smoke PVC sheathed overall.

Insulation
PVC insulation shall be "Hard Grade" to BS 6746 with a radial thickness of 0.7mm nominal 0.57mm minimum. Minimum insulation resistance per 1000 metres of conductor at 20˚C shall be 10,000 Megohms. Cable laid parallel to overhead lines shall be polyethylene insulated polyethylene inner sheath for l5kV between conductors and armour with a thickness of insulation 0.8mm nominal 0.66mm minimum. The Contractor shall provide calculations to show induced voltage levels under overhead line ground fault conditions.

Laying Up
The insulated conductors shall be uniformly twisted together with a right hand lay to form a pair. The length of lay is not to exceed 150mm and the lays for each adjacent pair are to differ from one another in length. In any case, the length of lay of the pairs shall be such that any cross-talk from pair to pair is the least possible.

Core Identification
The insulation of the cores shall be colour coded in accordance with IEC 60189-2 for 20 unique cabling elements (pairs) as described in Appendix A of IEC 60189-2.

6.6.2.6 Pilot Cables

Telephone-type cable laid in the ground alongside HV power cables shall take into account the effects of induced voltages.

6.7 Straight-through Joints

Each cable shall be run in one continuous length. Straight-through joints will not be permitted.

6.8 General Methods of Cable Installation

The arrangement of cables and the methods of laying shall be approved by the Engineer. Cables shall be installed by the following methods only:

- in concrete trenches
- in ducts
- on cable racks or trays.

Concrete trenches shall be provided in switchrooms. Cables shall be installed in a manner which permits the required ratings and with due regard to the number of cables following a given route, including future plant extensions.

All cables routed under roads and access ways usable by vehicular traffic shall be installed in ducts.

At all such crossings spare ducts shall be installed; the number of spare ducts shall be two, or 20% of the total number of ducts installed at each crossing, whichever is greater.

Mechanical protection to the Engineer's approval shall be installed at all, points where the cable is vulnerable to mechanical damage. Locations where this protection shall be installed shall include all points where cables pass through a wall, floor, side or top of a cable trench. In outdoor locations cables shall be provided with mechanical protection from ground level to a minimum height of 1 metre or the cable box on the apparatus, whichever is lower.

Cables shall be installed in such a manner as to avoid undue risk of damage during installation. The Contractor shall provide all necessary rollers and supports, and bending radii shall comply with the recommendations of cable specifications and be to the approval of the Engineer.

Sunshields shall be provided in all locations where the cable would otherwise be subjected to direct sunlight.

6.9 Cables laid Directly in the Ground

The method of installation shall be as follows:

Trenches shall be excavated to the minimum depth shown in Drawing for cable trench. Covers shall be provided over cables laid in the trench.

Filling in of trenches shall not be commenced before inspection and approval by the Engineer of the cables and accessories in-situ.

The Contractor shall lay the cables direct in the ground in the following manner:

70mm minimum of builders fine and graded and washed sand or other approved material shall be placed to form a bed for the cables.

After the cables have been laid they shall be covered with additional riddled sand well punned over and around the cables. No mechanical punners shall be used for this work. Protective covers of concrete shall be provided and installed.

Where, in the opinion of the Engineer, the soil on the site is unsuitable for backfilling, the Contractor shall arrange for the importation of suitable material.

Where three single core cables are laid direct in the ground and form one three phase circuit, they shall unless otherwise stated, be laid touching one another in trefoil formation, with one cable uppermost. In order to maintain a trefoil formation the three cables shall be tied together with tarred twine or by other approved means at intervals of 1.5m.

Unless otherwise approved, auxiliary control cables shall be laid under the same covers as the power cables and there shall be at least 50 mm of riddled sand between the two types of cable. Above the protective covers (tiles) there shall be provided 150 mm wide Teri-tape in yellow with "CAUTION - ELECTRIC CABLE" in English.

After any cable has been laid and until all of the cables to be laid in the trench have been covered with their protective covers, no sharp metal tools, such as spades or fencing stakes, shall be used in the trench or placed in such a position that they may fall into the trench. Rollers used during the laying of cables shall have no sharp projecting parts liable to damage the cables.

6.10 Cables drawn into Ducts

Ducts and pipes 35 mm minimum in excess of cable diameter shall be supplied and installed by the Contractor in accordance with the building and civil works section.

Ducts shall be of rigid PVC and shall be surrounded by concrete of minimum thickness of 150.

Before pulling cables through ducts, the Contractor shall remove any loose material from the ducts, and prove them by drawing through a mandrel of slightly less diameter than the duct. Any lubricant used shall have no deleterious effect on the cables.

Any ducts or pipes not used shall be sealed by plugs (detail subject to approval) supplied by the Contractor before backfilling.

The ducts shall be water and vermin proof sealed, after completion of cable installation.

6.11 Cables installed in Concrete Trenches

The cable trench system shall be designed by the Contractor to the approval of the Engineer. It shall be complete with removable covers and shall comply with the building and civil works Section.

All cables routed in concrete trenches shall be suitably supported by means of cleats or racks and raised from the trench floor by means of suitable spacers. All cables shall be run in a neat and orderly manner and the crossing of cables within the trench shall not be acceptable without the prior approval of the Engineer.

The Contractor shall be responsible for removing and replacing the trench covers free of charge during the execution of his work as directed by the Engineer.

6.12 Cables Supported on Racks, Trays, Etc.

6.12.1 General

All single core and multicore main power cables shall be installed in cleats or saddles fixed at intervals. Multicore power cables shall be installed on trays or racks but segregated from other cables on the same tray by a space of 300 mm.

All control cables shall be installed on racks or trays with adequate clamps, cleats or ties to avoid excessive sagging. The Contractor shall include for the preparation and provision of single line cable routing drawings and detailed cable supporting steelwork drawings, necessary to enable the Engineer to give his approval for all main and subsidiary routes before installation commences.

Ample allowance shall be made in the design for additional cabling for future extensions.

Racks and trays shall be secured to channel or similar inserts installed in accordance with Building and Civil works section.

All cables shall be run with a particular regard to neatness of appearance. Multiple runs shall be arranged so that cables entering or leaving the run do so in a logical manner.

Trays and supporting steelwork shall be securely bonded and grounded to the main earthing/grounding system. Bonding and grounding connections shall be adequate to carry prospective fault currents without exceeding thermal or voltage limits.

6.12.2 Supporting Steelwork

All supporting steelwork shall be hot dip galvanised after manufacture and shall be to the approval of the Engineer.

Steelwork section shall not be less than 50 x 50 x 6 mm for steel channels and 50 x 50 x 5 mm for angles.

On all main cable runs, supporting structures shall be designed and drilled to accommodate additional cable racks or cleats to the extent of 20% of cables installed under the Contract and those required for known future extensions. The spacing between supporting structures shall be not greater than 1 m unless otherwise approved by the Engineer.

In cases where cables or their supports must be fixed to structural metal work, care shall be taken to avoid eccentric load transfer to beams or other structural metal. Also, local overloading or deformation of structures shall be avoided. The Contractor shall, if required, demonstrate that the loading resulting from the attachment of cabling steelwork has been taken into account in the steelwork design.

6.12.3 Cable Clamps, Cleats, Saddles and Ties

For single core cables carrying three phase alternating current, non-magnetic trefoil cleats shall be used and for other single core and three core cables claw type single or multicore unit cleats shall be used. The cleating arrangements for single core cables shall be adequate to withstand all short circuit forces.

Cable clamps shall be used at any change of direction of cable laying, but at agreed intervals on straight runs cable ties of approved design may be used.

Every non-flexible type cable shall be securely supported at a point not more than 1 m from its terminal gland to prevent stressing the termination, and on vertical runs passing through floors, immediately above the floor.

6.12.4 Trays and Racks

The Contractor shall provide all necessary trays or racks which shall be fixed at not more than 1 m centres. On all main runs trays or racks shall be installed to accommodate additional cables to the extent of 50% of those installed under the Contract or known future requirements.

Cables shall be installed on trays, in general as follows:

- Up to 16 mm² - double layer touching.
- 25 to 70 mm² - single layer touching.
- Above 70 mm² - single layer with 25 mm (minimum) spacing.

All cable trays shall be perforated.

All trays and racks shall be galvanised to a thickness not less than 1.6 mm and shall be PVC coated in exposed areas. The erection of steelwork, trays or racks shall not proceed until the Engineer's approval for such has been obtained.

Where cables are run on trays or racks, they shall be tied to the tray at 1 m intervals using materials approved by the Engineer.

The cable tray system shall have minimum of 20% spare cable capacity throughout.

6.13 Cables Installed on Structural Steelwork and Brickwork or Concrete

The majority of cables shall be routed on steel racks or trays but where cables have to be installed on buildings and building framework the cables shall be held by spacer saddles or cleats screwed or welded in position. The Contractor shall supply all necessary spacer saddles or cleats and fix these in position in the least obtrusive manner possible, copper cleats being used for copper sheathed MICS cable.

Cables shall not be routed on tiled, lagged or other special finished surfaces.

6.14 Terminations

6.14.1 General

The Contractor shall be responsible for making all terminations, checking and setting-to-work the completed installation. All cables provided as part of the Contract shall be terminated at both ends.

For control wiring the cable tails shall be so bound that each wire may be traced back to its associated cable without difficulty. Cores in twisted pairs or groups shall be kept together. Any spare cores shall be numbered and terminated in the spare terminals furthest away from the cable gland. All cables shall be long enough to permit a second termination if necessary at a future date to the remotest termination location in the panel.

Cable glands shall be used at all equipment to support the weight of cable from the terminations and to seal the cable to the equipment, unless otherwise approved by the Engineer. PVC, XLPE, silicone rubber and PTFE insulated cables shall be terminated via glands to BS 6121.

Glands in all outdoor locations and within the Substation and other areas where water may impinge on cables shall be type EIU, with inner and outer seals and armour clamp. Unarmoured single core cables in these areas shall have type A2 glands.

Glands in indoor locations with the exceptions as noted above shall be type C for armoured cables and type A2 for unarmoured single core cables.

PVC shrouds shall be supplied and installed over each gland.

6.14.2 Power Cables

The Contractor shall ensure that the correct phase rotation and connections are achieved. Particular care shall be taken in the case of heavy cables, where subsequent correction may be difficult. Phase

tests will be witnessed by the Engineer and, if found necessary, the Contractor shall carry out the reversal of phase connections. Connections to electric motors shall be made as specified. Where motors have tails rather than bushings, a heat shrink or equivalent PVC tube for insulation of the crimp joint shall be provided.

Where insulated glands are provided, the Contractor shall ensure that the insulation is maintained after jointing the cable and shall, if required, demonstrate this to the satisfaction of the Engineer. The tails of two or three or four core cables in air insulated terminations shall be identified by a band of approved tape of appropriate colour over the self-sealing tape.

Single core cables shall be similarly identified by coloured tape over the cable beneath the gland.

6.15 Terminating and Jointing Conductors

Compression (indentation) type cable lugs and ferrules shall be provided and all necessary tools, including dies and other materials for making compression joints, shall be provided by the Contractor, who shall comply with the recommendations of the supplier of cables and lugs in the preparation and execution of each termination.

For stud type terminals approved crimping lugs shall be used.

Where clamp type terminals are used, the conductor shall be terminated without lugs, with the exception of flexible conductors having wires of 0.3 mm or smaller which shall be fitted with crimps to more than one conductor shall be terminated in each clamp.

6.16 Core Identification

A uniform core identification system shall be used throughout the Station. The following clauses outline the broad requirements but the exact implementation shall be agreed with the Engineer.

Approved numbered ferrules shall be supplied and fitted to every cable core of control and instrument cables at each termination. The ferrules or sleeves shall be of interlocking ring insulating materials such as plastic which shall be black engraved on yellow background and have a glossy finish. The ferrules or sleeves shall be unaffected by oil or damp. Identification marks on self-sticking cloth shall not be used. The ferrules shall be of "O" or "D" cross section. Ferrules of "C" type cross section shall not be used.

Single d.c. wires shall be identified by a red or blue coloured ring (positive or negative polarity) followed by the identification of the polarity concerned (instrumentation, klaxon, alarm, etc.).

Direct a.c. circuits shall be identified by a yellow end piece followed by an identification of the phase concerned.

Wiring for secondary circuits of voltage transformers shall be identified by a grey end piece and wires in current transformer secondary circuits shall be identified by a green end piece. This identification shall be completed by a terminal index.

All markings for terminal blocks, cables, cable conductors and wiring shall be located on the corresponding fault finding drawing.

Characters suitably marked "TRIP" in white shall be fitted on all wires associated with trip circuits.

A common system of ferrule numbering shall be adopted such that ferrule numbers at terminations shall agree with ferrule numbers on the internal wiring of equipment.

6.17 Cable Identification and Schedules

The Contractor shall prepare and submit computerised cable schedules, the content and style of which shall be to the general approval of the Engineer. These shall include cable identification numbers for all cables except those provided for lighting and small power circuits and those which are connected to the load side of distribution boards for lighting and small power circuits.

The cable identification number system shall be such as to give a brief general indication of the type and function of individual cables and shall be approved by the Engineer.

The Contractor may use a fully computerised system for rating, and routing of cables, but shall provide a system that readily permits the cables to be scheduled on the following basis in sequence of cable identification number:

a) By cable identification number only
b) By type and size of cables
c) By function of cable
d) By main LV AC and DC, switchboard, actuator boards.
e) By agreed electrical and mechanical plant functional groups.

The Contractor shall provide copies of the cable schedule in an approved format. The Contractor shall provide a standard software package together with a suitable personal computer to permit the Engineer to access, display, print and edit the schedules. The schedules shall be accessed by simple interactive dialogue using 'menu-selection' or other approved procedure.

In addition, the Contractor shall provide selected copies of the above schedules in a computer printout form at agreed intervals.

Each end of every cable, except those provided for lighting and small power circuits and which are connected to the load sides of distribution fuse boards, shall be identified with a separate cable reference number fitted in a suitable position under the cable termination.

Where cables enter and leave ducts or pipes, suitable identification markers shall be fitted.

The materials of the markers and fastenings shall be such as to avoid corrosion or deterioration due to incompatibility of materials and shall ensure permanent legibility.

6.18 Inspection and Testing

Inspection and testing during manufacture and after installation on site shall be in accordance with Section 15 of this Specification.

7. Earthing System and Lightning Protection

7.1 Scope

These chapters describe the general requirements for the earthing and lightning protection and shall be read in conjunction with the project requirements and schedules.

7.2 References

7.2.1 American Standards

ANSI/IEEE/std 80	IEEE Guide for Safety in AC Substation Grounding
ANSI/IEEE/std 81	IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potential of a Grounding System

7.2.2 German Standards

VDE 0140	Earthing Systems for Power Installations with Rated Voltages above 1 kV

7.2.3 British Standards

BS EN 13601	Specification for copper for electrical purposes: high conductivity copper rectangular conductors withdrawn or rolled edges.
BS EN 13601	Specification for copper for electrical purposes. Rod and bars
BS EN 12449	Specification for copper and copper alloys. Tubes
BS 2874	Specification for copper and copper alloy rods and sections (other than forging stock).
BS 4360	Specification for weldable structural steel
BS 6360:	Specification for conductors in insulated cables and cords.
BS 6651	Protection of Structures against Lightning
BS 6746	Specification for PVC insulation and sheath of electric cables.
BS 7430	Code of Practice for Earthing

7.3 General

An earthing system generally in accordance with the requirements of IEEE 80 and BS 7430 shall be designed under this Contract. The earthing system shall include earth electrodes to provide the connection to the general body of the earth, all earthing conductors and connections to all electrical equipment and metallic structures on the site. The earth electrodes shall limit the potential rise under fault conditions and buried conductors shall be provided to limit potential differences on the site and adjacent to the site to ensure safety to people and animals.

Protection for all electrical equipment against lightning shall also be provided.

7.4 Extent of Work

The Work under this Section comprises the design, supply and installation including excavation, back-filling and site testing of earthing systems and connections to electrical apparatus at 230kV and 132kV substation. Also included is the lightning protection scheme and the provision of portable earthing devices.

The Contractor shall be required to undertake all necessary earth resistivity tests at the substation sites and, from these tests, to undertake the design of the earthing systems. These designs, as well as providing safe passage to earth for the stated earth fault currents, shall also include calculation of step, touch and mesh potentials, which shall be within the allowable limits of the standards quoted in this specification.

The design calculations of step, touch and mesh potentials, accompanied by full installation drawings and material requirement schedules, shall be submitted to, and receive the approval of, the Engineer before materials procurement or installation commences.

7.5 Soil Survey

The preliminary Bid design shall be based on a value of 100 ohm-m. soil resistivity.

Not later than one month after the site has been handed over for access, the Contractor shall carry out an earth resistivity survey of the sites and report in writing to the Engineer in accordance with the approved programme. The report shall detail the methods and instruments used and the results of the surveys. Based on the results the Contractor shall include in the report his proposals for the resistivities to be used in the design of the earthing system.

The surveys shall show the variation of resistivity across the site and with the depth below the site. The Contractor shall consider if there is a need to model the resistivity in two layers and if there is any advantage in the use of deep rod electrodes.

The surveys shall also determine the depth and nature of any underlying rock, which may limit the depth for driving earth rods or if boring will be necessary for installing earth rods.

The weather conditions prior to and at the time of the surveys shall be recorded in the report and an assessment made of the seasonal variations in resistivity based on meteorological data for the area. The programme for the project should, as far as possible, time the resistivity surveys to take place during a dry season.

The report should also state if there are any indications that the ground is corrosive to bare copper.

The report shall be approved by the Engineer before proceeding with the design of the earthing system.

7.6 Fault Current and Duration

Each site shall be provided with an earth grid of buried conductors designed for an earth fault current of 50 kA one second for 230kV and 40kA one second for 132kV. The preliminary earthing design shall be such that the potential rise shall not exceed 5 kV.

7.7 Earth Electrode System Design

7.7.1 Design Calculations

The design of the earth electrode systems shall be based on the approved earth resistivity data and the system fault currents and their duration.

The design calculations shall be to the approval of the Engineer and shall be based on the methods given in the standards listed. The calculations shall include the following parameters:

(a) earth resistance of the whole system and of its components
(b) earth potential rise
(c) step, touch and mesh potentials inside and outside the perimeter fence
(d) requirements for a high resistance surface layer
(e) conductor ratings

Earthing points shall be provided such that the combined resistance of the earth grid and all other earthing points does not exceed the allowable limit dictated by the standards for the fault current and duration specified measured during the dry season.

The earth potential rises shall not exceed the CCITT limits appropriate to the classification of the system unless special precautions are taken to cater for transferred potentials.

Step, touch and mesh potentials shall be within the permitted limits calculated in accordance with the standards given in IEEE 80 for the proposed surface layer

7.7.2 Earth Electrode

The earth electrode shall comprise a system of bare conductors forming a mesh buried near the surface of the ground and supplemented, if required, by one or more of the following electrodes:

(a) a system of interconnected rods driven into the ground
(b) a mesh system of bare conductors buried in the ground
(c) structural metalwork in direct contact with the ground
(d) reinforcing steel in buried concrete
(e) a system of bare conductors buried near the surface of the ground outside the perimeter fence

7.7.3 Mesh System

The mesh system shall be designed to limit touch, step and mesh potentials taking into account the combined length of the mesh conductors, other buried conductors and rods but excluding any buried conductors outside the perimeter fence. Due regard shall be given to non-linear distribution of the fault current giving rise to the highest potentials at mesh comers.

The rating of the mesh conductors shall be compatible with the fault cur-rents after allowing for parallel paths of hard drawn high conductivity copper strip with a minimum conductor size of 150 mm².

The conductor shall be installed in trenches excavated by the Contractor to a depth of 500mm. The system will be installed after all foundations have been laid and the site filled to 100mm below finished level. When the earthing grid has been laid and backfilled, bricks will be laid up to finished site level. Where the excavated material is rocky or may be difficult to consolidate, the backfilling shall be carried out using other material to the approval of the Engineer. The cost of such material shall be deemed to be included in the Contract.

7.7.4 Earthing Rods

If the design calculations show that a mesh alone is unable to limit the potentials to the required values, then the mesh shall be supplemented by the use of interconnected earthing rods driven into the ground or installed in bored holes.

Rods shall be installed inside the perimeter fence to enclose the maximum possible area compatible with the earthing of any metallic fence. (The spacing between rods shall not be less than their length, unless rating considerations determine otherwise). The copper rod electrodes of 15mm diameter shall be interconnected in groups of four to eight rods by insulated copper conductors and non-ferrous clamps to form a ring. Each group shall be connected to the mesh by duplicate insulated copper conductor via disconnecting test links.

Individual rods may be connected directly to the mesh, provided the rod can be disconnected for testing.

The calculation of potentials in the design of the complete installation shall be made without the group of rods with the lowest estimated resistance to simulate the condition with the group disconnected for testing.

7.7.5 Other Conductors

As an alternative to rods to supplement a mesh, additional bare copper conductors with a cross-section area of not less than 150 mm² may be used. They shall be buried in the ground within the perimeter fence to enclose the maximum possible area compatible with the earthing of any metallic fence. Such conductors may be laid below the mesh, below foundations or in areas where there is no plant. It shall be shown by calculation that the step potentials are low in such areas.

The conductor shall be in a ring, or a part of a ring, with at least two widely separated connections to the mesh or other parts of the earthing system.

7.7.6 Reinforcing Steel

The reinforcing steel in the foundations of buildings containing the primary electrical equipment may be used as auxiliary electrodes, subject to the approval of the Engineer. The Contractor shall show in the design calculations that the fault currents and d.c. stray currents will not damage the structure.

Steel reinforcing mesh in the floors of the building may also be used for the control of step and touch potentials within the building, subject to the approval of the Engineer.

7.7.7 Conductors Outside Perimeter Fence

If the design calculations show that the step and touch potentials outside the perimeter fence or wall exceed the limits, then additional bare conductors shall be buried in the ground outside the fence in the form of rings encircling the whole site.

The distance of the conductors from the fence and the depth shall be determined in the design to ensure that step and touch potentials are within the limits.

The minimum conductor size shall be 75 mm² copper and shall be connected to the fence or the mesh with 75 mm² conductors at each comer of the site and at intervals of not more than 100 m. These conductors shall not be included in the calculations called for above.

7.8 Design of Earthing System

7.8.1 Earthing System

An earthing system shall comprise the following components:

(a) the conductors between the earthing electrode and the main earthing bar
(b) the main earth bar
(c) the conductors between the main earth bar and the metallic frames, enclosures or supports of electrical equipment
(d) the conductors between structural metalwork and non-electrical equipment and the main earth bar

The rating of earth system conductors connected between an item of electrical plant and the earth electrode system shall be sufficient to withstand the fault currents and duration, after allowing for the parallel paths through the earth system conductors, with any one conductor disconnected.

The design of earth system shall take into account the corrosiveness of the soil based on the soil survey.

The design comprising all the above mentioned items shall be submitted to the Engineer for approval within four months of the award of Contract.

7.8.2 Connection of System Neutrals and Earth

The system neutral points within a substation shall have duplicate connections to the closest earthing point.

The earth electrodes of a neutral earthing point shall be arranged in two groups with a conductor from each group to a test link and there shall be duplicate bare copper conductors of cross sectional area not less than 150 mm² from each test link to the earth grid. The duplicate connection may be in the form of a ring.

Neutral earthing connections between the substation system (transformer) neutral and the test links shall be of bare copper tape, secured and supported on stand-off insulators so that there is no contact between copper tape and transformer tank.

Neutral earthing conductors shall normally be buried directly in the ground but where necessary, they may be cleated to walls, fixed to cable racks or laid in the cable trenches.

7.8.3 Main Earthing Bar

The main earthing bar shall be in the form of a ring or rings of bare conductors surrounding, or within, an area in which items to be earthed are located. Where two or more rings are installed, they shall be interconnected by at least two conductors which shall be widely separated.

The main earthing bar, or parts thereof, may also form part of the earth electrode system, providing this is bare conductor.

Each main earthing bar shall be connected by at least two widely separated conductors to the earth electrode system.

The minimum conductor size for the main earth and interconnections between earthing bars and the earth electrode system shall not be less than 150 mm².

7.8.4 Electrical Equipment and Structure Connections to Earth

Connections between: (a) all HV electrical equipment and (b) LV electrical equipment comprising substantial multi-cubicle switchboards and the main earth bar shall be duplicated. The bare copper conductor size shall have a minimum cross section area of 150 mm².

All substation equipment, including disconnectors, earthing switches, main transformer tanks, current and voltage transformer tanks, switchgear, electrical supporting steelwork and gantries etc. shall all be connected with the earth grid.

Surge arresters installed for the protection of transformers and reactors shall be connected by low reactance paths both to the transformer tanks and to the earthing system.

Capacitor voltage transformers used in connection with line traps shall be connected by direct low reactance paths to a single earth rod for each arrester, in addition to the earth grid.

Where necessary an earthing mat shall be installed at all operating positions for outdoor HV equip-

ment manual operating mechanism boxes and local electrical control cubicles to ensure the safety of the operator. The mat shall be directly bonded to the cubicle and the conductors forming the mat and the bonding connection shall have a minimum copper cross-section area of 75 mm².

Galvanised structures comprising bolted lattice components shall not be used as the sole earth connection path to post and strain insulators or to overhead line earth conductors.

Buildings containing electrical equipment shall be provided, at each level, with a ring of earthing conductors which shall have duplicate connections to the earth grid outside the building. The frames of all switchgear, control and relay panels and other electrical equipment and exposed structural metal work shall be connected by branches to a ring. The ring and branch conductors shall be of the same material as the earth grid. Strip run within buildings, inside cable trenches or above ground level on apparatus shall be neatly supported in non-ferrous clamps.

Fixed earthing connectors for use with portable earthing devices specified below shall be provided on each busbar and on both sides of high voltage equipment.

Rigid loops in the copper earthing strip branch bond between the equipment and the earthing grid shall be provided adjacent to each item of high voltage equipment for use with the portable earthing devices. The rigid loops shall be marked green.

Connections between other LV electrical equipment and the earth bar need not be duplicated. The single conductor shall be rated to withstand the fault rating of the equipment.

7.8.5 Connections to Non-Electrical Structural Metalwork and Equipment

All metalwork within the project area which does not form part of the electrical equipment shall be bonded to the main earth bar except where otherwise specified. The bonding conductor size shall be not less than 150 mm².

Individual components of metallic structures of plant shall be bonded to adjacent components to form an electrically continuous metallic path to the bonding conductor.

Small electrically isolated metallic components mounted on non-conducting building fabric need not be bonded to the main earth bar.

7.9 Materials and Installation

7.9.1 Earthing Conductors

Conductors shall be of high conductivity copper in the form of circular conductors stranded to IEC 60228 (BS 6360) or solid rods or bars to BS 1433.

Conductor sheaths shall be of PVC to meet the requirements of BS 6746 Grade TM1 or IEC 60502 Grade ST1 with a minimum thickness of 1.5 mm.

Bare strip conductors only shall be used for earth electrodes or voltage control meshes.

Conductors buried in the ground shall normally be laid at a depth of 500 mm in an excavated trench. The backfill in the vicinity of the conductor shall be free of stones and the whole backfill shall be well consolidated. Earthing conductors not forming part of a voltage control mesh shall be laid at the depth required by the approved design and, in the case of a PVC sheathed conductor, at the same depth as any auxiliary power or control cables following the same route.

All conductors not buried in the ground shall be straightened immediately prior to installation and supported clear of the adjacent surface.

7.9.2 Earthing Rods

Earth rods shall be driven to a depth below the ground water table level, to be determined by the Contractor during soil investigation and survey of site.

The earth rods shall be of hard-drawn high conductivity copper with a diameter of not less than 15 mm with hardened steel driving caps and tips. The rods should be as long as possible but couplings may be used to obtain the overall depth of driving required by the design.

The rods shall be installed by driving into the ground with a power hammer of suitable design to ensure the minimum of distortion to the rod. Where it is not possible to drive rods to the full depth required due to the presence of a strata of rock, then holes shall be drilled or blasted in the rock. The holes shall be filled with bentonite or other approved material prior to inserting the rod. If difficult driving conditions arising from hard or rocky ground are encountered or are anticipated or there is a need for deep rods, then high tensile steel rods shall be used. 11igh tensile steel rods shall have a molecularly bonded high conductivity copper coating with a minimum radial thickness of not less than 0.25 mm. The overall diameter shall be not less than 12 mm. Rolled external screw threads shall be used on the rods for coupling and after rolling the thickness of the copper coating on the threaded portion shall be not less than 0.05 mm.

Rods, driving caps and tips shall abut at couplings to ensure that the couplings and screw threads are not subject to driving forces. All screw threads shall be fully shrouded at the couplings. Alternatively, conical couplings may be used to the approval of the Engineer.

High conductivity copper for earth rods shall have a minimum copper content (including silver) of 99.90% to ISO 1337, Cu-ETP or Cu-FRHS (BS 2894 Grade C101 or C102) for copper earth rods and to ISO 1337 Grade Cu-ETP (BS 28734 Grade C101) for the molecular bonded copper coating of steel rods.

The steel for copper-clad steel rods shall be low carbon steel with a tensile strength of not less than 570 N/mm² to ISO 630, Grade Fe 430A (BS 4360, Grade 43A) or better.

Couplings for copper rods shall be of 5% phosphor bronze (copper-tin-phosphorous) to ISO 427, CU Sn4 (BS 2874, Grade PB 102M) and for copper bonded steel rods of 3% silicon or 7% aluminium bronze to BS 2874, Grade CS 101 and BS 2871, Grade CA 102.

7.9.3 Fittings

Clips for supporting strip conductors not buried in the ground shall be of the direct contact type and clips for circular conductors shall be of the cable saddle type. The clips shall support the conductors

clear of the structure.

Conductors shall be connected to earth rods by a bolted clamp to facilitate removal of the conductor for testing the rod.

Disconnecting links shall comprise a high conductivity copper link supported on two insulators mounted on a galvanised steel base for bolting to the supporting structure. The two conductors shall be in direct contact with the link and shall not be disturbed by the removal of the link. Links for mounting at ground level shall be mounted on bolts embedded in a concrete base.

Disconnecting links mounted at ground level and the connections at the earth rods shall be enclosed in concrete inspection pits, with concrete lids, installed flush with the ground level.

All conductor fittings shall be manufactured from high strength copper alloys with phosphor bronze nuts, bolts, washers and screws. Binary brass copper alloys will not be acceptable. All fittings shall be designed for the specific application and shall not be permanently deformed when correctly installed.

Sheathed conductor support fittings may be of silicon aluminium, glass-filled nylon or other tough non-hygroscopic material for indoor installations.

Fittings not in direct contact with bare or sheathed conductors may be of hot-dip galvanised steel. Bi-metallic connectors shall be used between conductors of dissimilar materials and insulating material shall be interposed between metallic fittings and structures of dissimilar materials to prevent corrosion.

7.9.4 Joints

Permanent joints shall be made by exothermic welding below ground, or crimping for above ground connections.

Detachable joints shall be bolted and stranded conductors at bolted joints shall be terminated in exothermically welded lugs or a crimped cable socket. The diameter of any holes drilled in strip conductors shall not be greater than half the width of the strip.

Connections to electrical equipment shall be detachable and made at the earthing studs or bolts provided on the equipment by the Manufacturer. When an earthing point is not provided, the point and method of connection shall be agreed with the Engineer.

Connections to metallic structures for earthing conductors and bonding conductors between electrically separate parts of a structure shall be either by direct exothermic welding or by bolting using a stud welded to the structure. Drilling of a structural member for a directly bolted connection shall only be carried out to the approval of the Engineer.

Bolted joints in metallic structures, including pipework and which do not provide direct metallic contact, shall either be bridged by a bonding conductor or both sides of the joint shall be separately bonded to earth, unless the joint is intended to be an insulated joint for cathodic protection or other purposes.

When the reinforcing in concrete is used as a part of the earthing system, the fittings used to provide a connection point at the surface of the concrete shall be exothermically welded to a reinforcing bar. This fitting shall be provided with a bolted connection for an earthing conductor. The main bars in the reinforcing shall be welded together at intervals to ensure electrical continuity throughout the reinforc-

ing.

No connections shall be made to reinforcing bars and other steelwork which do not form part of the earthing system and are completely encased in concrete.

7.10 Lightning Protection

Overhead earthwire shall be provided to protect the equipment from direct lightning strikes. The screens shall be of aluminium clad steel wires of not less than 50 mm². total section, and connected to provide low impedance paths to earth.

The layout of the earth wires shall be such that equipment to be protected generally lies within areas bounded by two or more conductors, in which case the protected angle shall not exceed 45˚. Where equipment is protected by a single earth wire, the protective angle shall not exceed 35˚ to the vertical.

The overhead earthwire shall be suitable for extension to protect the substation equipment to be installed in future stages of development.

7.11 Earthing of Fences

7.11.1 Method

Metallic fences shall be separately earthed unless they come within 1.8m of any equipment or structure above the surface of the ground and which is connected to the main earthing system. If the separation of 1.8m cannot be obtained, the fence shall be bonded to the main earthing system.

7.11.2 Separately Earthed Fences

The earthing of a fence shall be provided by connecting certain metallic fence posts to an earth rod by a copper conductor. The earth rod shall be driven adjacent to the posts inside the fence line to a depth of not less than 3.0m. Where no metallic posts are provided, the earth rods shall be connected directly to the metal wires, mesh or other components of the fence.

If, owing to the nature of the ground, it is not possible to drive earth rods, then fence posts shall be connected to the centre point of a 20 m length of bare copper conductor buried in the ground at a depth of 500 mm, running closely parallel to the inside of the fence.

The earth rods or bare conductor electrodes shall be installed at each comer post, below the outer phase conductors of overhead line connections passing over the fence, at each gate and at intervals of not more than 100 m.

7.11.3 Bonded Fences

Fences which need to be bonded to the main earthing system of the installation shall be connected by copper conductors to the nearest accessible point on the main earthing system at each point where

the fence comes within 1.8 m of any electrical equipment. Bonds shall also be made to each corner post, below the outer phase conductors of overhead line connections passing over the fence, at each gate and at intervals of not more than 100 m.

7.11.4 Bonding of Fence Components

Fences made up of bolted steel or other metallic components do not require bonding between components. Where such fences have non-metallic components, bonds shall be installed to maintain continuity between metallic components. Reinforced concrete components shall be treated as being non-metallic.

Longitudinal wires for supporting other fence components, or for anti-climbing guards and the wires of chain link, shall be directly bonded to each fence earth electrode or to each bond to the main earthing system.

Metallic components on masonry, brick, concrete or similar boundary wall shall be treated in the same manner as metallic fences.

Wire fence components coated for anti-corrosion protection shall be earthed in accordance with this Clause.

7.11.5 Gates

The fixed metallic components on both sides of the gate shall be directly bonded together by a copper conductor installed under the surface of the access way. Flexible conductors shall be installed to bond the moving parts of the gates to the metallic fixed parts. An earth rod or a bond to the main earthing system shall be installed at each gate.

7.11.6 Potential Control Outside Fences

Where the approved design calculations show that the touch or step potentials outside the fence or boundary wall would otherwise be excessive, bare copper conductors shall be buried in the ground outside the fence or boundary wall at such depths and spacings as are shown in the approved design calculations to give acceptable touch and step potentials. The conductors shall form complete rings surrounding the installation and each ring shall be bonded to the adjacent ring and to the fence at each comer, below the outer phase conductors of overhead line connections passing over the fence, at each gate and at intervals of not more than 100 m. In this case separate earth electrodes are not required for the fences.

If the boundary fence or wall is substantially non-metallic, the rings of conductors shall be bonded to the main earth system at each comer of the site and at intervals of not more than 100 m. Any metallic components on such boundary fences or walls shall be bonded to the earthing system in accordance with this Specification.

If the boundary fence is metallic and is not within 1.8 m of any part of the main earthing system or equipment bonded thereto, the fence and outer conductor rings shall not be connected to the main earthing system unless the approved design calculations show otherwise.

Any meshes formed by bonding the outer conductors to the main earthing system shall be sub-divided by additional conductors, if required, to give acceptable touch, step and mesh potentials.

7.11.7 Conductors

All conductors used for earthing and bonding the fences and components and for outer rings shall have a cross-sectional area of not less than 70 mm²

Connections shall be made of copper strip of 30 mm x 5 mm. cross section between the overhead earthed screen wire and the main substation earthing system at each support unless the galvanised steel support structure has sufficient area and current carrying capacity.

Earth wires shall be held in clamps with free pin type joints between clamps and supports.

Connections shall be provided for the terminations of the earth wires of the overhead lines, including bimetal connectors where necessary.

The design of all structures shall generally comply with Section 11 of the specification and in addition is to ensure that in the event of breakage of one earth wire, the Factor of Safety is not less than 1.5.

7.12 Portable Earthing Devices

Portable earthing devices for use with outdoor 230 kV and 132 kV apparatus in substations shall be supplied in the numbers stated in Schedule A of Requirements and shall comprise:

(a) Copper alloy earth end clamp for connection to the rigid loops in equipment earth bonding connections.
(b) Aluminium alloy line and busbar end clamp to suit the connectors of the type supplied under the Contract.
(c) Flexible stranded aluminium alloy conductor with clear protective PVC sheath, sized suitable for the specified fault level and duration.
(d) Telescopic operating pole of glass fibre or similar material, of sufficient length to reach the height of connections to high voltage equipment from ground, but retractable into a carrying length not exceeding 2.5 m, and complete with non-slip hand grips.

The preferred types of portable earthing devices are Raguar Stalskog and Karl Pfisterer.

8. Batteries, Chargers and DC Switchgear

8.1 Scope

These clauses describe the General Technical Requirements for Batteries, Chargers and DC switchgear for use in substations for 110V DC power for switchgear operations, protection, control, alarms, indications, and emergency lighting.

The equipment to be supplied, installed and commissioned is shown on bid drawings of this specification.

8.2 References

8.2.1 IEC Standards

IEC 60051	Direct acting indicating analogue electrical measuring instruments and their accessories.
IEC 60146	Semiconductor converters
IEC 60146-1-1	Semiconductor converters ; Basic requirements
IEC 60146-1-3	Semiconductor converters ; Transformers and reactors.
IEC 60529	Degree of protection provided by enclosures
IEC 60439	Low voltage switchgear and control gear assemblies (BS EN 60439)
IEC 60623	Vented nickel cadmium prismatic rechargeable single cells

8.2.2 British Standards

BS EN 60269	Cartridge fuses for voltages up to and including 1000 V AC and 1500 V DC.
BS 381C	Specification for colours for identification coding and special purposes.
BS 5634	Method of Test for Potassium Hydroxide.
BS 6231	Specification for PVC insulated cables for switchgear and control gear wiring.

8.3 Design Requirements

8.3.1 General

Batteries shall be located in separate mechanically ventilated rooms, which will be provided with sinks and water supplies. Storage facilities will be provided for electrolyte, distilled water and maintenance equipment.

The voltage measured at the main distribution switchgear shall not vary by more than plus 10 per cent or minus 20 percent of the nominal voltage under all charging conditions when operating in accordance with the requirements of this Section.

Two 100% duty batteries shall be connected to duplicate 100% duty chargers, having boost and float facilities, in such a way that either charger can be disconnected without interrupting the output of the other charger or the battery.

The complete equipment shall preferably be a Manufacturer's standard but any departure from this specification shall be subject to the approval of the Engineer.

8.4 Batteries

8.4.1 Type of Battery

The battery shall be of the high performance Nickel Cadmium pocket plate type complying with IEC 60623 and shall be designed for a minimum life expectancy of 25 years.

Battery cases shall be of high impact translucent plastic or annealed glass and shall be indelibly marked with maximum and minimum electrolyte levels. The design of the battery shall permit the free discharge of the gases produced during the normal operating cycle, whilst excluding dust. Spray arresters shall be included.

The electrolyte shall be free from impurities and the Potassium Hydroxide used shall comply with BS 5634. Dilution of the alkaline electrolyte and topping up of cells shall be carried out using distilled water only.

A complete set of test and maintenance accessories, suitably boxed, shall be provided for each battery.

A syringe hydrometer and a durable instruction card shall be included in each set.

Cells shall be numbered consecutively and terminal cells marked to indicate polarity.

Cells shall be permanently marked with the following information:

- Manufacturer's reference number and code
- Year and month of manufacture
- Voltage and nominal capacity at the 3, 5 and 10 hour discharge rate

The electrolyte capacity and general design of the cells shall be such that inspection and maintenance, including topping up of the electrolyte, shall be at intervals of not less than twelve months.

8.4.2 Initial Charge and Test Discharge

The initial charge, test discharge and subsequent re-charge of the battery must be carried out under continuous supervision. Resistors, instruments, leads, and the other apparatus will be necessary for the initial charge, test discharge and subsequent recharge of the battery.

8.4.3 Battery Duty

Each battery shall have sufficient capacity to supply the following continuous and intermittent loads for the periods specified, with the chargers out of service.

Standing DC loading for protection, control, indications and alarms for ten hours. This loading shall be determined from all equipment to be supplied on this Contract. In addition the future circuit requirements estimated on the same basis as the present requirements.

At the end of ten hours the battery shall have sufficient capacity to complete the operations listed below, at the end of which duty the system voltage shall not have dropped below 90 per cent of the nominal voltage with the standing loads, specified above, connected.

1. Two closing operations on all circuit breakers (including future) supplied by the battery.
2. Two tripping operations on all circuit breakers (including future) supplied by the battery. Where busbar protection is provided, it shall be assumed that all circuit breakers in any one busbar protection zone trip simultaneously.
3. Charging of DC motor wound circuit breaker closing springs (where applicable) to enable the closing operations to be carried out.
4. At the end of these duties, the battery voltage shall not have dropped such that the voltage at the battery terminals falls below 90 % of the nominal system voltage when supplying the standing load.
5. In addition, the voltages at the terminals of all components in the system (eg. relays, trip and closing coils) shall not be outside of the individual voltage limits applying to them.
6. A margin of 10 % shall be allowed for derating of this battery over its life time.

All quantities derived in this manner shall be quoted in the Tender, but shall not be used for ordering materials until specifically approved by the Engineer. Detailed calculations, and loading characteristics on which these are based, shall be submitted to the Engineer at an early stage.

8.4.4 Location of Batteries

The batteries shall be housed in a ventilated battery room. The charging equipment and distribution switchboards shall be housed in a separate room.

Battery rooms shall be dimensioned and the ventilation system designed to cater for the installation of 48V communications batteries. Suitable outgoing feeders shall also be provided on the station AC distribution boards to supply these future DC systems.

The floor of the battery room shall be coated with a suitable electrolyte resistant protective coating. The floor shall be fitted with a drain and shall have sufficient slope to prevent any major electrolyte spillages from entering into other areas.

No ducts or any other items shall penetrate the floor or create a means whereby spillage can drain away apart from the drain provided for this purpose.

8.4.5 Battery Mounting Connections and Accessories

Batteries shall be placed on timber boards mounted in double tiers on steel stands of robust construction and treated with acid resisting enamel or gloss paint to BS 381C No.361. The cells shall be arranged so that each cell is readily accessible for inspection and maintenance and it shall be possible to remove any one cell without disturbing the remaining cells. The stands shall be mounted on insulators and be so dimensioned that the bottom of the lower tier is not less than 300mm above the floor.

Alternatively, batteries may be mounted in a similar manner on treated hardwood stands.

Batteries shall be supplied and erected complete with all necessary connections and cabling. Connections between tiers, between end cells and between porcelain wall bushings shall be by PVC cables arranged on suitable racking or supports. Before jointing, joint faces shall be bright metal, free from dirt, and shall be protected by a coating of petroleum jelly. Terminal and inter-cell connections shall be of high conductivity corrosion free material.

Cartridge fuses shall be provided in both positive and negative leads, positioned as close to the battery as possible and shall be rated for at least three times the maximum battery discharge cur-rent at the highest operating voltage. The two fuses shall be mounted on opposite ends of the battery stand or rack in an approved manner. These fuse links shall comply with BS 88 Clause DC. 40 and shall be bolted in position without carriers.

Warning labels shall be fitted to warn personnel of the danger of removing or replacing a fuse whilst the load is connected and that fuses should not be removed immediately following boost charge due to the possible ignition of hydrogen gas.

Fuses between the battery and charger shall be located adjacent to the battery in a similar manner to that described above. A warning label shall be placed on the charging equipment indicating the location of these fuses and the fact that they should be removed to isolate the charger from the battery.

It shall not be possible to leave the battery disconnected (by means of switches or removal or operation of fuses) without some local and remote indication that such a state exists.

One set of miscellaneous equipment, including two syringe hydrometers, one cell-testing voltmeter, two cell-bridging connectors, two electrolyte-pouring funnels, two electrolyte thermometers, battery instruction card for wall mounting, electrolyte airtight containers, labels, tools and other items necessary for the erection and correct functioning and maintenance of the equipment, shall be provided for each station.

8.5 Control and Charging Equipment

Each battery charging equipment shall comply with the requirements of BS 4417 (IEC 60146:), shall be of the Thyristor-controlled, automatic constant voltage type with current limit facilities and shall be suitable for supplying the normal constant load, at the same time maintaining the battery to which it is connected in a fully charged condition. All equipment shall be naturally ventilated.

All the equipment for each charger shall be contained in a separate ventilated steel cubicle. The charger cubicles shall normally be mounted immediately adjacent to the DC distribution panel to form a board and shall be of matching design colour and appearance.

Where their ratings permit, chargers shall preferably be designed for operation from a single-phase AC auxiliary supply with a nominal voltage of 230 V. Otherwise a three phase 400V supply may be utilised. Chargers shall maintain the float charge automatically for all DC loads between 0 and 100%, irrespective of variations in the voltage of the ac supply within the following limits:

- Frequency variation: 47 to 51 Hz
- Voltage variation: ± 15%

The mains transformer shall be of a suitable rating and design. Clearly marked off-circuit tappings shall be provided on the primary windings and change of tapping shall be by means of easily accessible links. The transformer shall be of the natural air-cooled type capable of operating continuously at full load on any tapping with the maximum specified ambient temperature.

All rectifiers and semi-conducting devices employed in the charger shall be of the silicon type. They shall be adequately rated, with due regard to air temperature within the charger enclosure, for the maximum ambient temperature.

The rating of the charger on float charge shall be equal to the normal battery standing load plus the recommended finishing charge rate for the battery.

Each charger shall also incorporate a boost charge feature which shall, after having been started, provide an automatically controlled high charge rate sufficient to restore a fully discharged battery to the fully charged state within the shortest possible time without excessive gassing or any form of damage to the battery. The boost charge shall be initiated manually or automatically upon detection of a significant battery discharge. An adjustable timer shall be provided to automatically switch the charger to the float condition after the correct recharge period.

Should the AC supply fail while a battery is on boost charge, the switching arrangements shall automatically revert the charger to float charge status and then reconnect the battery to the distribution board.

The output voltage regulator shall be adjustable for both float and boost charge modes, within limits approved by the Engineer, by means of clearly marked controls located inside the cubicle.

Although it is not intended that the charger be operated with the battery disconnected, the design of the charger shall be such that with the battery disconnected the charger will maintain the system voltage without any damage to itself and with a ripple voltage no greater than 2.0% rms of the nominal output voltage.

The charger shall automatically adjust the charging current from a value not less than the battery capacity divided by 10 hours to a minimum value of not more than the battery capacity divided by 200 hours. The charging circuitry shall be so designed that the failure of any component will not give a situation which will cause permanent damage to the battery by overcharging.

Each charger shall have a float charge maximum current rating sufficient to meet the total standing load current on the dc distribution board plus a battery charging current equal numerically to 7% of the battery capacity at the 10 hour rate.

Each charger shall be designed with a performance on float charge such that with the output voltage set at approximately 1.45 V per cell at 50% load and rated input voltage and frequency, the output voltage shall not vary by more than plus 3% to minus 2% with any combination of input supply voltage

and frequency variation as stipulated in this specification and output current variation from 0-100% of rating.

Each charger shall be suitable for operating alone or in parallel with the other charger. When operating with both chargers, one charger shall be arranged to supply the standing load with the second charger in the quiescent standby mode.

Each charger shall also have a taper characteristic boost charging facility which shall be selectable by a float1boost charge selection switch and which will give boost charging of 1.60 -1.75 voltage per cell.

Each charger shall be designed with a performance on boost charge such that with rated input voltage and frequency the charger output shall not be less than its rating in Watts at 1.3 V and 1.65 V per cell, and also the output voltage shall be 1.60 - 1.75 V per cell over an output range of 0 - 100% of rating.

The boost charging equipment shall be capable of recharging the battery within six hours following a one hour discharge period.

In the event of the battery becoming discharged during an AC supply failure, the rate at which recharging commences shall be as high as possible consistent with maintaining the automatic charging constant voltage feature and with the connections remaining undisturbed as for normal service.

The charger shall have an automatic boost/quick charge feature, which shall operate upon detection of a significant battery discharge. When, after a mains failure, the AC supply voltage

returns and the battery has been significantly discharged, the charger will operate in current limit. If the current limit lasts for more than a specified time and the charging current does not fall back to float level, the automatic high rate charge shall be activated.

An override selector switch shall be provided inside the charger unit to enable a first conditioning charge to be made, in line with the battery Manufacturer's recommendations, for batteries which are shipped dry and require forming at site.

A blocking diode unit shall be incorporated in the output circuit of each charger to limit the load voltage during boost charging of the battery. The diode unit shall not be in service in the normal float charging mode. Should the stabiliser fail in the boost charging mode, the charger shall automatically revert to the float mode.

An anti-paralleling diode shall be provided in each positive feed to the DC distribution board to prevent faults on one supply affecting the other. These diodes shall be continuously rated to carry the maximum possible discharge current likely to occur in service and a safety factor of 4 shall be used to determine the repetitive peak reverse voltage rating. The 12 t rating of the diodes shall be such that in the event of a DC short circuit, no damage to the diodes shall result.

Each charger shall be capable of sustaining, without damage to itself, a continuous permanent short circuit across its output terminals. The use of fuses, MCBs or other similar devices will not be acceptable in meeting this requirement.

Suitable relays shall be provided for each charger to detect failure of the incoming supply and failure of the DC output when in float charge mode. These relays shall operate appropriate indicating lamps on the respective charger front panel and shall have additional voltage free contacts for operating remote and supervisory alarms. These alarms shall be immune from normal supply fluctuations and

shall not be initiated when any one charger is taken out of service.

The charger shall also be fitted with a device to de-energise the charger in the event of a DC output float over voltage.

Each charger shall be provided, as a minimum, with the following instrumentation, indication and alarm facilities:

- indicating lamps for the AC supply to the rectifier and DC supply from the rectifier.
- indicating lamps for float and boost charging operations.
- voltmeter - input voltage.
- voltmeter - output voltage.
- ammeter - output current.
- alarm - charger failure.
- alarm - mains failure.

The following battery alarms shall also be provided

- battery fuse failure
- diode assembly failure
- battery circuit faulty
- low DC voltage
- high AC voltage
- earth fault +ve
- earth fault -ve

Lamp test facilities shall be included.

A "charger faulty" alarm for each charger and a "battery faulty" alarm shall be provided in the substation control room and to the SCADA system where applicable.

Each battery charger shall be equipped with charge fail detection equipment to give local indication and remote alarm if the voltage from the charger falls below a pre-set level which will be lower than the nominal float charge voltage. Suitable blocking diodes shall be provided to prevent the battery voltage being supplied to the equipment and so prevent charge fail detection.

The device shall not operate on switching surges or transient loss of voltage due to faults on the AC system. The voltage at which the alarm operates shall be adjustable for operation over a range to be approved by the Engineer.

Each charger shall be equipped with a switch-fuse for the incoming AC supply and an off load isolator for the DC output.

Bidders shall include particulars with their tender on the method of adjustment included to compensate for ageing rectifier elements. The construction of the charger shall be such that access to all components is readily available for maintenance removal or replacement. Internal panels used for mounting equipment shall be on swing frames to allow for access to the charger interior.

8.6 Distribution Switchboards

The switchboard shall comply with the requirements of BS 5468 (IEC.60439)

The distribution switchboard shall be of the cubicle type or otherwise incorporated in the cubicles for battery chargers. Double pole switches and fuses or switch fuses (miniature circuit breakers to BS 4752 or IEC 60157 may only be used if it can be shown that there will be no discrimination problems with sub-circuits) shall be fitted to the DC switchboard as required by substation services but, as a minimum requirement, that set out in the Schedule B of Requirements.

Distribution panels shall be mounted adjacent to the charger control panel and shall be of the cubicle type complying with the general requirements of cubicle type control panels. No equipment associated with the chargers shall be installed in the distribution board.

Distribution panels shall incorporate double-pole switches and fuses for each of the outgoing DC circuits and double-pole isolators for the incoming DC supplies The panel shall be provided with a voltmeter and centre zero ammeter on each incoming circuit.

A double pole switch or contactor shall be provided for the purpose of sectionalising the busbar.

A battery earth fault detecting relay, which will centre tap the system via a high resistance, shall be incorporated in the distribution panel.

A low voltage detecting device for the system shall be incorporated in the distribution panel. No-volt relays will not be accepted for these devices. The voltage setting shall be adjustable over an approved range.

In addition to any other requirements specified elsewhere, the battery earth fault detecting relays and low voltage devices shall each have three alarm contacts, one for local visual annunciation, one for the station control panel alarm indication and one for potential free contact for external supervisory alarms. A lamp test facility shall be provided.

Connections between the battery and the distribution cubicle shall be made in PVC insulated cable as required. Cable laid in runs where it may be subject to damage shall be protected by wire armouring, be sheathed overall and be cleated to walls as required.

Cable boxes or glands shall be provided as appropriate for all incoming and outgoing circuits of the distribution switchboard and associated battery chargers. Each circuit shall be suitably labelled at the front of the panel and at the cable termination where the terminals shall be additionally identified.

Charging and distribution switchboards shall be provided with an earthing bar of hard drawn high conductivity copper which shall be sized to carry the prospective earth fault current without damage or danger.

The cubicles for the chargers and distribution boards shall be of rigid, formed sheet metal construction, insect and vermin proof, having front facing doors allowing maximum access to the working parts, when open. The design of the cubicles for the chargers shall be such as to prevent the ingress of dust and minimise the spread of flames or ionised zones, shall be to IEC 60529 IP52, but at the same time shall provide all necessary ventilation and cooling. The design of the frames shall allow the clamping and holding of all chokes, transformers and similar sources of vibration, so that vibration will be mini-

mised, satisfy relevant standards, and not limit the life of the equipment. The frame shall allow the fixing of lifting and so that the equipment remains properly mechanically supported whilst being transported, lifted and installed.

8.7 Labelling

All relays, instruments and control devices, and each unit of the equipment, shall be provided with a label. All labels and lettering shall be of sufficient size to provide easy reading from the normal operating or maintenance positions and shall consist of black lettering on a white background. All warning and danger labels shall have white lettering on a red background. Labels shall be of the non-corrodible type and lettering shall be of motorway script or similar. If plastic labels are used, these shall be laminated to avoid warping.

8.8 Special Tools

The Contractor shall provide a complete set of all special tools and services necessary for the erection and maintenance of the complete equipment.

8.9 Inspection and Testing

Inspection and testing during manufacture and after installation on site shall be in accordance with Section 15 of this specification.

9. LV AC Distribution Switchgear

9.1 Scope

These clauses describe the General Technical Requirements for LVAC switchboards for supplies to "Substation Services" including outdoor switchyard lighting and control building services (Section 13).

9.2 References

IEC 60044-1	Current transformers
IEC 60044-2	Voltage transformers
IEC 60044-5	
IEC 60269	Low voltage fuses
IEC 60439-1	Specification for low voltage switchgear and control gear assemblies.
IEC 60644	Specification for high-voltage fuse links for motor circuit applications.
IEC 60898	Electrical accessories - Circuit breakers for overcurrent protection for household and similar installations.
IEC 60947-1	Low-voltage switchgear and control gear - General
IEC 60947-2	Low-voltage switchgear and control gear - Circuit breakers
IEC 60947-3	Low-voltage switchgear and control gear - Switches, disconnectors and fuse combination units.
IEC 60947-4	Low-voltage switchgear and control gear - Electromechanical contactors and motor starters.

9.3 Switchboard Design

9.3.1 General

Main switchboards and MCB sub-distribution boards for substation and building supplies will be constructed to IEC 60439, (BS EN 60439) in accordance with the following:

The classification of the main switchboards shall be:

(a) The external design of switchboards shall be of the multi- tier, multi-cubicle type.
(b) Installation shall be indoors.
(c) Switchboards shall be free standing and fixed to the floor.
(d) Enclosures degree of protection shall be not less than IP42.
(e) Switchboards shall be of metal clad construction.
(f) All instrumentation and metering shall be fixed to a hinged lockable compartment.
(g) Switchboards and all associated equipment shall be suitable for use on a 400/230 volt, three phase, four wire, 50 Hz system having the neutral solidly earthed.
(h) Each circuit shall be clearly labelled to show the destination of the associated cable and the "ON" and "OFF" positions of the switches.

(i) Distribution boards for exterior use shall be galvanised, weatherproof and to category EP55 degree of protection.

The equipment shall be of the single busbar type with circuit equipment housed in separate compartments.

Where two or more incoming circuit breakers are provided at substations, these shall be mechanically and electrically interlocked to prevent more than one circuit closing at the same time.

The enclosures of all switchboards shall be dustproof and vermin proof. Access doors shall be mounted using concealed hinges. All removable covers shall be fitted with captive screws. Anti-condensation heaters with control switches shall be provided on switchboards. They shall be suitable for a tropical climate.

9.3.2 Rating

Incoming supplies to all switchboards shall be protected at the point of supply. All switchboards shall be suitably rated for a prospective short-circuit breaking capacity of 15 kA at 400V for three seconds.

9.3.3 Busbars

Busbars shall be capable of carrying the full rated current continuously without exceeding the maximum temperature specified in IEC 60439 under site ambient conditions.

Busbars shall be of copper, individually covered with a heat resistant phase coloured PVC. Busbar links between panels shall not be used. Neutral busbars shall have the same cross sectional areas as the phase busbars. Busbars shall be of the same current rating throughout their length and shall be capable of extension at both ends with the minimum disturbance to the busbar and cubicle enclosure.

9.3.4 Busbar and Circuit Shutters

For draw-out equipment shutters shall be provided over busbar and circuit orifices to close automatically and positively when the equipment is isolated or withdrawn. Means shall be provided for padlocking the sets of shutters. Busbar orifice shutters shall be painted signal red and labelled 'BUSBAR' in white letters. Circuit orifice shutters shall be painted lemon yellow.

One blanking cover of each size shall be provided to prevent access to a circuit compartment when the equipment has been completely withdrawn from the panel.

9.3.5 Circuit Labels

Approved type title labels are to be fitted externally on the front cover of each distribution board giving details of the points controlled by each circuit. The circuit list shall be typed or printed stating the location of the equipment served, rating of the protective unit and the circuit loading. The lists shall be mounted on the inside of the cover door and shall be protected by an acrylic sheet slid into a frame over the circuit list, the list and cover to be easily removable to permit circuit modifications.

9.4 Circuit Breakers

All MCB and MCCB circuit breakers shall be high speed fault limiting, thermal/magnetic type with quick break, trip free mechanisms which prevent the breaker being held in against overloads or faults, shall comply with IEC 60947 (BS EN 60898 and be fitted with overcurrent releases of both thermal and instantaneous type. Short circuit performance shall be to IEC 60947.

Where circuit breakers incorporate thermal overload protection and short-circuit protection, their settings shall be subject to agreement with the Engineer.

Tripping arrangements shall be such as to ensure simultaneous opening of all phases. Arc extinction shall be by de-ionising arc chutes.

Circuit breakers on the incoming circuits shall have facilities for locking in the "off" position.

The fault interrupting capacity of the circuit breaker shall not be less than that of the switchboard itself, or if this is not the case, back up fuses shall be included.

9.5 Switch Fuses

Each switch-fuse unit shall be housed in a separate metal compartment and provided with a hinged metal door, interlocked with the switch mechanism so that:

(a) The door cannot be opened whilst the switch is closed.
(b) The door, on opening, automatically locks the switch in the "off' position. Facilities shall be incorporated to allow for the deliberate release of this interlock for maintenance purposes, should it be desired to observe the switch in operation.

An insulating barrier shall be fitted to segregate the fuses and neutral link from the switch and the connections of the latter shall be effectively shielded by an inner metal screen when the compartment door has been opened to obtain access to the fuses.

The switch-fuses may be either of the combination fuse-switch type or of the type with the switch and fuse in separate units. In either case, interlocking shall be provided to prevent access to the fuses until the associated switch is opened and provision shall be made for padlocking the switch in the "on" and "off' positions.

The switch shall have a quick make and quick break action, independent of the speed at which the switch handle is operated, and shall be entirely suitable for switching the inductive loads associated with motor circuits.

9.6 Oil Filtration Socket Outlet and Plug

The contract shall include heavy-duty weatherproof three phase and neutral interlocked switched socket outlets and plugs suitable for supplying the transformer oil filtration units.

9.7 Inspection and Testing

Inspection and testing during manufacture and after installation on site shall be in accordance with Section 15 of this specification.

10. National Load Dispatch Centre (NLDC)

10.1 Scope

In order to provide the tele-control & tele-metering facilities required at the existing National Load Dispatch Centre (NLDC) at Rampura the complete design, supply, delivery, installation, testing & commissioning of new hardware and software, extension of the existing equipment, necessary adjustment, adaptation, modification, integration and configuration of new and existing equipment in NLDC, shall be provided for integration of new plants, in new and existing substations, which are in the scope of the work, under this Contract.

All plant supplied under this Contract shall be equipped with potential free auxiliary contacts for indications and alarms. CT and VT circuits shall be fitted, where required, with the appropriate shorting and fused terminals. All required electrical quantities shall be transmitted to the NLDC through the Industrial Gateway of the substation automation system.

All HV breakers, motorized disconnectors, tap changer, etc. shall be controlled form NLDC through the Gateway or RTU of the substation automation system using IEC 60870-5-104 protocol. Cabling between the Substation Automation gateway and the communication equipment shall be included in this contract.

10.2 Requirements

10.2.1 Indications

The following indications shall be provided:

- 245kV and 145kV circuit breaker, disconnector and earth switch positions.
- Transformer tap change selection on Auto/Manual.
- Transformer tap position.
- Control switches on Local/Supervisory.
- Trip relays operated.
- Auto-reclose on/off

10.2.2 Load Flows, System Voltage and Frequency

Electrical quantities shall be provided to enable the following measurements:

- Power flow (MW and MVar) on all 230 kV and 132 kV feeder circuits on the 132 kV side of 235/132 kV transformers and on the 33 kV side of 132/33 kV transformers.
- 230 kV and 132 kV busbar voltages and frequencies.
- 230 kV and 132 kV feeder voltages

10.2.3 Alarms

Alarm facilities shall be provided to alert the System Control Engineer at NLDC in the event of the following operations:

- Tripping of 245kV and 145kV circuit breakers
- Busbar protection operated
- Feeder main 1 protection operated
- Feeder main 2 protection operated
- Feeder back-up protection operated
- Circuit breaker fail protection operated
- Feeder-end protection operated
- Auto-reclose operated
- Transformer protection operated (per transformer)
- Transformer non-trip alarms (per transformer)
- Transformer winding/oil temperature alarm (per transformer)
- Tap change out of step alarm
- Tap change incomplete alarm
- Circuit breaker faulty alarm (e.g. low pressure)
- Protection faulty alarm
- Busbar protection faulty alarm
- Battery fault (per battery)
- Battery charger fail (per battery)
- LV AC System Fail
- Substation common alarm
- Communication equipment alarm urgent
- Communication equipment alarm non-urgent
- Teleprotection channel fail.
- Circuit breaker spring uncharged
- Circuit breaker motor supply trip
- Auto reclose blocked
- DC supply failure

10.2.4 Controls

The following facilities shall be controlled from the NLDC.

- 245 kV and 145 kV circuit breakers and motorised disconnectors
- Trip relay reset
- Auto-reclose in/out
- Transformer tap change raise/lower
- Tap change control remote/supervisory
- Auto/non-auto voltage control.

10.3 Interfaces

This contract includes Industrial grade Gateway to the NLDC. The Gateway shall have adequate capacity to cater to the future extensions of substation. The cabling between the Gateway and the communication equipment shall be provided under this contract.

At the existing substations, extensions of the existing gateway or RTU shall be provided and included in the contract price.

11. Supporting Structures for Outdoor Equipment

11.1 Scope

Where specified structures shall be provided under this contract for supporting the conductors, busbars, insulators, isolating switches, circuit breakers, current and voltage transformers, surge arresters, line traps, coupling capacitors, sealing ends or cable boxes and cables where necessary and other items of plant generally as shown on the relevant drawings. Facilities shall also be provided where specified for the termination of the incoming transmission lines.

All structure designs shall be such as to facilitate inspection, painting, maintenance, repairs and operation with the continuity of supply being the prime consideration.

11.2 Structure Arrangement

The arrangement of the high level structures supporting conductors and/or busbars shall be either lattice structures primarily composed of angle sections, or low visual impact A-frame type structures primarily composed of welded hollow or composite sections. Angle, hollow or composite sections shall be either steel or aluminium as specified. For lattice structures a fully triangulated system of bracings shall preferably be adopted. For A-frame structures the primary connections between major components shall be bolted, for ease of transportation and erection.

Low level support structures shall be either lattice structures primarily composed of angle sections or 'moment' type structures primarily composed of welded hollow or composite sections.

The design and arrangement of supporting structures shall be subject to approval by the Engineer.

The type of arrangement of high-level structures and acceptable materials for both high and low level structures shall be as specified in the Schedule of Technical Requirements.

11.3 Design

11.3.1 General

The supporting structures shall be designed to ensure that the specified minimum phase, earth and section clearances are maintained under all conditions. Where applicable special attention shall be paid to the design of the line termination structures to ensure minimum phase clearance is obtained for the complete range of angles of entry specified.

The strength and rigidity of structures shall be such that the alignment of the equipment which they carry shall not be affected by the static and dynamic loads to which the structures are subjected.

The assumptions made in the overall structural design especially in the load transfer between the gantry beam and column shall be adequately reflected in the design and detailing of the beam-column connection.

11.3.2 Assumed Loading Combinations

The supporting structures shall be designed to resist the ultimate applied loading, determined in accordance with the following load combinations:

Load Combination 1 - Design Wind, Coincident Temperature, (Ice)

(a) The wind pressure specified in Table 11-1 below applied to the projected area of all conductors and electrical equipment;
(b) The wind pressure specified in the Schedule of Technical Requirements applied to the projected area of all members of the windward face of structure;
(c) Where appropriate the conductor and/or earthwire tensions or busbar forces, including due allowance for both horizontal and vertical deviations / inclinations;
(d) Self weight of the equipment and structure;
(e) When stated in the Schedule of Technical Requirements the effects of the specified radial ice thickness shall be taken into account in the determination of the wind area of the conductor, earthwire, busbar, electrical equipment and the supporting structure, the conductor and earthwire tensions and the self-weight of the equipment and the structure.

The wind directions considered shall include transverse, longitudinal and if appropriate 45˚ to the major axis of the structure.

Table 11-1: Wind Pressures

Line	Description			
1.	**Structure Arrangement [clause 11.2]**			
	• High Level • Low Level • Primary Material		• Lattice or A-Frame • Lattice or Moment • Steel	
2.	**Load Combination 1 [clause 11.3.2]**		**Structures only**	**Structures, Busbars, etc.**
	• Wind pressure at above G.L. q_{ref}	kN/m^2	3.54	1.21
	• Power law factor	α	0	0.095
	• Coincident temperature	˚C	5	
	• Radial ice thickness	mm	0	
	• Density of ice	kg/m^3	-	
	Load combination 2			
	• Minimum temperature	°C	5	
	• Maximum operating temperature	°C	80	
	Load combination 3			
	• Seismic coefficient	g	0.1	
	• Coincidence temperature	°C	5	

Line	Description			
3.	**Line Termination Structure [clause 11.3.3]**		**Phase**	**Earthwire**
	Conductor Designation		Mallard	7 x 4.0
	Type		ACSR/SA	GSW
	Number of sub-conductors		2	-
	Maximum working tension per sub-conductor	kN	7,0	4.5
	Wind pressure	kN/m²	1.40	1.76
	Radial ice thickness	mm	0	0
	Maximum downlead span	m	75	75
	Maximum angle of entry horizontal	deg.	45	45
	Vertical	deg.	0-30	0-30
	Low duty tension set wind area	m²	0.7	-
	Mass	kg	100	-
4.	**Partial Load Factors [clause 11.3.4]**		**Steel**	**Aluminium**
	Load combination			
	• 1		1.35	n.a.
	• 2		1.0	n.a.
	• 3		1.0	n.a.
	• 4		1.5	1.5
5.	**Safety and Access Requirements [clause 11.3.7]**		**High Level**	**Low Level**
	Step bolts		Yes	No
	Ladders:		Yes	No
	• Cage protection		No	No
	• Fall arrest system		No	No
6.	**Partial Material Factors [clause 11.3.8]**			
	Steel		0.85	
	Aluminium		-	
	Foundations		0.76	
7.	**Minimum Member Thickness [clause 11.3.8]**		**Steel**	**Aluminium**
	Main member	mm	6.0	n.a.
	Other bracing members	mm	5.0	n.a.
	Secondary (redundant) members	mm	5.0	n.a.
	Plates	mm	6.0	n.a.
	Bolt diameters	mm	16.0	n.a.
	Minimum thickness specified shall apply to both hot rolled and hollow sections			
8.	**Protective treatment (clause 11.6)**			
	Galvanising thickness	µn	85	n.a.
	Protection procedure		BS 729	no

Load Combination 2 - Still Air, Short Circuit, Minimum Temperature or Maximum Operating Temperature

(a) Conductor and/or earthwire tensions or busbar forces including the dynamic affects calculated in accordance with IEC 865-1.
(b) Self weight of the equipment and structure;

Unless agreed to the contrary, the "resultant spring constant" (s) of both supports of one span for strained conductors shall be taken as 10^7 N/m for steel structures.

Load Combination 3 - Still Air, Seismic, Coincident Temperature (Ice)

(a) Conductor and/or earthwire tensions or busbar forces;
(b) Seismic forces;
(c) Self weight of the equipment and structure;
(d) When stated in the Schedule of Requirements the effects of the specified radial ice thickness.

Seismic forces shall be applied as a static horizontal force transversely and alternatively longitudinally to the major axis of the structure, and shall be equal in value to the seismic coefficient stated in the Schedule of Technical Particulars multiplied by the self-weight of the conductor, earthwire, busbar, electrical equipment and structure, and applied at the centre of gravity of the equipment and structure as appropriate.

Load Combination 4 - Still Air, Erection, Coincident Temperature

(a) Conductor and/or earthwire tensions or busbar forces;
(b) Self weight of the equipment and structure.

For erection conditions any one complete phase conductor bundle or busbar or earthwire shall be assumed not to be erected in any one span.

For the purposes of design all high level structures shall be considered as terminal structures. For multi-bay continuous structures, central columns shall be designed for the most onerous condition of adjacent bays being loaded or unloaded.

11.3.3 Line Termination Structures

For details of the incoming transmission line phase conductor and earthwire details, and angles of entry reference should be made to the Schedule of Technical Requirements.

11.3.4 Partial Load Factors

The partial load factors to be applied to the loading combinations determined in accordance with Clause 11.3.2 shall be as specified in the Schedule of Technical Requirements.

11.3.5 Wind Loading

The reference wind pressure to be adopted for the design of the outdoor supporting structures shall be based upon the value specified in the Schedule of Technical Requirements. The reference wind pressure q_{ref} N/m^2 at a height of 10m above ground level shall be subjected to variation for height and shape of the structure or equipment under consideration to give the total wind load.

The total wind load on the structure or equipment surface shall be determined from the expression:

The total wind load on the structure or equipment surface shall be determined from the expression:

$$F_w = q_{ref}\left(\frac{H}{10}\right)^{2a} C_{shp}\ W_A$$

Where

F_w =	The calculated total wind load on the structure or equipment:
q_{ref} =	reference wind pressure
H =	Height to top of the panel under consideration
α =	power law index
C_{shp} =	aerodynamic shape factor
W_A =	windward face area of the structure or equipment

The aerodynamic shape factor C_{shp} shall be as specified:

• Flexible conductors	1.0	
• Earthwires	.2	
• Tubular busbars Re < 4.1 x 105	1.2	[1]
• 4.1 x 105< Re < 8.2 x 105	0.6	
• Support insulators, porcelain for apparatus or cap & pin insulator strings	1.2	[2]
• Flat truss structures consisting of profiles	1.6	
• Square & rectangular lattice towers & supports consisting of profiles	2.8	
• Sharp edged structures & components other than above	2.0	
• Flat truss structures consisting of tubes	1.2	
• Square & rectangular lattice towers & supports consisting of tubes	2.1	

Notes: [1] Re = Reynolds Number [2] Based on external diameter of insulator.

11.3.6 Equipment and Conductor Terminations

All supporting structures shall be provided with such holes, bolts and fittings as may be necessary to accommodate insulators, isolating switches and other equipment provided under the Contract.

Where incoming transmission lines and/or conductors and/or earthwires are terminated at structures with tension sets, approved shackle or swivel attachments shall be provided. To facilitate maintenance and erection, additional attachment points shall be provided adjacent to the main termination attachment. The supply and connection of the incoming transmission line will be undertaken under a separate contract.

Structures required to support cable sealing ends shall be provided with arrangements for supporting the cables. Attachment holes for the connection of earthwire bonds shall be provided adjacent to the

earthwire attachment point. Attachment holes for the connection of the substation earthing grid shall be provided on the vertical face of the structure, approximately 300mm above the top of concrete. Foundation holding-down bolts shall not be used for the attachment of earth connections.

11.3.7 Safety and Access Requirements

To facilitate safe inspection and maintenance all supporting structures which cannot be maintained from ground level shall be provided with climbing facilities, inter-circuit screens, guards etc. in appropriate positions as agreed with the Engineer.

All members inclined at 40˚ or less to the horizontal, shall be designed to resist a mid-point load of 1.5 kN, with no other loading being considered.

Where specified step bolts of an approved type shall be fitted to supporting structures at not more than 450 mm centres starting as near as practicable to the base and continuing to within 1m below the top of the structure. It shall be noted on the erection drawings that all step bolts are to be removed after construction for a distance of 2.0m above ground level. Adequate clearance shall be provided between the step bolts and any obstructions which might interfere with their use. Step bolts shall not be less than 16mm diameter, project not less than 150mm, and be fixed with nut, washer and nut.

Where specified ladders of an approved type generally in accordance with the requirements of BS 4211, 450mm wide and 350mm rung spacing shall be fitted to supporting structures. They shall be incorporated into the structure either integrally or separately. Where specified cage protection or fall arrest systems shall be fitted to the ladder. Means shall be provided to prevent unauthorised access of ladders.

Inter-circuit screens shall be provided where necessary to prevent access between adjacent circuits on multi-bay structures. Inter-circuit screens shall be fabricated from a 50mm x 50mm mesh formed from 3mm diameter galvanised steel wire.

All structures shall be fitted with identification/notice plates as appropriate.

11.3.8 Structural Design

The allowable ultimate unit stresses used in the determination of the nominal member strength of supporting structures shall be based on the following:

Lattice steel structures	ANSI/ASCE 10-90
Steel A frame or moment structures	BS 5950
Aluminium structures	BS 8118: Part I

Partial factors to be applied to member nominal strength determined in accordance with the above stated codes shall be as specified in the Schedule of Technical Requirements. For ANSI/ASCE 10-90 the appropriate reference stress levels shall be based on the values specified in BS 5950.

The maximum allowable slenderness ratios shall not exceed the following:

Steel Aluminium

- For column or support leg members, beam chords 120

- For other load bearing compression members 200
- For secondary (redundant bracings) 250
- For tension only members 350

Members shall be of such shape, size and length to preclude damage or failure from vibration or stress reversal, including the detailing of connections.

Minimum member thickness and diameter of bolts shall be as specified in the Schedule of Technical Requirements
Holding down bolts shall be used to connect the structures to their foundations. The design of holding down bolts shall make adequate provision for combined axial and shear forces.

The nuts of all bolts attaching conductors, busbars or earthwire tension sets etc., shall be locked with a locknut. No screwed threads shall form part of a shearing plane between members, and bolts shall not project more than 10mm beyond the nut.

11.3.9 Design Submissions

The Contractor shall submit all design calculations, drawings and method statements as required. All sets of calculations shall be complete, bound, properly titled and given a unique drawing number. An agreed system of identification of the structure design reference, fabrication drawings and substation general arrangement drawings shall be used.

Calculations shall contain a Design Information sheet, derivation of all applied loadings including sag and tension and dynamic tension calculations, the design load for each member group under the critical loading case, member size, slenderness ratio, allowable load, end connection detail and foundation load schedule. Codes or standard references should be quoted and where computer programs are used, a full explanation in the English language shall be provided to assist the Engineer's approval of the calculation.

11.4 Materials

All steel shall comply with BS EN 10025 or BS EN 10210 as appropriate and shall be suitable for all usual fabrication processes including hot and cold working within the specified ranges. The Contractor must take due cognisance of the minimum ambient temperature, quality of steel, charpy impact value and stress relieving.

The quality of finished steel shall be in accordance with BS EN 10163. All steel shall be free from blisters, scale, lamination, segregation's and other defects. There shall be no rolling laps at toes of angles or rolled in mill scale.

Hot rolled steel plate 3mm thick or above shall be in accordance with the requirements of BS EN 10029.

Bolts and nuts shall be ISO Metric Black Hexagon to BS 4190 and shall be threaded ISO Metric

Course Pitch to BS 3643: Part 2, Tolerance Class 7H/8g. Only one grade of steel shall be used per bolt diameter. Washers shall be in accordance with BS 4320 Grade E and BS 4464 Type B as appro-

priate.

Consumables used in metal arc welding shall be in accordance with the relevant standard.

All materials for aluminium. structures shall be in accordance with BS 8118: Part 2.

11.5 Workmanship

The Contractor shall submit panel assembly (fabrication) drawings which shall show all materials in place, complete with all fabrication and connection details. A complete tabulation listing all pieces, bolts, nuts, washers etc. shall also be shown on the drawings. The Contractor shall make changes to the fabrication details which the Engineer determines necessary to make the finished structure conform to the requirements and intent of the specification.

The Contractor shall submit a detailed Method Statement of his proposed fabrication procedures including quality control procedures to ensure satisfactory assembly and erection, interchangeability of similar members, accuracy of dimensions, position and alignment of holes.

All welding shall be carried in accordance with BS 5135 for steel structures and BS 8118 Part 2 for aluminium structures. All members shall be stamped on before galvanising or other protective coatings, using characters 10mm high and shall be clearly legible after galvanising.

11.6 Protective Treatment

Unless otherwise specified after fabrication, all structural steelwork, including bolts, nuts and washers shall be hot dipped galvanised to meet the requirements of BS 729. Bolt threads shall be cleaned of surplus spelter by spinning or brushing. Dies shall not be used for cleaning threads other than on nuts. Nuts shall be galvanised and tapped 0.4mm oversize and threads shall be oiled.

Excessively thick or brittle coatings due to high levels of silicon or phosphorous in steel, which may result in an increased risk of coating damage and/or other features that make the final product non-fit-for purpose shall be cause for rejection. Protective treatment for aluminium shall be in accordance with the requirements of BS 8118.

Galvanising thickness and aluminium protection procedure shall be as specified in the Schedule of Technical Requirements

11.7 Quality Control

11.7.1 General

Routine tests on raw materials and fabricated individual members shall be undertaken in accordance with BS EN 10025, BS EN 10210 and BS 8118 as appropriate.

All steel ex-mills or received from merchant's stock shall be marked to identify the cast or casts from which it was rolled in accordance with Section 9 of BS EN 10025 and Section 10 of BS 102 10, and shall be covered by the appropriate (mill) certificate. The optional impact test BS EN 10210 option 1.6 for quality JO is required.

The material grades or alloy categories of individual pieces of steel/aluminium shall be capable of positive identification at all stages of the fabrication process.

Bolts and nuts shall be covered by the appropriate test certificate to prove compliance with BS 4190.

11.7.2 Welding

Unless specified to the contrary all structural welds shall be undertaken using approved welding procedures in accordance with BS EN 288. All welders shall be tested to the requirements of BS EN 287.

All welding shall be subject to a non-destructive testing (NDT) programme, which shall include visual, ultrasonic and magnetic particle testing as appropriate. Visual inspection shall be in accordance with BS 5289, ultrasonic to BS 3923 and magnetic particle to BS 6072. Acceptance criteria shall be in accordance with BS 5135, except for porosity and BS 8118: Part 2. All welds especially butt welds must be continuous to ensure a pickle-tight connection when galvanised.

The Contractor's NDT programme shall be submitted to the Engineer for approval prior to the commencement of fabrication.

11.7.3 Check Erection

Prototype structures shall be check erected in order to verify the accuracy of detailing and fabrication.

The degree of check erection shall be sufficient to verify not only the main structure, but all auxiliary steelwork. Sufficient blocking and support shall be provided to prevent distortion and overstressing of members to ensure proper fit. Assembly shall be accomplished without extraordinary effort to align bolt holes, or to force pieces into position. Bolt holes shall not be reamed or enlarged. Any damage to protective coatings during check erection if the check erection is undertaken on coated structures, shall be recoated at the fabricator's cost.

11.7.4 Galvanising

Tests on galvanised members and components shall be carried out at the works to ensure compliance with the requirements of BS 729.

11.7.5 Tolerances

The fabrication tolerances after galvanising for steel members, which are not to be considered cumulative shall be as follows:

a)	On linear dimensions of nominal sections as per BS 4, BS 4848, BS EN 10024, BS EN 10034 & BS EN 10056-2.	
b)	On overall length of member	± 1 mm
c)	On centres of holes	± 1 mm
d)	On groups of holes	± 2 mm
e)	On back-gauges	± 1 mm
f)	On corresponding holes in opposite faces of a member	± 1 mm
g)	On specified hole diameter on the punch side (in the black), or when drilled	± 0.3% - 0 mm
h)	Taper on the punched holes as measured between the specified hole diameter on the punch side and the hole diameter on the die's side (in the black)	± 1.0 mm
i)	On specified bends, open and closed flanges	± 0.02%

The permitted tolerances for straightness after galvanising shall not exceed an offset of 1: 1000.

Tolerances for aluminium structures shall be in accordance with BS 8118: **Part 2.**

11.8 Erection

The Contractor shall when requested provide the Engineer with a Method Statement detailing his proposed erection methods. Due cognisance shall be taken of the relevant parts of BS 5531 and current health and safety legislation.

All structural members stored on site shall be kept clear of the ground where possible. Contact with substances likely to attack the protective coatings shall be avoided and all members kept in a clean and tidy condition. Care shall be taken to prevent damage/deterioration of any protective coating during transportation, storage and erection. Unless otherwise agreed damaged members shall be replaced. The renovation of damaged areas of protective coatings shall be carried out using techniques agreed with the Engineer.

The Contractor shall ensure that the structures are not strained or damaged in any way during erection. Structures shall be erected vertically within a tolerance at the top, or the centre of the beam of 0.5% of the overall structure height before equipment installation or conductor/busbar stringing.

12. Buildings and Civil Engineering Works

12.1 General

This section covers all earth work, foundations and buildings associated with the project together with roads, surfacing, cable trenches and tunnels, boundary walls, guard houses, foul and storm drainage and water supply.

12.1.1 Scope of Work

The work includes the design, detailing, construction and maintenance of the following:

1. performance of site investigation
2. foundations for all equipment to be installed in outdoor switchyards, control buildings, indoor switchgear and any other building required for the project
3. complete buildings consisting of structural reinforced concrete frames, brick walls, concrete roof and floor slabs.
4. roadways generally within sites, surfacing the entire area within site boundary and surface water drainage.
5. cable trenches, cable tunnels, cable ducts and pipe ducts

Included in the scope of work is the detailing, construction and maintenance of the following items which shall generally be constructed to the Employer's standards but full working drawings shall be prepared by the Contractor:

a. guardhouses
b. boundary walls and entrance gates
c. septic tank and soak way
d. underground water tank where water supply pressure is low
e. water supply tube well (Minimum depth of the well is 20m)
f. underground water storage tank.
g. the existing 132 kV control building floor shall be renovated by using homogeneous floor tiles and as per this section clause no. 12.3.8

Guardhouse, as stated in item (a) shall be designed as per enclosed drawing.

Boundary wall and entrance gate stated in item (b) shall be designed as per enclosed drawings.

Drawing and design of septic tank and soak way item (c) above, shall be prepared by the Contractor as per requirement of clause 12.3.3 and shall be finalized during detailed Engineering.

The Bidder shall state which approved local building Contractor(s) he proposes to employ to carry out the work.

12.1.2 Contractor to Satisfy himself as to all Conditions

The Contractor shall assess:

a. access conditions at all sites, plus ground conditions and ground bearing capacity
b. transport costs, materials costs and restrictions of availability of supply of materials locally
c. importation restrictions and delay due to customs controls
d. restrictions imposed by existing equipment on sequence of construction, access etc.
e. restrictions caused by cable laying and overhead line Contractors
f. ground conditions and temporary works required to provide support during excavation

12.1.3 Way Leaves, Land Purchase and Planning Permission

The Employer will be responsible for the purchase of all land within the permanent site boundary and the purchase of all land required to the base of the fill of any batter slopes. The Employer will also be responsible for obtaining land to provide a permanent single access to each site from a nearby road or waterway.

The Contractor shall perform the land development of the planned area. The substation location should be filled up and elevated above ground at least to the same level as the main road, so land back filling shall be performed and all cost shall be included in the Contract price. Elevation of the substation should take into consideration also the expected higher flood level, which is an impact of the climate change.

During the construction period the Contractor shall be responsible for maintaining this access in a reasonable condition by reinstating damage caused by his construction traffic and Employer traffic. The Contractor shall provide durable surface to access road.

Should the Contractor require more than one single access to a site or require additional land for construction activities outside the permanent site boundary, he shall be responsible for the purchase or way leave of the required land.

The Employer will be responsible for applying for planning permission. The Contractor shall be responsible for completing the approved site survey and the approved site layout plan, together with the approved architectural elevations of all facades of any buildings, by the key date given in the programme for each site so that the Employer may use these drawings to apply for planning permission.

12.1.4 Site Survey Drawings

For each site the Contractor shall prepare a survey at 1:200 scale showing existing ground levels on a minimum 10 metre grid and details of all features above and below the ground within the site boundary and up to 15 metres beyond it by the key date stated in the programme. Levels shall be related to bench marks clearly indicated on the plan. The plan shall be submit to approval by the Engineer and the agreed substation building floor levels shall be given on each site plan.

The Contractor shall propose the building floor level to the Engineer. It shall generally be 1000mm above the crown of the nearest public road or final site level or the highest known flood level, whichever is the greater.

12.1.5 Earth Works

Cut and fill where required shall be carried out by the Contractor. Source of fill material shall be planned and approved by the Employer. The Contractor shall be responsible for providing a level or uniform sloping site to suit his substation layout design. The final soil levels (i.e. the level below the brick surfacing) shall be stated on the site survey plan to be prepared by the Contractor.

Earth works to make the substation land suitable for installation of supporting structures and equipment, for extinction of the control building and related dependencies, with drainage to evacuate water in all conditions and of sufficient size to allow access to maintenance equipment and gravelling of switchyard surface.

Access road and switchyard internal circulation ways shall be extended. Extend drainage network made of perimeter trenches, switchyard internal sub soil drainage trenches or pipes.

All fill shall be compacted in layers not exceeding 150mm deep to a minimum of 90% optimum density as defined by the Proctor Test.

12.1.6 Engineer's and Employer's Accommodation/Surveying Equipment

On each major site the Contractor shall provide an office of approx. size 5 x 6m equipped with desk, 2 chairs, light and fan for the sole use of the Engineer and his inspectors. Similar facilities are to be provided for the Employer.

The Contractor shall also provide in the Engineer's site office one set of personal computer. The PC shall be fully equipped with all peripherals.

The Contractor shall loan his surveying instruments to the Engineer and his staff when required. Instrument checks shall be carried out at monthly intervals.

12.1.7 Programme

The Contractor's programme shall at Bid stage define the following key dates for each site. Where drawings are to be submitted for approval, they shall be submitted at least 6 weeks before the key dates to allow for the Engineer to comment and his comments to be incorporated in the drawings:

6. Issue of approved site survey drawing complete with soil levels and floor levels
7. Issue of approved electrical layout drawings
8. Completion of site investigation field work
9. Issue of approved Site Investigation Final report
10. Completion of loading tests on a foundation on each fill site and any other site where settlement is likely to be a problem
11. Issue of approved drawings required for planning permission
12. Issue of a full complete set of civil building drawings
13. Construction start date
14. Date access will be given for:
    a) Installation of equipment in buildings
    b) Installation of outdoor plant
15. Construction finish date

The Contractor's programme shall outline the number of sites he proposes to build at any time and shall show the order of completion of sites and how crews will move from site to site. This information shall be used to establish the number of expatriate site supervisors required.

The drawing programme shall ensure that complete set of approved civil building drawings will be issued at least 21 days before construction start at any site, in accordance with the Project Requirements in Schedule A of Volume 3 of 3.

The Construction programme shall be expressed in an 'S' curve for the whole project, with the percentage (of the total value of work in the schedules) given for each site each month. The overall percentage completion of the project each month shall also be given.

12.1.8 Monthly Progress Certificates/Progress Reports

In accordance with the Project Requirements in Volume I the Contractor shall submit agreed progress certificates for each site before the seventh day of the next month. These certificates shall state the percentage completion of each item in the schedules and shall state the overall percentage completion of each site and that site's contribution to overall project percentage completion. An updated 'S' curve shall be submitted with the progress certificates.
In addition, the Contractor shall provide a monthly

- Environmental and Social and Compensation Inspection Report
- Health & Safety Report

12.1.9 Temporary Facilities

The Contractor shall provide all temporary buildings, workshops, cement and lime stores and latrines required for his use. The Contractor shall agree the location of these buildings with the Engineer, after submitting a drawing showing their proposed location.

When a Contractor is placed in possession of a site, or part of a site, he shall erect temporary fencing immediately to protect the site until the boundary wall shall be erected.

12.1.10 Site Supervision

Although the civil and building works may be let as a sub-contract to an approved local Contractor, the main Contractor shall ensure that an expatriate supervisor in his direct employ is continuously available at each site during construction. This supervisor shall have at least a working command of spoken English and be able to read, understand and discuss specifications and drawings.

The Contractor shall notify the Employer and Engineer in writing of every concrete pour and foundation casting the day before the work starts.

12.1.11 Designs and Drawings

The Contractor shall obtain the Engineer's approval for the use of all design codes and standards before design work starts. All design and drawing work shall be completed in the Contractor's own country, in direct coordination with the electrical plant design.

The Contractor shall supply one copy of all of codes for the Engineer in Dhaka. If non-English equivalent National codes are adopted, the Contractor shall supply English translations of these Codes to the Engineer.

One copy of calculations shall be submitted together with drawings. To avoid possible misunderstandings, calculations will not be approved separately from drawings.

The Contractor shall generally submit a complete set of drawings for each substation for approval after initially getting the electrical layout of each substation approved. Where possible, drawings shall be standardized and general drawings (00) issued covering several sites.

For each substation the Contractor shall provide a co-ordination plan at scale 1:200 showing bus bar sizes, structure types, foundation types, cable trenches, roads, ducts, buildings, boundary walls, earthing, drainage and all services in this Contract.

12.2 References

12.2.1 General

The design and construction shall conform to the latest edition of the relevant Codes and Standards. Any proposed substitution for the listed Standards by an equivalent Standard will be subject to approval by the Engineer. Relevant Standards include, but are not limited to, those listed in subsection 2.2 below.

12.2.2 Design and Construction Standards

- BS12 Portland Cement
- BS EN 124 Gully and Manhole tops for vehicular and pedestrian areas
- BS 812 Testing aggregates
- BS 882 Aggregates from natural sources for concrete
- BS 1377 Methods of test for soils for civil engineering purposes
- BS 1722: Part 10 Anti-intruder fences
- BS 1881 Testing concrete
- BS 2853 Design and testing of overhead runway beams
- BS 3148 Methods of test for water for making concrete
- BS 3921 Clay bricks
- BS 4449 Steel bars for the reinforcement of concrete
- BS 5262 External renderings
- BS 5395 Stairs, ladders and walkways
- BS 5572 Sanitary pipework
- BS 5628 Code of practice for use of masonry
- BS 5930 Code of practice for site investigations
- BS 6031 Code of practice for earthworks
- BS 6367 Code of practice for drainage of roofs and paved areas
- BS 6399: Part 1 Code of practice for dead and imposed loads
- BS 6399: Part 2 Code of practice for wind loads
- BS 6465 Sanitary installations
- BS 6651 Code of practice for protection of structures against lightning

- BS 6700 Design, installation, testing and maintenance of services supplying water for domestic use
- BS 8004 Code of practice for foundations
- BS 8005 Sewerage
- BS 8100 Lattice towers and masts
- BS 8102 Code of practice for protection of structures against water from the ground
- BS 8110 Structural use of concrete
- BS 8206 Lighting for buildings
- BS 8215 Code of practice for design and installation of damp-proof courses in masonry
- BS 8290 Suspended ceilings
- BS 8301 Code of practice for building drainage

12.3 Design

12.3.1 Architectural and Structural Requirements of Buildings

All new buildings shall be designed to be architecturally pleasing in appearance and to withstand the tropical climate with minimal maintenance.

Architectural elevations of all elevations of buildings shall be agreed before other detail plans are prepared.

Air conditioning units shall be provided in rooms listed in Section 13. Air conditioned rooms shall have a false ceiling such that the overall thermal transmittance of the roof shall be below 0.45 Watts/m^2°C.

The false ceiling shall be made from non-combustible materials, and shall be easily removable to provide easy access to small power cables.

All buildings shall be reinforced by a reinforced concrete frame which shall be capable of resisting a horizontal earthquake force of 0.2G.

Two storey buildings shall be designed. First storey is cable basement. Second storey shall be designed to have at least 3.5 metres high with an imposed load of 2.5 kN/m^2 floor loading. An external concrete open staircase shall be provided. The roof shall be a flat in situ concrete slab designed for 2.5 kN/m^2 live load and galvanised steel shall be provided up to the roof.

The roof shall be waterproofed with lime terracing 2:2:7 lime, shurki (powdered brick) and brick chips 0.75" down, which shall be beaten in accordance with local practice. The entire roof area shall be laid in one continuous operation. The minimum compacted thickness of terracing shall be 25mm at the low points of the roof with a 1: 150 slope to those points formed by a layer of terracing of increasing thickness. Once laid, the terracing shall be covered with a layer of bitumen emulsion and the edge of the terracing shall be protected against erosion into the downpipes. Downpipes shall be 100mm diameter cast iron pipe placed outside the wall but shall be enclosed in a facing brick buttress. There shall be at least one downpipe per 100 m² of roof. The Contractor shall guarantee the roof against leaks for a period of 5 years from the Taking Over Certificate date. The roof shall project at least 450mm beyond the face of all walls to form a sunshade and rain shelter to the walls below. The upper surface of this projection shall be sloped and a drip provided.

The main entrance to all buildings shall be shaded, either by a projection of the roof over the entrance veranda or by a separate roof at a lower level. This area of roof shall also be lime terraced and drained by rainwater pipes.

The roof parapet wall shall be about 0.8 metre high with an in situ concrete coping with DPC below it. Where facing bricks are used below the roof level, they shall also be used above roof level. An architectural feature shall be provided by panels of open decorative blockwork (Mirpur ceramics or similar approved) to ensure good air circulation over the roof. Air bricks shall be provided at 750 mm centres in solid portions of parapet wall.

The head of each downpipe shall be fitted with an enlarged hopper and purpose made cast iron grill set into a recess in the roof projection.

Window openings shall be fitted with protruding concrete sunshades above and at the sides of the openings.

All external walls shall be 230mm first class brickwork plus a 50mm thick layer of Mirpur Ceramics facing bricks or similar approved, or rendered with cement render and painted as required by the architectural plan. The internal walls shall also be generally of 105mm thick first class brickwork. Internal walls shall all be rendered and receive one sealer coat plus two finishing coats of emulsion paint. All brickwork shall be tied into the concrete frame by galvanised ties. Externally, rendered walls shall receive primer plus two finishing coats of PEP acrylic external quality paint or similar approved. At least two air bricks shall be provided to each room in which staff work/rest.

Particular attention must be given in the design of buildings and layouts to fire prevention and safety of personnel at all times. Buildings housing switchgear and control equipment shall be designed as far as practicable to exclude pollution under all likely weather conditions. Fire-proof or flame-retarding materials are to be used for floor, wall and ceiling finishes. Where areas are designed as having a fire resistance rating then materials shall be shown to have passed approved standard tests for that class of fire resistance.

The height of control rooms shall provide about 1 metre clearance over the top of the cabinets to the underside of the false ceiling. In the switchgear rooms, about 1 metre clearance shall be provided over the switchgear to the underside of the roof slab but the Contractor shall provide a greater clearance if it is required to remove equipment. The clearance maybe reduced below downstand beams provided no equipment is required to be removed from the top of the switchgear. All rooms in any building shall be one height.

Rooms shall have walls and roof slabs adequately insulated. Maximum thermal transmittance values for all rooms shall be 0.7 watts/m²/°C for walls and 0.57 for roofs. Air conditioning units shall be provided in rooms listed in Section 13. Air-conditioned rooms shall have a false ceiling such that the overall thermal transmittance of the roof shall be below 0.45 Watts/m^2/°C. The false ceiling shall be made from non-combustible materials, and shall be easily removable to provide easy access to small power cables. Suspended ceilings, with acoustic tiling and incorporating lighting and air-conditioning fixtures shall be used in corridors, offices, control room and SCADA rooms of the buildings and as per schedule of finishes

All structures shall be designed to carry the loads imposed by the structure itself, together with live loads in accordance with an approved standard or code of practice. The roof shall be designed for 2.5 kN/m² live load.

All doors opening outwards from the buildings shall be provided with panic latches or bolts which override any locking device, for escape in the event of fire. All doors shall be provided with overhead door closures of adequate capacity. Door labels incorporating electrical hazard warning in Bangla and English shall be fixed to each entry door. Vision panels shall be provided to frequently used doors.
Window openings shall be fitted with protruding concrete sunshades above and at the sides of the openings.

Float operated submersible pump of capacity 25 cum/hour at a head of 8 meters to be provided for sump of basements. The pumps shall be fixed in all respect ready for operation and discharge into storm water drainage system.

The domestic water supply system shall include all plumbing, underground pipework, high and low level storage tanks, valves, fittings and pumps (including the provision of a standby pump) for the provision of a pressurized water supply system for the static water tank and all buildings within the compounds.

On completion of the installation and prior to putting to use, the system shall be sterilized in accordance with an approved Code of Practice.

The Contractor shall be responsible for the provision and installation of a water supply serving the substation buildings. Every cistern, sink, basin, etc., shall be provided with as stop-cock in the supply pipe adjacent to the fitting. Each basin, sink and shower unit is to be provided with both hot and cold water. Provision shall be made for connection to the drinking water supply.

Toilets shall be provided with 1 no. western type WC, 1 no. Asiatic, type WC, 1 no. wash-hand basin, and 1 no. wall mounted mirror. All necessary fittings and accessories shall be provided.

Battery rooms shall be supplied with sink and drainer.

Control buildings housing switchgear and control equipment shall include a cable basement to facilitate connection to the equipment. Basements shall be constructed so as to protect the building substructure from water in accordance with BS 8102.

12.3.2 Ground Conditions, Foundations and Site Investigation

(a) Fill Sites

Fill will be placed by the Contractor. On fill sites where the depth of fill exceeds 3 metres the Contract assumes piled foundations shall be installed below buildings. If piled foundations are found to be unnecessary in the Final Site Investigation Report, a reduction in Contract value shall be agreed on the basis of schedule rates.

Piles shall be concrete (cast in situ or precast) complying with BS 8004.

On every fill site the Contractor shall prove that his switchyard foundation will not suffer settlement greater than 20 mm by constructing a foundation and load testing this to twice the design bearing pressure for a minimum of 20 days.

Outdoor equipment shall be provided with spread footings. The bearing capacity of proposed soil level for outdoor equipment shall be checked by the Plate Bearing Test. The Contractor will be provided by

the Employer with a survey of soil levels prior to filling. The Contractor shall impose the site layout on the survey to check for uneven depth of fill below any foundation and where uneven depth of fill exists his foundation proposals shall restrict final differential settlement to a 1 in 400 slope.

If a fill site has not been exposed to one wet season before foundation work starts, the Contractor shall flood the site to a depth of 50mm for 10 days. (Not required on hydraulic fill sites). This requirement is because silty sands will generally compact to a denser condition on first time flooding.

On all fill sites the Contractor shall pipe rainwater from down pipes down to paddy level and shall prevent water ponding in open foundations and backfill all foundations as soon as possible.

The Contractor shall monitor settlement of the fill (by placing concrete posts 50 x 50 x 750mm deep on a 10 metre grid and taking readings) at 30 day intervals from the time he is given access to each fill site.

When a fill site is handed over to the Contractor, the Contractor shall become responsible for maintaining the entirety of the fill in good condition, including all better slopes.

(b) Unfilled Sites

Original delta levels are generally below road level. Therefore most sites are historically fill sites but fill settlement can sensibly be considered complete, where fill is over 3 years old.

(c) Site Investigation

Detailed methodology for subsoil investigation shall be submitted before implementing the subsoil investigation. All laboratory tests shall be done at the test facility approved by the Employer.

The Contractor may appoint a Subcontractor to carry out the site investigation but all work and all lab work shall be witnessed by one of his own staff who shall countersign all recorded data.

Boreholes shall be taken on a 25 metre grid with at least three additional boreholes beside each building. Additional boreholes may also be required where uneven fill depth is encountered.

The number and location of boreholes shall be approved with the site survey drawing showing existing ground levels specified in the section 12.1.4. The boreholes shall be located to an accuracy of + 0.5m and shall be located to site layout considering existing obstacles at the field.

Boreholes shall be a minimum of 20 metres depth or twice building footing width, whichever is greater.

All boreholes shall be backfilled with compacted sand.

Borehole log together with a summary of all required laboratory tests is required to be prepared. Soil test locations are required to be indicated on the geographical map.
In each borehole the following tests shall be carried out:

- Standard penetration tests at 1.0 metre intervals.
- Undisturbed samples shall be taken at around 2.0 metres depth and 3.0 metres depth and tested by unconfined compression tests.
- One-dimensional consolidation tests shall also be carried out on undisturbed samples taken at 2, 3 and 4 metres depth. The samples shall be saturated and the range of applied pressure shall fully

reflect the in situ conditions. Graphs showing void ratio (e) and applied pressure shall be submitted along with the coefficient of compressibility for the range of loading anticipated. Mv shall be given in m^2/MN and shall be recorded at each stress increment. The coefficient of consolidation, cv, shall be given in m^2/year.

- Particle size analysis shall be carried out for each stratum and specific gravity, moisture content, liquid limit and plastic limit determined.
- Ground water level shall be determined by dipping the boreholes. Where collapse of the boreholes occurs, casing shall be used and left in until the water level remains constant for two days.
- In cohesive soils a vane tests to BS 1377: Part 9 shall be carried out at three different depths. The Contractor shall check the sensitivity of soil and ground water at each site to concrete and take all measures necessary to ensure the long term durability of concrete.

(d) Site Investigation Report

The site investigation and analysis of the data in a final report giving full details of foundation proposals shall be completed at each site by the programmed date. During site investigation, Geographical map shall be prepared indicating the locations of soil test.

The report shall be submitted by the key date at each site given in the programme. The Contractor shall submit 2 copies of the report to the Engineer. The report shall propose full details of foundations and loading thereon and shall provide estimates of likely settlements and differential settlements. The report shall be the work of the Contractor's own foundation engineers.

If the Contractor uses a local site investigation Contractor, he shall appoint one of his own staff to oversee the entire operation and each piece of data shall be countersigned by this person.

Where estimated settlement exceeds 25mm, the Contractor shall construct one foundation at an early stage an test load this foundation to confirm settlement predictions.

(e) Foundations

Regardless of the result of soil investigation report, the foundations of control building, transformer foundations, gantry structures for terminating lines and for transformers shall be provided with piles.

The minimum depth of all foundations shall be:

a)	Transformer bases and bund	1.5 m
b)	All other switchyard foundations	1.1 m
c)	Control building foundations, including all wall foundations and internal wall foundations	1.5 m
d)	Boundary wall foundations	1.1 m

All formations shall be hand rammed or mechanically compacted before placing 70mm minimum thickness of Class B concrete blinding, within 24 hours of bottoming excavation, which blinding shall project 300mm minimum distance beyond all footings. Each footing shall be inspected by the Engineer. Where soil condition is poor (on fill sites or already filled sites) or where the Contractor leaves

foundations exposed and soil conditions deteriorate, one of the following measures shall be carried out as agreed with the Engineer:

i) Blinding depth and projection shall be increased
ii) Soft soil shall be removed and replaced with compacted viti sand with the top 200mm consisting of viti sand and brick chips.

The cost of this work shall be borne by the Contractor.

The Contractor shall propose the allowable bearing pressure for all foundations based on soil strength parameters only and shall not be increased while wind loads exceeds 25% of dead load as well as shall not exceed 125kN/m^2. Between column footings all walls, including all internal walls, shall be provided with a reinforced concrete strip footing of minimum dimension 800mm wide by 250mm deep placed at the same level as column footings and linked structurally to the footings. In addition column footings shall be tied at foundation level and also floor level by beams to every adjacent column in both orthogonal directions.

These beams shall be designed to resist 1 in 200 differential settlements without distress and shall be capable of resisting the earthquake load of 0.1G.

The deepest parts of any foundations shall be completed first. All foundations shall be completed and backfilled, including all cable tunnel and cable trench work inside buildings, before walls are raised above floor levels. All other foundations shall be backfilled within 7 days of completing concreting.

All exposed concrete and the outer surfaces of cable trenches and cable tunnels shall receive two coats of bitumen mastic paint before backfilling to reduce ingress of water. The Concrete surface shall be ground smooth and all air holes etc. filled (rubbed down with a cement slurry) before painting.

The Contractor shall monitor settlement of all foundations each month and report this settlement to the Engineer until settlement has reduced to less than 1.5mm in 3 months.

The tops of all foundations shall terminate 200 mm. above site average finished surface level for new Substation & for existing substation the level should be as per existing. All exposed edges shall have 20 mm x 20 mm. chamfers.

Excavation shall only be carried out when the ground water table is at least 1000mm below foundation level. The excavation shall be kept dry during the construction period by providing sumps and pumps as required. During the rain season, shelters shall be erected over all open excavations.

Any over excavation shall be filled with Class B concrete.

All backfill shall be compacted to 95% maximum dry density as defined by BS 1377 test method, part 4, 2.5 kg rammer.

Before starting foundation work the Contractor shall clear all sites of trees, tree roots, shrubs, debris, surplus soil, and any buildings.

Foundations shall be designed to resist uplift, assuming the water table is at ground level and the weight of soil resting on a foundation is that included within a 15° frustum.

On fill sites where the depth of fill exceeds 3 metres, the Contractor shall provide piled foundations in accordance with BS 8004 for control buildings. The design of foundations for transformer, gantry, equipment support structure, etc. shall be as per requirement of subsoil investigation report. One working pile chosen by the Engineer shall be load tested at each site to 150% of design load in accordance with BS 8004.

12.3.3 Drainage

The entire surface within boundary walls shall be of uniform sloping site, sloping at 1 in 150 minimum slopes to open channels around the entire perimeter. These channels shall be designed for a rainfall intensity of 60mm per hour. Outside the boundary wall the Contractor shall be responsible for drainage up to 20 metres from the wall and will at some sites need to construct outlets with suitable erosion protection down to paddy level.

The concrete wall of cable trenches shall project at least 70mm. above brick paving level to prevent run off entering the cable trench. The floors of all cable trenches/tunnels shall be sloped to soakway as described in 12.3.16.

The cable trenches will thus form barriers to surface water drainage. If the cut-off area exceeds 30 m^2 it shall be drained by a 200 mm minimum diameter concrete pipe to the boundary drain. The Contractor's drainage design shall avoid all ponded water to avoid forming a mosquito breeding ground.

All drainage pipework within buildings shall be ductile iron, generally of 100mm diameter. Floor drains shall be placed in each battery room and toilet.

External pipework shall be 150 mm. minimum diameter concrete pipes at a minimum depth of invert of 700mm. Where pipes, including existing pipes alongside site, are less than 400 mm above adjacent foundations they shall be surrounded in concrete. Where required, drainage pipes shall be kept below cables, allowing 1.1 m cover to top of pipes.

Manholes shall be of brick construction with 600 mm. x 600 mm clear openings and airtight ductile iron covers to BS EN 124. Manholes shall be located at each change of direction. Minimum fall on all pipelines shall be 1 in 80. Manholes shall not be located in roads.

The Contractor shall be responsible for all negotiations with local authority WASA where a connection to a public sewer is proposed. Where high water levels in public sewers may cause effluent to back up into a site, non-return valves shall be fitted. The Contractor shall provide all protection required to existing sewers and shall deepen foundations, including boundary wall foundations, where required to ensure all foundations are below adjacent sewers. The Contractor shall draw longitudinal sections of all pipelines.

Each control building shall be provided with **a septic tank** designed for 10 users and a soak away of open brick construction 11 m deep by 2.2 m diameter filled with broken bricks. The septic tank shall be located at least 15 metres from buildings. Other buildings shall have septic tanks designed for the required number of users. All foul drains shall be vented by a vent pipe to above roof level. The inner surface of all manholes and septic tanks shall be painted with 2 coats of bitumen mastic paint to protect it against sulphate attack. The septic tank shall have access holes directly over the inlet pipes and outlet pipes. Where public sewers exist alongside a site, the Contractor shall connect directly to the foul sewer, provided effluent from the sewer is treated.

The Contractor shall construct the drainage first to ensure that at no stage is rainwater ponded on any part of the site. All rainwater shall be able to run off the site or shall be immediately pumped off site by the Contractor. The Contractor shall complete all necessary drains before casting any roof and large concrete area which will create large run off. The condensate drains for the air conditioning shall also be connected to the drainage. Two vents of minimum height 2.2 m shall be provided on each septic tank.

If a town's water supply is unreliable, the roof rain water shall be collected in an underground tank of standard Employer's design. Scope of this work shall be agreed at Bid stage.

12.3.4 Surfacing

For the whole of the switchyard outdoor equipment area the ground shall be surfaced with gravel or other readily available local stone as approved by the Engineer. The switchyard surfacing shall be clean, thoroughly washed when necessary, and free from clay, soil or contaminating material and shall be graded from 20 - 45 mm, laid and lightly compacted to a finished thickness of 175 mm. Below the gravel layer there shall be a 75 mm brick layer with cement mortar (1:6), laid over a 75 mm level of fine sand spread over the finished fill site.

The substation plot, outside of the designated switchgear equipment areas, shall be turfed. Turf shall be of good quality, free from weeds and shall be a minimum of 40mm thick. Samples of the turf which is proposed to use shall be submitted to the Engineer for his approval. The turfs shall be laid to even surfaces on a bed of vegetable soil, which shall be raked and consolidated to provide a suitable bed.

On sloping surfaces the Contractor shall provide and fix wooden pegs to retain turfs.

All areas to be surfaced shall first be treated with a total weed killer in accordance with the Manufacturer's instructions. Weed killer shall only be applied in dry weather when there is no risk of it being washed out to adjacent agricultural areas.

12.3.5 Roads

All roads within the site boundary shall be provided by the Contractor, plus access road outside the site boundary to connect to any adjacent public road or waterway. The extent of roads required is shown approximately on Bid drawings but the scope of the work may change.

The road surface shall be finished by concrete paving or equivalent. All roads shall be of reinforced slabs of approximately 25 cm thickness fitted with construction joints. Paving schedule and methodology shall be approved by the Employer.

Road layout shall generally permit vehicles to turn easily to avoid having to reverse out. Road layout shall be designed by the Contractor. The Contractor's Liability for roads outside the site shall be as stated in the Project Requirements of Volume 1.

The width of access road from outside the site boundary to connect to any adjacent public road shall be 6 meters. All roads within the site boundary shall be generally 6 metres wide between the outer edges of kerbs for main road and 3 meters wide for sub road.

The road edge shall be formed by a flush Class B concrete kerb 300mm wide by 250mm deep, placed over one layer of bricks laid flat. The road shall be a Class A concrete slab 150mm deep with 1:50 cross fall and stiff broom concrete finish reinforced with 6mm bars at 125mm centres longitudinally and 6mm bars at 400mm centres transversely placed 60mm below the upper surface. Expansion and contraction joins shall be detailed on site plans. Expansion joints shall have oil resisting grade polysulphide sealant. Below the slab shall be a layer of polythene 0.5mm thick laid over one layer of 1st class bricks laid on edge in herringbone fashion in and on cement mortar (mortar designation iv) laid over one layer of 1st class bricks laid flat in and on a layer of sand laid on in situ soil which shall be compacted as agreed with the Engineer. If the soil is clay a 75 mm drainage layer of broken bricks shall additionally be placed over the soil.

The radius of the road edge at comers shall not be less than 3 metres and 1.2 metres either side of the road shall be kept clear of obstacles. Bollards or raised kerbs shall be provided where required to protect items alongside a road from vehicles. Ducts shall be provided below roads for all services in this Contract and for all future services.

Where mortar designations are referred to see BS 5628 Mortar designation iv is 1 cement: 2 Lime: 8 to 9 sand.

At each new substation site a two bay hard standing car port, complete with sun shades, is to be provided adjacent to the control building.

12.3.6 Water Supply

The Contractor shall be responsible for providing a water supply both for construction and for operation of the completed sites. If a town's water supply is not available, the Contractor shall install a tube well of 40mm minimum diameter and 100m minimum depth but in that case guideline specified by WHO for drinking water is required to be satisfied. The Contractor shall supply and commission power supplies and all pumps required by tube wells.

If a town's water supply is available, the Contractor shall be responsible for making all necessary arrangements with WASA to connect a supply. If the pressure in the supply is inadequate to supply the roof tank continuously, the Contractor shall install an 1800 litre low level tank and pumps. This tank shall be below ground with a 200mm minimum air void around the tank to protect it from contamination. The pump control panel shall be located in the building. Water levels shall be controlled by float switches but the panel shall provide also for manual operation.

The supply shall be connected to an 1800 litre roof tank of 16 gauge galvanised steel plate with a lid secured by bolts. The tank shall be raised 400mm clear of the line terracing on four brick piers of minimum 350mm square. All supplies in buildings shall be fed from the roof tank. The supply to the tank shall have a valve at waist height. The tank shall have an overflow returning to the location of this valve. No pipes shall pass through the roof directly over any room. Pipework shall be routed up the outside of the building and return pipes shall return down the outside of the building before entering through the wall. Pipework shall be galvanised steel secured by clamps at 1-5 metre intervals and painted with alkyd paint to match walls.

12.3.7 Plumbing and Sanitary Fittings

The Contractor shall prepare a drawing of all plumbing and building drainage for each building. Sanitary fittings and plumbing materials shall generally be of approved local manufacture.

Every tap and cistern shall have stop cocks in the supply pipe. One external tap shall be provided on each building. Battery rooms shall be provided with a stainless steel sink of approximate dimensions 900 x 600 x 200mm with a draining board to one side. The battery room floor drain shall be connected to the foul drainage. All floor drains shall have P traps.

Mirrors shall be installed over toilet wash basins. Care shall be taken in orientation of toilets to avoid offending religious sensitivities. Toilets shall generally be orientated North South where possible. Each shower shall have a wall on two sides and a porcelain shower tray sunk into the floor. No hot water is required in any control building. Soap dishes shall be provided beside each shower.

Only foul water from WC pans shall be connected to septic tanks. All other water shall flow to surface water drains.

12.3.8 Control Building Floors

All topsoil containing roots shall be removed and the in situ soil compacted before placing backfill. All backfill, including the backfill to column footings, below the floor shall be sand but around the perimeter walls a band of broken brick 600 mm wide shall be placed with drain holes placed in the walls at 2.5 metre centres. The floor and all cable trenches shall be made of Class A concrete. The floor slab shall have a minimum 125 mm reinforced concrete Class A thickness, plus 25 mm Terrazzo and it shall rest on the fill. Below the slab shall be placed a layer of polythene 0.5 mm and a layer of compacted broken bricks at least 75 mm deep, hand rammed to a smooth upper surface.

The floor/equipment layout shall minimise the number of cable trenches over which station staff have to walk. Where power cables traverse a building to reach a switchgear room on the far side they shall generally be contained within a dedicated cable basement or cable tunnel.

All sand backfill shall be compacted to 92% optimum density and shall be tested. The fill within a building, above ground level, shall not be placed until all backfill outside the building is completed. All floor slabs shall have a damp proof membrane of 0.5mm thickness.

Each control building shall have a ramp at a slope of approximately 1 in 7.5, of 1.5m minimum width with a Concrete Class A slab of min depth 125mm with a stiff brush concrete surface finish, or other agreed non slip surface.

All floors except battery rooms shall have homogeneous floor tiles. Verandas and external steps shall also have homogeneous floor tiles where public access is given to buildings. Elsewhere, concrete surfaces shall be used for all external floors/steps. Verandas shall have a minimum 1: 50 slope to shed rainwater away from buildings. Maximum length or breadth of any panel shall be less than 1.75 metres. 200mm high skirting shall be installed beside each wall. Concrete floors and steps shall also be treated with 3 coats of Lithurin or other approved concrete dust proofer.

If floor tiles are not adequately durable to withstand switchgear movement when rolled out to the maintenance position, then galvanized steel chequered plates shall be inserted in the floor to resist the abrasion from switchgear wheels.

12.3.9 Cable Basement

Below ground level basements to buildings shall be of waterproof construction; designed and constructed in reinforced concrete to BS 8007 and BS 8102 [Type C (Drained protection)]. The external walls and base slab shall be a minimum 350mm thick. The design shall assume that the ground water table is at ground water level.

The walls and floor of the basement shall have a drained cavity with ventilation provided. The cavity shall drain to a sump, equipped with one hand operated and one electric pump, to facilitate the removal of water. The electric pump shall be of the submersible type with automatic control by float switches. The hand driven pump shall be rotary action and valve less giving smooth non-pulsating flow.

The basement shall be provided with air extraction equipment, 100% standby equipment to give uninterrupted ventilation, sufficient to change the air 6 times per hour. Air supply and exhaust shall be from within the building at ground floor level in a protected location and shall not connect directly to the outside. The stairs leading to the basement shall be enclosed with, from ground level and at basement floor level, entry through security door sets. Sufficient air ducting shall be provided to ensure adequate ventilation to the basement even if the extract fans cease to operate.

The basement shall be equipped with lighting and small power.

Where cables enter the building all ducts and trenches shall be sealed; the ends of all ducts entering trenches shall be bell-mouthed. The floor shall be screened, the walls finished as per the schedule of finishes.

12.3.10 Battery Room Floors

Battery rooms shall have a concrete floor sloping to a cast iron floor drain. The concrete surface shall be treated with Nitocote epoxy resin coating (Nitoflor primer plus two coats of Nitocote in accordance with Manufacturer's instructions), or similar approved material, to ensure resistance to battery electrolyte. There shall be no cable trenches in battery rooms. Cable entrances through the floor shall be protected by a raised plinth 50mm high around the opening with the annulus around the cable sealed after installation. The door of the battery room will open outside the room.

12.3.11 Control Room Floors

Control rooms where specified in the bid drawings shall have a raised floor (Multi access floor). The Contractor shall submit the drawings showing required details for construction of raised floor for approval by the Employer's representatives.

The raised floor shall be made of poly-urethane material having functions of fire resistance, waterproof and soundproof. Each panel of raised floor shall be installed on the structure frame. The floor material shall have function to easily accommodate cables, communication wiring, etc. on its lower part. The floor material shall include the shock-absorbing material and finishing stuff.

Panel elements shall be produced without fading or peeling on the finishing stuffs and trim by the injection moulding of finishing stuff with panel elements at the same time. By the injection moulding, the panel's thickness and the other standard (width, length, thickness, opposite angle, right angle, flatness

angle, etc.) should be precise.

Pedestal elements shall have the function of support for the panel element of raised floor material.

Shock-absorbing material shall be installed on the top of pedestal elements and prevent any vibration or impact of the panel elements.

The materials for raised floor shall be as shown below or similar. The details should be approved by the Employer.

- Panel stuff: polyurethane
- Panel dimension: 600 x 600 ± 0.5mm (including finishing stuff, trim)
- Panel thickness: 40 ± 0.5mm (including finishing stuff)
- Panel inside core: particle board 35mm
- Panel frame: width 3mm poly-urethane
- Finishing stuff: anti-static laminate tile
- Under structure: zinc electric galvanizing
- Central concentrated load transformation: less than 2.5 mm with 4,900 N

The materials should be kept on the well-ventilated places against rain and direct ray of light. When transporting and handling the stuffs, the handler should be alert not to be damaged. The damaged materials have to be taken out. The finishes of stuff have to be stuck in the panel element.

The floor surface must be dry before construction; also the impurities like dirt and other obstruction should be removed. The under-structures (Pedestal set) are installed at intervals of 600mm from the starting point of construction like radial shape. At this time, the under-structure is fixed strongly on the floor surface by using an adhesive. When each supporting structure is connected to the frame (stringer), the levelling work shall be done together. Horizontal angle shall be checked again after the construction is finished.

Panel lifter and other accessories necessary for maintenance shall be provided by the Contractor.

12.3.12 Site Clearance, Obstructions and Adjacent Structures

The Contractor shall be responsible for clearance of:

(1) Trees, shrubs and any vegetation including the extraction of all roots and compaction of backfill where roots have been extracted.
(2) The removal of all buildings, sheds or any other structures above or below ground including the removal of any septic tanks, drains or other underground services.
(3) The removal of any existing surfacing, roads, foundations or any other obstruction.

All material cleared away by the Contractor shall be the property of the Employer and shall be removed by the Contractor to a site in the Project area upon instructions of the Employer. The Employer may remove any buildings or structures himself from sites before the commencement of site works.

Where an existing service, existing equipment or adjacent building is to be retained, the Contractor shall take all necessary measures to protect the item concerned from damage and shall be responsible for ensuring that no movement of foundations occurs during or after completion of construction.

Any existing electrical equipment/cables which have to be modified or repositioned shall be included in the works at no extra cost. Any buried gas or water main services which require to be diverted shall be deviated by the Employer at his cost. However, where it is possible to retain these existing services and build new structures around them, the Contractor shall take all necessary measures to build in the service at no extra cost.

12.3.13 Guard Houses, Boundary Walls, Fences and Entrance Gates

The guard house serves for control of entrance. The gatekeeper shall be able to watch the area before and behind the guard house. The guard house shall be provided with water supply and toilet. Small power and lighting facilitates are to be provided in the Guard Houses.

Where sites are within existing Employer's boundary walls, the Contractor shall erect a permanent fence 2.9m high in accordance with BS 1722 part 10 or similar approved.

12.3.14 Windows

Even natural light shall be provided by windows to illuminate all areas of buildings. Window area shall be about 6% of floor area to limit solar heat gain. Tops of windows shall generally be below 2.5 metres from floor level but toilet windows may be higher. The bottom of windows shall be generally at least 1.25 metres above floor level to provide good protection to staff. Each window shall be provided with a sunshade projecting about 500mm from the wall above and at the upper sides of the window. Few windows shall be placed on south facing walls. Windows shall be spaced to give a wide view of the switchyard.

Windows shall have single glazing with 6mm thick glass, reinforced with wire mesh where windows are placed in or over doors.

Window frames shall be anodised aluminium.

Glass panels shall be placed over doors to provide natural light to internal corridors and rooms where required.

External sills shall have a sloping tile or similar detail with drip.

The Contractor shall prepare a window schedule for each building.

The schedule shall clearly indicate both fixed and opening windows.

The Control and Switchgear rooms in particular shall have opening windows to allow adequate ventilation.

Guard Houses are to include for opening windows with burglar bars and shutters. Small power and lighting facilitates are to be provided in the Guard Houses.

12.3.15 Doors

Internal doors and door frames shall be anodised aluminium. Main Entrance/Exit doors and door frames shall be steel.

The minimum size of the structural openings for doors shall be 1550 mm. wide for double doors and 930 mm wide for single doors. Door height shall generally be 2100 mm but switchgear and control rooms shall have a removable transom and removable panel over the door or a taller door to provide a total height of about 2500 mm. All door sizes and widths shall be adequate to get in and get out all equipment and future equipment.
All external doors shall have weather boards, hydraulic closers and cabin hooks to hold the door open.

External doors shall open inwards, except for switchgear room doors which must open outwards and be fitted with panic release latches.

Each door leaf shall have three 150 mm heavy iron hinges equally spaced. Door furniture shall be of approved local manufacture and shall generally be of brass. All corridor doors, external doors and rest room (toilet) doors shall be fitted with hydraulic closers. Door stops shall be fitted where required. Door frames shall generally be set 200 mm off a wall junction to enable the door to open fully through 90˚.

All external doors shall be shaded by either the roof canopy or a separate precast concrete canopy over the top and the upper sides of a door.

The Contractor shall prepare a schedule of all doors and all door furniture for each building.

12.3.16 Brickwork

Brickwork shall be designed to BS 5628. External panels of brickwork shall be checked for wind pressure calculated in accordance with BS 6399 for a wind speed of 160 kph 3 second gust.

Bricks shall be first class bricks from approved Manufacturers. 10 bricks shall be tested in accordance with BS 3921 to determine water absorption and crushing strength, which shall exceed 20N/mm^2. Mortar shall generally be of Mortar designation (iii), 1: 1: 5 to 6. cement, lime, sand.

All brick panels shall be tied to the concrete frame with galvanised ties of approved design. Ties shall be painted with bituminous paint.

Facing bricks shall be 8" x 2" x 2" facing bricks from Mirpur ceramics. Facing bricks shall be tied back to the main wall. External walls shall be 230mm thick brickwork, rendered internally and clad externally with facing bricks or rendered as required by the architectural plan.

Bricks shall be compacted down onto a full bed of mortar. Vertical joints shall be completely filled with mortar. Joints shall be raked out about 10mm deep where walls are to be rendered.

Brick walls shall be constructed so that tops of all meeting walls are about the same level with maximum variation of 0.75 m. Only 18 courses per day shall be laid. New work shall be protected from sunlight and drying winds for 4 days.

Lime and cement for all brickwork shall be stored in a dry building with a raised dry floor.

Reinforcement by mild steel rods shall be provided where required by the design. Additionally openings over 500mm. wide shall be reinforced for 2 courses above and below the opening, two 6mm. bars per course extending 900mm beyond the opening both sides where possible.

All exposed brickwork shall be rendered and painted where not faced with facing bricks.

12.3.17 Expansion Joints, Joint Fillers and Sealants

Expansion joints shall be placed in floors beside all ground floor walls. All filler board shall be bitumen bound fibre board. Any expansion joints on roofs shall be raised and protected by a metal flashing.

All expansion joints shall be sealed by polysulphide sealants, applied in accordance with the Manufacturer's instructions. Sealants shall be oil resisting grade where required. Sealant colours shall match or blend with adjacent wall colours.

12.3.18 Cable Trenches in Switchyards

Cable trench sizes shall be standardised. Layout drawings shall be submitted for each substation showing layout and size of trenches. No trench shall cross a road; power cables shall be placed in ducts of minimum 150mm diameter with bell-mouthed ends. Ducts shall extend 1500mm minimum beyond the edge of roads. Spare ducts shall be installed for likely future development.

Floors and walls of trenches shall be constructed of Class A reinforced concrete of minimum 150mm thickness, with the external surface painted with two coats of bitumen mastic paint. Walls and covers shall protrude at least 70mm above site finish level and the top of the wall shall be flat with no rebate.

Floors shall be sloped at 1: 150 minimum slopes to brick soak ways placed below the trench at low points; the volume of each soak away shall be 2.5m^3 per 150m^2 of trench.

Covers shall be of reinforced concrete Class A. Each cover weighs less than 55 kg. The minimum depth shall be 70mm, with down stand ribs along each side providing a minimum overall depth of 100mm. The ends of the cover shall overhang the wall by 15mm and in the centre of each end there shall be a hand hole of minimum size 100mm by 20mm high. This hole shall allow air to ventilate the trench so that heat built up in the trench shall be reduced. No gaps larger than 5mm shall be left between adjacent covers so that the cables are always shaded. Cover slabs shall sit squarely and uniformly on the trench walls without the need for bedding or shims. Because portable fire extinguishers will be rolled over and along trenches, each cover shall be capable of resisting a 250kg point load at mid span. The Contractor shall provide ramps up to the edge of covers in several locations, as agreed on site, to enable the wheeled extinguisher to mount the covers. Longitudinal edges may be inclined at 10˚ to the vertical, thus creating a larger gap at the bottom of adjacent slabs, again to reduce heat build-up. The upper surface of covers shall have a stiff broom non slip concrete finish. All sharp edges shall be stoned smooth. Outer edges shall be chamfered.

Longitudinal fire separation walls and transverse fire separation walls as required by the cable section, may be of brick or reinforced concrete.

12.3.19 Cable Trenches in Buildings

The base and walls of the trench shall be of reinforced Class A concrete of minimum thickness 110mm with the outside face painted with 2 coats of bitumen mastic paint. Cable trays may be supported by Unistrut P3300 inserts, or similar approved or drilled anchor bolts.

The building layout shall minimise trench lengths. Where power cables pass through a building to reach the far side, this shall generally be in a tunnel section. The Contractor shall be responsible for providing all trenches and ducts in a building, including ducts for outgoing power cables up to the site boundary and including any pulling pits required.

Trench covers shall be sheets of checkered plate or similar approved, consisting of wood fibres impregnated and compacted in synthetic resin, or a computer flooring composite board.

The weight of each cover shall be restricted to about 30 kg. The upper surface shall be non-slip. Deflection shall be limited to 1/250 of span under a load of 3kN/m^2. Only one thickness of board shall be used to standardize the edge support detail. The recess to receive the cover shall be protected by steel or brass on the vertical edge and bedding surface. Covers shall fit snugly around all cables. Where cables enter the building, all ducts/trenches shall be sealed. Fire/oil barriers shall be required to separate hazardous equipment. The ends of all ducts entering trenches shall be bell-mouthed.

Any beams used to support large span covers shall be removable. All metal work shall be painted as specified in the paint section.

All covers shall bed down evenly. Full detailed fabrication drawings shall be provided for all covers.

12.3.20 Rainwater Pipes

Down pipes shall be 100mm minimum diameter placed on the outside of walls but enclosed in a brick buttress of facing bricks. One downpipe shall be provided for each 100m^2 of roof area. The head of the downpipe shall be enlarged to 200mm diameter and a purpose made cast iron grill provided over the head. This grill shall be sited in a recess in the roof slab projection.

The foot of the pipe shall have a 90˚ bend and water shall be discharged into either:

i) a small open channel conveying the water to the boundary channel
ii) a pipeline conveying the water off the site. Rainwater shall not be connected to the septic tank or allowed to discharge directly onto switchyard paving.

12.3.21 Switchyard Foundations

The tops of all foundations shall be set at the same level, which shall be raised above the general switchyard level for the purpose of preventing surface water coming into contact with the equipment structures and holding-down bolts. The distance between the general surface level and the top of foundations shall be at least 200mm. All exposed concrete surfaces shall be painted with an acrylic weatherproofed or bituminous paint, and flat areas shall be sloped to shed water. No base shall permit ponding of water in any way, and free drainage shall also be possible from all areas inside any grouting.

Bases shall generally be of Class A reinforced concrete.

Bases shall have all recesses for cables and earthing detailed on drawings. The drawings shall clearly show the orientation of each base and the location of all recesses. Where new foundations are adjacent to existing foundations; the Contractor shall be responsible for verifying the extent of the existing foundation and ensuring its stability.

For anchorage design of switchyard foundations shear force, vertical accelerations, overturning moments and torsion due to mass eccentricities of the equipment for the earthquake load of 0.2G are required to be considered. Mild steel ductile bolts and headed studs cast-in-place anchor bolts shall be used. Thick plate washer is required to be welded to the equipment base plate. Normal washer shall be used under a nut in all cases.

12.3.22 Transformer Bases

The transformer base, together with its surrounding bund shall form a raft to distribute the load from the transformer over the entire area within the bund wall. The bund shall extend at least 700mm beyond any part of the transformer and its radiators. The level of the top of the bund and the skids shall be 200mm above general switchyard level. Skids shall extend to the edge of the bund.

50mm below the top of the wall shall be placed a layer of stone 225mm deep set on a galvanised grill painted with two coats of bitumen mastic paint. The volume of the bund below the stone shall equal 125% of the total volume of oil in the transformer and its radiators.

Rainwater will tend to collect in the bund. To evacuate rainwater a fixed submersible pump controlled by sensors and switches (Aqua Sentry or equal) shall be provided at each bund with power supplies and drainage manhole conveniently located. The bund water control system shall differentiate between water and oil to ensure that the pump will not be activated while oil is present in the bund.

The transformer base and the bund shall be founded a minimum 1.0 metres below average switchyard finished level.

Below the skids the walls shall be at least 600mm wide. Piers shall be provided below the jacking points. Each base shall be provided with two galvanised steel removable pulling posts on the other side of the access road to the bund and also at the back of the transformer bund.

The entire concrete surface of the bund and the transformer base which is not buried shall receive two coats of bitumen mastic paint. Skids shall receive 3 coats of bitumen mastic paint before being cast in.

A carriage way shall be provided with rail connected with all transformer bases.

Transformers shall be anchored to resist the earthquake load of 0.2G.

12.3.23 Blast Walls

The Contractor shall construct blast walls to reduce the risk of fire spreading from each three phase transformer unit to an adjacent transformer unit or control building. Blast walls shall also be constructed to resist impact forces causing from a transformer explosion damaging adjacent equipment.

The width of the blast walls for transformers shall be 500mm higher than the tops of transformer or same height of the tops of the HV bushing and 300mm wider at both sides than the width of transformer. The thickness of blast walls shall be 200mm.

The wall may be constructed in Class A reinforced concrete with all exposed edges chamfered.

12.3.24 Paints and Painting

All paints shall be of approved makes and colours and proven suitability for the prevailing climate and shall be approved by the Engineer. All surfaces for painting shall be cleaned down prior to being painted and rubbed down to a smooth finish.

All externally exposed concrete and render of the control buildings, boundary walls, blast walls and guard posts shall be painted with a fungicide, Snowcem primer and two coats of Snowcem. All exposed facing bricks and Snowcern painted surfaces shall be treated with one coat of clear silicone (5%) water proofing solution.

All exposed parts of foundations, the outer faces of cable trenches and cable tunnels shall be painted with two coats of bitumen mastic paint.

All ungalvanized metalwork shall receive two coats of red oxide paint at least 4 days before installation and shall receive two finishing coats of paint after installation, each coat being of different colour. Surface preparation before painting shall be SA 2.5 or an agreed rust convertor acid shall be used. All galvanized steel, including all brick ties, boundary wall wire supports, crane beams, and baseplates and holding down bolts and concrete plinths shall receive two coats of bitumen mastic paint. Galvanized steel shall not be painted until the surface has weathered.

Internal walls when fully dry shall have the surface rubbed down with sandpaper and be painted with a sealer and 2 finishing coats of plastic emulsion paint before equipment is installed. A further finishing coat shall be applied after completion of installation.

One day shall be allowed for drying of each coat before the next coat is applied. The interior of all septic tanks and manholes carrying foul sewage shall receive two coats of bitumen mastic paint.

12.3.25 Furniture

The Contractor shall supply a complete set of tables, chairs, stools, desks, benches, storage shelves and drawing cabinets as described in the Project Requirements, Volume I with layout top, for drawing examination, lockable cabinets for spares and test equipment and key boxes in each control building.

These shall generally be of steel of local manufacture and shall be of robust durable construction. In each rest room (toilet) two couches, approximately 900mm wide by 1900mm long with back rests against the wall, shall be provided.

The full details and specification of these materials shall be agreed before purchase. The Contractor shall arrange for a list of items to be handed over to the Employer, who will sign for receipt of a complete set as stated on the list.

Furniture shall be provided for new substations only.

12.3.26 Concrete

Only two grades of concrete shall be used. Class A shall be used for all structural work, piling and for all foundations which are not unreinforced massive blocks. Class B concrete shall be used for blinding, pipe surround and unreinforced or nominally reinforced concrete. Road slabs and floor slabs shall all be reinforced Class A concrete.

	Class A	Class B
Minimum cement content	360 kg/m³	170 kg/m³
Maximum water/cement ratio	0.55	-
Coarse aggregate type	broken stone	Jhama brick
Max. coarse aggregate size	200 mm (40 mm piling)	25 mm
Method of batching	volume batching	volume batching
Minimum characteristic of trial:		
• Mix at 28 days	30 N/mm²	-
• Minimum characteristic strength of trial mix at 7 days	14 N/mm²	-
• Minimum characteristic strength of works cubes at 28 days	20 N/mm²	-
Slump range (minimum / maximum)	30 mm / 100 mm	min. 50 mm
Slump for concrete placed below water in piling (minimum / maximum)	150 mm / 200 mm	

It should be noted that minimum specified cement content will produce significantly stronger concrete.

The Contractor's design shall be based on a 28 day crushing strength of 30 N/mm². Design shall be in accordance with this Contract and BS 8110 or other agreed standard.

Minimum cover to rebar shall be 60mm where concrete is in contact with backfilled soil against a shuttered face, 100mm where concrete is cast against soil, and 30mm for all above ground concrete. In detailing bars which traverse a member, a reduction of 5mm shall be made for a bent bar and 10mm for a straight bar to ensure adequate cover. Exposed ends of sunshades and roof projection shall have 70mm minimum cover.

All concrete design shall ensure easy access for vibrators of 50mm. minimum diameter. Because of the slowness of concreting using local methods of transport, congested reinforcement details and shapes which are difficult to concrete should not be used. The location of all cold joints shall be agreed in writing with the Engineer and all joint surfaces shall be scabbled. All joints shall be horizontal or formed against vertical stop ends. All cold joints shall be indicated on drawings. Roof slabs shall generally be cast in one continuous operation.

12.3.27 Concrete Reinforcement

The Contractor may use locally available mild steel bars from approved sources or import steel bars to any agreed standard. No bar or stirrup shall be smaller than 6mm diameter to ensure adequate rigidity during concreting.

If locally purchased bars are used, bending tests and tensile tests shall be carried out to ensure the bars meet the design standard adopted and weight per unit length shall be tested regularly.

Bar bending lists shall generally be shown on drawings, where possible with a diagrammatic representation of each bar to ensure clarity and ease site communication. The Engineer will not systematically check the accuracy of every bar on bar lists when approving drawings. The Contractor shall therefore arrange to check all bar lists. Drawings shall detail all chairs and ties and include these on bar lists.

Bars shall be tied at every intersection and the ends of tie wire bent away from concrete surfaces.

Anti-crack bars shall be provided at changes in slab or wall thickness and at the comers of every rectangular opening.

12.3.28 External Render

All brickwork which is not faced with facing bricks shall be rendered. Concrete columns and walls shall be rendered and painted in accordance with BS 5262 with a 3mm spatter dash coat a 12mm undercoat followed by a 9mm finishing coat. Surface preparation shall be as described in BS 5262. Joints shall be provided in all render where brickwork panels abut concrete columns and grade beams, as required by BS 5262.

A mix type II or III shall generally be used. The finishing coat shall be weaker than the undercoat.

The tops of all foundation blocks and all protruding concrete foundations shall also be rendered where required by the Engineer.

PVA Bonding agents shall not be used because of the risk of early drying in the tropics. All concrete surfaces to be rendered shall have the entire surface scrabbled and brushed with a stiff brush to remove all loose material. The surface of the undercoat shall be roughened to ensure bonding of the finishing coat.

All render once completed shall be kept continuously damp for 10 days, after which if shall be treated with a fungicide. Any existing backgrounds shall be treated with a fungicide and all growth cleaned after 5 days of contact with the fungicide.

12.3.29 Goalposts

In each outdoor switchyard with live conductors crossing roads the Contractor shall erect a permanent goalpost at the edge of the danger area with red and white metal warning boards hanging down from the goalpost to warn high vehicles of the overhead danger. This structure shall conform and match those supporting structures in Section 12 of this Contract for the high voltage switchgear.

12.3.30 Lifting Beams

In two storey control buildings a galvanised steel lifting beam shall be provided for hoisting equipment to all upper floors. The beam shall be fixed permanently in place and shall project the required distance from the building to lift the largest equipment from road transport. Beams shall be designed in accordance with BS 2853 and deflection shall be limited to 1/900th of span. An approved (Morris of Loughborough 190 Series with Morris 164 travelling trolley or similar approved) hand chain hoist with hand geared travel and travelling trolley of capacity to suit the heaviest equipment or future equipment shall be provided on each beam. The chains shall reach to lorry level and provision shall be made to

hang up the chains to one side when not in use.

Inward opening doors shall close around the beam and be shaped to a close fit.

12.3.31 Stairs

Two storey buildings have an external staircase, which shall have a minimum clear width of 1,8 metre with a maximum slope of 30˚, all detailed in accordance with BS 5395. External staircases shall not be enclosed but shall be completely protected against rain by roof projections; steps shall be open with non-slip nosing. Internal staircases shall be terrazzo with non-slip nosing. Solid rendered and painted walls, at least lm high, shall be provided alongside each flight of stairs.

All roofs which are not accessible by stairs shall be provided with a galvanised steel fixed ladder.

12.4 Concrete Workmanship

12.4.1 General

At all stages in the production, mixing, placing and curing of concrete, the work will be inspected by the Engineer's representative. If any material, dimension or practice is not at least equal to the standards set out herein, it shall be rejected and alternatives compliant with the said standards, and in addition to the satisfaction of the Engineer, shall be implemented.

12.4.2 Aggregates

Coarse aggregate shall be capable of passing through a 20mm sieve and be retained on a 5mm sieve. Fine aggregate shall be not larger than 5mm and not smaller than 0.06mm and shall be sharp in texture.

All aggregates shall be free of harmful quantities of organic impurities, clay, silt, salt or unsound particles. The amount of clay, silt and fine dust present in aggregate, whether as coatings or separate particles, may not be more than:

- 15% by weight in crushed sand
- 3% by weight in natural or crushed gravel sand
- 1% by weight in coarse aggregate.

If the Engineer considers that any aggregate which the Contractor proposes to use contains an excess of fine particles or any harmful substances, the Contractor shall either replace the aggregate or, at his option and entirely at his expense, institute a series of approved tests at an approved laboratory to determine the nature and extent of the fine particles and harmful substances. Following receipt by the Engineer of the results of the analysis and tests, he will advise the Contractor in writing whether the proposed aggregate may or may not be used. The Engineer's decision in this respect shall be final.

Tests to determine the extent of impurities or fine particles shall include (but shall not be restricted to) the relevant tests specified in BS 882:1992, ASTM. C40-79 (Colorimetric test) and ASTM. C33-82.

12.4.3 Sampling

At least four weeks before he envisages first receiving aggregate from any source the Contractor, in the presence of the Engineer, shall obtain samples for testing. Samples shall be taken in accordance with the procedure quantities laid down in BS 812 and shall be subjected to those tests which the Engineer considers necessary to demonstrate the soundness of the material.

Such tests shall be carried out in an approved manner at the Contractor's expense and may include the manufacture, both in the laboratory and at site, of test cubes or cylinders to determine crushing strength.

12.4.4 Grading

The Contractor shall ensure that his offer includes the full cost of obtaining and transporting suitably graded stone aggregates to site.

Grading of aggregates should, together with the required minimum cement content and water cement ratio, ensure adequate durability, density and characteristic strength of the finished concrete. The

Contractor shall submit in writing to the Engineer the make-up of the mix he proposes to use, together with the grading analysis for the particular material and any details concerning his or others' experience with the use of aggregate obtained from the same source.

12.4.5 Cement

Ordinary Portland Cement shall comply with BS 12. The Contractor may obtain cement, bagged or in bulk, from any approved source in Bangladesh but shall always submit sufficient samples from each delivery, as required by the Engineer, to ensure that all cement complies with the minimum requirements of BS 12. All cement shall be stored in a weather tight shed at least 300mm off the floor. Regular checks shall be made on the weight of cement in each bag.

12.4.6 Water

All water used in the preparation of concrete for foundations shall be clean, fit for drinking and free from all earth, vegetable matter and alkaline substances, whether in solution or in suspension, and shall comply with BS 3148.

12.4.7 Reinforcing

Where reinforcing is specified in any foundation design, it shall comply with BS 4449 or an approved similar standard. Before any reinforcing is used, the Contractor shall provide the Engineer with a certified mill certificate, verifying its grade and quality, and proof test such samples as the Engineer considers necessary. All reinforcement shall be clean and free from loose mill scale, dust, loose rust and paint, oil or any other coating which in the opinion of the Engineer may destroy or reduce bond.

12.4.8 Storage

The Contractor shall ensure that all the materials he provides for the preparation of concrete shall be stored in a manner which prevents contamination by dust, clay, water or any other harmful material.

Heaps of coarse and fine aggregate shall be separated by at least one metre. Where aggregate is tipped directly onto the ground, the bottom 20cm of the heaps shall not be used.

Bagged cement shall be protected from rain, mixing water or damp soil during storage/transport. Cement from accidentally split or damaged bags shall not be used.

Where the Engineer considers it necessary, special precautions shall be taken to ensure that aggregate stored on site shall remain dust free. Such precautions may include the bagging of aggregate at the pit if sites are adjacent to dusty roads or if heavy rain is liable to wash out fine material or saturate the aggregate to an extent which might influence the water content of a mix.

Where the Contractor establishes central depots for receiving cement prior to despatch to individual sites, he shall ensure that the cement storage areas are sufficiently raised above the surrounding ground to prevent contamination of the cement by surface water. The material from which storage plinths are made shall be approved by the Engineer.

12.4.9 Design Mix

Prior to ordering any aggregate the Contractor shall inform the Engineer of the source(s) of his aggregates and deliver samples to the Engineer. The Contractor will authorise at an approved laboratory tests to show the sieve analyses, relative densities, moisture content of the samples of aggregate from each source. At least four test specimens of concrete shall be mixed at an approved laboratory and tested after 7 and 28 days.

Depending on the moisture content of the samples of aggregate the Contractor will report to the Engineer on the expected water/cement ratio and the aggregate/cement ratio of concrete to be produced on site.

Following the successful testing of the laboratory samples the Contractor shall make trial mixes at site (from which he will take at least 4 test specimens) using the proportions advised to the Engineer (and in the presence of the Engineer) and using the equipment he intends to use in the normal day to day manufacturing of concrete. The minimum 28 day crushing strength of any such test specimen shall be not less than 20.7 N/mm^2.

After successful testing of the test specimens made at site, the Engineer may then approve the source(s) of aggregate and the mix design.

No changes to the approved mix design will be permitted unless the type or source of aggregate differs from those already tested, in which case further tests at both the laboratory and at site will be made.

Any concrete placed which does not conform to the approved mix designs, shall be removed and replaced by the Contractor at his own cost.

12.4.10 Mixing and Placing of Concrete

Proportions of aggregates and cement and the quantity of water for each batch of concrete shall be closely monitored by an experienced mixer operator. Aggregate shall preferably be weight batched but, where this is not possible, volume batching shall be permitted, provided that the net volumes of

the loading equipment are approved by the Engineer. Containers for measuring quantities of water shall be clearly marked and only approved quantities of water shall be used in the manufacture of concrete.

Mechanical mixers shall be in good condition and well maintained. After loading, the constituent parts of the concrete shall be mixed together for a period of not less than two minutes or 30 revolutions of the barrel, whichever is the greater. For mixers with a capacity greater than 1.5m^3 these periods may be increased if the Engineer so requires.

When the constituents are adequately mixed, the fresh concrete shall be discharged from the mixer and placed in the foundation with the minimum of delay. Chutes shall be used to ensure that fresh concrete is not dropped by more than 1.5 metres.

No concrete shall be placed until all form work, installation of parts to be embedded, and preparation of surfaces involved in the placing have been approved. No concrete shall be placed in or through water, except with the written permission of the Engineer, and the method of depositing such concrete shall be approved by the Engineer.

Concrete shall not be placed in running water and shall not be subjected to the action of running water until after the concrete has hardened for seven days. All surfaces of forms and embedded materials that have become encrusted with dried mortar or grout from concrete previously placed, mud or other foreign material, shall be cleaned of all such refuse before the surrounding or adjacent concrete is placed. Immediately before placing concrete, all surfaces of foundations upon or against which the concrete is to be placed shall be free from standing water, mud and other foreign matter. The surfaces of concrete which have set, and against which new concrete is to be poured, shall be thoroughly cleaned to remove all foreign material and laitance, and be saturated with water immediately before placing concrete. Concrete shall be deposited continuously and as rapidly as possible until the unit being poured is complete. If for any reason the work is stopped before completing the unit of operation, a construction joint shall be installed in accordance with the instructions of the Engineer. Concrete shall be so deposited as to maintain, until the completion of a unit, a plastic surface approximately horizontal.

The method and equipment used for transporting concrete shall be such that concrete having the required composition and consistency will be delivered as near as practical to its final position without segregation or loss of slump. All concrete mixing and placing equipment and methods shall be subject to approval by the Engineer. Concrete placement will not be permitted when, in the opinion of the Engineer, weather conditions or other pertinent factors prevent proper placement and consolidation.

Bidders are reminded that, as a minimum standard, the following series of inspections should be carried out by the Contractor before concreting can begin:

1 Formwork coated with mould oil and correct in type, quantity and condition
2 Centre lines of template to coincide at the centre peg
3 Formwork to be well strutted and correctly located
4 Vibrator to be in working order
5 Mixer to be in working order
6 There is provision to maintain continuous mixing and pouring, by hand if necessary, in the event of a mixer breaking down
7 Where necessary, re-bar is on site ready bent and complete with tie wire, stirrups and concrete or plastic preformed spacer packs
8 A reliable level is at hand

9 There is sufficient aggregate, cement and water to complete the pour
10 Excavations are safe and not cluttered around the top edges
11 The mixer barrel is clean, and the paddles are complete and in place and the barrel will rotate at the speed specified by the Manufacturer
12 A suitable chute is in place
13 Both an air thermometer and concrete thermometer are on site
14 There is a large quantity of hessian sacking at hand

Where any of the above items are not complied with, the Engineer may suspend concreting pending their implementation.

12.4.11 Testing of Concrete

Samples shall be taken and tested in accordance with BS 1881. Testing shall be carried out by an approved laboratory, who shall arrange to immediately notify the Contractor and the Employer in writing of any cube failure. Failed cubes shall be kept for reference.

Concrete for the test specimens shall be taken at the point of deposit. To ensure that the specimens are representative of the concrete, a number of samples shall be taken from different points. Each sample shall be large enough to make one test specimen and shall be taken from one point in the work.

The tests specimens shall be stored at the site at a place free from vibration, under damp sacks for 24 hours $\pm$ 1/2 hour, after which time they shall be removed from the moulds, marked and stored in water at a temperature of 10˚ to 21˚C until the test date. Specimens which are to be sent to a laboratory for testing shall be packed for transit in damp sand or other suitable damp material, and shall reach the laboratory at least 24 hours before test. On arrival at the laboratory, they shall be similarly stored in water until the date of the test.

One compression plate of the testing machine shall be provided with a ball seating in the form of a portion of a sphere, the centre of which coincides with the central point of the face of the plate. Test specimens shall be placed in the machine in such a manner that the load is applied to the sides of the specimen as cast.

Cube strengths for concrete are to be not less than 14.8N/mm^2 within seven days after mixing and 20.7N/mm^2 within 28 days after mixing.

One cube shall be tested at 7 days to obtain an indication of the concrete strength. The remaining three cubes shall be tested at 28 days and the average of their strengths shall be calculated. Should the average of the cube strengths fall below the specified 28 days cube strength, the Engineer may order the affected concrete to be removed and replaced at the Contractor's expense, or the Engineer may allow the Contractor to take a cylinder for further testing in accordance with BS 1881, if Schmidt Hammer readings indicate below strength concrete.

The diameter of the cylinder shall be not less than three times the size of the maximum aggregate and its length will be at least double the diameter, after allowing for preparation and facing prior to the test.

Both a report and compression test will be completed for the sample in accordance with BS 1881. Only one such test will be permitted from any one sample and if the crushing strength of the sample is in excess of that required by the design the Engineer may, after the Contractor has made suitable re-

pairs to the part disturbed by taking the sample, accept the concrete.

In addition to cube sampling, 30% of concrete pours shall be tested by Schmidt Hammer. The Contractor is to pay for all remedial work and testing. Readings shall be taken at locations agreed with the Engineer and shall be witnessed by the Engineer. At least 15 readings shall be taken such that, after discarding the highest and lowest, some 12 readings remain from which the mean shall be calculated.

Readings shall be restricted to the middle third of a beam, slab or column and shall not be closer than 50mm to an edge or closer than 50mm. to any other readings. Immediately on completion of hammer testing, the concrete surface shall be painted to seal it with two coats of snowcem primer.

12.4.12 Formwork

Formwork shall conform to the shape, lines and dimensions of the concrete as called for on the Plans and shall be sufficiently strong to carry the dead weight of the concrete without undue deflection or bulging, and sufficiently tight to prevent leakage of mortar. It shall be properly braced and tied together so as to maintain position and shape. Members used in forms at exposed surfaces shall be dressed to uniform thickness and shall be free from loose knots or other defects. Joints in forms shall be horizontal or vertical. At all unexposed surfaces and rough work, undressed timber may be used. Timber reused in shutters shall have nails withdrawn and surfaces to be in contact with concrete thoroughly cleaned before being reused. Formwork shall not be disturbed until a minimum of 48 hours has passed from time of placement and concrete has hardened sufficiently to support any construction loads that may be imposed when stripping forms, metal wedges or tools shall not be used to pry panels loose. If wedging is necessary, it shall be done with wood wedges lightly tapped to break adhesion.

All columns and beams will have exposed edges chamfered 20 mm x 20mm.

12.4.13 Reinforcing Steel

Steel reinforcing bars shall be positioned in the concrete at the places shown on the drawings, or where reasonably directed by the Engineer.

Before reinforcing bars are placed in position, surfaces shall be cleaned of heavy flaky rust, loose mill scale, dirt, grease and all foreign matter. Once in position, reinforcing bars shall be maintained in a clean condition until they are completely embedded in concrete. Reinforcing bars shall have at least the minimum concrete cover shown on the drawings. Reinforcing bars shall be accurately placed and secured in position, such that they will not move during placing of concrete. Precast concrete block spacers may be used for supporting reinforcing bars.

12.4.14 Consolidation of Concrete

Concrete shall be consolidated to maximum practical density, without segregation, by vibration so that it is free from pockets of coarse aggregate and closes against all surfaces and embedded materials. Vibration of concrete in structures shall be by electric or pneumatic-driven immersion type vibrators of 50mm minimum diameter, operating at speeds of at least 8,000rpm when immersed in concrete. The vibrator shall be inserted vertically at close enough intervals so that the zones of influence overlap.

The vibrator shall be inserted to the full depth of the layer being treated and withdrawn slowly. When

concrete is being placed in layers, the tip of the vibrator shall extend approximately I 00mm. into the underlying layer. Vibrators shall not be used to move concrete horizontally. Care shall be exercised to avoid over-vibration of the concrete and direct contact between the vibrator and reinforcing shall be avoided.

12.4.15 Curing of Concrete

For foundations where excavations are to be backfilled immediately following the striking of shutters, the concrete is to be thoroughly wetted before backfilling commences. Where shutters are to be struck and backfilling of the excavation is not to take place immediately, the concrete is to be covered with wetted hessian sacking and be enclosed in polythene sheeting to avoid rapid drying of the concrete.

12.4.16 Hot Weather Concreting

In hot weather the following additional precautions shall be taken.

(a) In hot weather suitable means shall be provided to shield the aggregate stockpiles from the direct rays of the sun or to cool the mixing water/aggregates to ensure that the temperature of the concrete when deposited shall not exceed 32˚C.

(b) In hot dry weather suitable means shall be provided to avoid premature stiffening of concrete placed in contact with hot dry surfaces. Where necessary the surfaces, including reinforcement, against which the concrete is to be placed shall be shielded from the rays of the sun and shall be sprayed with water to prevent excessive absorption by the surfaces of water from the final concrete.

12.5 Workmanship of all Other Materials

This specification only describes concrete work in detail. All other materials workmanship shall be in accordance with an agreed standard. Before starting any new item of work the Contractor shall submit samples of the materials to the Engineer for approval in writing and the method of installation shall also be approved. The first item of any type to be installed shall be inspected and checked in detail by the Engineer before other items are constructed.

12.6 Fire Extinguisher

12.6.1 Control Room / Communication Room / Battery Rooms

These rooms shall be protected by a portable CO_2 fire extinguisher system. The system shall consist of all equipment required for directing the CO_2 gas discharge at a fire including, but not limited to, CO_2 cylinders and necessary piping, a flexible hose along with a jet nozzle. The effective reach of CO_2 gas jet release shall be sufficient to fight small fires that could develop in a control room area. Fire extinguishers shall be placed at strategic locations as per instruction of project engineer. The quantity of extinguisher at each new substation are given in Table-1.

12.6.2 Cable Room / Outdoor Switchyard

These areas shall be protected by a portable dry-type ABC powder fire extinguisher system. The system shall consist of all equipment required for directing the dry ABC powder discharge at a fire including, but not limited to, a wheel carriage (only for 15 kg capacity) loaded with portable cylinders and necessary piping and a flexible hose along with a jet nozzle and pressure gauge. The extinguisher material shall be non-explosive, non-hazardous, non-corrosive, non-toxic. The effective reach of jet release shall be sufficient to fight small fires that could develop in an outdoor switchyard, cable room and store room area. Fire extinguishers shall be placed at strategic locations as per the instructions of the Project Engineer. In addition, sand buckets shall also be provided, with a metal frame for hanging buckets and shall be placed at locations directed by project engineer. The quantities of extinguishers at each new substation are given in the table below:

Type, characteristics	Quantity
CO_2 type, 5 kg	5 sets
CO_2 type, 3 kg	5 sets
ABC dry powder type, 5 kg	5 sets
ABC dry powder type, 15 kg, including wheel carriage	4 sets
Sand bucket, with metal frame, with all accessories	2 sets

13. Lighting, Small Power, Heating and Ventilation

13.1 Scope

This section of the specification includes for the interior and exterior lighting, small power, heating and ventilation systems.

Whenever practicable, fixtures shall be sourced locally. All lamps, fittings, plugs, sockets and general accessories of the same size and types shall be similar and interchangeable throughout the installation.

The lighting and small power equipment and installation shall comply with other sections of this Specification as appropriate.

All civil works associated with this section of the works shall be deemed to be included as part of the works in this section. No additional payments will be made for such requirements.

The requirements of this section of the works are subject to the Main Conditions and Specifications laid down in other sections of the Bid Document.

13.2 References

British Standards

- BS 7671 Code of Practice Regulations for Electrical Equipment in Buildings 15th Edition. Institution of Electrical Engineers
- BS 6004 Specification for PVC insulated cables (non-armoured) for electric power and lighting
- BS 6346 Specification for PVC insulated cables for electricity supply
- BS 6500 Specification for insulated flexible cords and cables
- BS 6121 Mechanical cable glands
- BS EN 60947 Specification for control gear for voltages up to and including 1000V AC and 1200V DC
- BS 4533 Luminaries
- BS 3677 Specification for high-pressure mercury vapour lamps
- BS 1363 Specification for 13A fuse plugs and switched and unswitched socket outlets
- BS 1362 Specification for general purpose fuse links for domestic and similar purposes (suitable for use in plugs)
- BS 4568 Specification for steel conduit and fittings with metric threads of 150 form for electrical installation
- BS 4066 Test on Electric cable under fire conditions
- BS 4434 Specification for safety aspects in the design construction and installation of refrigerating appliances and systems
- BS 5970 Code of Practice for thermal insulation of pipework and equipment
- BS 848 Fans for general purposes

- BS 6540 Method of test for atmospheric dust spot efficiency and synthetic dust weight arrestance
- BS 2871 Specification for copper and copper alloys: tubes
- BS 1470 Specification for wrought aluminium and aluminium alloys for general engineering purposes, plate, sheet and strip

Institution of Heating and Ventilation, Engineers Guide to Current Practice.

American Society of Heating Refrigeration and Air Conditioning, Engineers Recommendations

Heating and Ventilation Contractors Association of U.K., Specification DW / 121

13.3 Defects Liability Period

The Contractor shall be responsible for the efficient and good working of the installations comprising this section of the Specification for the agreed period as set out in the Specification document.

13.4 Approvals

The Contractor shall submit to the Engineer for approval copies of all his calculations forming the basis for the designs of the specified systems, which shall be shown on the working drawings, also to be submitted for approval.

Any approvals shall not, however, relieve the Contractor of his contractual responsibilities which include obtaining local authority approvals for electrical wiring installations.

13.5 Lighting Requirements

The lighting installations shall be designed to give the standard service illuminations and shall incorporate emergency lighting where indicated. Control rooms, relay rooms, telecommunications equipment rooms, offices and stores shall have the service illumination measured at 850 mm above finished floor level. All other areas shall have the service illumination measured at floor level.

The installations shall also meet the limiting glare index requirements as set out in the specified codes of practice. This section of work gives proposals for the types of lighting fittings to be used in the area, type of control to be employed, number of socket outlets and the types of mounting expected to be suitable for the respective areas. Where discharge and fluorescent light sources are to be used in areas containing rotating or reciprocating machinery, the fittings shall be allocated between the 3 phase and neutral in such a manner as to avoid stroboscopic effects. When 3 phase lighting installations are to be used, contactor switching controlled by pushbuttons located in the area to be illuminated is preferred.

In all rooms and corridors having two entrances the lighting installation shall have two way switching, the switches being located in appropriate positions adjacent to the entrances.

Emergency lighting shall be arranged to illuminate all stairways, exits and entrances and provide some

illumination in operational areas within the control building and the switchyard, e.g. circuit breaker and transformer locations.

Security lighting shall be installed around the perimeter walls illuminating the external area and shall be controlled from the gatehouse. The level of illumination for security lighting shall be measured at a distance of 3 metres outside the boundary wall.

13.6 Schedule of Design Requirements

The lighting system shall include provision for ease of erection, maintenance, cleaning, lamp replacement and future extension. Lamp replacement and maintenance should, unless otherwise approved, be possible without necessitating outages on main plant items.

Lighting apparatus shall be of top quality, designed to ensure satisfactory operation and service life under all variations of load, frequency and temperature. Sodium discharge lighting shall be used for road and security lighting. Switchyard floodlighting shall use 500W Halogen lamps unless otherwise specified.

Key to Abbreviations:

L	Local switches
S1, S2 etc.	Socket outlets or fused spur circuits
P.B	Pushbutton for remote control
T.S	Time switch control
C	Ceiling mounted
W	Wall mounted
P	Pole or earth mast mounted
M	Recessed modular mounting
D	Suspended
F	Flush installation
S	Surface installation
A	Automatic on mains failure.
BH	Behind ceiling diffuser.

13.7 Coding Systems

The Contractor shall, when preparing drawings showing the respective designs, use a code to identify each lighting fitting and socket outlet.

The code shall comprise letters and figures so compiled that the following information can be readily identified:

1. The lighting distribution board to which the fitting or socket outlet is connected.
2. If connected to the normal supplies or to the emergency DC supplies.
3. The circuit number and phase of the distribution board to which the fitting is connected.
4. The sequence of the fitting in a particular circuit.

13.8 Distribution Boards

The distribution boards and all component parts shall be manufactured and tested in accordance with the latest standards and designed to suit the fault level of the transformers supplied. The Contractor shall demonstrate by calculation that this has been complied with.

Each, current carrying component shall be so designed that under continuous rated full load conditions in the climatic conditions at Site the maximum total temperatures permitted under the relevant Standards are not exceeded.

Each distribution board shall have a rustproof metal case of sheet steel with either a galvanised or enamelled finish. The colour of the enamel finish shall match the colour of other switchgear. The metal casing is to be provided with a number of knock-outs or other approved form of cable entries, corresponding to the circuit capacity of the distribution board, and a suitable screened brass earthing stud. Busbars, including neutral bar, shall be of high conductivity copper supported to withstand all normal and fault condition stresses.

All busbars, neutral bars and primary conductors are to be PVC sleeved in respective phase and neutral colours.

Distribution boards for exterior use shall be galvanised and weatherproof.

Neutral bars shall have an appropriate number of ways relative to the size of the board. They shall have a rating not less than that of the associated phase busbars.

The metal surface adjacent to any live part and all spaces between phases shall be protected by barriers of fireproof insulation material.

The distribution boards shall be either single pole or triple pole and neutral types and shall be equipped with means to provide overcurrent protection to each circuit. This protection may comprise an HRC fuse or a miniature circuit breaker, both of which shall be removable without exposing live connections.

Fuse bases and bridges, where used, shall be of an approved non- hygroscopic insulation suitable for the receipt of HRC fuses.

Residual current circuit breakers shall be incorporated to protect all lighting circuits, socket outlets and supplies to appliances, etc. These shall comply with the requirements of the main electrical part of this Specification.

The current rating of the busbars in each distribution board is not to be less than the sum of maximum current rating of all outgoing circuits. The neutral connection for each circuit is to be direct to the neutral busbar.

Title labels of an approved type and inscriptions are to be fitted externally on the front cover of each distribution board giving details of the points controlled by each circuit. The circuit lists shall be typed or printed stating the location of the equipment served, rating of the protective unit and the circuit loading. The lists shall be mounted on the inside of the cover door and shall be protected by an acrylic sheet slid into a frame over the circuit lists. The lists and cover are to be easily removable to permit circuit modifications.

The cables feeding the distribution boards will be connected directly to the incoming isolator or neutral bar as appropriate, unless otherwise indicated by the Specification.

Switch fuse units or isolators connected on the incoming side of a distribution board shall be mechanically attached to the board with solid copper electrical connections between the units. A suitable insulated barrier is to be supplied to prevent copper or carbon dust released under fault conditions passing from one unit to the other.

Distribution boards for use on the direct current system shall be double pole types equipped with adequately rated fuses.

Mixed capacity boards shall be employed and all contactors and time switches associated with the respective outgoing circuits shall be accommodated within the distribution board.

13.9 Miniature Circuit Breakers

Miniature circuit breakers shall comply with the requirements of the main electrical part of this Specification.

13.10 Cables

Cables shall be XLPE insulated, single wire armoured and PVC sheathed overall and be manufactured and tested in accordance with the requirements of BS 5467, 600/1000V grade or equivalent. The outer sheath shall be coloured black and incorporate flame retardant characteristics to meet the requirements of BS 4066 and IEC 60332. Jute fillings will not be permitted. Cables shall comply with the requirements of the cable section of this Specification.

Flexible type cables for pendant cords and final connections to fixed apparatus are to be butyl or silicone rubber insulated and sheathed, manufactured and tested in accordance with the requirements of BS 6500, 300/500V or 300/300V grade as applicable.

The conductor is to comprise multi-strands of 0.25 mm wire. The number of strands are to be not less than 30 and in all cases of a number suitable for the protection rating of the respective circuits.

All cables used for lighting and small power shall have copper conductors.

The Contractor is to select conductor sizes for the respective final circuits to meet the following conditions:

(a) That the minimum conductor size for lighting circuits is to be 1.5 mm^2 and for socket outlets 2.5 mm^2.
(b) That the size is to be adequate for the current to be carried as set out in the cable Manufacturer's specification.
(c) That the size is sufficient to keep the voltage drop in the phase and neutral conductor to the farthest lighting or power point, under normal full load conditions, to within the final circuit limit specified in BS7671. Diversity will not be allowed.

13.11 Cable Terminations

Terminations for cables shall comprise compression type glands with armour and bonding clamps to meet the requirements of Type E1 to BS 6121, or equivalent, and are to be designed to secure the armour wires, to provide electrical continuity between the armour and the threaded fixing component of the gland and to provide watertight seals between the cable outer sheath and gland and between the inner sheath and threaded fixing component. The glands are to project at least 10 mm above the gland plate to avoid moisture collecting in the cable crutch.

Earth bond terminal attachments are to be provided.

Terminations for rubber insulated cables are to comprise compression type glands where the function of the gland is to secure the outer sheath of the cable, in accordance with the requirements of Type A2 to BS 6121 or equivalent. A watertight seal is to be provided between the outer sheath and the gland. Only one cable is to be terminated in each gland.

13.12 Sealing and Drumming

Immediately after the works tests, both ends of all cables shall be sealed against the ingress of moisture, dirt and insects and the end projecting from the drum shall be adequately protected against mechanical damage during handling and shall be fitted with a pulling eye bonded to cores, sheath and armours.

13.13 Conduit

All wiring shall be installed in screwed heavy gauge welded steel conduit or heavy gauge PVC conduit, at the discretion of the Engineer. No conduit less than 20 mm diameter will be permitted.

Surface mounted	-	steel	-	switchrooms, battery rooms, i.e. painted blockwork.
Flush mounted	-	PVC	-	relay control rooms which have a decorative finish.

Steel conduits shall be manufactured in accordance with BS 4568, Part 1 or equivalent, heavy gauge screwed and welded Class B and shall be galvanised. Conduit fittings are to be manufactured of good quality galvanised malleable cast iron and of small circular pattern to BS 4568, Part 2 or equivalent, with internally tapped spouts minimum length 21 mm. threaded to the correct length at intersections, tees, draw throughs and stop-ends.

Conduit fittings of PVC shall be of the plain bore pattern suitable for a push-on compression type joint and shall be sealed with a hard setting vinyl cement to prevent ingress of vermin, water, dust, etc. Inspection bends, solid or normal bends, elbows or tees are not to be used except with the approval of the Engineer.

Conduit runs shall, wherever possible, be concealed in ceilings, voids and walls, chases etc., and in rooms of secondary importance (with back outlet entries to switch boxes etc. especially on fair faced brickwork) otherwise the conduits shall be securely fixed to the surface of walls using heavy cast distance saddles. Where plastered finishes are called for, buried conduit systems shall be provided.

Where the system of wiring is concealed, the 'loop-in' system of conduit shall be used and the 'looping-in' boxes shall conform to BS 31, Class B3.

A separate insulated earth conductor, coloured green and yellow, shall be run in PVC conduits and such facilities shall be provided at all terminal points.

Wherever the installation is specified as being flame-proof, the conduit runs entering these areas shall have a barrier box inserted in the run immediately before the conduit passes into the flame-proof area. All conduit work inside the flame-proof area shall be carried out with solid drawn galvanised conduit and all conduit fittings, sockets and accessories shall be galvanised and certified suitable for Group 1 hazard. At the completion of the wiring all machine faces on accessories shall be thoroughly cleaned and greased, prior to the screwing or bolting of all accessory cover plates into their final flame-proof secure position.

The ends of all steel conduits shall be reamered to remove all burrs or sharp edges after the screw threads have been cut. All dirt, paint or oil on the screw threads, the conduit, sockets and accessories must be removed prior to erection. All conduits shall be swabbed through prior to installation of cables.

The ends of the conduit shall butt solidly in all couplings. Where they terminate in fuse-switches, distribution boards, adaptable boxes or non-spouted switch boxes, they shall be connected thereto by means of smooth bore male brass bushes, compression washers and sockets. All exposed threads and all bends shall be painted with an aluminium spirit paint after erection.

All conduit and accessories, after being installed, shall be examined and all parts where the surface has been chipped or scratched shall be painted.

All conduits shall be kept 80 mm clear of water, gas and other services. Should this prove impracticable, then they shall be properly bonded by means of pipe clamps or other device ensuring mechanically sound, electrically continuous connection.

The method of installing PVC conduit and fittings shall conform strictly to the Manufacturer's recommendation. These recommendations shall be submitted when seeking approval to the system proposed. In general the clauses dealing with steel conduit shall apply.

PVC tube not exceeding 25 mm in diameter shall be bent cold by means of the appropriate spring and the tube shall be saddled as quickly as possible after bending. When bending larger sizes of tube, the tube must be heated in an approved manner until it is pliable. A 90° bend shall have a radius of not less than five times the outside diameter of the tube.

Joints between conduits and conduit fittings shall be watertight and shall be made by means of a solvent adhesive as recommended by the Manufacturer. Care shall be taken to ensure that the tube is clean and free from damp and grease and in particular dust, mould and oil.

The Contractor shall provide PVC tube ends and flexible covers to prevent ingress of concrete grout into the tubing and boxes.

All bends are to be made on Site to suit conditions and not more than two right angle bends will be permitted without the interposition of a draw box. No tees, elbows, sleeves, either of inspection or solid type, will be permitted. Generally long straight conduit runs from point to point shall have draw boxes installed at maximum intervals of 10 metres.

Deep boxes or extension rings on standard circular conduit boxes shall be used where necessary in order to bring the front of each box flush with the surface of the ceiling or wall. Where conduits are laid direct on the shuttering of the reinforced slab construction, conduit extension rings or deep boxes shall be used to raise the run of conduit to between the top and bottom reinforcing. Galvanised draw wires or other approved types shall be provided where conduits are not to be wired on completion or are to be wired by others.

All draw boxes and junction boxes shall be of ample size to permit the cables being drawn in and out. They shall be made of malleable iron or PVC approved type and the jointing surface machined to ensure a dust tight joint. All circular boxes shall be provided with long spouts internally threaded incorporating a shoulder for the proper butting of the conduit and a solid brass earth terminal tapped and screwed into the base of the box.

All conduit boxes shall be screwed on or in walls, ceilings etc. by countersunk wood screws of appropriate size. Holes in boxes shall be adequately countersunk to ensure the complete recession of the fixing screws. All inspection and draw-in boxes shall be provided with covers fixed by round head brass screws.

Where surface conduit is specified, it shall be fixed by means of distance saddles and shall terminate in raised back pattern conduit boxes. Surface conduits shall not be bent or set to enter accessories, and where they turn through walls back outlet boxes shall be provided. Conduits shall be fixed at 1200 mm centres on vertical runs and 900 mm apart on horizontal runs.

Vertical conduit runs shall have saddles at 300 mm maximum from their points of emergence from floors or ceilings and the remaining saddles shall be fixed consistent with the requirements of spacing and appearance. Saddles shall be fixed on each side of every bend at 300 mm maximum from the point of intersection of the centre line conduit.

Conduits in ceiling cavities shall be supported independent of the suspended ceiling.

Where conduits cross expansion joints, the Contractor shall allow for the installation of expansion couplers at the positions of the expansion joint and at fight angles to it. He shall provide a bonding earth wire between each terminal fitted in the nearest conduit box each side of the coupler.

All flexible metallic tubing shall be galvanised watertight pattern fitted with sweated brass adaptors. External earth conductors, wrapped around the tubing, shall be provided.

Where conduits are laid in slab floor etc., the Contractor shall arrange for a competent person to be in attendance whilst the concrete pouting or screeding operation is being carried out, in order to avoid damage being caused to the conduits and also to ensure that the conduit work is in sound condition, properly and efficiently maintained during this installation period.

Particular care should be taken when setting out conduit runs to outlet points where they are to be fitted to furniture, kitchen fittings, etc. The Contractor shall ascertain exact details of the furniture and fittings construction in order that all conduit work shall wherever possible be concealed.

Conduits installed in chases of walls and floors shall be firmly secured by wrought iron pipe hooks or crampets and these fixings shall in themselves be sufficient to hold the conduits in place. Conduits installed in chases shall be painted with one coat of bitumastic paint before erection and a further coat shall be applied to all accessible surfaces including the hooks and the crampets after erection.

Recessed conduits buried in plaster shall permit a full 6mm. depth of cover over its entire length. Provision shall be made for the tapping of condensed moisture.

Care shall be taken to prevent water, dirt or rubbish entering the conduit system during erection. Screwed metal caps or plugs shall be used for protecting open ends.

All conduit systems shall be erected completely with all conduit accessories connected. They shall then be offered for inspection and approval by the Engineer before any cables are installed. Conduit boxes shall be fixed to the structure of the building independently of the conduit.

Where a conduit is exposed to different temperatures (either by surrounding air conditions or by virtue of the surrounding medium with which it is in contact) at any particular time, the section of the conduit at the higher temperature shall be isolated from the section at the lower temperature by means of a conduit box filled with an approved permanently plastic compound, after completion and testing of all wiring. Such a condition would arise if a conduit running in a warmed building is run to exterior points.

Where galvanised conduit is specified, all conduit, accessories, switch boxes and all associated apparatus used in the installation must also be galvanised. Galvanised conduit shall be used when mounted outside a building, installed in floor chases subject to dampness or accidental flooding, or buried in the ground. Conduit systems shall be weatherproof when erected outside a building. Exposed conduit threads shall be given a coat of zinc rich paint.

Conduit buried in the ground shall be wrapped with PVC self-adhesive tape half lapped. The taping shall be extended for a distance of 150 mm beyond the point where the conduit emerges from the ground. Joints in galvanised conduit systems shall be made watertight using lead, aluminiurn paint and hemp and/or gaskets. The joints shall be partially screwed up before the paint and hemp are applied to maintain continuity.
All adaptable boxes shall be grey iron pattern unless otherwise specified. Where adaptable boxes are fitted flush, the cover plates shall be heavy gauge metal with 12 mm overlap on all sides. The internal depth of a box shall be not less than 40 mm.

Covers shall be secured by a screw at each comer and by additional screws as necessary to provide a maximum spacing of 300 mm between adjacent screws. Fixing screws shall be brass (round or cheese head).

Covers for boxes shall be of the same material as the box. For boxes mounted in weatherproof situations, the cover shall have a machined surface around the perimeter mating with a similar machined surface on the box and shall be complete with a gasket.

Every flush outlet box to which a luminaire pull cord switch or similar is to be fitted, shall be equipped with an approved type of break joint ring.

13.14 Cable Trunking

Where trunking is specified it shall be constructed of 1.65 mm minimum thickness zinc coated mild steel or PVC and shall have a removable cover throughout its length with centre screw latch fixings.

Trunking shall be rigidly fixed and supplied complete with purpose manufactured fittings, connectors, dividers, flanges, cable retaining clips, racks and copper earth continuity links. As an alternative, if ap-

proved, a proprietary brand of heavy duty plastic trunking may be acceptable. When submitting details for approval, full installation instructions as recommended by the Manufacturer shall be included in the details.

All cables installed in trunking shall be labelled and identified in an approved manner. Clips shall be at 600 mm from centres. Vertical cable trunking shall be fitted with cable pin racks arranged to avoid any strain on the cables.

All trunking shall be rust proofed, primed and painted and fixed at intervals not greater than 1,000 mm.

13.15 Cable Trays

Cable trays, where required as part of the Contract supply, are to be the perforated galvanised sheet type.

Trays are to have upturned edges and be of a width suitable for the number of cables to be supported and are to be supplied with purpose- made galvanised steel brackets suitable for mounting from the building structure. External cable trays shall be provided with covers.

Where site cutting of trays or support bracket steelwork is unavoidable, recutting bare steel shall be protected with two coats of an approved zinc rich paint immediately after cutting.

13.16 Cable Jointing

The Contractor shall be responsible for the sealing and jointing of all cables supplied and installed as part of this Section of the Contract. Straight jointing of cables is not permitted without the written consent of the Engineer.

13.17 Contactors

Contactors shall comply with BS 5424 or equivalent and shall be of the electrically held-in types contained in heavy gauge sheet steel cases suitable for panel mounting. Each contactor shall be continuously rated and suitable for thirty inductive switching operations per hour.

13.18 Switches and Pushbuttons

Switches shall be rated for 15 amps, shall be single pole types and be provided with an earth terminal. Switches shall be one way, two-way or intermediate as required and, where mounted together, they shall be fitted in a common box.

Switches for use in areas designated for surface installation shall be quick-make-quick-break fixed grid industrial types mounted in galvanised malleable iron boxes with protected dolly and arranged where necessary for multi-gang switching.

Switches for use in areas designated for flush installation shall be micro-break types fixed to white plastic cover plates and mounted in galvanised steel flush type boxes.

Switch-boxes shall be galvanised and fitted with screwed stainless steel front plates having a 6 mm overlap minimum for flush installations. They shall be suitably barriered and labelled where two phases are connected in the same box.

Switches mounted externally shall be of weatherproof pattern to IP55 level fitted with machined box and cover joint, brass operating handles, neoprene weathertight seals and external fixing feet.

Where DC emergency lighting circuits are to be switched, double-pole quick make, quick break switches with pillar type terminals and earthing straps shall be provided.

Switches shall be mounted 1.4 m above finished floor level.

Pushbutton switches shall either be flush or surface types contained in galvanised steel boxes and be single pole rated for 5 Amps. Pushbuttons shall be made of non-hygroscopic material, be non-swelling and so fitted as to avoid any possibility of sticking.

The terminals for all switches shall be adequate to accommodate 2 conductors, each a minimum of 1.5 mm^2 in area.

13.19 Lighting Fittings

Illustrations and/or samples of all lighting fittings which the Contractor proposes to purchase shall be submitted to the Engineer for approval before issuing any sub-orders.

Lighting fittings for interior and exterior use are to be manufactured and tested in accordance with the appropriate sections of BS 4533, IEC 60162 or equivalent and together with all components are to be suitable for service and operation in the tropical climate stated.

Each fitting is to be complete with all lamp holders, control gear, internal wiring, fused terminal block, earth terminal and reflectors or diffusers as specified. The design of each fitting is to be such as to minimise the effect of glare and such that the ingress of dust, flies and insects is prevented, where open type fittings are used it is to be impossible for insects to become lodged therein.

The control gear for use with fluorescent lamps is to be quick or resonant start type without starters.

Chokes are to be impregnated and solidly filled with polyester resin, or other approved high melting compound, are to be manufactured to restrict the third harmonic content to less than 17% of the uncorrected current value, and are to be silent in operation.

The built-in ballast units shall comply with IEC 60082 and shall include radio interference suppressors and capacitors to correct the fitting power factor to a minimum of 0.85 lagging. Control gear noise levels shall be minimal.

Fittings shall be supplied complete with closed end vitreous enameled metal reflectors or totally enclosed opal plastic diffusers, which shall be fully interchangeable.

Dispersive reflector fittings suitable for mercury bulb fluorescent or tungsten filament lamps shall be of heavy gauge sheet steel finished vitreous enamel. They shall be fitted with anti-vibrators and arranged for conduit box mounting, direct or pendant, on galvanised ball and socket dome type lids.

Bulkhead fittings shall have cast bases tapped for conduit entry, hinged bezels, heat resisting prismatic glasses fitted with neoprene gaskets and porcelain lamp holders. Circuit cable shall not be connected direct to bulkhead fittings but shall terminate in a fixed base connector mounted in a conduit box adjacent to the fitting. Final connections to each fitting shall be carried out with silicone rubber covered cable. All bulkhead fittings shall be watertight pattern.

Internal connections are to comprise stranded conductors not less than 0.75 mm^2 covered with heat resistant insulation to the requirements of BS 6500 or equivalent. All internal wiring is to be adequately cleated to the fitting casing with an approved form of cleat. The finish of fittings for interior use is to be impervious to deterioration by atmospheric reaction. Fittings for exterior use shall have a vitreous enamel, natural aluminium or galvanised finish according to the Manufacturer's standard product.

Lampholders for tungsten lamps up to 150 watts shall be brass or porcelain BC type and for higher ratings shall be ES or GES type according to size. Fittings for housing tungsten lamps exceeding 150 watts rating are to be provided with an approved method of dissipating heat from the lamp cap and terminal housing.

Lampholders as applicable are to be suitable for the lamp specified.

Lighting fittings are to be of the type description as generally set out in the schedule appended to this section of the Specification. The type references used are to be repeated in the Schedules and on the drawings.

13.20 Lamps

The Contract includes the supply and erection of all lamps and tubes necessary to complete the installation.

Fluorescent lamps shall be manufactured and tested in accordance with BS1853, IEC 60081 or equivalent, shall be bi-pin types and shall have colour rendering values of X = 0.335 and Y= 0.342 (i.e., Colour 2) on the CIE chromaticity scale.

Tungsten lamps shall be manufactured and tested in accordance with BS 161 or equivalent and shall be bayonet cap for lamps up to and including 100 watts. Lamps rated for 150 watts and higher shall have Edison screw caps. Low wattage lamps used in exit signs and emergency lighting units may be small or miniature Edison screw.

Discharge lamps shall be manufactured and tested in accordance with BS 3677 or equivalent. Mercury vapour lamps shall be fluorescent types having a 10% red ratio colour correction, whenever used.

13.21 Socket Outlets and Fused Spur Outlets

Each socket outlet shall comply with the requirements of the BS 1363 or equivalent and shall be the interlocked shuttered and switched types arranged for surface or flush mounting in single or multi-gang units as appropriate.

Each fused spur outlet shall be equipped with double pole isolator, a fuse to BS 1362 or equivalent and where required front entry for flexible connection.

Each socket outlet and fused spur outlet shall be equipped with a galvanised metal box with earth terminal.

Each group of five socket outlets is to be provided with a matching fused plug top.

All socket outlets for exterior use shall be galvanised and weather- proof and be equipped with screwed dustproofed cap attached to the socket by means of a chain.

13.22 Time Switches

Time switches for use with lighting systems shall be the synchronous motor wound types protected by a suitably rated fuse for 230 volts operation with a nine hour reserve spring and are to be fitted with a twenty-four hour hand set dial, two "OFF" and two "ON" levers and manual operation pushbutton. The main contacts shall be rated for 20 Amps on a 230 Volt 50 Hz AC supply.

Time switches shall be suitable for mounting in the distribution boards supplying the circuits to be controlled.

13.23 Poles

Lighting poles shall be tapered, of hot dip galvanised steel with bituminous preservative inside and outside at the base and shall be approved by the Engineer.

Each pole shall be equipped with a base section compartment of 470 mm by 150 mm to house an inspection trap, lockable door, fused cut out, cable entry and terminations for both the incoming and outgoing power cables and secondary cables feeding the light sources.

Poles for substation lighting shall support the floodlights at 11m above ground level and poles for access roadway lights shall support the lanterns at 4.5m above ground level.

The Contractor shall ensure each pole is provided with foundations suitable for the ground conditions occurring at each site.

13.24 Interior Installations

Wiring for the lighting and socket outlet installations shall comprise PVC cables drawn into conduits attached to walls, structural or roof steelwork or ceilings as appropriate (see chapters **13.13 and 13.14).**

Surface and flush type installations are required according to the particular area as indicated in the schedule appended to this section.

In areas where flush type installations are indicated the wiring shall be drawn into conduits buried under wall finishes or concealed above ceilings as appropriate.

All fixings shall be of a type approved by the Engineer and all metalwork used shall be galvanised. Fixings to structural steelwork shall be with purpose made brackets or clamps; the drilling of structural steelwork will not be permitted.

Cleats with two screw fixings shall be used for supporting conduits at not greater than 2 m intervals.

All switchboxes, socket outlet boxes and items of a similar type shall be fixed with two screws or bolts.

Switches and pushbuttons for lighting circuits shall be mounted at 1400 mm above finished floor level.

Socket outlets shall be mounted 500 m above finished floor level but those for use with workshop benches shall be mounted 150 mm clear of the bench working surface.

Lighting fittings shall be attached to ceilings, walls, trunking or roof steelwork or suspended therefrom as appropriate.

Where fittings are to be suspended, rod type suspension units shall be employed.

Final connections to all suspended lighting fittings shall be with heat resistant flexible cable terminated in porcelain clad connectors in the ceiling or junction box which shall also terminate the main circuit cable. The cable length shall be such that the suspension unit supports the full weight of the lighting fittings.

Where recessed type lighting fittings are to be installed suspension units shall be used to prevent the weight of the fittings being applied to the suspended ceiling. It shall be possible to carry out maintenance from the underside of the fitting without disturbing the false ceiling. To facilitate this need the final connection to each fitting shall be with heat resistant flexible cable from a plug in type ceiling rose mounted above the false ceiling.

All cables not contained within conduit for their whole route shall be terminated with a cable gland.
Where lighting fittings are mounted direct on walls or ceilings, the main circuit cables may be connected into the fitting terminal block. Where terminal blocks do not exist within the lighting fitting, flexible heat resistant cable shall be used connected to a separate junction box.

Earth continuity shall be maintained throughout the entire wiring installation with separate insulated earth continuity conductors of adequate cross-section ultimately connected to a common earth terminal at the respective distribution board.

Within the interior installation adequate provision shall be made for connection to small ventilating fans, which are not energised from the central air conditioning control and starter panel.

Each and every trunking route shall be bonded across all joints with external copper bonding links supplied for the purpose.

13.25 Exterior Installation

Exterior substation lighting fittings shall be attached to substation walls at high level or pole mounted as appropriate. Security lighting round the perimeter wall/fence is to be provided.

When locating the floodlights for the switchyard lighting, the Contractor shall ensure that all floodlights are outside safety clearance for the high voltage switchgear at the particular location.

Cables to exterior lighting shall be laid direct in ground, laid in concrete trenches or cleated to buildings structures as appropriate to the route requirement. The cables shall be terminated at a cut-out located at the base of each support. Wiring between the cut-out and the control gear or lantern shall be with multicore cable run within poles or with cable drawn into galvanised steel conduit attached to the supporting structure.

13.26 Emergency Lighting

Emergency lighting shall comprise lighting fittings of the types indicated in the schedule appended to this section of the Specification.

The system shall be so arranged that on failure of the normal a.c. supplies to the lighting installation the emergency lighting system will automatically be switched on. Other than those of the "on demand" type, all emergency lighting shall be switched "off" 5 minutes after restoration of normal supplies. Each emergency lighting unit shall have a minimum 3 hour rating.

Sufficient fittings of Type E3 shall be provided in each room to enable the rooms and building to be evacuated safely.

In addition, in designated working areas emergency manually switched lighting, to give not less than 30 lux, shall be provided utilising type E4 fittings. Switches shall be labelled to the approval of the Engineer.

The security lighting scheme shall illuminate the area to 6 metres inside the perimeter wall to the lighting level specified.

13.27 Telephone System

A complete conduit/duct system shall be provided throughout the building to enable the telephone cables to be run to the proposed extension points. This includes telephone wiring to operators' desks and office in the control building.

Telephone instruments, the PABX and connections to PTT exchange lines shall be carried out by other Contractor.

13.28 Schedule of Lighting Fittings and Socket Outlets

All lighting schemes are to utilise fittings and lamp types which are available locally in Bangladesh to ensure that replacements are readily acceptable.

Lighting fittings described in this Schedule shall also meet the general requirements of the Clause for Lighting Fittings of this Specification.

Type F1 Shall indicate a basic channel complete with control gear and lamp holders for one fluorescent lamp, equipped with an open ended metal reflector having upward light slots.

Type F2 Shall indicate a fitting which shall comply generally with the description for Type Fl but be equipped for use with two lamps.

Type F3 Shall indicate a recessed modular fitting suitable for mounting in a suspended ceiling and equipped with a clear prismatic controller. The metalwork and trim are to comprise a rigid welded unit so arranged as to be invisible when erected complete with controller. The fitting is to be equipped with a pre-wired removable gear tray and adjusting facilities to enable levelling relative to the ceiling to be carried out after erection. The assembly is to be complete with control gear and lamp holders for one 1500 mm long 65 watt fluorescent lamp.

Type F4 Shall indicate a fitting which shall generally comply with the description F3 but with an open type grid diffuser.

Type F5 Shall indicate a dust-tight, weatherproof and vapour resistant fitting, having a grey polyester fibre glass reinforced chassis containing the control gear and having lampholders for one 1500 fluorescent lamp. The fitting shall be complete with a vacuum formed acrylic diffuser which is secured to the body with injection moulded toggles and sealed with a neoprene gasket.

Type F6 Shall indicate a weatherproof bulkhead fitting with a cast aluminium base and vandal resistant diffuser equipped with control gear and lampholders for two fluorescent lamps.

Type E1 Shall indicate a self-contained, self-sustained (normally off) emergency lighting unit, complete with integral batteries and control gear, with the words "EXIT" in white letters on red background in English and Arabic. It shall be energised from the batteries under mains failure conditions. The mains failure device shall be sensed by an unswitched phase connection from the local lighting circuit.

Type E2 Shall indicate a self-contained, self-sustained (normally off) wall mounted emergency lighting unit comprising a pilot light and two 100 watt spotlights complete with integral batteries and control gear. The pilot light shall be energised under mains failure conditions with manual "on demand" switches for the spotlights. The mains failure device shall be sensed by an unswitched phase connection from the local lighting circuit.

Type E3 Shall indicate a self-contained, self-sustained (normally off) wall or ceiling mounted emergency lighting unit complete with integral batteries and control gear. The lamps shall be energised under mains failure conditions. The mains failure device shall be sensed by an unswitched phase connection from the local lighting circuit.

Type E4 Shall indicate a 110V DC wall or ceiling mounted emergency lighting unit which shall be manually switched and be similar to type E3.

Type H1 Shall indicate forward throw floodlight fitting comprising a sheet steel vitreous enamelled or spun aluminium reflector housing a 500 Watt Halogen lamp. The fittings to be complete with wall mounting bracket.

type H2 Shall indicate a semi cut-off roadway and perimeter security lantern with housing manufactured from a one piece LM6 aluminium alloy casting enamelled white internally and equipped with reflector bowl of heat resisting glass, all suitable for housing the lampholder and control gear for one 150 Watt sodium vapour lamp. The fitting to be equipped with pole arm suitable to give an outreach of 1 metre.

Type S1 Shall indicate a 13 Amp single or double gang flush mounted switched socket outlet.

Type S2 Shall indicate a 13 Amp single or double gang surface mounted switched socket outlet.

Type S3 Shall indicate an ironclad one gang heavy duty 4 pole interlocked switched socket outlet with scraping earth connection suitable for use on a 400V 3 phase 4 wire 50 Hz for 125A. Each socket is to be supplied complete with cable box with 2 glands, suitable for terminating a PVCWPVC cable and shall be fitted with a screwed dustproof cap attached to the top of the socket by means of a chain. Matching plugs to be provided in each socket.

Type S4 Shall indicate a 15 amp 3 phase 4 wire switched socket outlet with plug flush mounted.

13.29 Schedule of Lighting Requirements

13.29.1 Control Building

Location	Service Illuminance (Lux)	Glare Index
Control relay room	400	25
Behind panels	100	-
Office	500	20
Battery room	100	-
toilet	100	-
Corridors, stairs	100	20

13.29.2 Outdoor Areas

Location	Service Illuminance (Lux)	Glare Index
Switchyard floodlighting	20	-
Transformer compounds	120	-
Roadway lighting	20	-
Perimeter wall security	10	-
Control building exterior	15	-

13.30 Air Conditioning and Ventilation

13.30.1 Scope of Work

This Section of the works covers the design, supply, delivery, installation, commissioning and setting to work of the heating and ventilating systems for the control building.

All heating and ventilating systems shall be fully automatic in operation and shall be capable of maintaining internal conditions within the bands of temperature and humidity specified hereafter. the substations are normally manned and allowance shall be made for at least four persons on site in the design.

13.30.2 Heating

Electrical heating shall be provided for each room of the building. Except for the battery room, the heating shall comprise of 1500mm long tubular heaters with a load of 60 watts/foot (300mm) which shall be mounted in double tier banks. Electric heaters shall be fitted with bright plate safety guards affording full protection to the heating tubes. The Contractor shall assess the thermal performance of the building and ensure that the sizes of units are adequate to maintain internal temperatures of 5 °C when the external temperature is -3 °C, measured 1200mm above finished floor level out of an air stream.

The heaters in each room shall be controlled by contactors which have thermostats connected into the coil circuit. Thermostats shall be located in each room and have a maximum cut-off temperature of 17 °C.

Each heater bank shall be equipped with a local isolator. The lower tubular heater shall be mounted at 500 mm above finished floor level.

13.30.3 Air Conditioning

The following areas shall be air conditioned:

- Office
- Control & Relay Protection room
- Telecommunication/SCADA/PLC room
- AC 6 DC Auxiliary Power Supply room

Air conditioning shall be provided in the form of Air Cooled Split System Air Handling Units. The systems shall handle predominantly recirculated air with a controlled quantity of fresh air introduced either at each unit or independently via a separate supply and extract system. Supply air distribution ducts for the Control/Relay room shall be located in the false ceiling serving supply diffusers. Return (recirculated) air shall be drawn in through the front of each unit.

The cooling medium for the split System Air Handling Units shall be direct expansion provided by air cooled refrigeration condensing units located on the roof of the building or wall mounted on building exterior, and interconnected by refrigerant pipework to multi circuit direct expansion cooling coils.

Air conditioning system shall be thermostatically controlled to maintain internal conditions under continuous operation within the limits stated. Plant shall be arranged to facilitate maintenance and future replacement of equipment.

13.30.4 Mechanical Ventilation

Supply and extract ventilation shall be provided to serve the following areas:

- Battery Room
- Toilets (Extract only)
- Cable basement

Supply air handling plants shall consist of a sand trap fresh air intake louvre, insect screen, pre-filter, bag filter, electric air heater battery, fan and distribution ductwork.

The air intake shall not face the prevailing wind.

Extract ventilation shall be provided by means of wall mounting fans, roof extract units or ducted systems with louvered discharges to atmosphere. Individual extract fans shall be provided for Battery room and toilets.

Extract fans for battery room shall be corrosion resistant throughout, with a 4 mm PVC lining.

13.30.5 Basis for Design

(a) External Design Conditions

The external conditions for the calculation of duties for the mechanical services shall be with mean monthly, maximum and minimum values as below:

- Maximum ambient shade temperature: 45 °C
- Minimum ambient shade temperature: 4 °C
- Maximum daily average temperature: 35 °C
- Maximum annual temperature: 25 °C
- Relative humidity: maximum 100%, minimum 80%
- Solar radiation: 100 mW / m²

All plant and equipment installed externally, or which can be affected by external condition shall be capable of withstanding without damage or deterioration the effects of solar radiation, rain, wind, dust,

sand storms or other weather phenomena prevalent in the area in which particular building is located.

(b) Internal Design Conditions

Air conditioning systems shall be capable of maintaining internal l conditions in all air conditioned areas within the following bands or, if necessary for the satisfactory operation of the equipment housed, more stringent requirements:

For substations 22 + 4 °C DB, 40 to 70% R.H.

The following air change rates/hour shall be provided in mechanically ventilated area:

Battery rooms	10
Toilets	12 (extract only)
Cable basement	6
Other general areas	4

All air conditioning and ventilating systems shall be designed for continuous operation. Plant shall be arranged to facilitate maintenance and future replacement of equipment.

The Contractor shall calculate heat gains and losses under the specified conditions for each part of each building, taking into account solar radiation, thermal transmittance through roofs, walls, floors and windows, fresh air requirements, heat emission from installed e1ectrical equipment and lighting, personnel, infiltration and any other sources. The Contractor shall be responsible for determining the heat transfer coefficients for all materials used in building construction. In the event of any change in materials. design or method of building construction, the Contractor shall at all times be responsible for rechecking the design of all systems to ensure that they are capable of meeting the specified design requirements.

13.30.6 Air Cooled Condensing Units

The cooling medium for the air conditioning shall be direct expansion refrigeration provided by air cooled condensing units located externally.

The condensing units shall be of the fully packaged type requiring only site connection of refrigeration pipework, isolated electrical supply and input from the control system.

The individual item of refrigerant equipment shall be matched such that the required performance of the evaporator is achieved concurrently with the satisfactory operation of the compressor and adequate heat rejection at the condenser. Each system as a whole shall maintain the correct duty at the design ambient and operate at the maximum ambient conditions stated without exceeding the safe operational limits of any individual item of equipment and without causing any safety device to operate.

All electrical equipment, control, magnetic coils and solenoids shall be manufactured specifically for operation at the electrical characteristics specified herein and such items designed for any other characteristics shall not be used.
Air cooled condensing units and air handling units that are inter-connected on site with refrigerant piping shall all be supplied by the same Manufacturer.

The casings of the condensing unit shall be weatherproof and shall incorporate adequate access and inspection panels secured in place by rustproof fasteners.

The whole of the casing shall be treated for corrosion and weather resistance and ungalvanised mild steel shall not be used (even if painted). The unit shall be finished in not less than two coats of weather resistant finish, such as baked enamel of a light reflective colour.

The access panels shall be adequately sized for the service and removal of all working parts of l the unit. All panels shall be stiffened and supported to prevent flexing and drumming.

Electrical equipment shall he contained in a fully weatherproofed enclosure with internal division between the power connections and equipment and the control connections and equipment.

13.30.7 Refrigeration Systems

Liquid lines shall be insulated where they are in direct sunlight or where they pass though non-air conditioned areas.

Suction lines shall be insulated over their entire length.

All insulation to refrigeration pipework shall be of flexible, closed cell l foam phenolic rubber type with a temperature range of -40°C to +105°C. They shall have a thermal conductivity of 0.0375 w/m °C at 21 °C and a water vapour transmission of less than 6.0 ng/Ns.

The thickness of insulation shall be in accordance with the following tables:

Location	Insulation Thickness for O.D.	Pipe Size Range
Suction Lines		
	6-10 mm	12-22 mm
Exposed to weather	13 mm	19 mm
In air conditioned spaces	9 mm	19 mm
In non-air conditioned spaces	9 mm	9 mm
Liquid Lines		
Exposed to weather and in non-air-conditioned spaces	9 mm	19 mm

The refrigerant used shall conform to BS 4334 Group 1 or equivalent and shall be non-explosive, non-combustive, non-toxic and non-irritating.

Packaged air conditioning plant items requiring interconnection with refrigeration piping on site shall be leak tested by the Manufacturers and delivered to site with a holding charge of refrigerant.

13.30.8 Console Air Conditioning Units

Console model room air conditioners shall be of the slim-line pattern and complete with 4-way adjustable grilles, heavy gauge zinc coated stove enamelled sheet steel casing with single or two colour decorative finish. Electrical-heaters shall not be fitted.

The casing and position shall be such as to protrude not more than 250 mm into the air-conditioned space and no external projection beyond the building line will be permitted other than the fixing of the condenser cooling air grille.
The units shall be extremely quiet ill operation, the noise level not being higher than 30 dB. All sections of the casing shall be acoustically and thermally insulated.

Compressors shall be of the fully hermetic type, fitted with resilient mountings and complete with thermal overload protection and starting relays.

Evaporators shall be manufactured of' copper tube with copper or aluminium fins mechanically bonded.

The evaporator fan shall be of double inlet, double width type and complete with continuously rated totally enclosed electric motor.

Filters shall be of the washable type, suitably positioned for easy access for cleaning.

Automatic control by means of an integral thermostat shall be provided, together with the safety control to prevent excessive cooling.

Motors shall be air-cooled and units shall be complete with internally mounted condenser cooling fans with totally enclosed motors.

Fresh air shall be introduced separately by means of a central fresh air plant, where these units are proposed to serve individual offices in a building.

Units shall be supplied as a whole and be suitable for easy removal and re-positioning should this be desired at a later date.

13.30.9 Ductwork

All sheet metal ducting shall be manufactured and installed in accordance with the Institution of Heating arid Ventilation Engineers Guide to Current Practice Section B 16, the American Society of Heating, Refrigeration and Air Conditioning Engineers, or the Heating and Ventilating Contractors Association of United Kingdom Specification DW/142 or equivalent international standards for sheet metal ductwork for low velocity low pressure air system with air velocity of up to 10 m/s.

Ail ductwork and fittings serving hazardous areas, such as battery rooms where corrosive fumes are expected, shall be of rigid PVC materials.

13.30.10 Condensate Drains

Provision shall be made for condensate to be passed into the rainwater drainage system. Condensate drains must be routed directly into the drainage system or individual soakaways. Pipes discharging on-to substation or building brick paving will not be permitted.

13.30.11 Extract Ventilation Units

This clause covers fan powered extract ventilation units for mounting in walls and windows, on roofs and in plant rooms.

Extract units shall incorporate propeller. aerofoil, axial, centrifugal or hybrid type fans which shall be constructed in accordance with the relevant sections of this Specification.

Roof units shall comprise a galvanised sheet steel base suitable for use as a weathering skirt, a mild steel fan/motor mounting frame and a spun aluminium cowl. The sheet steel base shall be constructed to support the fan/motor without distortion and where the fan is belt driven shall incorporate a rigid subframe for motor mounting. Fans shall be diaphragm mounted or fitted with a cylindrical casing de-signed for removal from the unit from inside or outside the building without disturbing the weathering skirt or cowl fixings. The cowl shall be weatherproofed and shall be hinge mounted to provide com-plete access to the fad/motor.

Lubricating points shall be extended to a convenient access point. Stainless steel nuts, bolts and washers shall be used for all fixings exposed to the weather.

13.30.12 Air Filters

All filter media hall be properly bonded and protected against filter fibre or particle migration. The di-rection of air flow shall be clearly marked on all filter panels and on installation frames.

Access to filters shall be through removal panels fitted with quick release fasteners and rubber sealing gaskets.

Each disposable panel filter system shall be provided with 4 complete spare sets for use during the commissioning period. These sets shall be in addition to any filter cells supplied as spares in accord-ance wit11 the general clauses of this specifications.

Filter performance shall, unless otherwise noted, be taken to mean the Overall Gravometric Efficiency against BS 6540:Part I Duct Test or equivalent.

Filter media of all types and sizes shall be supported in rigid peripheral frames with internal or external wire support of the media to ensure that the media shall not collapse under air flow. The
holding frames shall incorporate accurately sized channel sections to provide a good fitting for the fil-ters.

The type of washable and/or disposal panel filters shall be subject to the Engineer's approval.

13.30.13 Grilles and Louvres

Grilles shall be of aluminium construction and shall be fixed by means of subframe with spring clips or screw fixings.

The corners of front flanges of grilles and subframes shall be mitred and jointed to produce a clean unbroken appearance and visible aluminium sections shall be free from extrusion marks.

Front flanges shall be at least 30mm wide and shall incorporate a lip of at least 4.5 mm and a felt gasket. Blades shall be fixed at even centres with intermediate mullions giving support for blades of more than 550 mm long. Grille finish shall be anodised natural aluminium colour except where otherwise indicated.

All grilles shall be fitted with an opened blade damper for regulation purposes and shall be fitted with acoustically lined inlet plenums where necessary in order to comply with the acoustic limits of this Specification.

Outdoor air louvres shall be of all extruded aluminium construction fitted with opposed blade dampers in the connected ducting where necessary for air flow regulation, Movable blade louvres shall not be used.

Louvres shall be weatherproof and shall incorporate an aluminium wire mesh screen on the inside surface.

The dimensions of louvres for mounting in the building structure shall suit the concrete block or brick modules and shall be fixed to a hardwood frame.

13.30.14 Control Equipment

Each item of shall be provided with local isolation and/or emergency stop buttons to facilitate maintenance, inspection and emergency operation.

The control system shall be of the electronic type, capable of providing the degree of thermostatic control specified. The Contractor shall provide full wiring diagram of all control circuits giving terminal connection reference.

The control system shall incorporate all necessary safety interlocks for the successful operation of the mechanical plant and system. All of the individual control elements shall be provided by the same Manufacturer.

Temperature sensors shall be of the resistance type using nickel based elements and shall be accurate to $\pm$ 1°C over the range of 0 ^{o}C to 30 ^{o}C. The sensor resistance shall be compatible with the measuring bridge of the matching control box.

13.30.15 Electrical Connections

All electrical power control cables and wiring associated with the air conditioning and ventilation systems, including all connections between control panels, valves, thermostats, sensing probes and other like items shall be supplied, installed and connected up as part of this Contract.

The cabling and wiring system shall comply with the requirements of the relevant clauses of this Specification and be either surface or flush installation as appropriate.

Cables and wiring shall comprise either PVCWPVC laid in cleats or trenches, or PVC drawn into galvanised conduits and trunking.

Final connections to electric motors and all other items of plant subject to movement and vibration shall comprise flexible cable in flexible conduit.

13.30.16 Manufacturers

Wherever possible all air conditioning and ventilating plant shall be selected from a single Manufacturer's product range and origin. Where this is not possible, because of practical or technical constraints. then the number of different sources of origin shall. be kept to a minimum. Local service facilities shall be available for the equipment proposed.

The Contractor shall provide, with his submission, illustrated technical literature covering all plant and equipment offered.

13.30.17 Standards

All air conditioning and ventilation equipment shall conform to British Standards, Chartered Institution of Building Services or ASHRAE recommendations or other recognised International Standards.

13.30.18 Approval

The Contractor shall submit to the Engineer for approval copies of all his calculations forming the basis for the selection of all air conditioning and ventilating plant, plant selection details and full working drawings. Such approval shall not relieve the Contractor of his contractual responsibilities.

13.30.19 Maintenance

The Contractor shall be responsible for the maintenance of all installations covered by this section of the Specifications for the period stated elsewhere in the Specification.

13.31 Earthing and Bonding

All equipment being supplied under this Section shall be effectively bonded to ensure earth continuity throughout the system. Continuity may be provided by means of cable armouring but a separate earth continuity conductor shall be included with all wiring in conduits. No reliance shall be placed on metal to metal joints in conduits for earth continuity. The earth continuity conductors shall as far as possible be in one continuous length to the furthest part of the installation from the controlling switchboard. The earth conductor shall connect all metal cases housing electrical equipment. The branches shall be connected to the main conductor by permanently soldered on mechanically clamped joints.

13.32 Testing and Commissioning

The Contractor shall be required to prove that the installed system meets the design requirements and Specification to the satisfaction of the Engineer.

14. Fibre-Optic Multiplexer Equipment for Communication and Protection

14.1 Scope of Specification

This specification describes the communication requirements for the transport of voice, data and protection signals between the new substations existing substations and the National Load Dispatching Centre (NLDC) in Rampura, including engineering, configuration, testing, installation, commissioning and training.

The scope of work is to connect the Substation Automation System to the existing communication system to be installed under this contract for securing the transport of voice, data and protection signals, complete system for new substations and extension and integration into the existing system for existing substations.

The scope of work is to connect REMOTE END substations, too. All necessary equipment, material and services shall be included in the contract price.

OPGW with 48 cores of optic fibre in 230kV Overhead Line and 24 cores of optic fibre in 132kV Overhead Line will be installed by the transmission Line Contractor, but this optic fibre will be used for optical connection for current differential protection of the 230kV & 132kV line.

All materials and equipment offered shall be brand new, from the Manufacturer's normal and standard construction, designed and manufactured according the latest technological methods.

For the purpose of standardisation of operating performance and facilities offered equipment shall be compatible with the existing ones.

For standardization of operation performance, facilities and spare requirements, the fibre optic multiplexer equipment for communication and protection to be supplied under this project shall consist of equipment which can totally be integrated into the existing telecommunication system in PGCB's network, including the telecommunication network management system. The fibre optic multiplexeres presently used in PGCB’s network are:

- ABB FOX 515/615, and
- Areva MSE 5001

14.2 Summary of Standards

The Equipment shall comply with the latest ITU-T recommendations for the plesiochronuous and synchronous hierarchies.

The equipment shall be KEMA type tested.

14.2.1 PDH Interfaces

The PDH interfaces shall conform to the following recommendations:

ITU

ITU-T G.702	General aspects of digital transmission systems - Terminal equipment Digital hierarchy bit rates
ITU-T G.703	Digital transmission systems - Terminal equipment - General Physical/electrical characteristics of hierarchical digital interfaces
ITU-T G.704	Digital transmission systems - Terminal equipment - General Synchronous frame structures used at 1544, 6312, 2048, 8448 and 44 736 kbit/s hierarchical levels
ITU-T G.706	General aspects of digital transmission systems - Terminal equipment- Frame alignment and cyclic redundancy check (CRC) procedures relating to basic frame structures defined in recommendation G.704
ITU-T G.71 1	Pulse code modulation (PCM) of voice frequencies
ITU-T G.712	Transmission performance characteristics of pulse code modulation channels
ITU-T G.732	General aspects of digital transmission systems - Terminal equipment - Characteristics of primary PCM multiplex equipment operating at 2048 kbit/s
ITU-T G.735	Characteristics of primary multiplex equipment operating at 2048 kbit/s and offering synchronous digital access at 384 kbit/s and/or 64 kbit/s
ITU-T G.736	General aspects of digital transmission - Characteristics of a synchronous digital multiplex equipment operating at 2048 kbit/s
ITU-T G.737	Characteristics of external access equipment operating at 2048 kbit/s and offering synchronous digital access at 384 kbit/s and/or 64 kbit/s
ITU-T G-823	The control of jitter and wander within digital networks, which are based on the 2048 kbit/s hierarchy
ITU-T G.826	Error performance parameters and objectives for international, constant bit rate digital paths at or above the primary rate

14.2.2 Architecture of Optical SDH Interfaces

The architecture of optical SDH interfaces shall conform to the following recommendations:

ETS/EN

ETS 300 147:	Synchronous digital hierarchy multiplexing structure

ETS 300 417:	Transmission and Multiplexing (TM); Generic requirements of transport functionality of equipment
ETS 300 417-1-1 / EN 300 417-1-1 V 1. 1.2:	Generic Processes and Performance
ETS 300 417-2-1 / EN 300 417-2-1 VI.1.2:	SDH and PDH Physical Section Layer Functions
ETS 300 417-3-1 / EN 300 417-3-1 V 1. 1.2:	STM-N Regenerator & Multiplex Section Layer Functions
ETS 300 417-4-1 / EN 300 417-4-1 V 1. 1.2:	SDH Path Layer Functions

ITU

ITU-T G.707	Network node interface for the synchronous digital hierarchy
ITU-T G.783	Characteristics of synchronous digital hierarchy (SDH) equipment functional blocks
ITU-T G.803	Architecture of transport networks based on the synchronous digital hierarchy (SDH)
ITU-T G.805	Generic functional architecture of transport networks
ITU-T G.826	Error performance parameters and objectives for international, constant bit rate digital paths at or above the primary rate
ITU-T G.841	Types and characteristics of synchronous digital hierarchy (SDH) network protection architectures
ITU-T G.957	Optical interfaces for equipment and systems relating to the synchronous digital hierarchy
ITU-T G.958	Digital line systems based on the synchronous digital hierarchy for use on optical fibre cables
ITU-T M.2101.1	Performance limits for bringing into service and maintenance of international SDH paths and multiplex section
ITU-T T.50	International Reference Alphabet (IRA) - Information technology 7 bit coded character set for information interchange

14.2.3 Synchronisation and Timing of Optical SDH Interfaces

The synchronisation and timing of optical SDH interfaces shall conform to the following recommendations:

ETS/EN

ETS 300 417-6-1 / EN 300 417-6-1 V 1. 1.2	Synchronisation Layer Functions
ETS 300 462-1 / EN 300 462-1-1 V 1. 1. 1	Transmission and Multiplexing (TM); Generic requirements for synchronisation networks; Part 1: Definitions and terminology for synchronisation networks.
EN 300 462-4-1 V1.1.1	Transmission and Multiplexing (TM); Generic requirements for synchronisation networks; Part 4-1: Timing characteristics of slave clocks suita-

	ble for synchronisation supply to Synchronous Digital Hierarchy (SDH) and Plesiochronous Digital Hierarchy (PDH) equipment
ETS 300 462-5 / EN 300 462-5-1 V1.1.2	Transmission and Multiplexing (TM); Generic requirements for synchronisation networks; Part 5: Timing characteristics of slave clocks suitable for operation in Synchronous Digital Hierarchy (SDH) equipment

ITU

ITU-T G.813:	Timing characteristics of synchronous digital hierarchy (SDH) equipment slave clocks (SEC)

14.3 Abbreviations

ADM	Add-drop multiplexed
ALS	Automatic Laser Shutdown
BIP	Bit Interleaved Parity
CAP	Carrier-less Amplitude and Phase
CAS	Channel Associated Signalling
CRC	Cyclic Redundancy Check
DTMF	Dual Tone Multi-Frequency
EN	European Norm
EOW	Engineering Order Wire
ETS	European Telecommunications Standards
GPS	Global Positioning System
HDSL	High Density Subscriber Line
IEC	International Electrical Commission
IP	Internet Protocol
ISDN	Integrated Services Digital Network
ITU	International Telecommunication Union
LAN	Local Area Network
MCMI	Multi Coded Mark Inversion
MS	Multiplex Section
NE	Network Element
NMS	Network Management System
OS	Optical Section
OSPF	Open Shortest Path First
PDH	Plesiochronous Digital Hierarchy
PPP	Point-to-Point Protocol
RS	Regenerator Section
SDH	Synchronous Digital Hierarchy
SNMP	Simple Network Management Protocol
SOH	Section Overhead
STM	Synchronous Transport Module
TCP	Transmission Control Protocol
TTI	Trail Trace Identifier
VC	Virtual Container
VF	Voice Frequency

14.4 General Requirements

The digital multiplex equipment shall be universal, software-controlled, and provide various interface cards to connect tributary interfaces signals such as voice, teleprotection and data to aggregate interfaces. On aggregate level 2Mbit/s and 8Mbit/s electrical interfaces complying with ITU-T recommendations G.703 / G.704 and 2Mbit/s HDSL interfaces shall be available. In addition, optical STM-1 aggregate interfaces on 155Mbit/s shall be available. All modules shall form an integrated part of a shelf.

The multiplexer shall provide means to drop and insert individual 64 kbit/s signals and allocate them to determined time slots in the 2Mbit/s streams. Path protection on 64 kbit/s and 2Mbit/s shall be supported.
It shall be suitable for operation in substation with harsh environment with high electromagnetic interference, be highly reliable and provide secure communication for real time signals such as voice, SCADA, teleprotection and status/control signals.

The equipment offered shall already be working successfully in telecommunication networks operated by power utilities. It shall comply to the latest ITU-T standards and be able to be interconnected with telecommunication equipment.

Any equipment in the network shall be manageable from a control centre and there shall be means to supervise external/existing equipment as well.

As a minimum modules for the following user signals shall be available as plug-in units for the digital multiplexer:

- Analogue subscriber interface: subscriber and exchange side
- 4-wire E&M voice interface
- G.703, 64kbit/s data Interface
- X.24/V. 11 (RS-422), Nx 64kbit/s data interface
- V.24/V.28 (RS-232), data interface
- V.35, Nx 64kbit/s data interface
- Data interface V.36 (RS-449), Nx 64kbit/s data interface (V. 10)
- Alarm collection interface
- Teleprotection command interface
- Binary signal (status and control) interface
- 2Mbit/s electrical interface for unframed signals acc. to ITU-T G.703 and framed signals acc. to G.703 and G.704.

Additionally, the equipment shall provide the following aggregate interfaces:

- STM-1 (155 Mbit/s) optical 1+1 interface for medium and long distances, with automatic laser shut down.
- STM-1 (155 Mbit/s) optical add-drop interface for medium and long distances, with automatic laser shut down
- STM-1 (155 Mbit/s) electrical interface
- 2 Mbit/s HDSL interface

The equipment shall be equipped with a ringing generator for analogue subscriber interfaces.

14.5 General Conditions

The same equipment shall be used as a terminal, for through connections (transit, repeater) and as add-drop multiplexer (ADM) with integrated optical line modules.

First order multiplexing (2048 Mbit/s), second order multiplexing (8448 Mbit/s/s) and STM-1 multiplexer shall be integrated.

Conference for voice channels and point-multipoint function for data signals shall be possible.

The equipment shall be of fully modular design, based on a single shelf.

14.5.1 Channel Capacity: Digital Cross Connection

The equipment shall be equipped with a redundant cross connection function with decentralised cross connection functions on each board.

The cross connect capacity shall be minimum 40x 2Mbit/s, or 200x 64kbit/s non-blocking.

14.5.2 Redundant Centralised Functions

The equipment shall be equipped with redundant circuits for all centralised functions.

14.5.3 Power Supply

The multiplex equipment shall operate at 48VDC +/- 15%. Redundant power-supply shall be supported.

14.5.4 ITU Compliance

The Equipment shall comply to the latest ITU-T recommendations for the plesiochronuous and synchronous hierarchies, such as:

G.702-704, G.706, G.711-714, G.732, G.735-737, G.742, G.826, G.823, Q-552

14.5.5 Electromagnetic Compatibility and Safety Regulations

The equipment shall comply with the EN50022, EN50082, IEC 801-2, IEC 801-6 and shall be conformant with CE.

14.5.6 Ambient Conditions

Storage and transport:	-40... +70˚C; 98% (no condensation)
Operation:	-5... +45˚C, humidity of max. 95% (no condensation)

14.5.7 Mechanical Construction

The equipment shall be of robust design. All tributary and aggregate units shall be integrated in the same shelf.

All connectors shall be accessible from the front.

14.5.8 Network Management System

The equipment shall be software programmable, either by a local craft terminal - preferably notebook - or a centralised Network Management System (NMS).

Traffic through the multiplexer shall under no circumstances depend on Network Management System; i.e. the multiplexer has to operate without being connected to any management system.

The Network Management System shall be used to supervise the PDH and SDH network.

14.5.9 1+1 Path Protection

The equipment shall provide means to protect 64 kBit/s channels. The protection shall be end to end from one interface (telephone or data) to the other. It shall switch automatically from the main channel to the standby channel. It shall be configurable whether the system switches back to the main channel (reversible switching) or not (non-reversible).

If a path has switched to its standby route because the main route is disturbed this shall be indicated with an alarm.

The switching shall be done within the multiplexer without using the network management system.

14.5.10 1+1 Section Protection

The equipment shall provide means to protect 8Mbit/s and 155 Mbit/s connections. It shall be possible to use two independent links: one as the main and the other as the standby. The system shall automatically switch to the standby connection and generate an alarm if the main connection is disturbed.

The switching shall be done within the multiplexer without using the Network Management System.

14.5.11 Network Topology

It shall be possible to build point to point, linear, ring, T, and meshed networks.

14.5.12 Synchronisation

The equipment shall be synchronisable with an external clock, with connected 2048 Mbit/s signals and/ or with internal oscillator. The synchronisation shall be configurable and it shall be possible to distribute the synchronisation to other equipment as well.

The system shall have means to switch to select the synchronisation source as well as means to prevent the system from switching synchronisation loops. The equipment shall be capable select the synchronisation source by means of the SSM (Synchronisation Status Messaging) feature according to ITU-T G.704 or priority based.

14.5.13 Alarms

Each module shall supervise its functions and shall have an alarm-indication LED on its front. All alarms shall be collected by the NMS.

Each node shall be capable to collect up to 50 external alarms.

14.5.14 Test Loops

The equipment shall provide means to loop signals on 64kBit/s level as well as on 2Mbit/s level. It shall indicate an alarm if a loop is activated. It shall have the possibility to determine the time after which an activated loop is switched back.

14.5.15 Maintenance Facilities

Every Network Element shall have a built-in Signal Generator and Analyser to analyse communication paths. It must be possible to cross connect the Generator and Analyser to transmission channels and terminate the signal in other Network Elements. The configuration must be possible locally with the craft access terminal and remotely with the NMS or the craft access terminal.

It must be possible to loop-back signals locally and remotely using the craft access terminal or the NMS.

14.6 Requirements for Transport Level

14.6.1 SDH Aggregate Units

The interface shall be designed for use on single mode fibre at 1310nm and 1550nm. The optical connectors shall be E2000.

The following main functions shall be supported:

- Termination of the OS-, RS-, MS- and VC-4 layer
- Extraction and insertion of the SOH communications information through connections of VC-12 and VC-3

The following maintenance functions shall be supported:

- Status indications
- Loops
- Restart after ALS

- TTI monitoring
- BIP Error Insertion

The following SDH interfaces shall be available:

- STM-1 (155Mbit/s) optical 1-port interface
- STM-1 (155Mbit/s) optical 2-port interface

This interface shall provide Multiplex Section Protection (MSP): 1+1 Section Protection

- STM-1 (155Mbit/s) electrical 1-port interface

14.6.2 HDSL Aggregate Units

2Mbit/s HDSL interface

The HDSL interface shall provide means to interconnect the multiplexer over two pairs of copper wire up to 12km using CAP modulation (Carrier-less Amplitude and Phase). It shall communicate either with another interface of the same type or with a remote desktop terminal.

2Mbit1s HDSL Desktop Terminal

This Terminal shall provide a HDSL interface to transmit 2Mbit/s over two pairs of copper over a distance up to 12 km. It shall be housed in a metallic indoor case. The following interfaces shall be available:

- G.703, 2 Mbit/s, 75 ohm
- G.703, 2 Mbit/s, 120 ohm
- X.21/V 11, Nx 64 kbit/s (N = 1 .. 32)
- V.35, Nx 64kBit/s (N = l.. 32)
- V.36 / RS449, Nx 64 kbit/s (N = l.. 32)

LAN Connection:

l/0 base ethernet connection for e.g. router supporting LAN protocols: IP, IPX; routing protocols: RIP; WAN protocols: HDLC, PPP, frame relay (including RFC 1490). It shall inter-operate with Cisco, Wellfleet, 3Com etc. and be manageable locally, remotely, and with Telnet and SNMP. Two such desktop terminals shall be connectable to provide a 2 Mbit/s link over two pairs of copper.

HDSL Repeater:

An HDSL repeater solution for distances longer than 12km shall be offered including a remote powering solution.

HDSL Line Protection:

The HDSL equipment shall (where necessary) be protected against influences of induced voltages up to 10 kV.

14.7 Tributary Units

14.7.1 4-Wire Interface (VF Interface)

This interface shall provide 8 voice channels with a bandwidth of 300 Hz to 3.4 kHz and 2 signalling channels (M => E, M' => E') per voice channel.

Each interface shall be configurable to operate with or without CAS. With CAS it shall use the a and b bits for the two signalling channels.

The level shall be software adjustable within the following range:

- Input: +7.5 to -16 dBr
- Output:+7.0 to -16 dBr

Modules where each interface can be individually configured with 1+1 path protection shall be available.

14.7.2 Analogue Subscriber Interface

An interface with at least 10 subscribers as well as high-density analogue subscriber card with 60 subscribers shall be available. The ringing generator shall be integrated in the subscriber module interface. The ringer frequency shall be adjustable for 20 Hz, 25 Hz, and 50 Hz.

The following main functions shall are supported:

Downstream signalling:

- Ringing
- Metering
- Polarity reversal
- Reduced battery
- No battery

Upstream signalling:

- On/off-hook
- Pulse and DTMF dialling
- Flash impulse
- Earth key

General:

- Constant current line feeding
- Line test
- Permanent line checks
- CLIP (On-hook VF transmission)
- Metering after on-hook

14.7.3 Exchange Interface

This interface shall provide 12 interfaces to connect remotely connected analogue subscribers to an exchange. It shall provide the following functions:

- pulse dialling
- tone dialling (DTMF)
- earth key function
- metering function(12 kHz or 16 kHz)
- flash impulse
- polarity reversal
- indication of busy lines

The following parameters shall be configurable by software:

- input voice level -5 to +4 dBr
- output voice level -7.5 to -1 dBr
- metering pulse enable/disable
- signalling bit definition
- loop back of voice to the telephone

14.7.4 Party Line Telephone System (Engineering Order Wire)

An engineering order wire (EOW) facility shall be provided at each multiplexer. The EOW shall be configured as a party line and use in band DTMF signalling to call another EOW-Terminal. The terminal shall have an integrated DTMF decoder allowing to program a subscriber call number (LA digits), and two group call numbers (LA digits each).

14.7.5 V. 24N.28 RS232 Interface

It shall support the following bit rates:

- 0... 0.3 kbit/s transp. (V. 110)
- 0.6... 38.4kbit/s synchronous / asynchronous (V. 110).

Modules where each interface can be individually configured with 1+1 path protection shall be available.

14.7.6 V.11/X.24 Interface

This interface shall comply to the ITU-T X.24 recommendation for signal definition and to V. 11 for electrical characteristics.

It shall support the following bit rates:

- 48, 56, Nx 64 kbit/s (N = 1... 30) synchronous
- 0.6... 38.4 kbit/s synchronous / asynchronous (X.30)

Modules where each interface can be individually configured with 1+1 path protection shall be available.

14.7.7 V.35 Interface

This interface shall comply with the ITU-T V.35 and V. 110 recommendations. It shall support the following bitrates:

- 48, 56, Nx 64kbit/s (Nx = 1... 30) synchronous
- 0.6... 38.4 kbit/s synchronous / asynchronous

Modules where each interface can be individually configured with 1+1 path protection shall be available.

14.7.8 V.36 / RS 449 Interface

This interface shall comply with the ITU-T V.36 and V. 110 recommendations. It shall support the following bit rates:

- 48, 56, Nx 64kbit/s (N = 1... 30) synchronous
- 0.6... 38.4 kbit/s synchronous / asynchronous

Modules where each interface can be individually configured with 1+1 path protection shall be available.

14.7.9 64 kbit/s Co-directional Interface

This interface shall comply with the ITU-T G.703 part 1.2.1 for co-directional data transfer. A module shall have at least 8 interfaces.

Modules where each interface can be individually configured with 1+1 path protection shall be available.

14.7.10 LAN Interface

There shall be a l0BaseT interface available with Router Bridge and FRAD Function available. The following specification shall be covered:

Ethernet connection:	1013aseT
LAN protocols:	IP, IPX
Routing protocols:	static IP route, OSPF2 V2
WAN protocols:	PPP, Frame Relay (including RFC 1490)

The interface shall be manageable locally, remotely, with the management system of the platform. The LAN interface shall support linear-, ring- and star-configurations. The WAN side shall support link capacities n*64kBit/s and 2Mbit/s.

14.7.11 Alarm Interface

This interface shall provide means to collect various alarms, which will be displayed, on the network management system. It shall be used to manage non-PDH equipment with the PDH network management system.

It shall have at least 24 binary inputs and at least 4 outputs, which can be switched by the network management system.

It shall be possible to connect an input to an output so that if an alarm occurs, the output contact will be switched.

It shall be possible to label an alarm. The label-text shall be read from the interface module so that it can be indicated on the network management system as well as on the local craft terminal.

14.7.12 Teleprotection Interface

The protection of the overhead lines shall be arranged as detailed in Section 5. Teleprotection equipment shall be provided for permissive tripping and direct tripping on the lines. The permissive tripping signals are required to operate circuit breaker trip relays in conjunction with the distance protection and directional earth fault relays. The direct tripping signals are required to operate remote circuit breaker tripping relays.

Technical Requirements

This interface shall provide means to transmit four bi-directional command channels. The signals shall be adjustable from 24 to 250VDC by means of software.

All inputs and outputs shall be isolated and with EMC immunity for harsh environment.

Security, dependability and transmission speed shall be selectable and programmable.

It shall be able to drop and insert commands, transfer commands as a transit station, it shall be possible to have AND- and OR-connections between commands.

The interface shall support T-nodes.

The teleprotection interface shall provide an integrated non-volatile event-recorder which shall be synchronisable either internally or by GPS or a command counter which counts trip commands.

The teleprotection interface shall provide means for signal delay measurement.

1+1 protection must be available; the switching shall be done within less than l0ms. The interface shall do automatic loop test every 60s.

Under no circumstances shall the interface cause trip-commands in case of power supply failure or when put in or out of service.

It shall be possible to synchronise all teleprotection interfaces with one GPS in one station. The GPS

time shall be distributed over the teleprotection channel.

An 8-bit command addressing shall be used to prevent tripping if the signal is inadvertently re-routed through the telecommunication network.

14.7.13 Optical Protection Relays Interface

This interface shall have an optical port to connect protection relays for teleprotection to the multiplexer. It shall operate on 1300nm use MCMI line coding and be suitable for teleprotection relays.

14.7.14 Binary Contact Interface

- This interface shall provide means to transmit binary signals.
- The inputs and outputs shall be isolated.
- The inputs shall be suitable for 24 V DC to 60 V DC.
- Outputs shall be solid state relays.
- The interface shall provide a 24 V DC short circuit proofed auxiliary power supply.
- It shall be able to drop and insert commands, transfer commands as a transit station, it shall be possible to have AND- and OR-connections between commands.
- The teleprotection interface shall provide an integrated event recorder, which shall be synchronisable either internally or by GPS.

14.7.15 2NIbit/s G.703 / G.704 Interface

- This interface shall comply with the ITU-T G.703 and G.704 recommendations.
- The interface module shall have at least four interfaces to be activated individually. It shall be possible to have 128 interface modules a multiplexer.
- In order to connect different equipment, the interfaces shall be available with the impedance of 120 ohms and 75 ohms.
- The interface shall support CRC-4 multi-frame according to ITU-T G.704 (enabled and disabled by software).
- The CAS signalling according to ITU-T G.704 table 9 shall be activated optionally.
- The interface shall be able to extract the 2.048 MHz clock, which can be used to synchronise the multiplex equipment.
- The interface module shall support 2 Mbit/s loop-back of the incoming signal as well as the loop-back of the internal signals.

14.8 Telephone System

An IP phone facility shall be provided at each new substation. The IP phone shall be incorporated by IP connection from upstream substation through IP network in the operational telephone system which is controlled from the existing call manager at NLDC Dhaka. At least three IP telephone sets proper to above mentioned administrative telephone system shall be provided at each new substation.

New substations will become remote subscribers in the administrative telephone system. Facility for minimum 10 x 2 W remote subscribers shall be provided and installed at the substation and the re-

mote subscribers shall be connect with the nearest existing exchange of the existing telephone network.

Necessary cards required at the nearest exchange and its associated multiplexer shall be included in the contract price. At least three telephone sets proper to the above mentioned administrative telephone system shall be provide at each new substation

The trunk numbering plan shall be compatible with the present scheme in service in Bangladesh.
The telephone signalling (dialling) system shall be compatible with the present system.

An alarm system shall be provided to indicate traffic failure including blown fuses, loss of power supply, etc. In addition, contacts shall be provided to facilitate extension of the alarms to the telecontrol equipment.

14.9 Communications DC Power Supply Equipment

14.9.1 General

14.9.1.1 Basis of Design

The equipment shall comply with IEC 60146 and 60478.

The charger shall be of either the Thyristor-controlled type or of the SMPS type. The battery shall be nickel cadmium type - as detailed in a separate section of this Specification.

The design and selection of equipment and components shall be based on achieving a minimum lifetime of 20 years, when operating under the specified service conditions.

14.9.1.2 Operating Principle

The output of the charger shall, during normal operation, continuously supply the power requirements of the load whilst simultaneously maintaining the battery charge in the float charge mode. In the event of an interruption in the a.c. mains supply to the charger, the battery shall supply the load requirements for not less than the specified standby time - whilst maintaining the output voltage within permissible limits.

Upon restoration of the a.c. mains supply, the rectifier shall automatically resume supply of the load requirements whilst simultaneously recharging the battery at the float voltage.

14.9.2 Configuration

The power supply installation shall comprise two batteries and two charging sources. each charger shall be able to float charge both batteries as well as supplying the total load.

The total battery capacity shall be able to supply the total load (comprising the delivered load together with 20%. spare for future use) for at least 10 hours in the event of failure of the a.c. mains supply.

The d.c. power supply equipment is required to limit the output voltage to the load within plus 15% and minus 15% of the nominal value, provided these values do not exceed the voltage guarantee of the load equipment. The power supply output positive shall be earthed.

14.9.3 Charger

14.9.3.1 General

The charger shall operate according to the constant voltage current limiting principle and shall incorporate a soft start feature to gradually accept load on initial energising.

The charger shall restart automatically upon restoration of the a.c. mains supply following a mains supply interruption, and recharge the battery at the float voltage.

Internal cooling shall be by natural ventilation. Forced cooling is not acceptable.

The charger shall be suitable for operation in parallel with one or more chargers, and shall include a current sharing facility.

The charger shall be of sufficient output capacity for the application, parallel operation of chargers (where required) is for the purpose of redundancy and not to satisfy the output current requirements.

14.9.3.2 Charger Output

The output characteristic shall provide an output voltage regulation of ±1%, over the specified a.c. mains voltage and frequency range and for load changes 0-100%. The output voltage regulator shall be adjustable within limits approved by the Engineer and shall be so designed that special tools are not required for such adjustment. Compensation for battery temperature shall be provided.

The charger shall have protection against overloads or short circuits and shall limit the output current.

Recovery to a constant voltage characteristic shall occur automatically at the end of the overcurrent/short circuit.

14.9.3.3 Boost Charging

Manual boost charging shall be provided. A boost timer shall be included to prevent overcharging.

Operation of boost charging shall disconnect the charger and battery from the load. It shall not be possible for both chargers to be selected to boost charging at the same time, or for the load to become disconnected from both batteries and chargers simultaneously.

If the a.c. mains supply fails during boost conditions the two batteries shall be automatically connected in parallel by "no volt" contactors to the load.

It shall not be possible to connect a "boosted" battery to the load until its terminal voltage has fallen below the load equipment upper voltage limit.

14.9.3.4 Noise and Interference

To avoid unacceptable levels of electrical noise in the load equipment smoothing of the d.c. output is required. This shall achieve a psophometric noise level at the output, for loads between 0 and 100%, not exceeding the equivalent of 2 rnV at a frequency of 800 Hz after weighting as specified by ITU-T (CCITT).

The relative harmonic content of the input current shall comply with the European Directive for EMC, the EN 60555-2 standard. In the case of SMPS chargers active power factor correction (i.e. boost for step up converter) shall be provided to control the power factor.

The production of radio frequency interference voltages shall not exceed the values of suppression grade "N", as defined in EN 55014/55015 - for Thyristor-controlled type chargers, and suppression grade "B" as defined in EN 55022 for SMPS type chargers.

The performance of the d.c. power supply equipment unit shall not be affected, or in any way degraded, by the use of the following when the severity of the electromagnetic radiation environment corresponds to Class 3, in accordance with IEC 801-3:

- private mobile radio operating in designated or planned radio frequency bands
- current cellular radio equipment
- future cellular equipment
- mobile data equipment.

It is the Contractor's responsibility to determine the radio frequency bands applicable in the locality.

14.9.3.5 Efficiency/Rating

The charger efficiency shall not be less than 80%.

All chargers supplied shall preferably have the same rating, or be in fixed multiples, to limit the number of different charger ratings.

14.9.3.6 Instruments, Controls and Alarms

The charger shall be equipped with the following:

- a.c. mains input circuit breaker
- d.c. output circuit breaker
- charger output current meter
- charger output voltage meter
- alarms for charge fail, d.c. volts high etc.

Each alarm shall be provided with local annunciation and two sets of potential free contacts, for connection to external alarm monitoring systems.

14.9.4 Battery

14.9.4.1 Type

Nickel cadmium cells shall be of the pocket plate type in accordance with IEC 60623.

Cell containers shall be of the moulded plastic type, non-flame propagating and mechanically shock resistant. They shall provide for the electrolyte level to be viewed through the container material.

Cells shall be permanently marked with the following information:

- Sec-14: Fibre Optic Multiplexer
- Manufacturer's reference number and code
- year and month of manufacture
- voltage and nominal capacity at the 10 hour rate
- cell number.

14.9.4.2 Mounting

The batteries shall be mounted on metal stands, or racks, in a manner such that all the plates of each cell are visible for inspection, test and maintenance purposes. Stands or racks shall have a maximum of two tiers. In all cases adequate space must be left between the tiers for maintenance purposes and to permit the topping up of electrolyte. Stands or racks shall have a protective finish of not less than two coats of electrolyte resisting enamel or gloss paint. Alternatively, an epoxy resin sintered finish may be used.

At locations where the battery is not housed in a separate battery room the battery stand/rack shall be fitted with cladding. The cladding shall permit the free flow of air to the battery, and shall be removable for maintenance purposes.

Cell containers shall be accurately set up in alignment on the stand or rack with lead and/or rubber discs under the feet moulded on each container. Cell lids shall be so positioned that at least one topping up aperture is on the access gangway side of the cell and not obstructed by any inter-cell connecting arrangements.

14.9.4.3 Battery Main Fuses

Bolted cartridge fuses shall be provided in both positive and negative leads and positioned as close to the battery as possible and shall be rated at five times the charger float output rated current. A cartridge fuse shall be provided in the charger input lead to the negative pole of the battery and rated at twice the charger float output rated current. These fuses shall be mounted preferably on the end of the battery stand or rack. These fuse links shall comply with BS 88.

Class DC 40 or equivalent and shall be mounted in fuse carriers with an insulated barrier between the poles.

The cable or busbar to the battery shall be firmly supported at a point near the cell terminal pillar. Where two cables are used they shall be terminated one to either side of the terminal pillar. These cables shall be arranged as to allow some flexibility and to avoid any forces being applied to the cell ter-

minal pillar.

14.9.4.4 Connections

The positive pole of each battery shall be connected to station earth via a single bolted link at the distribution cubicle. Low resistance inter-cell connectors shall be used. Connections between tiers of cells and between end cells and fuses shall be made with insulated copper rod which shall be of equivalent cross-section to the distribution busbars.

Connections from the battery fuses to the chargers and distribution cubicles shall be made with insulated cable of equivalent cross-section to the distribution busbars. The positive and negative terminals of each cell shall be clearly indicated. The positive and negative terminals of the complete battery shall be indicated by red and black marking respectively.

14.9.4.5 Capacity

The battery capacities shall be 200 ampere hours at the 10 hour rate.

14.9.5 D.C. Distribution and Instrumentation

14.9.5.1 General

The distribution section shall be designed for incoming and outgoing d.c. supplies as follows:

- Two independent supplies (including one for future use) incoming from the batteries and associated chargers. The battery negatives shall be connected to the distributed busbar through a single pole switch. The 48V battery positive shall be directly connected to the positive busbar.
- Each load equipment shall be connected to a distribution outlet. The use of teed supplies to more than one load equipment will not be permitted.
- Double pole miniature or moulded case circuit breakers to IEC 157 shall be supplied, fitted with auxiliary contacts which operate when the circuit breaker trips.

The MCBs shall be rated to meet the load requirements and shall be labelled with the destination of the load. Outgoing connections shall be brought to terminals, mounted in the cubicle, provided with strip connectors and cable lugs. The number of outlets shall cater for the quantity of load equipment items plus 50%, with a minimum of 10 outlets being provided, Space shall also be available for the installation of 10 extra outlets for future use.

14.9.5.2 Instruments and Alarms

Instrumentation shall comprise:

- battery ammeter (charge and discharge)
- battery voltage
- load current ammeter
- busbar voltage

An alarm indication shall be provided if the busbar voltage falls outside set limits.

The MCB auxiliary contacts and the high/low voltage alarm shall each provide local annunciation and two sets of potential free contacts, for connection to external alarm monitoring systems.

14.9.6 Housing

The above covers the mounting/housing for batteries.

A modular construction is preferred for the battery charger and d.c. distribution/instrumentation, with each unit comprising a single 19" or ETSI standard rack configuration, all mounted in a single cubicle.

The modular construction shall provide:

- simple plug in units for easy assembly and servicing
- individual battery charger unit removal in safety, without loss of output power to the load.
- expansion of capacity at a later date

In the case of Contractors who do not offer a modular construction, separate cubicles are required for each charger and the d.c. distribution/instrumentation.

14.10 Schedule of Requirements

No.	Description	Unit	Required
1.0	**General:**		
1.1	Type of multiplexer		SDH: ADM
1.2	Complying to ITU-T rec.		Yes
1.3	Transmission Capacity	Mbit/s	STM-1: 155
1.4	Access capacity on 64 kbit/s	channels	Minimum 200
1.5	Access capacity on 2 Mbit/s	channels	Minimum 40
1.6	Redundant central processor		Shall be available
1.7	Digital cross connect function		Fully non-blocking
2.0	**Available Aggregates**		
2.1	Optical aggregates (ITU-T G.957)		L- 1.1, L- 1.2
3.0	**Available Trunk Interfaces**		
3.1	HDB3, 2 Mbit/s interfaces per module	No.	Minimum 8
3.2	Complying to ITU-T rec.		G.703, transparent G.704, selectable
3.3	HDSL, 2 Mbit/s interface: • no of copper wires • Capacity on 2 Mbit/s or on l Mbit/s • Capacity selectable	 No. ch ch / pair of wire	4 or 2 30 or 15 30/2 pairs 30/1 pair 15/1 pair
4.0	**Available User Interfaces**		
4.1	**Voice interfaces for trunk lines:**		
4.1.1	1 + 1 corn path protection, available for all		yes

No.	Description	Unit	Required
4.1.2	Analogue, 4 wire with E&M: • Input level • Output level	 dBr	 +7.5..-16 +7.0..-16.5
4.1.3	Analogue, 2 wire with E&M: • Input level • Output level	 dBr	 +6.5..-12.5 -1.0..-20
4.1.4	Digital, 2 Mbit/s CAS or PRI		
4.2	**Voice interfaces for remote subscriber:**		
4.2.1	2 wire, subscriber side	dBr	
4.2.2	12 wire, PABX side	dBr	
4.3	**Integrated teleprotection**		
4.3.1	Interface for commands:		
4.3.1.1	Number of independent commands	No.	4
4.3.1.2	Transmission time max.	ms	6
4.3.1.3	Signal voltage	Vpeak	250
4.3.1.4	1 + 1 corn path protection		Yes
4.3.2	Interface(s) for differential protection:		
4.3.2.1	Electrical interface: G.703	kbit/s	64
4.3.2.2	Optical interface	kbit/s	Minimum 64
4.4	**Data: channels per module**		
4.4.1	1 + 1 com path protection, available for all		Yes
4.4.2	V.24N.28 (RS-232): up to 38.4kbit/s	No.	4
4.4.3	V.11/X.24(RS-422): 64kbit/s	No.	4
4.4.4	V.35: 64kbit/s	No.	4
4.4.5	V.36 (RS-449): 64kbit/s	No.	2
4.4.6	G.703: 64kbit/s	No.	8
4.4.7	Ethernet: • 10Base T • WAN capacity • Protocols	 No. Mbit/s	 1 Min: 2 x 2 Mbit/s Min.: IP
4.5	**Integrated alarm gathering module:**		
4.5.1	Number of external alarms per module	No.	Min. 20
4.5.2	Auxiliary power supply for ext. contacts		Yes
4.6	**Network Management System**		
4.6.1	Type/Name of configuration tool		
4.6.2	For fault / configuration management		Yes/ yes
4.6.3	For local / remote operation		Yes/ yes
4.6.4	Data communication network (DCN)		Ethernet/IP or Ethernet /OSI
4.7	**Ambient Conditions:**		
4.7.1	Storage: ETS 300 019-1-1,class 1.2	˚C / % hum	-25..+ 55 /class 1.2
4.7.2	Transport: ETS 300 019-1-2, class 2.2	˚C / % hum	-25..+ 70 /class 2.2
4.7.3	Operation: ETS 300 019-1-3, class IIE	˚C / % hum	-5 .. +45 / class 3. 1 E
4.8	**Power Supply**		
4.8.1	Operation	VDC	48 / 60 (-15/+20%)
4.8.2	Fully redundant power supply		Yes

15. Quality Assurance, Inspection, Testing, Commissioning and Warranty

15.1 Scope of Section

The whole of the plant covered by this Contract will be subject to inspection and witnessing the tests by the Employer during manufacture, erection and on completion. The inspection and witnessing the tests at Manufacturer's works may be done by the Employer or an Independent Inspection agency.

The approval of the Employer/Engineer or the passing of any such inspection or test will not, however, prejudice the right of the Employer to reject the plant if it does not comply with the specification when erected or when in service.

The Employer/Engineer or their designated representatives are entitled to attend the **factory acceptance tests**, which shall be performed at the Manufacturer's works/testing laboratories. Factory acceptance tests shall be performed at least for the following equipment:

- power transformer 230/132 kV
- power transformers 132/33 kV,
- circuit breaker 230 & 132 kV,
- disconnectors 230 & 132 kV,
- instrument transformers 230 & 132 kV,
- substation automation system,
- protection relays and
- communication equipment.

The Contractor shall be responsible for bearing the costs for the above mentioned witnessing of factory acceptance tests by three Employer's engineers in each visit, considering visa fees and health insurance to cover all medical costs that may be required during visit, the return air fare, hotel charges, travelling expenses from airport to hotel and hotel to place of testing and return, food, laundry, together with a per diem allowance of USD 100 for maximum 7 (seven) days for each of the Employer's Engineer.

The Contractor shall provide **training** for of 4 (four) Employer's Engineers at the Manufacturer's premises, for installation, testing, operation and maintenance of the following equipment:

- OLTC,
- circuit breakers 230 & 132 kV,
- substation automation system,
- protection relays,
- DFDR, and
- communication equipment;

The Contractor shall be responsible for bearing the costs for the above mentioned trainings for four Employer's Engineers in each training, considering visa fees and health insurance to cover all medical costs that may be required during visit, the return air fare, hotel charges, travelling expenses from airport to hotel and hotel to place of testing and return, food, laundry, together with a per diem allowance of USD 100 for maximum 14 (fourteen) days for each training (as per the necessary and agreed train-

ing schedule) and for each of the Employer's Engineer.

The Contractor shall provide, during and after the installation, **on-site training** for operation and maintenance of the works, for no more than 15 (fifteen) Employer's staff, in the duration of minimum 1 (one) weeks.

The Contractor shall be responsible for bearing all costs for the above mentioned training. All costs are deemed to be included in the contract price.

For notification of testing, four weeks shall be deemed as reasonable advance notice.

Within 45 days of the letter of acceptance for the contract the contractor shall submit a quality assurance programme and a work quality programme for the Engineer's approval.

The Contractor shall have an approved quality management system.

After the award of Contract, the Engineer shall have the right to carry out a review of the quality assurance procedures operated by the Contractor. The Engineer's review may consider quality assurance in relation to the design and manufacture of plant items, but may equally investigate the Contractor's quality assurance procedures for the overall control of the wide range of design activities necessary for a complex project of this type, and the dissemination of paperwork, design drawings and data amongst the various design and manufacturing organisations within the Contract. The Contractor shall give all necessary help and assistance to the Engineer in carrying out such a quality assurance review. The Contractor shall consider and discuss the results of the review and make any reasonable improvements in his procedures.

Before any plant is packed or despatched from the Main or Sub- Contractors' works, all tests called for shall have been successfully carried out in the presence of the Engineer unless otherwise agreed.

30 days' notice shall be given when the plant is ready for inspection or tests and every facility shall be provided by the Contractor and his Subcontractors to enable the Engineer and Employer to carry out the necessary inspection and witnessing of tests.

In the cases where tests or inspection are specified as being carried out on only a sample of the total quantity of items in the Works, and where one or more items of the sample fail the test or inspection, a further batch of the items, at least equal in quantity to the proportion originally specified, shall be tested or inspected. This process shall continue until a sample proves completely acceptable.

15.2 Subcontracts

Within two months of acceptance of the Bid and in order to facilitate the inspection of bought-out materials and plant, the Contractor shall submit to the Engineer for approval three copies of all sub-orders placed by him as soon as they are issued. One copy of any drawing or schedule referred to in the sub-order shall be submitted simultaneously unless agreed otherwise with the Engineer. Any reference to price may be deleted from the copies so submitted.

The sub-orders and drawings submitted to the Engineer shall cover all components which are subject to electrical and mechanical pressure or stress when the plant is in operation and also auxiliaries and spares which are to be despatched to Site direct from the Subcontractor's factory.

Sub-orders are to include a statement advising the Subcontractor that the items being ordered will be subject to inspection and test by the Engineer and Employer.

The Contractor shall advise his Subcontractors of all the pertinent clauses in the Specification when ordering bought out plant, equipment or materials.

Every sub-order or subcontract shall contain the following information:

- Main Contractor's name and sub-order or sub-contract number.
- Quantities and description of work.
- Delivery requirements.
- Delivery consignment instructions.
- Details of Employer and/or main Contractor's applicable drawing or schedule numbers.
- Name of the Engineer.
- A note advising that the plant or equipment which is the subject of the order shall comply in every respect with the Engineer's, Specification and shall be subject to inspection by the Engineer, Employer and the Contractor.
- A reference, particularised in the accompanying Specification, covering the following information:
  - Employer's name
  - Project title
  - Contract No.
  - Engineer's reference number

Subcontractors shall comply with all the applicable requirements of this Specification and the onus is upon the Contractor to ensure that Subcontractors comply with these requirements.

For the purposes of this clause, interworks orders shall be treated as sub-orders.

15.3 Guarantees

The Contractor shall state and guarantee the technical particulars listed in the Technical Schedules and other sections as specified by the Contract for testing procedures. These guarantees and particulars shall be binding and shall not be departed from without the written permission of the Engineer.

The Contractor shall further guarantee that all equipment supplied complies with the Contract Documents.

The tolerances permitted in the IEC and British Standards shall apply unless otherwise stated.

15.4 Quality Audit

The quality programme established by the Contractor shall be followed for all inspection and testing procedures.

The Engineer and Employer may, from time to time, visit the Manufacturer to carry out a quality audit of the Manufacturer's organisation.

15.5 Measuring and Testing Equipment

At prescribed intervals, or prior to each use, all measuring and testing equipment used in inspection shall be calibrated and adjusted against certified equipment having a known valid relationship to internationally recognised standards.

The Manufacturer shall prepare a calibration schedule showing equipment type, identification number, location, frequency of checks, method of checking and action to take when results are unsatisfactory.

15.6 Inspection Plan and Procedure

The Inspection Plan, as submitted by the Contractor to the Engineer for approval, shall cover the following:

- Relevant International Standard. For each of the following stages of the work, the acceptance criteria shall be stated.
- The stages of inspection which shall include but not be limited to the following:
  - Tests to review or approve certification of material;
  - Review and approval of manufacturing procedures;
  - Witnessing tests or review and approval of certification of operator's qualification to carry out the work required;
  - Visual and dimensional examination of components;
  - Pressure tests on casings and vessels;
  - Non-destructive examination of materials in progress;
  - Functional tests on sub-assemblies, performance tests, type tests on complete units;
  - Examination of painting, packing and documentation for shipment.

The Engineer will indicate the inspection requirements on the agreed inspection programme in accordance with the following.

Hold point - Requires a mandatory inspection by the Engineer. This inspection or test shall be witnessed by the Engineer and Employer and further progress in manufacture shall not be made until the plant is approved by the Engineer.

Witness point - Inspection or test of material may be carried out by the Engineer and Employer at their discretion.

Document review - Certification of material and functional test shall be approved by the Engineer before despatch from the works.

15.7 Test Certificates

Triplicate sets of all test records, test certificates and performance curves, whether or not they have been witnessed by the Engineer and Employer, shall be supplied to the Engineer for all tests carried out in accordance with the provisions of this Contract.

Sets of all test certificates shall be endorsed with sufficient information to identify the material or equipment to which the certificates refer, and shall carry in the top right hand comer the following reference:

- Employer's name
- Project title
- Contract No.
- Engineer's reference number

All test documentation shall be in the English language.

15.8 Material Tests

The Contractor shall provide test pieces as required by the Engineer to enable him to confirm the quality of the material supplied under the Contract. Such test pieces shall be prepared and supplied free of charge and any cost of the tests shall be borne by the Contractor.

If any test piece fails to comply with the requirements of the appropriate specifications for the material in question, the Engineer may reject the whole of the material represented by that test piece; the Contractor's or Subcontractor's designers and metallurgists will be consulted before any material is so rejected.

If the Engineer is furnished with certified particulars of tests which have been carried out for the Contractor by the suppliers of material, he may, at his own discretion, dispense with the previously mentioned tests.

15.9 General Requirements for Tests at Manufacturers' Works

15.9.1 Testing of Plant

Tests at Manufacturers' works shall include mechanical, electrical and hydraulic tests to ensure that the plant being supplied complies with the requirements of the Specification.

Works tests shall include all routine electrical, mechanical and hydraulic tests in accordance with the relevant IEC or British Standards, except where departures therefrom and modifications thereto are embodied in this Specification.

Should the plant or any portion thereof fail under test to give the required performance, further tests which are considered necessary by the Engineer shall be carried out by the Contractor and the whole cost of the repeated tests borne by the Contractor. This also applies to tests carried out at the Subcontractors' works.

The Employer or its representative or independent inspection agency may witness the tests. Sufficient notice (minimum of 30 working days) shall be given to enable the necessary arrangements to be made.

If the plant, or any portion thereof, fails under test to give the required performance, such further tests which are considered necessary by the Engineer shall be carried out by the Contractor and the whole cost of the repeated tests shall be borne by the Contractor. This also applies to tests carried out at Subcontractors' works.

Tests shall be conducted in accordance with the specified standards. When no standards are specified, the test procedure shall be agreed between the Employer and the Contractor.

Specific details of tests to be carried out at the Manufacturers' works are defined elsewhere in this Specification.

15.9.2 Rejection of Plant

If any item fails to comply with the requirements of this Specification in any respect whatsoever at any stage of manufacture, test, erection or on completion at Site, the Engineer may reject the item, or defective component thereof, whichever he considers necessary, and after adjustment or modification as directed by the Engineer, the Contractor shall submit the item for further inspection and/or test.

In the event of a defect on any item being of such a nature that the requirements of this Specification cannot be fulfilled by adjustment or modification, such item is to be replaced by the Contractor, at his own expense, to the entire satisfaction of the Employer.

15.10 Specific Requirements for Tests at Manufacturers' Factories

15.10.1 Pressure Vessels

a) All pressure vessels shall be designed, fabricated, inspected and tested in accordance with an approved pressure vessel code or standard.
b) An approved method of radiographic or other non-destructive testing shall be used for proving all welding, at all positions of possible high stress concentration, such as large branch welds, and their vicinities after all heat treatment is completed. This shall be done whatever the programme of non-destructive testing before heat treatment.
c) Hydrostatic test shall be conducted in accordance with BS 5500.

15.10.2 Substation Automation System, Control, Relay Protection and Metering

All equipment for substation automation system, control, relay protection and metering shall be fully assembled at the Manufacturer's works and subject to the complete routine and functional test

For **factory acceptance test** all equipment for substation automation system, control, relay protection and metering, for each substation, shall be fully assembled at the Manufacturer's works and subjected to visual and functional tests

All control and relays and associated equipment shall be routine tested to prove the quality and accuracy. Routine tests shall be in accordance with relevant IEC Recommendations supplemented by additional tests as are considered necessary by the Employer. Routine test reports shall be submitted for each relay and piece of equipment. The reports shall record all measurements taken during the tests.

All relays shall be subjected to the appropriate routine tests as listed below, the individual tests being as detailed in IEC 60255 or as otherwise agreed with the Employer.

- Accuracy of calibrated pick-up and drop-off levels over the effective range of settings
- Insulation tests
- Accuracy of timing elements
- Correct operation of flag (or other) indicators
- Mechanical requirements, integrity/safety of draw-out units, check of contact pressure and alignment.

15.10.2.1 Wiring

All circuits shall be subjected to the high voltage test specified in the relevant IEC or approved standard. The insulation resistance of all circuits shall be measured before and after any high voltage tests. For AC secondary injection tests a substantially sinusoidal test supply shall be used.

The operating and resetting level (current and/or voltage) and timing of all relays shall be measured over an agreed range of settings for all relays.

For directional relays phase-shifting transformers shall be used to determine the maximum torque angle and the boundaries of operation/restraint.

Other relays shall be fully tested in accordance with the Manufacturer's recommendations.

All DC elements of protection relays shall be tested for operation at 70% rated voltage.

All DC supplies shall be checked for severity of current inrush when energised by switching on or inserting fuses or links.

15.10.2.2 Mechanical Inspection

All panel equipment is to be examined to ensure that it is in proper working condition and correctly adjusted, correctly labelled and that cases, covers, glass and gaskets are in good order and properly fitting.

15.10.2.3 General

Sufficient tests shall be performed on the relays and protection schemes to:

- establish that the correct equipment has been supplied and installed.
- confirm that the various items of equipment have been correctly interconnected.
- confirm performance of schemes designed on the bases of calculation e.g. differential protection.
- to provide a set of figures for comparison with future maintenance values allowing the condition of the equipment to be determined.

15.10.2.4 Secondary Injection

Secondary injection shall be carried out on all AC relays, using voltage and current of sinusoidal wave form and rated power frequency to confirm satisfactory operation and range adjustment.
The polar characteristic of all distance protections shall be recorded at a minimum of 30 degree intervals.

For circulating current protection employing high impedance voltage operated relays, the points of injection for relay voltage setting tests shall be across the relay and stabilizing resistance.

The fault setting for the type of protection is to be established by secondary injection, where it is impracticable to ascertain this value by primary injection. Injection is to be made across the appropriate relay bus wires with all associated relays, setting resistors, and CT's connected.

15.10.2.5 Primary Injection

All current operated relays shall be tested by injection of primary current to record the actual relay setting and as a final proof of the integrity of all secondary connections.

The stability of all differential schemes shall be checked by injection of primary current.

Primary current injection tests are to be carried out by the Contractor and the methods employed for a particular installation are to be agreed with the Engineer.

Tests are to be carried out as follows:

- Local primary injection to establish the ratio and polarity of current transformers as a group, care being taken to prove the identity of current transformers of similar ratio.
- Overall primary injection to prove correct interconnection between current transformer groups and associated relays.
- Fault setting tests, where possible, to establish the value of current necessary to produce operation of the relays.

15.10.2.6 DC Operations

Tests are to be carried out to prove the correctness of all DC polarities, the operating levels of DC relays and the correct functioning of DC relay schemes, selection and control switching, indications and alarms. The correct functioning of all isolation links and fuses shall also be checked.

15.10.2.7 Tests on Load

Tests on load shall also be done to demonstrate stability and operation of protection relays as required by the Engineer.

All tripping, control, alarm and interlocking circuits shall be functionally tested to prove satisfactory and fool-proof operation and/or resetting. The functional and safety aspects of all shorting and/or isolation links, fuses and switches devices shall be proved.

The total burdens connected to all voltage transformer circuits shall be measured and recorded.

The total capacitance of all wiring and apparatus connected to the negative pole of each main tripping battery shall be measured and recorded; the value shall not exceed 10 microfarad.

The continuous current drain of all trip circuit supervision relays shall be measured and shall not be greater than half the minimum current required for tripping. The supervision current shall be measured with the circuit breaker (or other device) both open and closed.

15.10.3 Relays

All relays and associated equipment shall be routine tested to prove the quality and accuracy. Routine tests shall be in accordance with relevant IEC Recommendations supplemented by additional tests as are considered necessary by the Employer. Routine test reports shall be submitted for each relay and piece of equipment. The reports shall record all measurements taken during the tests.

All relays shall be subjected to the appropriate routine tests as listed below, the individual tests being as detailed in IEC 60255 or as otherwise agreed with the Employer.

- Accuracy of calibrated pick-up and drop-off levels over the effective range of settings
- Insulation tests
- Accuracy of timing elements
- Correct operation of flag (or other) indicators
- Mechanical requirements, integrity/safety of draw-out units, check of contact pressure and alignment.

15.10.4 Electrical Instruments and Meters

One instrument and meter of each type and rating shall be subjected to the tests as specified in IEC 60051.

15.10.5 AC Switchboards

Routine tests shall include general inspection and electrical operation tests.

15.10.6 Contactors

One contactor of each type and rating shall be subjected to type tests as specified in IEC 60292-1.

15.10.7 PVC Cable

Each size and rating of PVC cable shall be subjected to type tests as specified in BS 6346. Routine tests are detailed in Section 5 of this document.

15.10.8 Switchgear (Other than GIS)

All circuit breakers shall be fully assembled at the Manufacturer's works and subjected to routine testes according to the IEC 62271-100.

For **factory acceptance test** one or at least 20% of the circuit breakers of each type, shall be fully assembled at the Manufacturer's works and subjected to routine testes according to the IEC 62271-100.

15.10.9 Disconnectors and Earth Switches

All disconnectors and earthing switches shall be fully assembled at the Manufacturer's works and subjected to routine testes according to the IEC 62271-102.

For **factory acceptance test** one or at least 10 % of the disconnectors and earthing switches of each type, shall be fully assembled at the Manufacturer's works and subjected to routine testes according to the IEC 62271-102.

15.10.10 Current and Voltage Transformers

All current transformers and voltage transformers shall be fully assembled at the Manufacturer's works and subjected to routine testes according to the IEC 60044.

For **factory acceptance test** three or at least 20 % of the current transformers and voltage transformers of each type, shall be fully assembled at the Manufacturer's works and subjected to routine testes according to the IEC 60044.

15.10.11 Structures of Electrical Equipment

Sample tests on the assembly and galvanising of the structures shall be carried out. A mechanical type test with the structure loaded with working load multiplied by the appropriate factor of safety shall be carried out.

15.10.12 Surge Arresters

All surge arresters shall be fully assembled at the Manufacturer's works and subjected to routine testes according to the IEC 60099-4.

For **factory acceptance test** three or at least 20 % of the surge arresters of each type, shall be fully assembled at the Manufacturer's works and subjected to routine testes according to the IEC 60044.

15.10.13 Batteries and Battery Chargers

Battery:	The Contractor shall demonstrate that the battery will perform the duties specified.
Battery charger:	Routine tests according to IEC 60146 (BS 4417)
DC Switchboard:	Routine tests according to IEC 60439 (BS 5486:Part 1)

Complete charge and discharge tests on each of the combined batteries and chargers shall be conducted and results recorded so as to permit verification of the ampere-hour capacity of the battery.

During these tests the Engineer shall select at random reference cells and the voltage curves thereof shall be checked when the battery is discharged over three and ten hour periods. The alarm levels and the automatic voltage control feature of the charger shall be demonstrated over the specified load range. Where load changeover facilities are included, integrity of the changeover system without break or voltage variations during loading of the standby or test charger shall be demonstrated.

15.10.14 Control Panels

Routine operation tests and insulation resistance tests shall be carried out.

15.10.15 Busbars

Routine tests including millivolt drop tests shall be carried out in accordance with the specified standard.

15.10.16 Instruments

Calibration tests shall be witnessed on all important pressure gauges and other instruments as required by the Engineer.

15.10.17 Neutral Earthing Resistor

Routine leakage and over voltage tests.
Bushing insulator wet flashover tests (internal and external).

15.10.18 Power Transformers

Inspection and testing during manufacture shall be in accordance with the General Conditions of Contract and this section of the Specification.

Works tests shall include all routine electrical, mechanical and hydraulic tests in accordance with the relevant IEC Standard, except where departures therefrom and modifications thereto are embodied in this Specification. For Plant not covered by any IEC Standard or specifically mentioned in this Specification, such tests as are relevant shall be agreed with the Engineer.

Should the Plant, or any portion thereof, fail under test to give the required performance, further tests which are considered necessary by the Engineer shall be carried out by the Contractor and the whole costs of the repeated tests borne by the Contractor. This also applies to tests carried out at the Subcontractors' works.

After satisfactory completion of the witnessed tests at the Works, the Plant shall be submitted for the Employer's approval during dismantling preparatory to shipment. No item of Plant is to be despatched to Site until the Employer has given his approval in writing.

All power transformers shall be fully assembled at the Manufacturer's works and subjected to routine testes and special tests

For **factory acceptance test** all power transformers shall be fully assembled at the Manufacturer's works and subjected to repetition of the all routine testes and special tests

15.10.18.1 Main Transformers

Routine Tests

All transformers shall be subject to the following routine tests in accordance with IEC 60076 and the requirements of this Specification.

- Measurement of winding resistance on all tap positions and phases.
- Ratio, polarity and phase relationship.
- Impedance voltage.
- Load loss at normal, maximum and minimum taps.
- No load loss and no load current at normal voltage Un and at +5% Un and at +10% Un.
- Magnetising current at nominal voltage Un and at -5% Un and +5% Un and at +10% Un.
- Insulation resistance.
- Dielectric withstand tests:
  - On uniformly insulated windings with highest voltage Um = 36kV, tests shall comprise:
    - induced over voltage withstand.
    - short duration power frequency voltage withstand.
    - full wave lightning impulse withstand for line terminals.
    - lightning impulse chopped wave at 115% of the full wave level.
  - On non-uniformly insulated windings with highest voltage Um 145 W, tests shall comprise:
    - induced over voltage withstand combined with partial discharge.
    - short duration power frequency voltage withstand.
    - full wave lightning impulse withstand for line terminals.
    - lightning impulse chopped wave at 115% of the full wave level.
  - On non-uniformly insulated windings with highest voltage Um = 245kV, tests shall be carried out according to a combination of methods 1 and 2 and comprise:
    - short duration power frequency voltage withstand.
    - induced line to earth overvoltage withstand test at 460kV (method one routine test).
    - full wave lightning impulse withstand for line terminals.
    - lightning impulse chopped wave, at 115% of the full wave level.
    - induced power frequency overvoltage withstand test with partial discharge measurement.
- ix) Insulation Resistance

Type Tests

- Temperature rise test:
  The test shall be in accordance with IEC 60076-2, and shall be carried out on one transformer of each size and type. Temperature-rise tests shall be conducted on the tapping corresponding to the maximum losses.
- Noise level tests:
  A noise level test to IEC 60076 shall be carried out on one transformer of each type specified under items 1 and 2 in accordance with IEC 60551**.**

Special Tests

- Measurement of Zero Phase - Sequence Impedance
  The test shall be in accordance with IEC 60076-1 Clause 8.7 and shall be carried out on one transformer of each type.

15.10.18.2 Voltage Control Equipment

Routine Tests

Each finished tap changer shall be subjected to the routine tests specified in JEC.214 but in addition the mechanical test shall be carried out at rated voltage and no load.

Type Tests

Shall be carried out entirely in accordance with IEC 60214 except that evidence of the service duty type test shall be in excess of 100,000 operations.

15.10.18.3 Magnetic Circuit

Routine Tests

Each core completely assembled shall be tested for one minute at 2,000V AC between core bolts, side plates, structural steelwork and core at the core and coil stage. After the transformer is tanked and completely assembled, a further test shall be applied between the core and the earthed structural steelwork to prove that the core is earthed through the removable link, at one point only.

15.10.19 Outdoor Bushing Assemblies with Porcelain Insulators

Hollow insulators tested in accordance with IEC 60233
Complete bushings tested in accordance with IEC 60137

Routine Tests

Routine tests shall include:

- Oil leakage test
- 50Hz dry withstand test
- Power factor/voltage test
- Partial discharge test on all bushings of which the major insulation is either oil impregnated paper or resin impregnated paper.

15.10.20 Tanks

Routine Tests

Oil Leakage: All tanks, conservators and oil filled compartments, which are subjected in service or during maintenance to oil pressure, shall withstand without leakage a hydraulic pressure test equal to 69 kN/m² or the normal pressure plus 34 kN/m² whichever is the greater, for 24 hours during which time no leakage or oil ingress into normally oil free spaces shall occur.

15.10.21 Cooling Plant

Routine Tests

- Coolers: Pressure test to be as specified above.
- Motors and Control Gear: To the requirements as specified.

15.10.22 Gas and Oil-Actuated Relays

Routine Tests

- Oil leakage: When subject to an internal oil pressure of 207 kN/m² for fifteen minutes.
- Gas collection
- Oil surge
- Performance test under service conditions. oltage: 2 kV for one minute between electrical circuits and casing.

15.10.23 Galvanizing

Routine Tests

To the requirements of BS 443 or BS 729 whichever is applicable

15.10.24 Earthing Transformers

Routine Tests

- Measurement of winding resistance
- Ratio, polarity and phase relationships
- Measurement of impedance voltage
- Measurement of loss
- Short duration power frequency voltage-withstand test
- Induced overvoltage withstand test
- Insulation resistance of each winding

Special Tests

- Measurement of zero-phase sequence impedance

15.10.25 Fibre Optic Multiplexer Equipment

Works tests shall be in accordance with the IEC standard.

15.10.26 Deleted

15.10.27 Telephone Equipment

Comprehensive system testing including subscriber to subscriber tests with transit working shall be carried out with the exchanges fed from normal, high and low volts. Hunting, alternative routing and priority facilities, etc., shall be checked.

15.10.28 Teleprotection Equipment

Back to back tests shall be carried out to determine the satisfactory operation of the teleprotection equipment.

These tests shall be via fibre optic multiplexer equipment links, simulated lines or communication channels dependent on the actual application.

Random tests shall be performed which demonstrate to the Engineer the ability of the equipment to operate satisfactory (reliability) and within the specified time limits (speed) in the presence of interfering signals or noise and also the ability not to malfunction (security) in the presence of interfering signals or noise at levels likely to occur when the equipment is installed in the power system substations.

15.10.29 Transducers

Transducers shall be tested in accordance with IEC 60688-1.

15.11 Dismantling Prior to Shipment

After the satisfactory completion of all tests at the factory, the plant shall be submitted for the Engineer's approval during dismantling preparatory to shipping. No item of plant shall be despatched to site until the Engineer has given approval in writing.

15.12 Inspection and Testing during Site Erection

15.12.1 General

The Contractor shall be responsible for the submission to the Engineer of all plant supplied under the Contract for inspection and testing during site erection, to ensure correct erection and compliance with the Specification.

During the course of erection, the Contractor shall provide access as required by the Engineer for inspecting the progress of the works and checking its accuracy to any extent that may be required.

The Contractor shall provide, at his own cost, all labour, materials, stores, and apparatus as may be requisite and as may be reasonably demanded to carry out all tests during erection, whether or not the tests are specifically referred to in this specification.

Tests on completion of erection shall be carried out by the Contractor in accordance with the General Conditions of Contract. The Contractor shall provide all necessary test equipment to carry out the site tests, but where required in the Schedule of Prices, shall include the cost of the equipment so that the Employer may have the option to buy the equipment on completion of the Contract.

The Contractor shall submit a written programme of tests and checks according to this Clause for the approval of the Engineer.

A brief description of all tests and testing procedures shall be provided before tests commence and the method of testing, unless otherwise specified, shall be agreed with the Engineer.

The Contractor shall provide experienced test personnel and testing shall be carried out during normal working hours as far as is practicable. Tests which involve existing apparatus and outages may be carried out outside normal working hours. The Contractor shall give sufficient notice to allow for the necessary outage arrangements to be made in conformity with the testing programme.

The Contractor shall advise the Engineer in writing, at the time of commencement of site erection, of the site supplies which will be required for the operation of the test equipment, to enable the Engineer to arrange accordingly or to agree alternative arrangements should this be necessary.

The Contractor shall record the results of the tests clearly, on an approved form and with clear reference to the equipment and items to which they refer, so that the record can be used as the basis for maintenance tests during the working life of the equipment. The required number of site test result records shall be provided by the Contractor to the Engineer as soon as possible after completion of the tests.

No tests as agreed under the programme of tests shall be waived except upon the instruction or agreement of the Engineer in writing.

The Contractor's test equipment shall be of satisfactory quality and condition and, where necessary, shall be appropriately calibrated by an approved authority at the Contractor's expense. Details of the test equipment and instruments used shall be noted in the test sheets in cases where the instrument or equipment characteristics can have a beating on the test results.

The testing requirements detailed under this Specification may be subject to some variation upon the instruction or agreement of the Engineer where necessitated by changed conditions at Site or by differing design, manufacture, or construction techniques.

The Bidder is required to submit proposals for site dielectric tests and to include in his price the costs of such tests and of such equipment as deemed necessary.

15.12.2 Mechanical Equipment

The extent of testing during erection shall include, but not be limited to, the following:

a) Checking the accuracy and alignment of plant erected. The accuracy shall comply with the relevant standards, the specification or the plant Manufacturer's requirements as may be applicable or, where no requirements exist, to a standard to be agreed between the Engineer and the Contractor.

b) Checking the alignment of rotating equipment to the Manufacturer's requirements.

c) Non-destructive testing of site welds as required by the relevant standard and as detailed in this specification.

d) Hydrostatic testing of pipework systems at a pressure of 1.5 times the design pressure but not less than 4.5 bar for a period of 2 hours, or at such other conditions as may be required by the pipework design code.
Air piping shall be subjected to an air pressure test rather than a hydrostatic test.

e) Site fabricated tanks and vessels shall be subjected to hydrostatic tests in accordance with the relevant standards.

f) Hydrostatic tests shall be carried out on steam generating units in accordance with the boiler design code.
After the hydrostatic test is carried out, the complete assembly shall be drained and any non-drainable sections shall be injected with an oxygen-absorbent chemical and elements plugged.

g) Pressure vessels and other parts, including pipework, that are made up on site and are subject to pressure or vacuum under normal or abnormal working conditions, shall be subjected to a site hydraulic test at approved pressures and for approved periods in accordance with the relevant standard. Where no appropriate standard exists the hydraulic test pressure shall not be less than 1.5 times design pressure or at such pressure to be agreed by the Engineer.
Should, in the opinion of the Contractor and with the agreement of the Engineer, an hydraulic test be impracticable due to excessive loading on foundations other than steel, an air pressure test may be employed in accordance with requirements set out in BS 5500.
Vacuum tests shall be carried out at the maximum test vacuum obtainable and the condition maintained for a period of two hours with the system isolated. The Contractor shall state in the Schedule of Guarantees the fall in vacuum anticipated during this period but the rate of fall shall not exceed that which would occur due to the designed air leakage rate being attained.

h) Calibration checks on all instrumentation.

i) Tests to demonstrate the correct functioning of the control loops, protective devices, interlocks and alarms.
Flushing out of all pipework systems which have not been fully cleaned and sealed before shipping to site.

k) Other tests as specified which have not been previously conducted.

15.12.3 Electrical Equipment

15.12.3.1 General

A general check of all the main switchgear and ancillary equipment shall be made and shall include a check of the completeness, correctness and condition of earth connections, labelling, arcing ring and horn gaps, clearances, painted surfaces, cables, wiring, pipework, valves, blanking plates and all other auxiliary and ancillary items. Checks shall be made for oil and gas leaks and that insulators are clean and free from external damage. A check shall be made that loose items which are to be handed over to the Employer e.g. blanking plates, tools, spares, are in order and are correctly stored or handed over.

The following general tests are to be carried out on electrical equipment after erection at site:

- Routine high voltage tests to the appropriate IEC Standard. Where no relevant standard exists, tests shall be agreed with the Engineer.
- Insulation resistance tests on all electrical equipment.
- Continuity and conductivity resistance tests.
- Test operation of alarm and tripping, devices to local and remote.
- Rotational tests on all motors.
- Polarity tests on CTs and VTs.
- Oil tests.
- Grounding system and electrode tests.
- Ratio, Vector Grouping and magnetising current tests on each transformer.
- Calibration of winding and oil temperature devices.
- Vector group and phasing tests on VT circuits.
- Magnetisation current/voltage tests and winding resistance tests on all current transformers.
- Primary and secondary injection tests on relays, protection devices and equipment.

15.12.3.2 Circuit breakers

Circuit breakers shall be visually inspected. In the case of gas type circuit breakers testing will be required on the gas system to prove the gas pressure, quantity, dryness and dielectric strength.

Contact resistance tests shall be carried out. In the case of multi-interrupter circuit breakers resistance tests will be required at each interrupter or pair of interrupters as well as through the series of interrupters on each pole.

Operational tests shall include local and remote trip/close. Timing tests shall be carried out on all circuit breakers, except those which are below 66kV and which are neither assembled at Site nor have mechanically ganged pole operation.

Local air components associated with pneumatic operation, including air compressors, shall be tested and air loss measurements and pressure and alarm settings checked. Tests shall be made also on mechanical and hydraulic operating systems.

15.12.3.3 Disconnectors and Earth Switches

Manual operation of disconnectors and earth switches shall be subject to operational tests to confirm contact pressures, contact resistances, simultaneous operation of all phases and the ease of operation.

Motorised operation of disconnectors, and earth switches shall be tested to prove the motor operation, including local and remote operation, and timing tests shall also be carried out. Motor protection shall be tested.

Checks shall be made on interlocks, local and remote indications and operation of auxiliary contacts.

Earth switches shall be tested to confirm the opening and closing sequences and checks shall be made on interlocks, indications and manual locking devices.

15.12.3.4 Busbars and Connections

Flexible busbars and connections shall be tested to ensure that the correct tensions, sags and clearances will be maintained over the range of environmental conditions and loads without stress to other equipment. If dynamometers are used to check the sags and tensions, they shall be checked both before and after use.

Rigid busbars and connections shall be tested to ensure that the busbars will not cause overloading of the supporting insulators under load conditions and under the range of climatic variations applicable to the site and that expansion and contraction of the equipment is fully accommodated by flexible connections.

Conductivity tests shall be carried out on all connections and joints which are made on site, without exception.

15.12.3.5 Earthing System

Tests shall be made on the effectiveness of the bonding and earthing which will include conductivity tests on selected joints, on the main earthing system, and at the connections to equipment and structures. Checks shall also be made on precautions taken to avoid corrosion. attack on the earthing system.

Test probes at approximately 300 and 600 metres separation will normally be required to effectively test the earthing system. The use of transmission line conductors may be arranged to simplify these testing procedures.

The earth resistance shall be measured during the installation and on completion as follows:

- of each earth rod after driving

- of the earth grid after completion and backfilling of the trenches
- of each group of earth rods or earth point after completion of the connection from the test link terminal
- of the completed installation without any connections outside the substation

The tests shall be carried out by a method and with equipment approved by the Engineer. All tests are to be witnessed and the equipment and method used recorded with the test results.

The Contractor may also be called upon to provide assistance in the measurement of earth resistance after earth connections to the system have been completed.

15.12.3.6 Control Relays and Metering Panels, Instruments and Protective Devices

a) Wiring

- After complete erection and cabling, all circuits shall be subjected to the high voltage test specified in the relevant IEC or approved standard.
- The insulation resistance of all circuits shall be measured before and after any high voltage tests.
- For AC secondary injection tests a substantially sinusoidal test supply shall be used.
- The operating and resetting level (current and/or voltage) and timing of all relays shall be measured over an agreed range of settings for all relays.
- For directional relays phase-shifting transformers shall be used to determine the maximum torque angle and the boundaries of operation/restraint.
- Other relays shall be fully tested in accordance with the Manufacturer's recommendations.
- All DC elements of protection relays shall be tested for operation at 70% rated voltage.
- All DC supplies shall be checked for severity of current inrush when energised by switching on or inserting fuses or links.

b) Mechanical Inspection

All panel equipment is to be examined to ensure that it is in proper working condition and correctly adjusted, correctly labelled and that cases, covers, glass and gaskets are in good order and properly fitting.

c) General

Sufficient tests shall be performed on the relays and protection schemes to:

- establish that the equipment has not suffered damage during transit.
- establish that the correct equipment has been supplied and installed.
- confirm that the various items of equipment have been correctly interconnected.
- confirm performance of schemes designed on the bases of calculation e.g. differential protection.
- to provide a set of figures for comparison with future maintenance values allowing the condition of the equipment to be determined.

d) Secondary Injection

- Secondary injection shall be carried out on all AC relays, using voltage and current of sinusoidal wave form and rated power frequency to confirm satisfactory operation and range adjustment.
- The polar characteristic of all distance protections shall be recorded at a minimum of 30 degree in-

tervals.

- For circulating current protection employing high impedance voltage operated relays, the points of injection for relay voltage setting tests shall be across the relay and stabilizing resistance.
- The fault setting for the type of protection is to be established by secondary injection, where it is impracticable to ascertain this value by primary injection. Injection is to be made across the appropriate relay bus wires with all associated relays, setting resistors, and CT's connected.

e) Primary Injection

- All current operated relays shall be tested by injection of primary current to record the actual relay setting and as a final proof of the integrity of all secondary connections.
- The stability of all differential schemes shall be checked by injection of primary current.
- Primary current injection tests are to be carried out by the Contractor and the methods employed for a particular installation are to be agreed with the Engineer.
- Tests are to be carried out as follows:
  - Local primary injection to establish the ratio and polarity of current transformers as a group, care being taken to prove the identity of current transformers of similar ratio.
  - Overall primary injection to prove correct interconnection between current transformer groups and associated relays.
  - Fault setting tests, where possible, to establish the value of current necessary to produce operation of the relays.

f) DC Operations

Tests are to be carried out to prove the correctness of all DC polarities, the operating levels of DC relays and the correct functioning of DC relay schemes, selection and control switching, indications and alarms. The correct functioning of all isolation links and fuses shall also be checked.

g) Tests on Load

- Tests on load shall also be done to demonstrate stability and operation of protection relays as required by the Engineer.
- All tripping, control, alarm and interlocking circuits shall be functionally tested to prove satisfactory and fool-proof operation and/or resetting. The functional and safety aspects of all shorting and/or isolation links, fuses and switches devices shall be proved.
- The total burdens connected to all voltage transformer circuits shall be measured and recorded.
- The total capacitance of all wiring and apparatus connected to the negative pole of each main tripping battery shall be measured and recorded; the value shall not exceed 10 microfarad.
- The continuous current drain of all trip circuit supervision relays shall be measured and shall not be greater than half the minimum current required for tripping. The supervision current shall be measured with the circuit breaker (or other device) both open and closed.

15.12.3.7 Batteries and Chargers

Tests shall be carried out on the batteries and chargers to confirm the charger ratings and adjustment, the battery and charger alarm systems and battery capacity.

The open-circuit cell voltages of the batteries when fully charged shall be recorded.

The insulation to earth of the complete DC installation shall be tested.

15.12.3.8 Power Cables

Each completed circuit shall be tested for continuity and insulation resistance.

15.12.3.9 Current Transformers

A magnetisation curve shall be obtained for each current transformer in order to:

- Detect damage in transit or installation
- Prove that the correct cores have been wired out to the relevant terminals
- For high impedance relay schemes, to confirm that correct relay settings have been calculated.

The DC resistance of each current transformer secondary winding shall be measured and also the transformers and connecting leads, each item being recorded separately.

The insulation resistance of all secondary circuits shall be measured at 1000 volt and recorded.

Primary current injection tests shall be conducted on all current transformers using adequate primary current to prove correct ratio, polarity and, for differential protection schemes, to prove the correct relative polarities of all current transformers of each scheme.

15.12.3.10 Voltage Transformers

The transformer ratio and polarity shall be checked using a primary voltage high enough to give a clearly measurable secondary voltage or by using rated primary voltage and comparison with an already proven voltage transformer. The phasing and phase rotation shall be checked. For three phase voltage transformers a test shall be conducted to show that energising each primary winding produces an output from only the correct phase secondary winding. The residual voltage of any open delta or broken delta winding shall be measured with rated primary voltage applied.

15.12.3.11 Control and Instrumentation Equipment

The following general tests shall be performed on control and instrumentation equipment at site:

- High voltage testing of all circuits, as specified in the relevant IEC or approved standard.
- Insulation resistance testing of all circuits.
- Functional tests of all tripping, control, alarm and interlocking circuits.
- The testing of all equipment in accordance with the Manufacturer's instructions or as advised by the Engineer.

15.12.3.12 Transformers and Ancillary Equipment

The following tests shall be performed:

- Insulation resistance tests on bushings.
- Insulation resistance test at 500V between core and core clamping structure.
- Voltage withstand tests on insulating oil to BS 148.
- Ratio.

- Phase relationship.
- Magnetisation characteristics of current transformers of winding temperature devices.
- Calibration of winding temperature devices.
- Tap Selector and Diverter Switch alignment.
- Calibration of automatic voltage control equipment.
- Proving tests as necessary on control schemes.
- Measurement of winding resistance on all taps and phases.

Where applicable the above tests shall also be carried out on earthing transformers.

15.12.3.13 FOX, Teleprotection and Communication

Tests shall be exhaustive and shall demonstrate that the overall performance satisfies every requirement specified. The following tests shall be carried out:

- Physical inspection unit testing and demonstration of diagnostic aids as appropriate of al equipment in stand-alone mode.
- System testing of 48V power supply equipment.
- System testing of FOX equipment for speech and teleprotection.
- System testing of telephone equipment.
- System testing of teleprotection equipment to plant.

15.13 Staffing

During pre-commissioning the Contractor shall provide all necessary supervisory and operating staff.

The only involvement of the Employer's staff will be in accordance with the training and instruction as in this specification.

During the commissioning phase, the Employer's operating staff will operate plant and equipment under the supervision of the Contractor's supervisors.

The Contractor shall have satisfied himself as to the capability of the Employer's operators to carry out such operations as he may direct and shall remain responsible for the successful performance of such operations. Throughout the whole of the Commissioning Period the Contractor shall provide suitably qualified and experienced operating staff, who shall instruct the Employer's staff in the correct operating procedures.

The Contractor shall provide a team of suitably qualified and experienced engineers and technicians to pre-commission and commission the overall plant. The Contractor shall also ensure that a suitably qualified commissioning engineer from the respective Manufacturer's own service organisation shall visit the site to check the erection or installation of each significant plant item, and to supervise the commissioning of the plant item until the basic functioning of the item has been demonstrated to the Engineer's satisfaction.

At all times the Contractor shall ensure that his staff and any Subcontractor's or seconded staff, observe all prescribed safety rules and permit systems.

15.14 Taking Over

After satisfactory completion of the tests on completion, the Engineer will issue a Taking Over Certificate for the plant. The issue of any such certificate shall not however relieve the Contractor of any of his responsibilities in respect of proving that the performance of the plant meets the guaranteed values.

The Taking Over Certificate shall make reference to a schedule of outstanding minor defects and omissions which have been accepted by the Engineer as not affecting the full and safe operation of the plant. The Contractor shall rectify such defects and omissions not later than 3 months after Taking Over.
The date certified in the Taking Over Certificate shall be the date on which the tests on completion were completed.

15.15 Defects after Taking Over

In accordance with the General Conditions of Contract, the Contractor shall be responsible for making good defects or damage which may appear or occur during a 12 month guarantee period from the date certified in the Taking Over Certificate.

Following any remedial work or replacement of any component part during the 12 months, the guarantee period for such a part shall be extended, commencing from the date at which the remedial work was completed.

Immediately prior to the completion of this period the Employer reserves the right to request the Contractor to open up for inspection the whole or any part of the Plant. The Employer will provide the labour to work under the direct supervision of the Contractor's representative for the purpose of such inspection.

The Contractor shall submit for approval the arrangements he intends making under this Contract for the making good of defects and for providing the supervisory service detailed above.

15.16 Final Acceptance Certificate

Application for the Final Certificate may be made to the Engineer after the Contractor has ceased to be under any obligation under the Contract. This shall include the submission of final contract record drawings and fully bound version of the Installation, Operation and Maintenance Manuals. If a Taking-Over Certificate has been issued in respect of any Section or Portion of the Works, only one Final Certificate will be issued after all the said obligation has ceased. Final Certificate will be issued after all the said obligation has ceased. Where the Contractor has carried out replacements or renewals to the Works, the Contractor's obligations shall continue, but the right of the Contractor to apply for a Final Certificate other than for the replacements or renewals shall not be affected by that fact.

16. Power Cables and Cable Terminating Accessories

16.1 Scope

This chapter describes the general technical requirements for the 132 kV power cables & cable terminating accessories and installation of cables and shall be read in conjunction with the project requirements, schedules and drawings in the specification.

The 132 kV cables and accessories shall be suitable for connecting the 132 kV overhead transmission line with 132 kV AIS switchgear.

The Contractor shall demonstrate that the cables have been designed, built and installed in accordance with the relevant international standards and the specification. It shall also operate and perform on a site in accordance with the requirements of the specification and in the environment defined therein.

The design shall be proven by the submission of test certificates covering all specified tests deemed to be pertinent to the plant and to the conditions in which it will operate at the time of Biding.

The scope of work also includes supply and installation of cable sealing ends at both ends including terminating insulators.

16.2 Standards

The cable and accessories shall comply with this specification and the latest version of relevant IEC, BS or approved equivalent.

16.3 Conditions of Operation

All cables shall be suitable for operation, at the guaranteed continuous ratings specified, throughout all seasons of the year. The nominal system voltage to which the cables will be connected is 132 kV and the highest operating voltage Um will be 145 kV.

Cable shall be designed to operate continuously at temperature of 90°C. Each conductor and the metal sheath/screen shall be capable of carrying the specified fault current for the specified time and its final temperature shall not exceed 250°C. Adequate measure should be taken to protect against ingress of moisture and water.

Short circuit earth fault rating of cable metal sheath or metallic screen for 132 kV cable shall be 40 kA for 1 sec. respectively.

The maximum continuous current carrying capacity and maximum permissible conductor temperature, and the factors for determining such rating and temperature, shall be based on IEC recommendation

No. 287 and subsequent amendments, and all conditions obtaining on Site. The following conditions for the design of the cables shall be assumed:-

Transmission capacity for 132 kV cable circuit: 300 MVA

Other conditions for cables laid in concrete ducts/tunnels/buried pipes shall be assumed:

- Max. ambient air temperature: 45°C
- Continuous conductor temperature: 90°C
- Max. conductor temperature under fault: 250°C

The Contractor shall confirm that the cable sizes are adequate for the required circuit ratings based on the specified foregoing parameters, and he shall also confirm that the cables are adequate for the short-circuit requirements specified. The Contractor will be required to produce cable design calculations to verify that the selected cable sizes are suitable for the selected cable laying conditions in concrete cable ducts, tunnels or buried pipes.

If the Contractor considers that the conditions and the proximity to other power cables, spacing and method of installation are likely to reduce the maximum current carrying capacity he shall increase the cable conductor cross section accordingly.

The conductor section of the cable circuits shall be adequate for carrying the specified short-circuit current when operating under the specified load conditions without deterioration of the dielectric or other component materials of the cable.

16.4 Type Approval

Cables and accessories shall have satisfactorily passed type approval tests in accordance with the Specification and details of the cable designs offered shall be given in the Schedule of Particulars and Guarantees. Type test reports shall include cable design details and design drawings of each jointing accessory included in the type test.

The Contractor shall certify that the cables and/or accessories offered will be identical in all essential particulars in respect of design, materials and workmanship with the cables and/or accessories for which type approval certificates are offered in support of this bid.

The Contractor shall also ensure that all materials used will be subjected to and shall have satisfactorily withstood such tests as are customary in the manufacture of the types of cable specified.

Records of such tests shall be available for inspection, if required by the Engineer.

16.5 Cable Lengths

Cables shall be supplied in maximum drum lengths bearing in mind the transport limitations in gaining access to the site. Cables shall be installed in maximum possible lengths and straight through jointing between shorter lengths will not be permitted.

The cable routes on the drawings attached to the Bidding Documents are provided for information only, and it is Contractor's responsibility to establish the exact quantities of cables and accessories required to complete the whole of the works as described in the Specification.

16.6 Cable Drums

Cable drums shall be non-returnable and shall be made of steel suitably protected against corrosion. They shall be lagged with closely fitting battens in accordance with the relevant BS or equivalent IEC standard.

Each cable drum shall bear a distinguishing number on the outside of one flange. Particulars of the cable, i.e. voltage, conductor size and material, number of cores, type, length, gross and net weights shall also be clearly shown on one flange. The direction of rolling shall be indicated by an arrow on both flanges. The method of drum marking shall be to the Engineer's approval.

Cable maintenance lengths and spare lengths shall be wound on to steel drums before they are handed over to the Employer's stores. Particulars of the cable (as stated above) shall be clearly marked on one flange.

16.7 Spare Cable

In addition to the cable maintenance lengths supplied against the Schedule of Spares the Employer shall have the option to purchase from the Contractor at the rates stated in the Schedule any spare cut lengths of cable for future maintenance purposes.

Brass or other approved sealing caps of the correct size shall be supplied for each end of spare cut cable lengths to enable them to be properly stored for future maintenance purposes. The Contractor shall be responsible for the immediate sealing of such cut lengths and the cost thereof shall be deemed to be included in the contract price.

16.8 Special Tools

Special tools used for the purpose of the cable installation, they shall be handed over to the Employer's stores after the taking over of the installation.

Price for such special tolls is to be considered as included in the price schedule.

16.9 Cable Jointing Instructions and Drawings

Copies of the instructions for the jointing of each type of cable terminating and jointing accessories supplied shall be submitted to the Engineer for approval before any work is commenced at site. One copy of each instruction shall be bound into each copy of the Operating and Maintenance Instructions to be supplied to the Engineer at the completion of the Contract for the use of the Employer.

The following drawings shall be submitted by the Contractor for approval by the Engineer. "As installed" drawings of cable routes shall be drawn to a scale of 1/200. The route shall be dimensioned in such manner that it may be used for pinpointing accurately the cables in the future. All drawings shall be submitted for approval before the issue of the Taking-Over certificate.

16.10 Cable Specification

16.10.1 General

This Specification applies to single core cables with triple extrusion type solid dielectric. They shall be generally manufactured in accordance with the relevant International Electrotechnical Commission Publication (IEC) and British Standard (BS) where applicable.

16.10.2 Conductors

Conductors shall be of stranded plain annealed copper wires to IEC or BS filled to make the cables longitudinally watertight by extrusion during stranding. This shall be to prevent ingress of water into the cable should the outer sheath become damaged. The allowable operating temperature of conductor and waterproofing shall be 90°C.

16.10.3 Conductor Screen

Semi-conductive tape for preventing ingress of semi-conductive XLPE and gluing onto the stranded conductors temperature resistance up to 250°C. Semi-conductive extruded cross-linked material to provide a smooth cylindrical equi-potential surface to which the insulation can be intimately bonded. The material shall be compatible in all respects with its conductor and insulation materials.

16.10.4 Insulation

Cross-liked polyethylene (XLPE) melted together with the conductor screen capable to operate at continuous conductor temperature of 90°C and short circuit temperature of 250°C. Cross-linking process using curing is not permitted, dry process shall be given. The insulation of the completed cable shall be substantially free from voids and contaminants.

16.10.5 Insulation Screen

Semi-conductive compound of extruded layer firmly bonded to the XLPE insulation. The conductor screen, the insulation and the insulation screen are to be extruded in a single process to keep the interface smooth.

16.10.6 Metallic Screen

Where the cable core screens are inadequate to meet the earth fault current specified, a metallic layer of adequate cross-sectional area shall be included in the design applied over the screen. The metallic layer shall be Copper screen with counter helix filled with swelling powder sheathed in accordance

with latest BS or IEC Publication.

16.10.7 Intermediate Layer

An intermediate layer of suitable compound shall be provided in between metallic screen and aluminium sheath if necessary.

16.10.8 Corrugated Seamless Aluminium Sheath

Metallic sheath shall consist of the extruded corrugated seamless aluminium sheath. Aluminium used for the sheath shall have the minimum purity of 99.5% and shall be of best quality metal free from pinhole flaws and other imperfections. The minimum thickness at any point shall not fall below 85% of the specified nominal thickness by more than 0.1 mm.

16.10.9 MDPE Outer Sheath

After applying the bitumen compound over the aluminium sheath, the extruded MDPE outer sheath shall be applied.

The nominal thickness of outer sheath shall be not less the specified value. The minimum thickness at any point shall not fall below 85% of the specified nominal thickness by more than 0.1mm.

An outer graphite coating shall be applied to outer sheath as an electrode for the voltage test on the extruded outer sheath.

16.10.10 Identification of Cable

The outer PVC sheath of all cables shall carry the following identification marks in three meter intervals approximately.

"Electric Cables - 132000 Volts/33000 Volts and cross section in mm² cu. PGCB, the name of the manufacture and the year of fabrication."

The letters and numerals shall comply with IEC or BS Publication.

16.11 Sealing and Drumming

Immediately after the works tests, both ends of the cable shall be sealed against the ingress of moisture, dirt and insects and the end projecting from the drum shall be adequately protected against mechanical damage during handling. The cable drums shall be arranged to take a round spindle and be lagged with strong, closely fitting so as to take a round spindle and be lagged with strong, closely fitting battens so to prevent damage to the cable. Only steel cable drum shall be used.

The complete cable shall be rolled on steel cable drums capable of withstanding the rough handling during transport without damage of the cable and enabling easy and safe unrolling of the cable during erection.

Each drum shall have marked in indelible point on both flanges, the following indications besides the shipping instructions.

- Destination
- Type of cable
- Exact length
- Net and gross weight
- Trade mark
- An arrow pointing in the direction of unrolling.

16.12 Terminating Accessories

Detailed drawings showing the types of cable sealing ends, terminal boxes and glands proposed for the installation shall be submitted at the time of Bidding. All cable sealing ends and terminal boxes shall be designed with jointing faces below compound level which will ensure the retention of the filling medium and/or cable compound under operating conditions and exclude the entry of air, dust or moisture. Cable sealing ends and terminal boxes designed for use with fluid or semi-fluid filling media shall have fanged joints, the faces of which shall be machined.

An earthing strip shall be provided on all boxes terminating lead sheathed cables.

The external dimensions, fixing cables and terminal arrangements for all sealing ends and terminal boxes shall be agreed with the Engineer.

Sealing ends and terminal boxes shall be provided with all necessary fittings, including external flexible connections as required. The design of flexible connections shall be to approval.

Drain plugs shall be of ample size to permit the filling medium to be removed. The contact faces of the cable sockets shall be thoroughly cleaned, the lugs shall be placed in the most suitable positions and arranged as required to avoid unnecessary bending of cable cores inside the box. Provision shall be made for earthing the body of the box, and for expansion of the conductors in the box. Provision shall also be made for the expansion of the filling medium and arrangements made to prevent the formation of air spaces when filling.

16.13 Installation of Cable

16.13.1 Cable Tunnels and Trenches with Pits, Ducts and Drains

The Contractor shall design and construct cable tunnels required for connecting 132 kV power cables. Width and height of cable tunnels shall conform to required cable spacing and working spaces. The structure of cable tunnels is reinforced concrete and must be designed enough bearing capacity cause by some parts of cable tunnel are under heavy equipment.

The Contractor shall design and construct all trenches required for the work. The depth of the cable trenches shall be minimum 1.5 meter from the Substation switchyard, finished level and the width shall conform to required cable spacing and working spaces.

The thickness of cable tunnel or trench wall and floor shall be minimum 150mm and should be designed to withstand the subsoil water pressure.

Cables in cable tunnels or trenches shall be laid on cable supports at every ½ (half) meter interval.

Cable trenches shall be covered with concrete trench covers. Trenches will be built with the top edge of the walls 50mm above the finished switchyard level.

The cable tunnels and trenches shall have a suitable bed slope with sufficient number of drainage pits so that water could be drained off naturally as well as by artificial means.

The removable trench covers shall be of recast reinforced concrete adequately designed to safely withstand a load of 2,500 N at the centre of each cover. The trench covers shall be of such size as to facilitate their handling by manual labour.

16.13.2 Supports and Racks

Cable laid supports and racks together with fixing clamps, bolts, nuts and screws for outdoor installations and in outdoor concrete lined trenches shall be of hot dip galvanised steel.

Cable support and rack designs shall be submitted for the written approval of the Engineer before Manufacturer or erection.

The single core cables shall be clamped to the racks with smooth finish split packing pieces or cleats with bores of the correct size for the cable diameters. The cleats shall be of Silicon aluminium, glass filled nylon or other tough non-hygroscopic or non-magnetic material. Wooden cleats are prohibited.

16.13.3 Bonding

The cables shall be installed as an insulated sheath system. Single core cable sheaths may either be solidly bonded (single bonding).

Bonding leads shall be of sufficient cross sectional area to carry the maximum imposed short circuit current level. A schematic diagram detailing the proposed bonding systems and stating bonding leads cross section shall be submitted with the Bid.

16.14 Tests

16.14.1 Type Tests

The cable shall be tested and shall satisfy the most recent relevant IEC publications. The tests need not be carried out again if they can be provided by already existing type tests reports of recognized laboratories. If the cable is not yet type tested, the relevant tests shall be carried out.

16.14.2 Routine/Sample Tests

The cable shall be tested and shall satisfy the most recent relevant IEC Publication.

16.14.3 Tests at Site

After completion of the erection and before commissioning, each cable shall be submitted to the following test:

- Verification of the proper and complete erection of the cable and the terminals.
- Verification of the proper phase displacement.
- Verification of the proper earthing of the sheath.
- DC voltage test.
- AC voltage test.

16.15 Earthing System

The cable sheath for single bonding of cable and cable end termination structures shall be earthed at earthing mat by extending the earthing system.

DRAWINGS FORMING PART OF THE SPECIFICATION

17. Bid Drawings

17.1 General

The drawings provided in this section are solely for the purpose of bid information and bid preparation.

They present the typical details of the project facilities and plant requirements for the following.

I. Extension of the Existing 230/132 kV Substation Rajshahi
II. New 132/33 kV Substation Bangura
III. Extension of the Existing 132/33 kV Substation Baghabari
IV. New 132/33 kV Substation Miithapukur

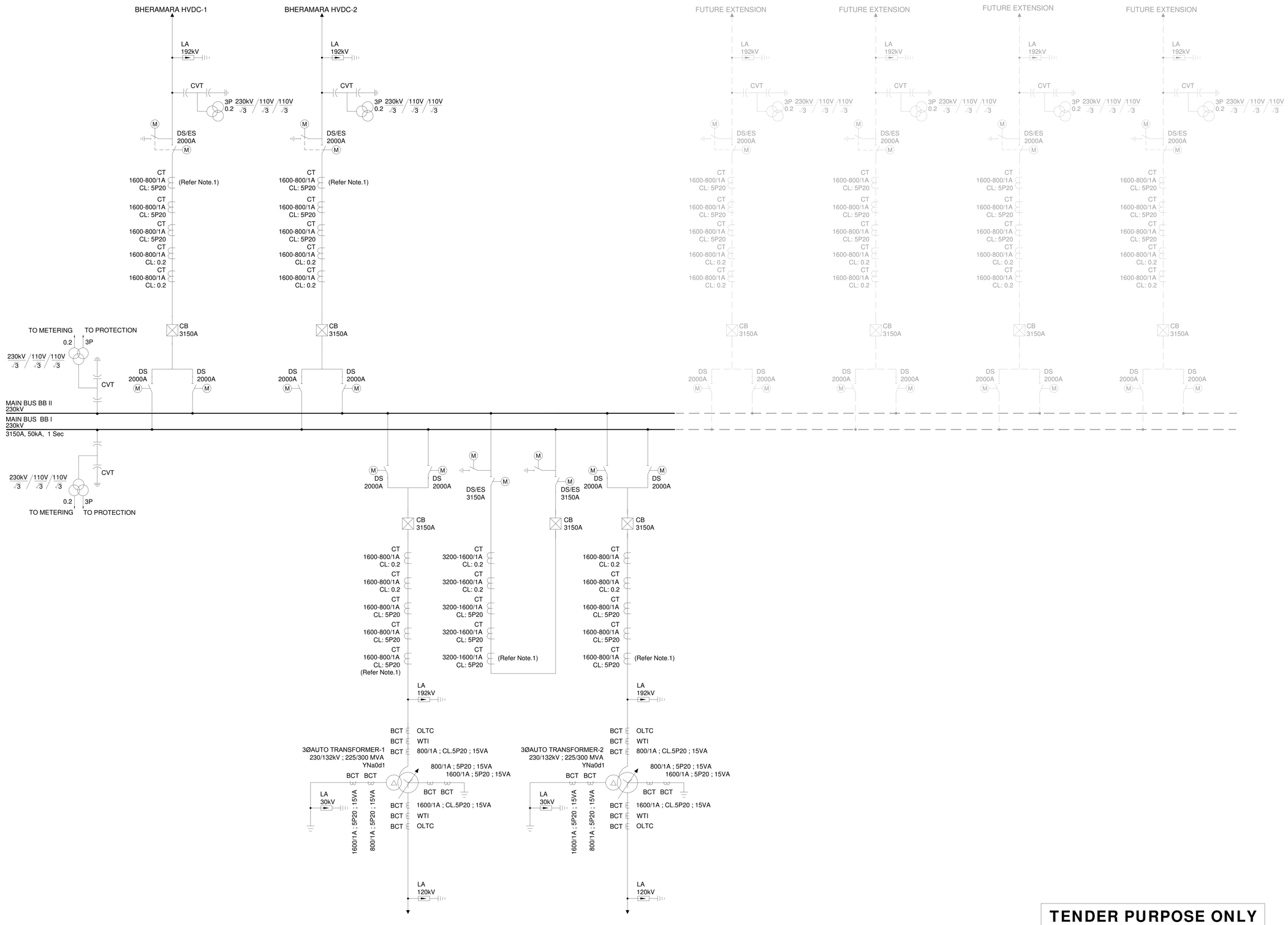
17.2 List of Bid Drawings

No.	Drawing No.	Drawing Title
I		**New 230/132 kV Substation Rajshahi**
1.1	NZSS/1.1	Extension of Existing 230/132 kV Substation Rajshahi - Single Line Diagram
1.2	NZSS/1.2	Extension of Existing 230/132 kV Substation Rajshahi - Substation Layout
1.3	NZSS/1.3	Extension of Existing 230/132 kV Substation Rajshahi - Cross Section 230 kV
1.4	NZSS/1.4	Extension of Existing 230/132 kV Substation Rajshahi - Block Diagram - Line Bay 230 kV
1.5	NZSS/1.5	Extension of Existing 230/132 kV Substation Rajshahi - Block Diagram - Transformer Bay 230/132 kV
1.6	NZSS/1.6	Extension of Existing 230/132 kV Substation Rajshahi - Block Diagram - Bus Coupler Bay 230 kV
II		**New 132/33 kV Substation Bangura**
2.1	NZSS/2.1	New 132/33 kV Substation Bangura - Single Line Diagram
2.2	NZSS/2.2	New 132/33 kV Substation Bangura - Substation Layout
2.3	NZSS/2.3	New 132/33 kV Substation Bangura - Cross Section 132 kV
2.4	NZSS/2.4	New 132/33 kV Substation Bangura - Block Diagram - Line Bay 132 kV
2.5	NZSS/2.5	New 132/33 kV Substation Bangura - Block Diagram - Transformer Bay 132/33 kV
III		**Extension of Existing 132/33 kV Substation Baghabari**
3.1	NZSS/3.1	Extension of Existing 132/33 kV Substation Baghabari - Single Line Diagram
IV		**New 132/33 kV Substation Miithapukur**
4.1	NZSS/4.1	New 132/33 kV Substation Miithapukur - Single Line Diagram
4.2	NZSS/4.2	New 132/33 kV Substation Miithapukur - Substation Layout
4.3	NZSS/4.3	New 132/33 kV Substation Miithapukur - Cross Section 132 kV

No.	Drawing No.	Drawing Title
4.4	NZSS/4.4	New 132/33 kV Substation Miithapukur - Block Diagram - Line Bay 132 kV
4.5	NZSS/4.5	New 132/33 kV Substation Miithapukur - Block Diagram - Transformer Bay 132/33 kV
4.6	NZSS/4.6	New 132/33 kV Substation Miithapukur - Block Diagram - Bus Coupler Bay 132 kV
V-IX		**General Drawings**
5.1	NZSS/5.1	Switchgear 33 kV
6.1	NZSS/6.1	Substation Automation System - Architecture
7.1	NZSS/7.1	LV DC System 110 V & 48 V
7.2	NZSS/7.2	LV AC System 400/230 V & UPS
8.1	NZSS/8.1	Telecommunication System - Architecture
8.2	NZSS/8.2	Telecommunication System - Block Diagram
9.1	NZSS/9.1	Building - Ground Floor
9.2	NZSS/9.2	Building - First Floor - I Version
9.3	NZSS/9.3	Building - First Floor - II Version
9.4	NZSS/9.4	Building - Section I
9.5	NZSS/9.5	Building - Section II
9.6	NZSS/9.6	Property Line, Boundary Line & Security Wall
9.7	NZSS/9.7	Guard House
9.8	NZSS/9.8	Gantry & Cable Trench
9.9	NZSS/9.9	Road

17.3 Drawings

BAY NUMBER	=D01	=D02	=D03	=D04	=D05	=D06	=D07	=D08	=D09
NAME	BHERAMARA HVDC-1	BHERAMARA HVDC-2	TRANSFORMER 1	BUS COPLER	TRANSFORMER 2	FUTURE EXTENSION	FUTURE EXTENSION	FUTURE EXTENSION	FUTURE EXTENSION



NOTES:-

1. CHARACTERISTICS OF CURRENT TRANSFORMERS ARE PRELIMINARY. FINAL CHARACTERISTICS SHALL BE DEFINE DURING DESIGN STAGE.
2. ALL BUSHING SHALL BE EQUIPPED WITH CURRENT TRANSFORMERS, WITH THREE CORES, FOR PROTECTION, WTI,... CHARACTERISTICS ARE ONLY PRELIMINARY AND FINAL CHARACTERISTICS SHALL BE DEFINED DURING DESIGN STAGE.

LEGEND:-

SYMBOL	DESCRIPTION
	DISCONNECTOR SWITCH , MOTOR OPERATED
	DISCONNECTOR WITH EARTH SWITCH, MOTOR OPERATED
	CIRCUIT BREAKER
	CURRENT TRANSFORMER
	LIGHTNING ARRESTOR
	AUTO TRANSFORMER
	CAPACITIVE VOLTAGE TRANSFORMER

TENDER PURPOSE ONLY

Purpose of Issue:	Rev	Date	Drawn	Approved
FOR TENDER	0	03/03/2016	MBB	VBC

EMPLOYER:

পাওয়ার গ্রীড কোম্পানী অব বাংলাদেশ লিঃ
POWER GRID COMPANY OF BANGLADESH LTD.
(An Enterprise of Bangladesh Power Development Board)

ENGINEER:

intec
GOFA International Energy Consultants

PROJECT:

DESIGN, SUPPLY, INSTALLATION, TESTING & COMMISSIONING OF 230/132kV AND 132/33kV SUBSTATIONS, NORTHERN ZONE

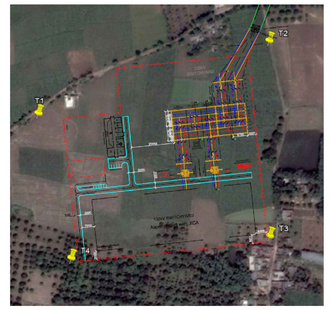
DRAWING TITLE:

EXTENSION OF EXISTING 230/132 kV SUBSTATION RAJSHAHI
SINGLE LINE DIAGRAM

Scale:	Drawn:	Checked:	Approved	Size:
NTS	MBB	BKP	VBC	A0

DRAWING NUMBER: PGCB/KfW/2012.66.436/SSNZ/1.1 — Rev: 0

KEY PLAN:-



NOTES:-

1. DRAWING IS PRELIMINARY, GENERAL AND FOR TENDER PURPOSE ONLY
2. CONTRACTOR SHALL PREPARE THE DRAWINGS FOR TENDER REALIZATION.
3. DIMENSIONS AT THE DRAWINGS ARE MINIMUM, PRELIMINARY AND GENERAL. CONTRACTOR IS OBLIGED TO PERFORM DETAIL CALCULATION AND TO TAKE CARE ABOUT THE CLEARANCE, HEIGHT AND WIDTH AS WELL AS FUNCTIONAL PERFORMANCE.
4. LIGHTNING PROTECTION AND EARTHING SYSTEM IS NOT SHOWN AT THE DRAWINGS AND CONTRACTOR IS OBLIGED TO PERFORM DETAIL CALCULATION AND TO TAKE CARE ABOUT THE LIGHTNING PROTECTION AND EARTHING.
5. CIVIL FACILITIES, GANTRIES AND SWITCHYARD FOUNDATIONS ARE SHOWN GENERALLY, CABLES TRENCHES, RAINWATER PIPES ETC ARE NOT SHOWN AT ALL.
6. THE CONTRACTOR'S RESPONSIBILITY IS TO PROVIDE THAT ALL PARTS OF THE WORKS TO BE COMPLETED IN EVERY RESPECT FOR OPERATION.
7. ALL DETAILS REQUIRED FOR THE COMPLETE INSTALLATION AND SATISFACTORY OPERATION OF THE WORKS ARE DEEMED TO BE INCLUDED IN THE CONTRACT PRICE.
8. THE CONTRACTOR RESPONSIBLE FOR ENSURING THAT ALL AND/OR ANY ITEM(S) OF WORK REQUIRED FOR THE SAFE, EFFICIENT AND SATISFACTORY COMPLETION AND FUNCTIONING OF THE WORKS, ARE INCLUDED IN THE BID PRICE.
9. RAJSHAHI SUBSTATION 230/132kV IS EXTENSION OF EXISTING RAJSHAHI SUBSTATION 132/33 kV. BOUNDARY WALL IS NOT IN THE SCOPE OF WORKS. LAND DEVELOPMENT, FOR 230kV PART OF SUBSTATION IS IN THE SCOPE OF WORKS.

FOR TENDER	0	29/02/2016	MBB	VBC
Purpose of Issue:	Rev	Date	Drawn	Approved

EMPLOYER:

পাওয়ার গ্রীড কোম্পানী অব বাংলাদেশ লিঃ
POWER GRID COMPANY OF BANGLADESH LTD.
(An Enterprise of Bangladesh Power Development Board)

ENGINEER:

intec
GOPA International Energy Consultants

PROJECT:

DESIGN, SUPPLY, INSTALLATION,
TESTING & COMMISSIONING OF
230/132kV AND 132/33kV SUBSTATIONS, NORTHERN ZONE

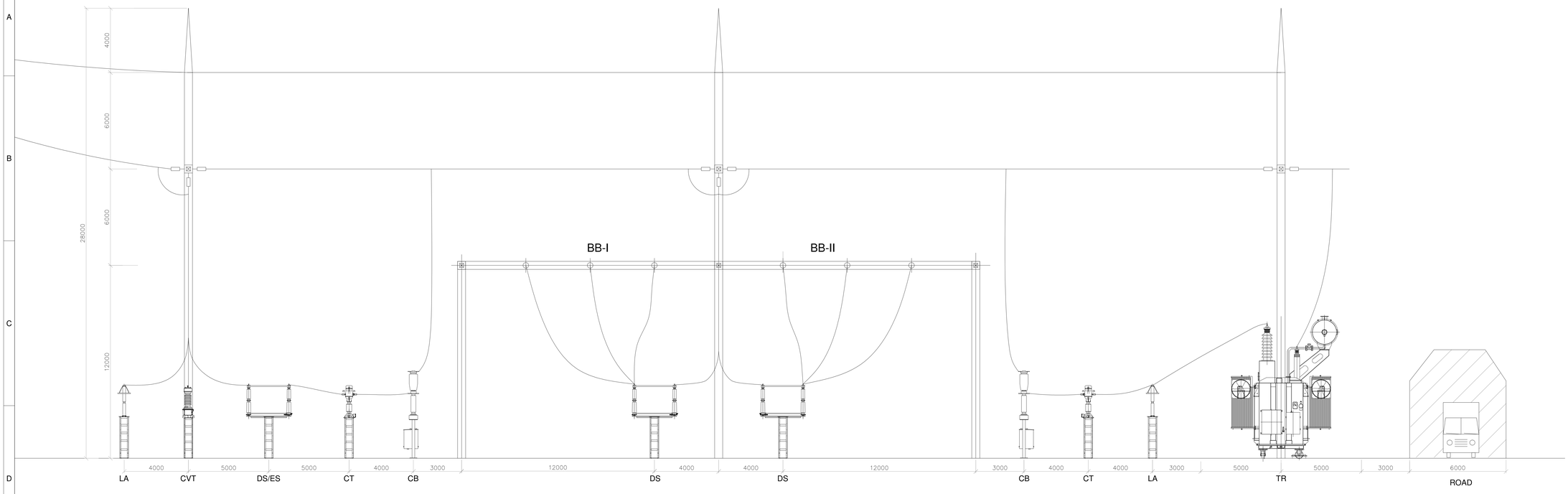
DRAWING TITLE:

EXTENSION OF EXISTING 230/132 kV SUBSTATION RAJSHAHI PLAN

Scale:	Drawn:	Checked:	Approved	Size:
1:250	MBB	BKP	VBC	A0

DRAWING NUMBER: PGCB/KfW/2012.66.436/SSNZ/1.2

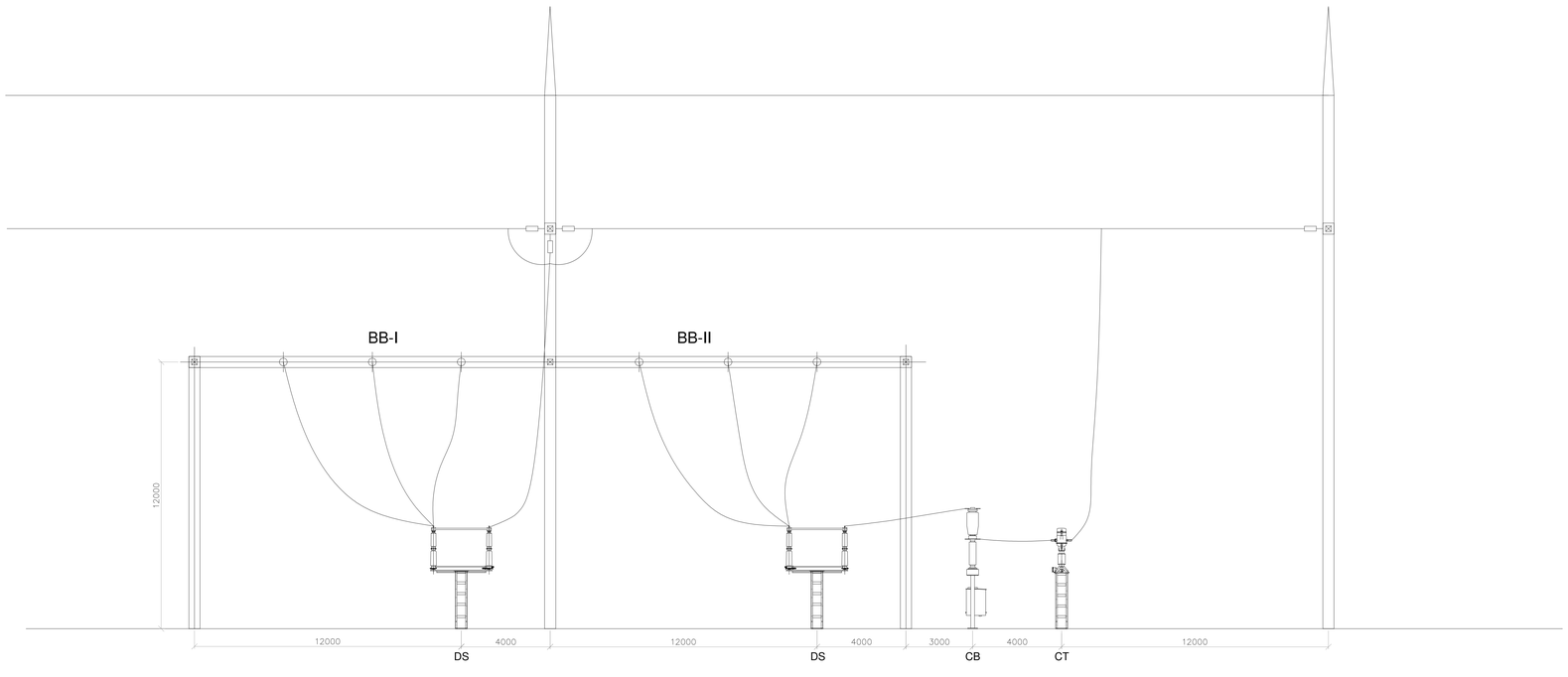
Rev: 0



230kV LINE BAY

230/132kV TRANSFORMER BAY

SECTION A-A'



230kV COUPLING BAY

SECTION B-B'

NOTES:-

1. DRAWING IS PRELIMINARY, GENERAL AND FOR TENDER PURPOSE ONLY
2. CONTRACTOR SHALL PREPARE THE DRAWINGS FOR TENDER REALIZATION.
3. DIMENSIONS AT THE DRAWINGS ARE MINIMUM, PRELIMINARY AND GENERAL. CONTRACTOR IS OBLIGED TO PERFORM DETAIL CALCULATION AND TO TAKE CARE ABOUT THE CLEARANCE, HEIGHT AND WIDTH AS WELL AS FUNCTIONAL PERFORMANCE.
4. LIGHTNING PROTECTION AND EARTHING SYSTEM IS NOT SHOWN AT THE DRAWINGS AND CONTRACTOR IS OBLIGED TO PERFORM DETAIL CALCULATION AND TO TAKE CARE ABOUT THE LIGHTNING PROTECTION AND EARTHING.
5. CIVIL FACILITIES, GANTRIES AND SWITCHYARD FOUNDATIONS ARE SHOWN GENERALLY, CABLES TRENCHES, RAINWATER PIPES ETC ARE NOT SHOWN AT ALL.
6. THE CONTRACTOR'S RESPONSIBILITY IS TO PROVIDE THAT ALL PARTS OF THE WORKS TO BE COMPLETED IN EVERY RESPECT FOR OPERATION.
7. ALL DETAILS REQUIRED FOR THE COMPLETE INSTALLATION AND SATISFACTORY OPERATION OF THE WORKS ARE DEEMED TO BE INCLUDED IN THE CONTRACT PRICE.
8. THE CONTRACTOR RESPONSIBLE FOR ENSURING THAT ALL AND/OR ANY ITEM(S) OF WORK REQUIRED FOR THE SAFE, EFFICIENT AND SATISFACTORY COMPLETION AND FUNCTIONING OF THE WORKS, ARE INCLUDED IN THE BID PRICE.
9. RAJSHAHI SUBSTATION 230/132kV IS EXTENSION OF EXISTING RAJSHAHI SUBSTATION 132/33 kV. BOUNDARY WALL IS NOT IN THE SCOPE OF WORKS. LAND DEVELOPMENT, FOR 230kV PART OF SUBSTATION IS IN THE SCOPE OF WORKS.

FOR TENDER	0	29/02/2016	MBB	VBC
Purpose of Issue:	Rev	Date	Drawn	Approved

EMPLOYER:

পাওয়ার গ্রীড কোম্পানী অব বাংলাদেশ লিঃ
POWER GRID COMPANY OF BANGLADESH LTD.
(An Enterprise of Bangladesh Power Development Board)

ENGINEER:

intec
GOPA International Energy Consultants

PROJECT:

DESIGN, SUPPLY, INSTALLATION, TESTING & COMMISSIONING OF 230/132kV AND 132/33kV SUBSTATIONS, NORTHERN ZONE

DRAWING TITLE:

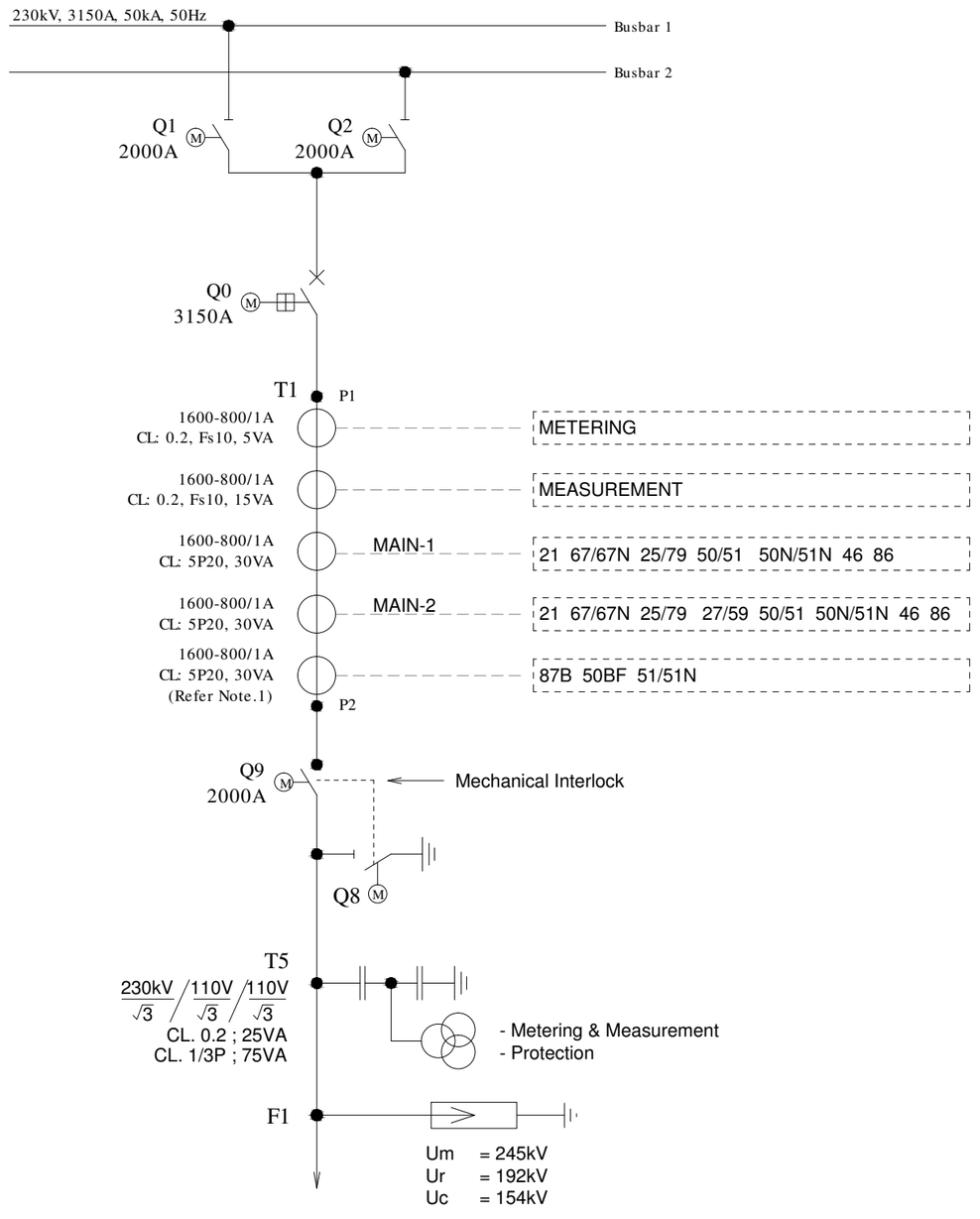
EXTENSION OF EXISTING 230/132 kV SUBSTATION RAJSHAHI
CROSS SECTIONS

Scale:	Drawn:	Checked:	Approved	Size:
1:100	MBB	BKP	VBC	A0

DRAWING NUMBER: PGCB/KfW/2012.66.436/SSNZ/1.3

Rev: 0

TENDER PURPOSE ONLY



LEGENDS :-

Symbols	Description
Q1, Q2	Disconnectors
Q0	Circuit Breaker
Q8/Q9	Disconnector with Earth Switch
T1	Current Transformer
T5	Voltage Transformer
F1	Surge Arrester

NOTES:-

1. CHARACTERISTICS OF CURRENT TRANSFORMERS ARE PRELIMINARY. FINAL CHARACTERISTICS SHALL BE DEFINE DURING DESIGN STAGE.

TENDER PURPOSE ONLY

FOR TENDER	0	03/03/2016	MBB	VBC
Purpose of Issue:	Rev	Date	Drawn	Approved

EMPLOYER:

পাওয়ার গ্রীড কোম্পানী অব বাংলাদেশ লিঃ
POWER GRID COMPANY OF BANGLADESH LTD.
(An Enterprise of Bangladesh Power Development Board)

ENGINEER:

intec
GOPA International Energy Consultants

PROJECT:

DESIGN, SUPPLY, INSTALLATION, TESTING & COMMISSIONING OF 230/132kV AND 132/33kV SUBSTATIONS, NORTHERN ZONE

DRAWING TITLE:

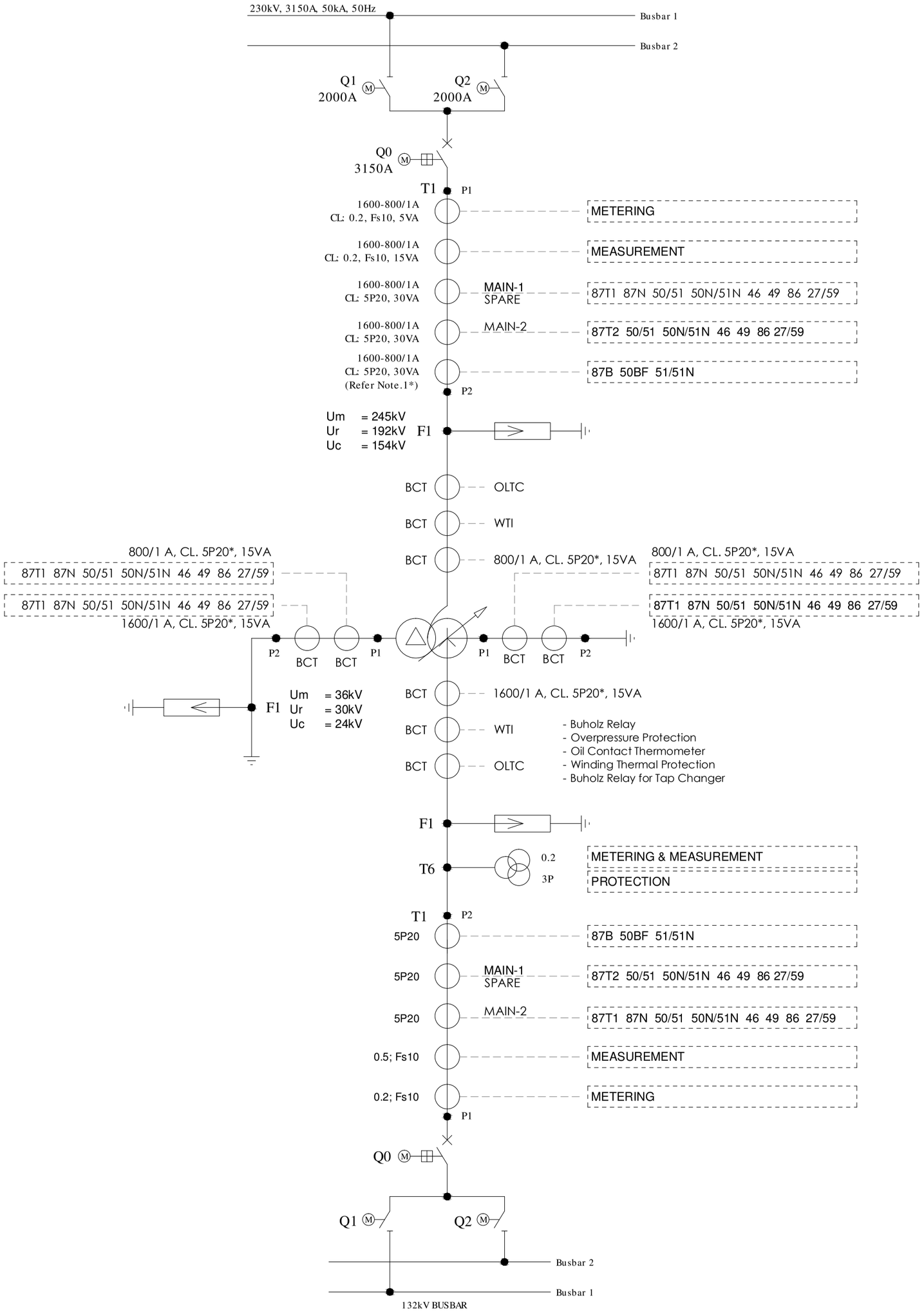
EXTENSION OF EXISTING 230/132 kV SUBSTATION RAJSHAHI
BLOCK DIAGRAM - LINE BAY 230kV

Scale:	Drawn:	Checked:	Approved	Size:
NTS	MBB	BKP	VBC	A3

DRAWING NUMBER:

PGCB/KfW/2012.66.436/SSNZ/1.4

Rev: 0



LEGENDS :-

Symbols	Description
Q1, Q2, Q4, Q7	Disconnectors
Q0, Q3	Circuit Breaker
T1, T2, T3, T11, T31, T32	Current Transformer
F1	Surge Arrester
T6, T7	Voltage Transformer

NOTES:-

1. CHARACTERISTICS OF CURRENT TRANSFORMERS ARE PRELIMINARY. FINAL CHARACTERISTICS SHALL BE DEFINE DURING DESIGN STAGE.
2. ALL BUSHING SHALL BE EQUIPPED WITH CURRENT TRANSFORMERS, WITH THREE CORES, FOR PROTECTION, WTI,... CHARACTERISTICS ARE ONLY PRELIMINARY AND FINAL CHARACTERISTICS SHALL BE DEFINED DURING DESIGN STAGE.

TENDER PURPOSE ONLY

Rev	Date	Drawn	Approved
0	03/03/2016	MBB	VBC

Purpose of Issue: FOR TENDER

EMPLOYER: POWER GRID COMPANY OF BANGLADESH LTD. (An Enterprise of Bangladesh Power Development Board)

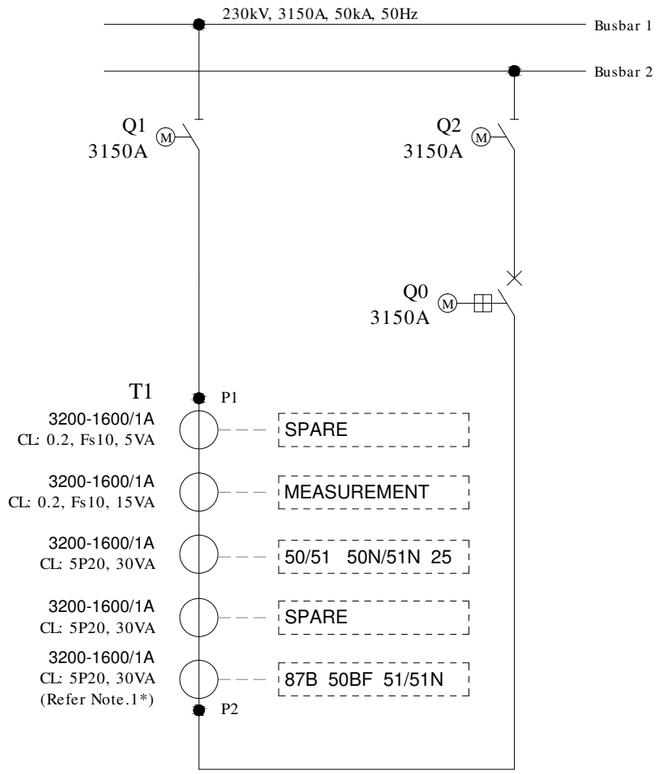
ENGINEER: intec (Consolidated Energy Consultants)

PROJECT: DESIGN, SUPPLY, INSTALLATION, TESTING & COMMISSIONING OF 230/132kV AND 132/33kV SUBSTATIONS, NORTHERN ZONE

DRAWING TITLE: EXTENSION OF EXISTING 230/132 kV SUBSTATION RAJSHAHI
BLOCK DIAGRAM - TRANSFORMER BAY 230kV

Scale:	Drawn:	Checked:	Approved	Size:
NTS	MBB	BKP	VBC	A3

DRAWING NUMBER: PGCB/KfW/2012.66.436/SSNZ/1.5 Rev: 0



LEGENDS :-

Symbols	Description
Q1, Q2	Disconnectors
Q0	Circuit Breaker
T1	Current Transformer

NOTES:-

1. CHARACTERISTICS OF CURRENT TRANSFORMERS ARE PRELIMINARY. FINAL CHARACTERISTICS SHALL BE DEFINE DURING DESIGN STAGE.

TENDER PURPOSE ONLY

Purpose of Issue:	Rev	Date	Drawn	Approved
FOR TENDER	0	03/03/2016	MBB	VBC

EMPLOYER:

পাওয়ার গ্রীড কোম্পানী অব বাংলাদেশ লিঃ
POWER GRID COMPANY OF BANGLADESH LTD.
(An Enterprise of Bangladesh Power Development Board)

ENGINEER:

intec
GOPA International Energy Consultants

PROJECT:

DESIGN, SUPPLY, INSTALLATION,
TESTING & COMMISSIONING OF
230/132kV AND 132/33kV SUBSTATIONS, NORTHERN ZONE

DRAWING TITLE:

EXTENSION OF EXISTING 230/132 kV SUBSTATION RAJSHAHI
BLOCK DIAGRAM - BUS COUPLER BAY 230kV

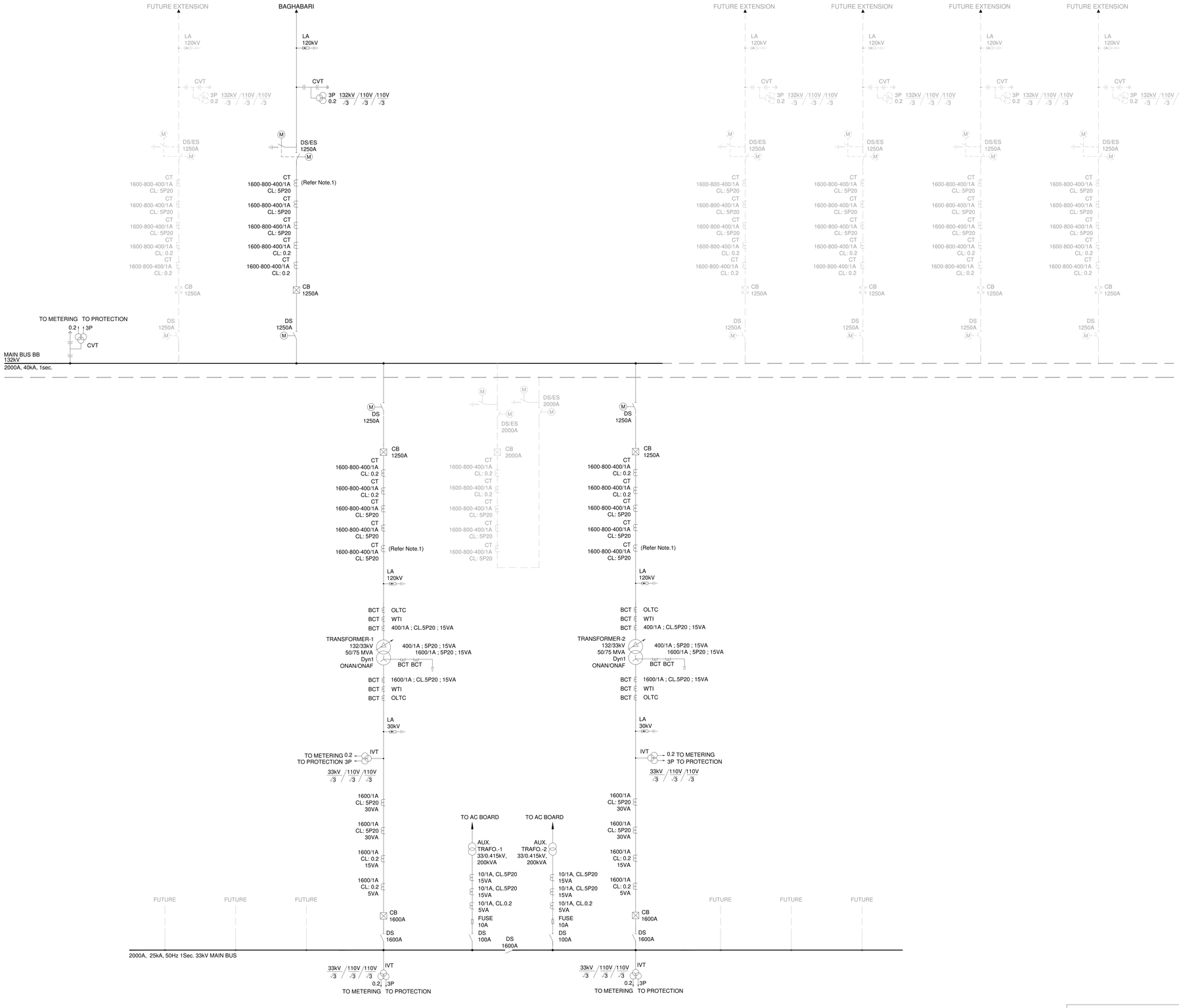
Scale:	Drawn:	Checked:	Approved	Size:
NTS	MBB	BKP	VBC	A3

DRAWING NUMBER:

PGCB/KfW/2012.66.436/SSNZ/1.6

Rev: 0

BAY NUMBER	=E01	=E02	=E03	=E04	=E05	=E06	=E07	=E08	=E09
NAME	FUTURE EXTENSION	BAGHABARI	TRANSFORMER 1	FUTURE BUS COUPLER	TRANSFORMER 2	FUTURE EXTENSION	FUTURE EXTENSION	FUTURE EXTENSION	FUTURE EXTENSION



LEGEND:-

SYMBOL	DESCRIPTION
	DISCONNECTOR SWITCH, MOTOR OPERATED
	DISCONNECTOR WITH EARTH SWITCH, MOTOR OPERATED
	CIRCUIT BREAKER
	POWER TRANSFORMER
	AUX. TRANSFORMER
	CURRENT TRANSFORMER
	CAPACITIVE VOLTAGE TRANSFORMER
	INDUCTIVE VOLTAGE TRANSFORMER (IVT)
	LIGHTNING ARRESTOR
	DISCONNECTOR SWITCH & FUSE
	DISCONNECTOR SWITCH

NOTES:-

1. CHARACTERISTICS OF CURRENT TRANSFORMERS ARE PRELIMINARY. FINAL CHARACTERISTICS SHALL BE DEFINE DURING DESIGN STAGE.
2. ALL BUSHING SHALL BE EQUIPPED WITH CURRENT TRANSFORMERS, WITH THREE CORES, FOR PROTECTION, WTI,... CHARACTERISTICS ARE ONLY PRELIMINARY AND FINAL CHARACTERISTICS SHALL BE DEFINED DURING DESIGN STAGE.

FOR TENDER	0	06/03/2016	MBB	VBC
Purpose of Issue:	Rev	Date	Drawn	Approved

EMPLOYER:

পাওয়ার গ্রীড কোম্পানী অব বাংলাদেশ লিঃ
POWER GRID COMPANY OF BANGLADESH LTD.
(An Enterprise of Bangladesh Power Development Board)

ENGINEER:

intec
GOPA International Energy Consultants

PROJECT:

DESIGN, SUPPLY, INSTALLATION, TESTING & COMMISSIONING OF 230/132kV AND 132/33kV SUBSTATIONS, NORTHERN ZONE

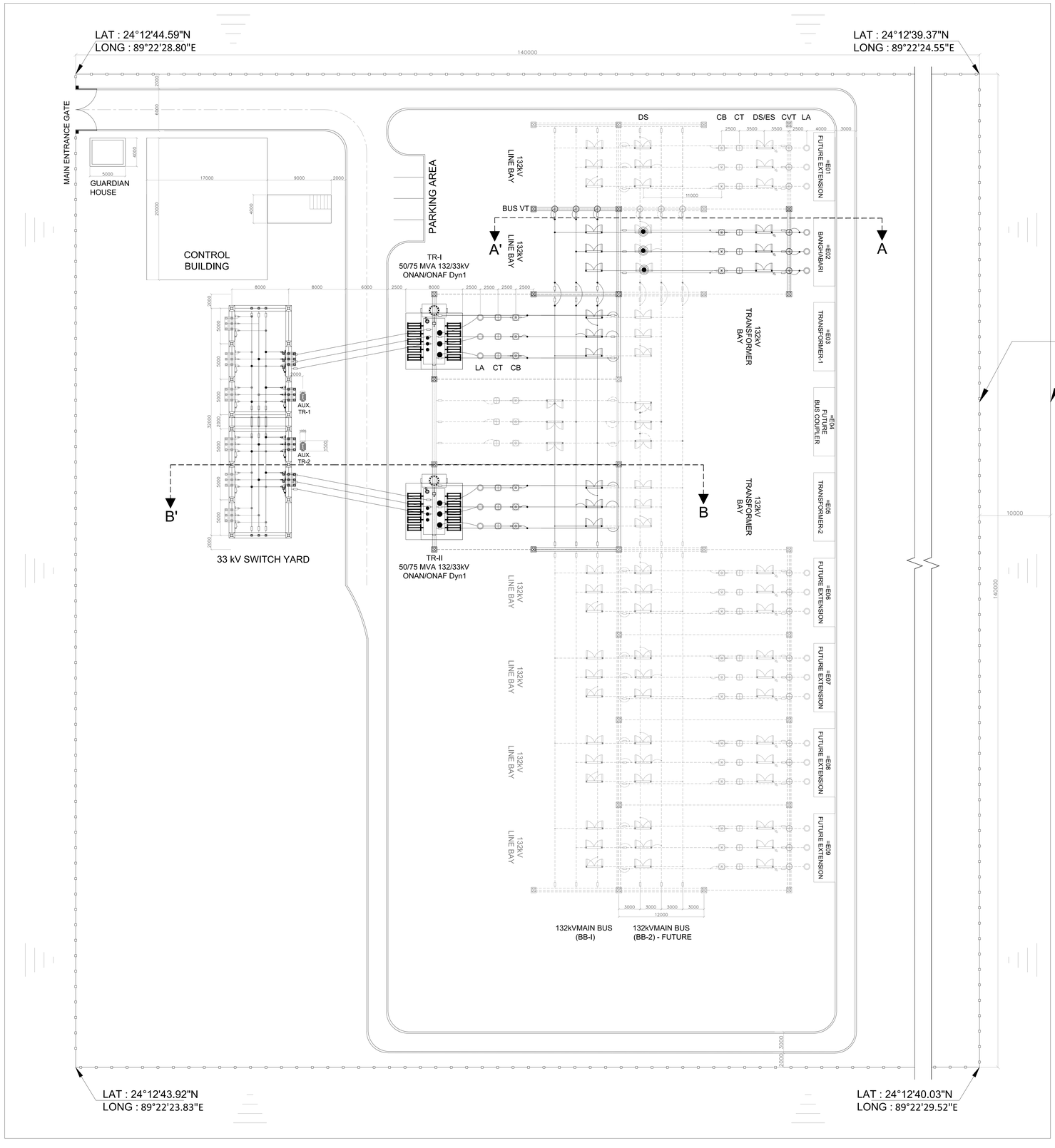
DRAWING TITLE:

NEW 132/33 kV SUBSTATION BANGURA
SINGLE LINE DIAGRAM

Scale:	Drawn:	Checked:	Approved	Size:
NTS	MBB	BKP	VBC	A0

DRAWING NUMBER: PGCB/KfW/2012.66.436/SSNZ/2.1 — Rev: 0

TENDER PURPOSE ONLY



KEY PLAN:-

NOTES:-

1. DRAWING IS PRELIMINARY, GENERAL AND FOR TENDER PURPOSE ONLY
2. CONTRACTOR SHALL PREPARE THE DRAWINGS FOR TENDER REALIZATION.
3. DIMENSIONS AT THE DRAWINGS ARE MINIMUM, PRELIMINARY AND GENERAL. CONTRACTOR IS OBLIGED TO PERFORM DETAIL CALCULATION AND TO TAKE CARE ABOUT THE CLEARANCE, HEIGHT AND WIDTH AS WELL AS FUNCTIONAL PERFORMANCE.
4. LIGHTNING PROTECTION AND EARTHING SYSTEM IS NOT SHOWN AT THE DRAWINGS AND CONTRACTOR IS OBLIGED TO PERFORM DETAIL CALCULATION AND TO TAKE CARE ABOUT THE LIGHTNING PROTECTION AND EARTHING.
5. CIVIL FACILITIES BUILDINGS, FENCES AND GATES, ROADS, GANTRIES AND SWITCHYARD FOUNDATIONS ARE SHOWN GENERALLY, CABLES TRENCHES, RAINWATER PIPES ETC ARE NOT SHOWN AT ALL.
6. THE CONTRACTOR'S RESPONSIBILITY IS TO PROVIDE THAT ALL PARTS OF THE WORKS TO BE COMPLETED IN EVERY RESPECT FOR OPERATION.
7. ALL DETAILS REQUIRED FOR THE COMPLETE INSTALLATION AND SATISFACTORY OPERATION OF THE WORKS ARE DEEMED TO BE INCLUDED IN THE CONTRACT PRICE.
8. THE CONTRACTOR RESPONSIBLE FOR ENSURING THAT ALL AND/OR ANY ITEM(S) OF WORK REQUIRED FOR THE SAFE, EFFICIENT AND SATISFACTORY COMPLETION AND FUNCTIONING OF THE WORKS, ARE INCLUDED IN THE BID PRICE.
9. CO-ORDINATES, WHICH ARE PRESENTED AT THE DRAWING AS CORNERS OF THE BOUNDARY LINE, ARE APPROXIMATE, FOR TENDER PURPOSE ONLY. FINAL CO-ORDINATES WILL BE DEFINED LATER. PROPERTY LINE IS APPROXIMATE ALSO. BETWEEN THE PROPERTY AND BOUNDARY LINE WILL BE A SLOPE. LAND DEVELOPMENT FOR COMPLETE AREA IS IN THE SCOPE OF WORKS.

FOR TENDER	0	06/03/2016	MBB	VBC
Purpose of Issue:	Rev	Date	Drawn	Approved

EMPLOYER:

পাওয়ার গ্রীড কোম্পানী অব বাংলাদেশ লিঃ
POWER GRID COMPANY OF BANGLADESH LTD.
(An Enterprise of Bangladesh Power Development Board)

ENGINEER:

intec
GOPA International Energy Consultants

PROJECT:

DESIGN, SUPPLY, INSTALLATION, TESTING & COMMISSIONING OF 230/132kV AND 132/33kV SUBSTATIONS, NORTHERN ZONE

DRAWING TITLE:

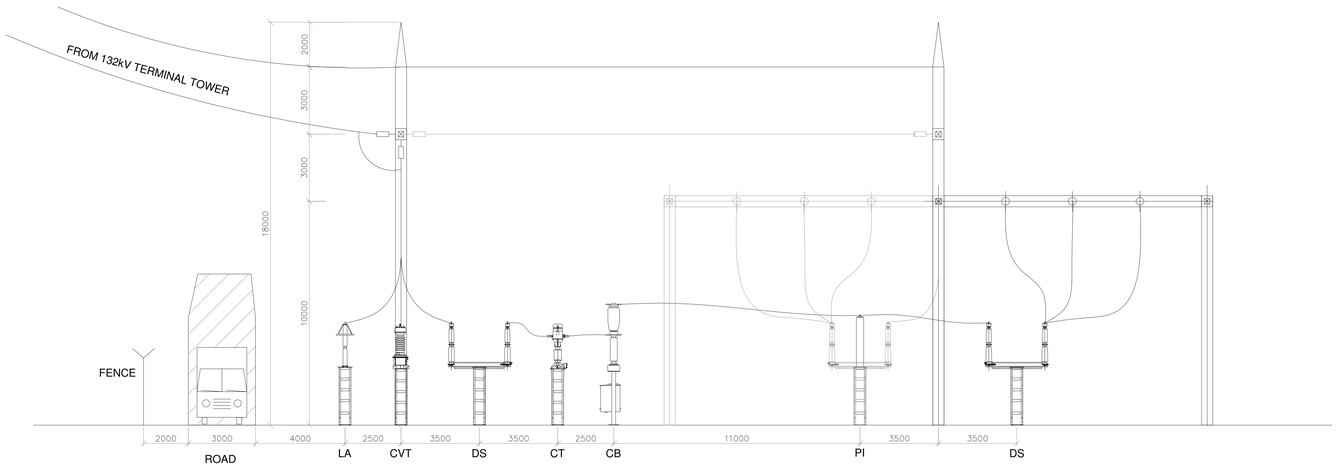
NEW 132/33 kV SUBSTATION BANGURA
PLAN

Scale:	Drawn:	Checked:	Approved	Size:
1:225	MBB	BKP	VBC	A0

DRAWING NUMBER: PGCB/KfW/2012.66.436/SSNZ/2.2

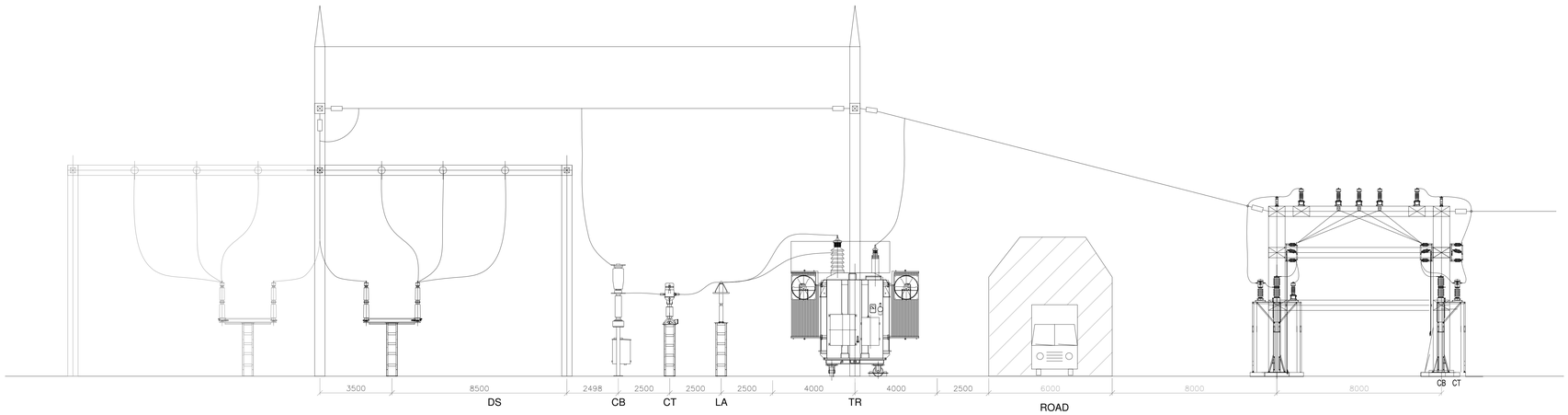
Rev: 0

TENDER PURPOSE ONLY



132kV LINE BAY

SECTION A-A'



132kV TRANSFORMER BAY

SECTION B-B'

NOTES:-

1. DRAWING IS PRELIMINARY, GENERAL AND FOR TENDER PURPOSE ONLY
2. CONTRACTOR SHALL PREPARE THE DRAWINGS FOR TENDER REALIZATION.
3. DIMENSIONS AT THE DRAWINGS ARE MINIMUM, PRELIMINARY AND GENERAL. CONTRACTOR IS OBLIGED TO PERFORM DETAIL CALCULATION AND TO TAKE CARE ABOUT THE CLEARANCE, HEIGHT AND WIDTH AS WELL AS FUNCTIONAL PERFORMANCE.
4. LIGHTNING PROTECTION AND EARTHING SYSTEM IS NOT SHOWN AT THE DRAWINGS AND CONTRACTOR IS OBLIGED TO PERFORM DETAIL CALCULATION AND TO TAKE CARE ABOUT THE LIGHTNING PROTECTION AND EARTHING.
5. CIVIL FACILITIES BUILDINGS, FENCES AND GATES, ROADS, GANTRIES AND SWITCHYARD FOUNDATIONS ARE SHOWN GENERALLY. CABLES TRENCHES, RAINWATER PIPES ETC ARE NOT SHOWN AT ALL.
6. THE CONTRACTOR'S RESPONSIBILITY IS TO PROVIDE THAT ALL PARTS OF THE WORKS TO BE COMPLETED IN EVERY RESPECT FOR OPERATION.
7. ALL DETAILS REQUIRED FOR THE COMPLETE INSTALLATION AND SATISFACTORY OPERATION OF THE WORKS ARE DEEMED TO BE INCLUDED IN THE CONTRACT PRICE.
8. THE CONTRACTOR RESPONSIBLE FOR ENSURING THAT ALL AND/OR ANY ITEM(S) OF WORK REQUIRED FOR THE SAFE, EFFICIENT AND SATISFACTORY COMPLETION AND FUNCTIONING OF THE WORKS, ARE INCLUDED IN THE BID PRICE.
9. CO-ORDINATES, WHICH ARE PRESENTED AT THE DRAWING AS CORNERS OF THE BOUNDARY LINE, ARE APPROXIMATE, FOR TENDER PURPOSE ONLY. FINAL CO-ORDINATES WILL BE DEFINED LATER. PROPERTY LINE IS APPROXIMATE ALSO. BETWEEN THE PROPERTY AND BOUNDARY LINE WILL BE A SLOPE. LAND DEVELOPMENT FOR COMPLETE AREA IS IN THE SCOPE OF WORKS.

TENDER PURPOSE ONLY

FOR TENDER	0	06/03/2016	MBB	VBC
Purpose of Issue:	Rev	Date	Drawn	Approved

EMPLOYER:

পাওয়ার গ্রীড কোম্পানী অব বাংলাদেশ লিঃ
POWER GRID COMPANY OF BANGLADESH LTD.
(An Enterprise of Bangladesh Power Development Board)

ENGINEER:

intec
GOPA International Energy Consultants

PROJECT:

DESIGN, SUPPLY, INSTALLATION,
TESTING & COMMISSIONING OF
230/132kV AND 132/33kV SUBSTATIONS, NORTHERN ZONE

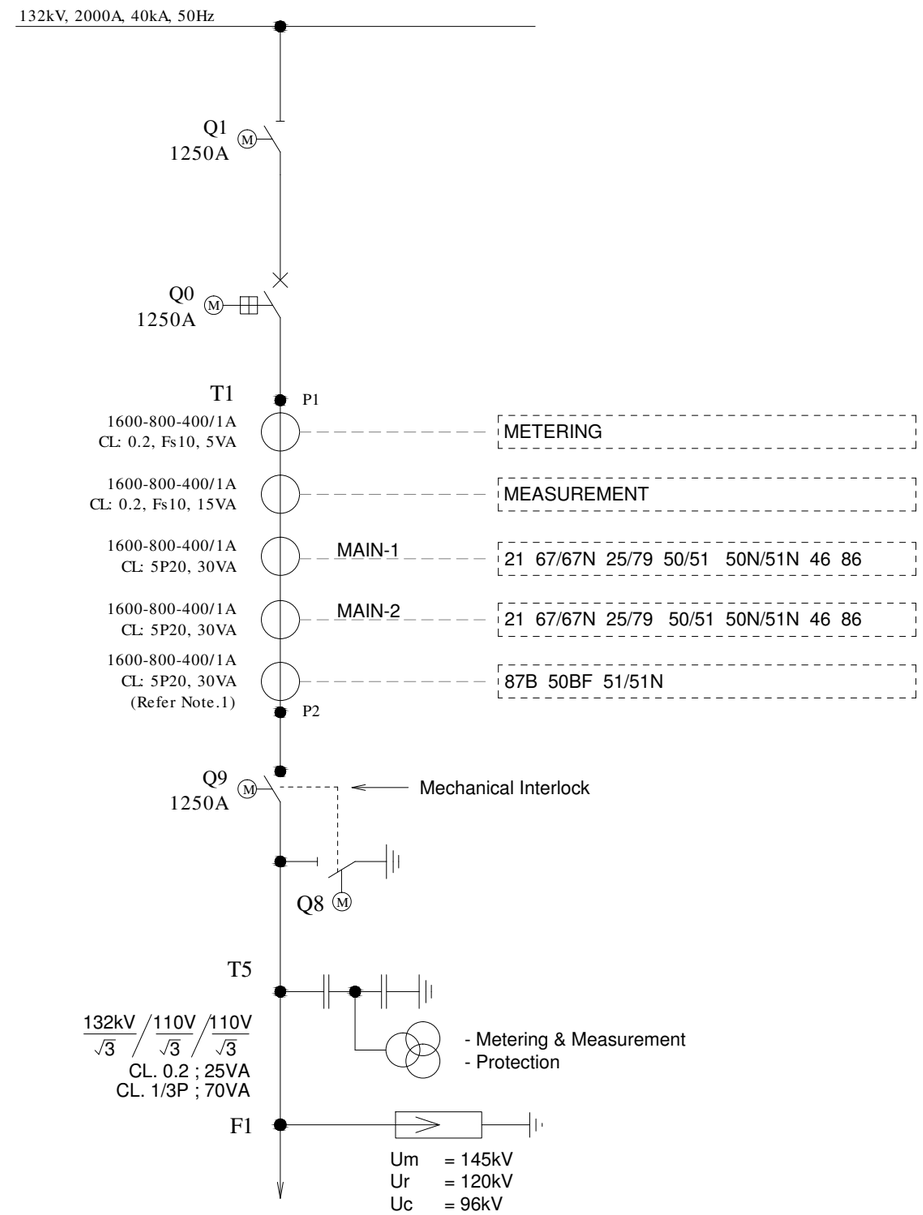
DRAWING TITLE:

NEW 132/33 kV SUBSTATION BANGURA
CROSS SECTIONS

Scale:	Drawn:	Checked:	Approved	Size:
1:100	MBB	BKP	VBC	A0

DRAWING NUMBER: PGCB/KfW/2012.66.436/SSNZ/2.3

Rev: 0



LEGENDS :-

Symbols	Description
Q1	Disconnectors
Q0	Circuit Breaker
Q8/Q9	Disconnector with Earth Switch
T1	Current Transformer
T5	Voltage Transformer
F1	Surge Arrester

NOTES:-

1. CHARACTERISTICS OF CURRENT TRANSFORMERS ARE PRELIMINARY. FINAL CHARACTERISTICS SHALL BE DEFINE DURING DESIGN STAGE.

TENDER PURPOSE ONLY

Purpose of Issue:	Rev	Date	Drawn	Approved
FOR TENDER	0	06/03/2016	MBB	VBC

EMPLOYER:

পাওয়ার গ্রীড কোম্পানী অব বাংলাদেশ লিঃ
POWER GRID COMPANY OF BANGLADESH LTD.
(An Enterprise of Bangladesh Power Development Board)

ENGINEER:

intec
GOPA International Energy Consultants

PROJECT:

DESIGN, SUPPLY, INSTALLATION, TESTING & COMMISSIONING OF 230/132kV AND 132/33kV SUBSTATIONS, NORTHERN ZONE

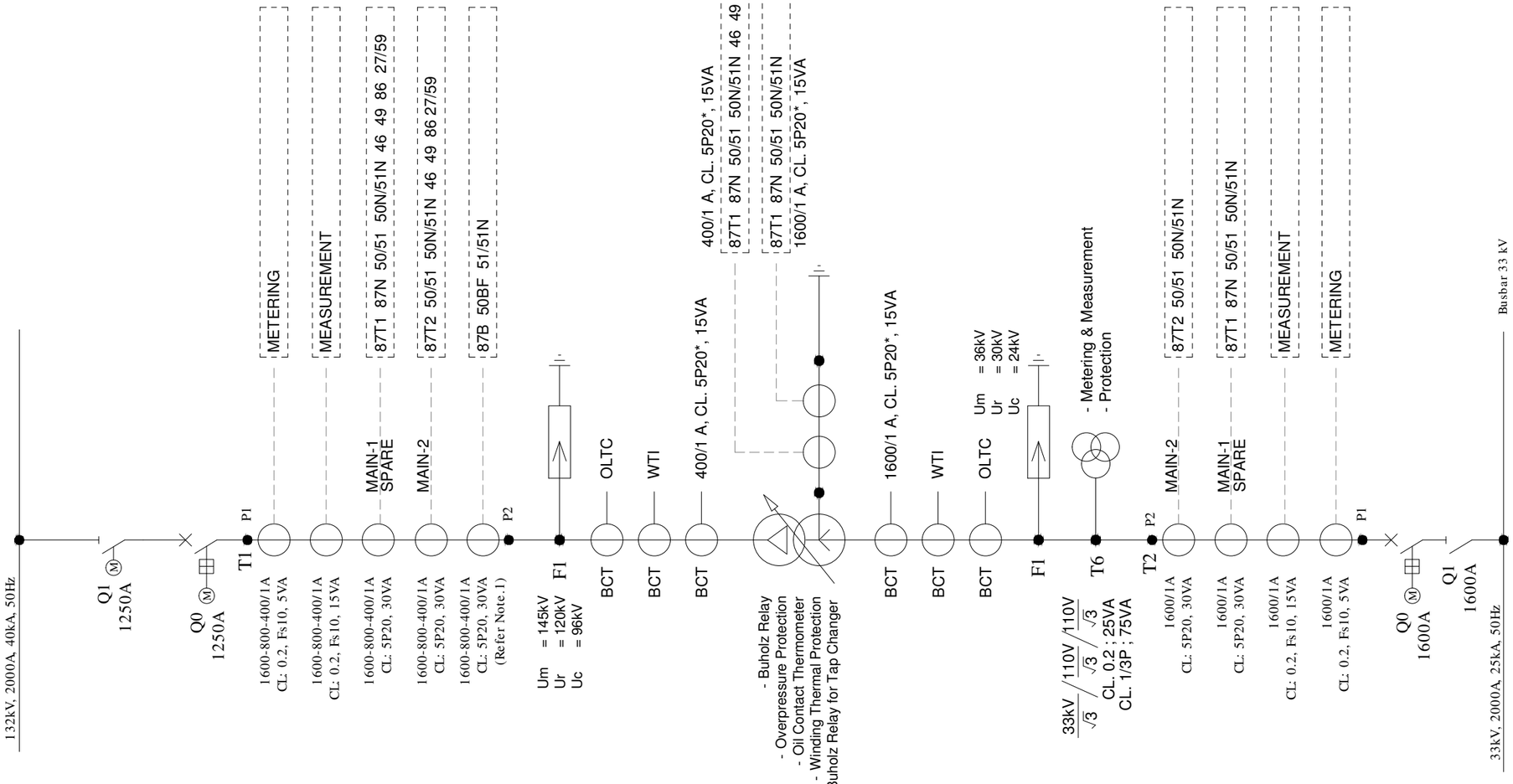
DRAWING TITLE:

NEW 132/33 kV SUBSTATION BANGURA
BLOCK DIAGRAM - LINE BAY 132kV

Scale:	Drawn:	Checked:	Approved	Size:
NTS	MBB	BKP	VBC	A3

DRAWING NUMBER: PGCB/KfW/2012.66.436/SSNZ/2.4

Rev: 0



TENDER PURPOSE ONLY

LEGENDS :-

Symbols	Description
Q1, Q7	Disconnectors
Q0	Circuit Breaker
T1, T2	Current Transformer
F1	Surge Arrester
T6	Voltage Transformer

NOTES:-

1. CHARACTERISTICS OF CURRENT TRANSFORMERS ARE PRELIMINARY. FINAL CHARACTERISTICS SHALL BE DEFINE DURING DESIGN STAGE.

2. ALL BUSHING SHALL BE EQUIPPED WITH CURRENT TRANSFORMERS, WITH THREE CORES, FOR PROTECTION, WTI,... CHARACTERISTICS ARE ONLY PRELIMINARY AND FINAL CHARACTERISTICS SHALL BE DEFINED DURING DESIGN STAGE.

FOR TENDER	0	06/03/2016	MBB	VBC
Purpose of Issue:	Rev	Date	Drawn	Approved

EMPLOYER:

পাওয়ার গ্রীড কোম্পানী অব বাংলাদেশ লিঃ
POWER GRID COMPANY OF BANGLADESH LTD.
(An Enterprise of Bangladesh Power Development Board)

ENGINEER:

intec
GOPA Internationale Energy Consultants

PROJECT:

DESIGN, SUPPLY, INSTALLATION, TESTING & COMMISSIONING OF 230/132kV AND 132/33kV SUBSTATIONS, NORTHERN ZONE

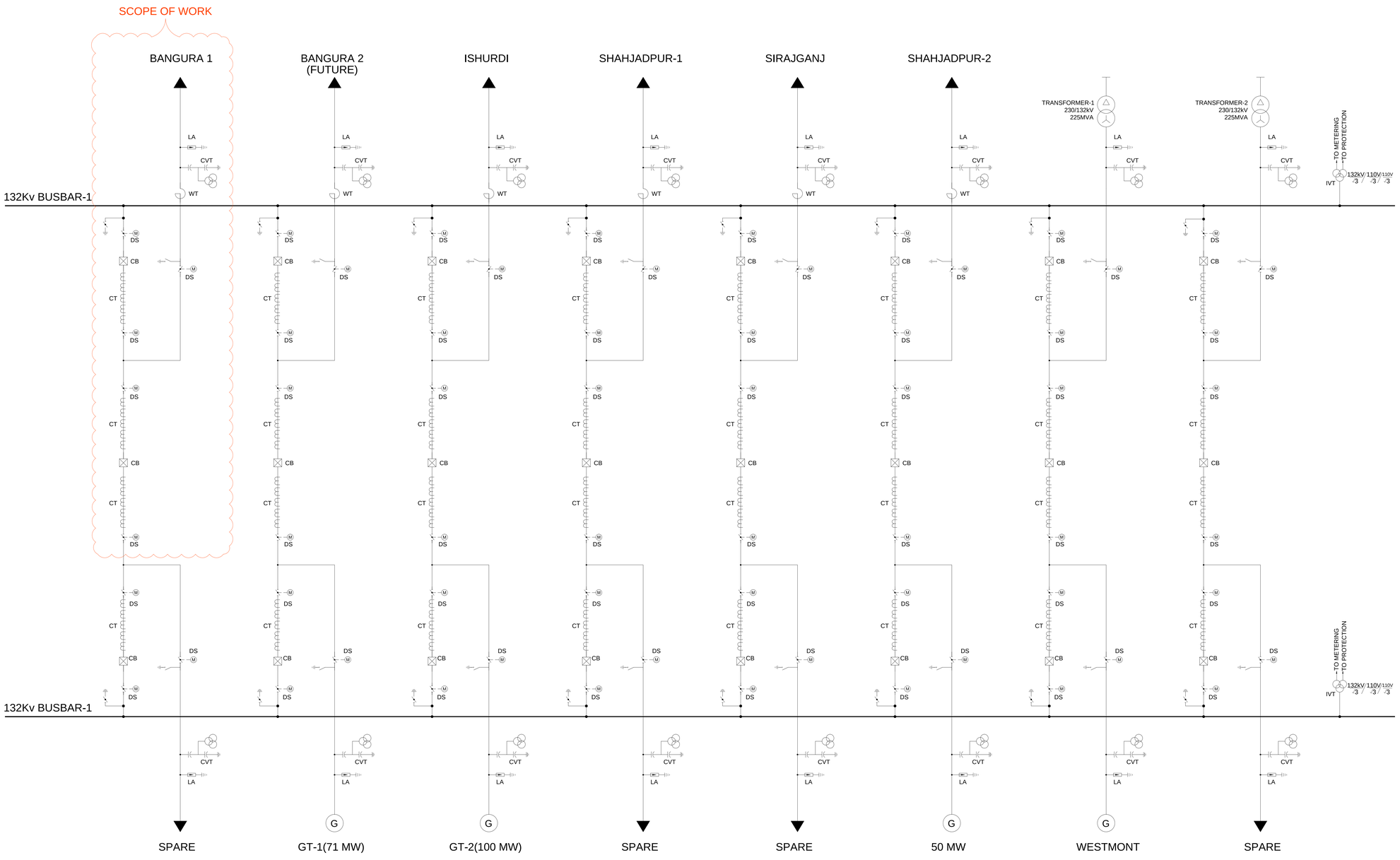
DRAWING TITLE:

NEW 132/33 kV SUBSTATION BANGURA
BLOCK DIAGRAM - TRANSFORMER BAY 132kV

Scale:	Drawn:	Checked:	Approved	Size:
NTS	MBB	BKP	VBC	A3

DRAWING NUMBER: PGCB/KfW/2012.66.436/SSNZ/2.5

Rev: 0



NOTES:-

LEGEND:-

SYMBOL	DESCRIPTION
	DISCONNECTOR DOUBLE BREAK
	DISCONNECTOR WITH EARTH SWITCH
	CIRCUIT BREAKER
	POWER TRANSFORMER
	CURRENT TRANSFORMER
	CAPACITIVE VOLTAGE TRANSFORMER
	INDUCTIVE VOLTAGE TRANSFORMER (IVT)
	WAVE TRAP
	LIGHTNING ARRESTOR
M	MOTOR

TENDER PURPOSE ONLY

FOR TENDER	0	29/02/2016	MBB	VBC
Purpose of Issue:	Rev	Date	Drawn	Approved

EMPLOYER:

পাওয়ার গ্রীড কোম্পানী অব বাংলাদেশ লিঃ
POWER GRID COMPANY OF BANGLADESH LTD.
(An Enterprise of Bangladesh Power Development Board)

ENGINEER:

intec
GOPA International Energy Consultants

PROJECT:

DESIGN, SUPPLY, INSTALLATION,
TESTING & COMMISSIONING OF
230/132kV AND 132/33kV SUBSTATIONS, NORTHERN ZONE

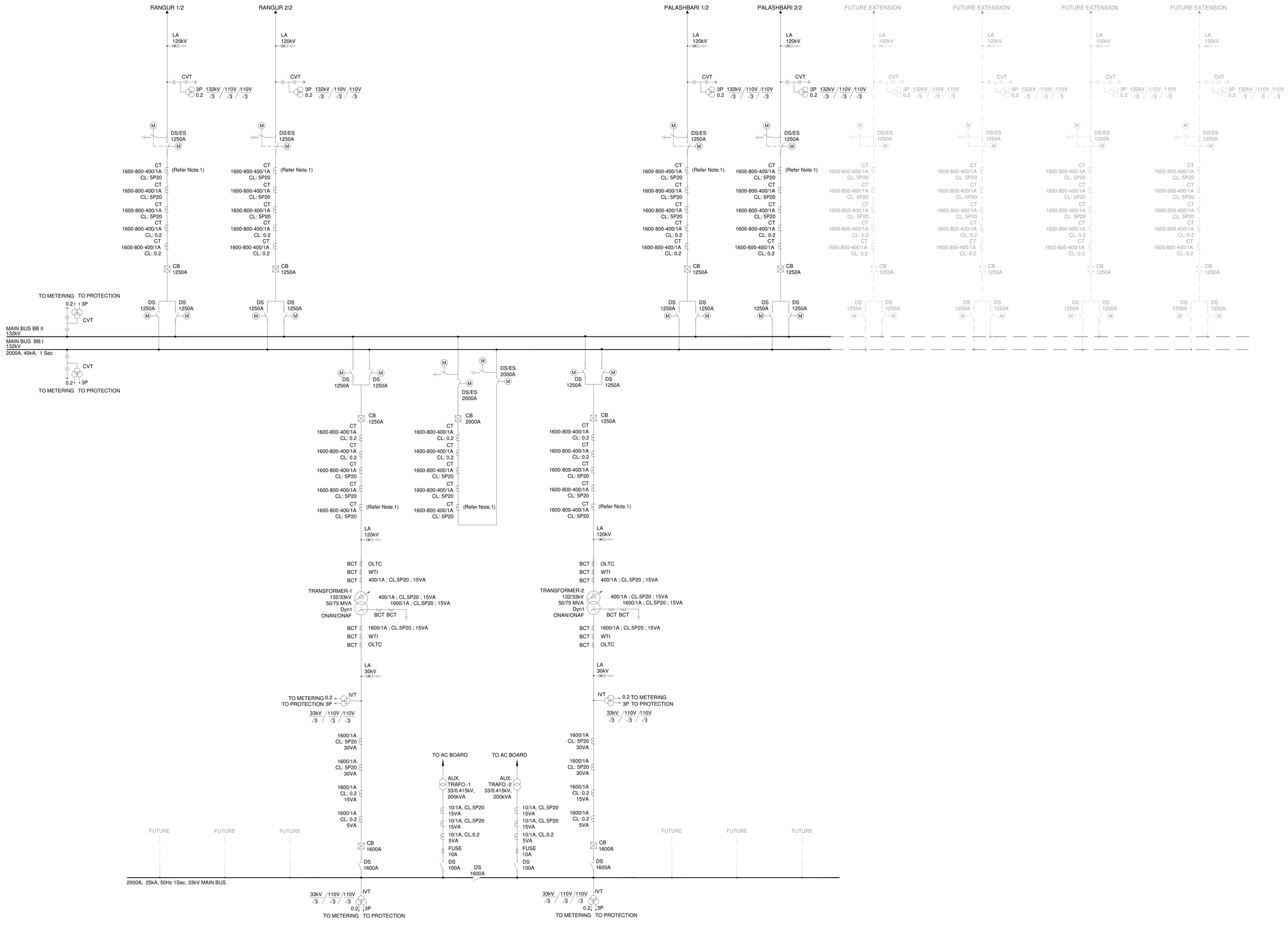
DRAWING TITLE:

EXTENSION OF EXISTING 132/33 kV SUBSTATION BAGHABARI
SINGLE LINE DIAGRAM

Scale:	Drawn:	Checked:	Approved	Size:
NTS	MBB	BKP	VBC	A0

DRAWING NUMBER: PGCB/KfW/2012.66.436/SSNZ/3.1 Rev: 0

BAY NUMBER	=E01	=E02	=E03	=E04	=E05	=E06	=E07	=E08	=E09	=E10	=E11
NAME	RANGUR 1/2	RANGUR 2/2	TRANSFORMER 1	BUS COPLER	TRANSFORMER 2	PALASHBARI 1/2	PALASHBARI 2/2	FUTURE EXTENSION	FUTURE EXTENSION	FUTURE EXTENSION	FUTURE EXTENSION



LEGEND:-

SYMBOL	DESCRIPTION
	DISCONNECTOR SWITCH, MOTOR OPERATED
	DISCONNECTOR WITH EARTH SWITCH, MOTOR OPERATED
	CIRCUIT BREAKER
	POWER TRANSFORMER
	AUX. TRANSFORMER
	CURRENT TRANSFORMER
	CAPACITIVE VOLTAGE TRANSFORMER
	INDUCTIVE VOLTAGE TRANSFORMER (IVT)
	LIGHTNING ARRESTOR
	DISCONNECTOR SWITCH & FUSE
	DISCONNECTOR SWITCH

NOTES:-

1. CHARACTERISTICS OF CURRENT TRANSFORMERS ARE PRELIMINARY. FINAL CHARACTERISTICS SHALL BE DEFINE DURING DESIGN STAGE.
2. ALL BUSHING SHALL BE EQUIPPED WITH CURRENT TRANSFORMERS, WITH THREE CORES, FOR PROTECTION, WTI,... CHARACTERISTICS ARE ONLY PRELIMINARY AND FINAL CHARACTERISTICS SHALL BE DEFINED DURING DESIGN STAGE.

TENDER PURPOSE ONLY

FOR TENDER	0	06/03/2016	MBB	VBC
Purpose of Issue:	Rev	Date	Drawn	Approved

EMPLOYER:

পাওয়ার গ্রীড কোম্পানী অব বাংলাদেশ লিঃ
POWER GRID COMPANY OF BANGLADESH LTD.
(An Enterprise of Bangladesh Power Development Board)

ENGINEER:

intec
GOPA International Energy Consultants

PROJECT:

DESIGN, SUPPLY, INSTALLATION, TESTING & COMMISSIONING OF 230/132kV AND 132/33kV SUBSTATIONS, NORTHERN ZONE

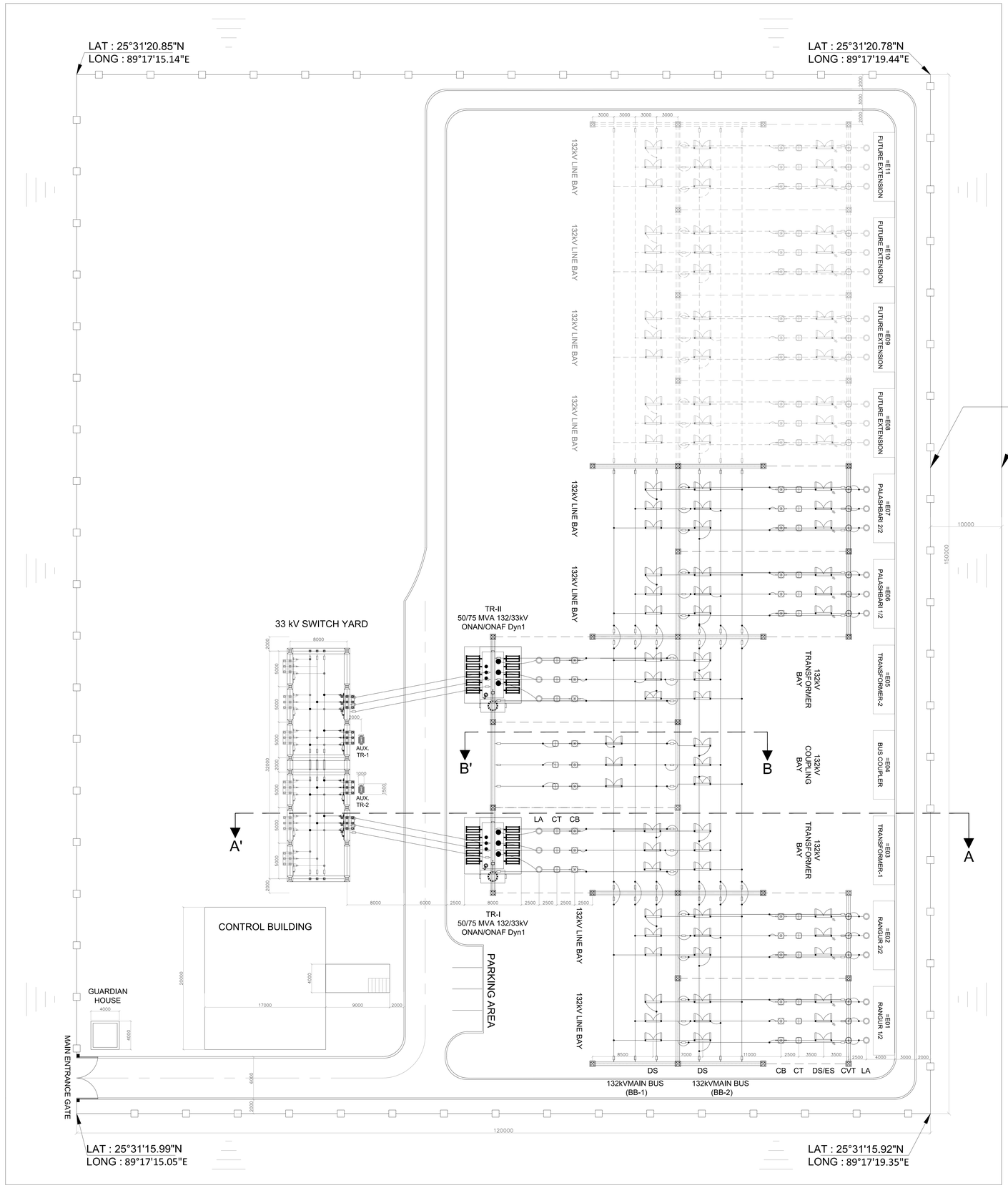
DRAWING TITLE:

NEW 132/33 kV SUBSTATION MITHAPUKUR
SINGLE LINE DIAGRAM

Scale:	Drawn:	Checked:	Approved	Size:
NTS	MBB	BKP	VBC	A0

DRAWING NUMBER: PGCB/KfW/2012.66.436/SSNZ/4.1

Rev: 0



KEY PLAN:-

NOTES:-

1. DRAWING IS PRELIMINARY, GENERAL AND FOR TENDER PURPOSE ONLY
2. CONTRACTOR SHALL PREPARE THE DRAWINGS FOR TENDER REALIZATION.
3. DIMENSIONS AT THE DRAWINGS ARE MINIMUM, PRELIMINARY AND GENERAL. CONTRACTOR IS OBLIGED TO PERFORM DETAIL CALCULATION AND TO TAKE CARE ABOUT THE CLEARANCE, HEIGHT AND WIDTH AS WELL AS FUNCTIONAL PERFORMANCE.
4. LIGHTNING PROTECTION AND EARTHING SYSTEM IS NOT SHOWN AT THE DRAWINGS AND CONTRACTOR IS OBLIGED TO PERFORM DETAIL CALCULATION AND TO TAKE CARE ABOUT THE LIGHTNING PROTECTION AND EARTHING.
5. CIVIL FACILITIES BUILDINGS, FENCES AND GATES, ROADS, TRANSFORMER BASED AND OIL PIT, GANTRIES AND SWITCHYARD FOUNDATIONS ARE SHOWN GENERALLY, CABLES TRENCHES, RAINWATER PIPES ETC ARE NOT SHOWN AT ALL.
6. THE CONTRACTOR'S RESPONSIBILITY IS TO PROVIDE THAT ALL PARTS OF THE WORKS TO BE COMPLETED IN EVERY RESPECT FOR OPERATION.
7. ALL DETAILS REQUIRED FOR THE COMPLETE INSTALLATION AND SATISFACTORY OPERATION OF THE WORKS ARE DEEMED TO BE INCLUDED IN THE CONTRACT PRICE.
8. THE CONTRACTOR RESPONSIBLE FOR ENSURING THAT ALL AND/OR ANY ITEM(S) OF WORK REQUIRED FOR THE SAFE, EFFICIENT AND SATISFACTORY COMPLETION AND FUNCTIONING OF THE WORKS, ARE INCLUDED IN THE BID PRICE.
9. CO-ORDINATES, WHICH ARE PRESENTED AT THE DRAWING AS CORNERS OF THE BOUNDARY LINE, ARE APPROXIMATE, FOR TENDER PURPOSE ONLY. FINAL CO-ORDINATES WILL BE DEFINED LATER. PROPERTY LINE IS APPROXIMATE ALSO. BETWEEN THE PROPERTY AND BOUNDARY LINE WILL BE A SLOPE. LAND DEVELOPMENT FOR COMPLETE AREA IS IN THE SCOPE OF WORKS.

FOR TENDER	0	06/03/2016	MBB	VBC
Purpose of Issue:	Rev	Date	Drawn	Approved

EMPLOYER:

পাওয়ার গ্রীড কোম্পানী অব বাংলাদেশ লিঃ
POWER GRID COMPANY OF BANGLADESH LTD.
(An Enterprise of Bangladesh Power Development Board)

ENGINEER:

intec
GOPA International Energy Consultants

PROJECT:

DESIGN, SUPPLY, INSTALLATION, TESTING & COMMISSIONING OF 230/132kV AND 132/33kV SUBSTATIONS, NORTHERN ZONE

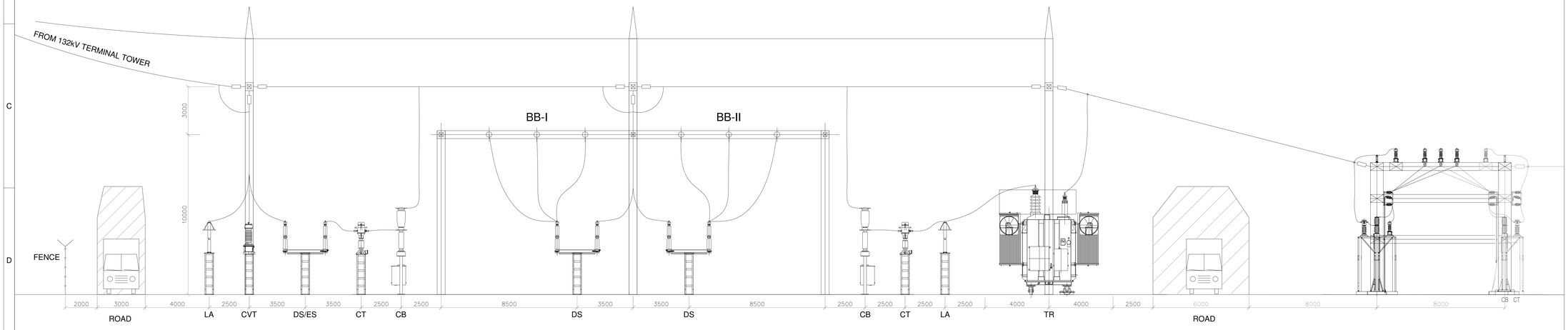
DRAWING TITLE:

NEW 132/33 kV SUBSTATION MITHAPUKUR PLAN

Scale:	Drawn:	Checked:	Approved	Size:
1:225	MBB	BKP	VBC	A0

DRAWING NUMBER: PGCB/KfW/2012.66.436/SSNZ/4.2 Rev: 0

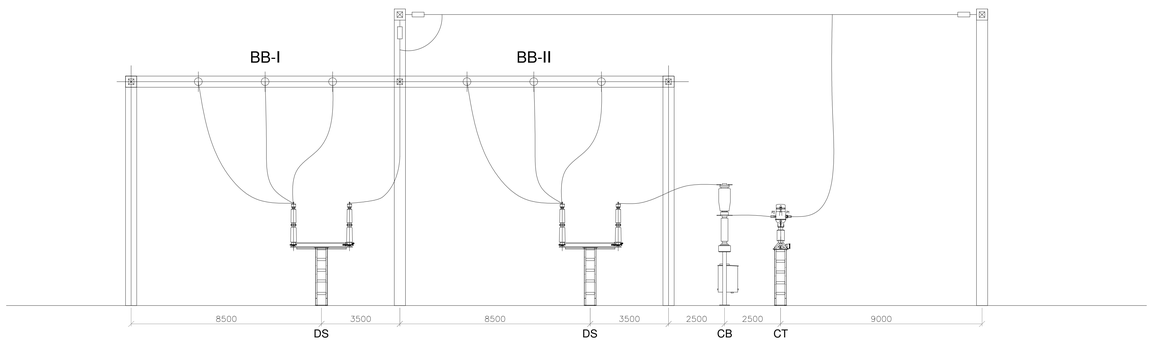
TENDER PURPOSE ONLY



132kV LINE BAY

SECTION A-A'

132kV TRANSFORMER BAY



132kV COUPLING BAY

SECTION B-B'

NOTES:-

1. DRAWING IS PRELIMINARY, GENERAL AND FOR TENDER PURPOSE ONLY
2. CONTRACTOR SHALL PREPARE THE DRAWINGS FOR TENDER REALIZATION.
3. DIMENSIONS AT THE DRAWINGS ARE MINIMUM, PRELIMINARY AND GENERAL. CONTRACTOR IS OBLIGED TO PERFORM DETAIL CALCULATION AND TO TAKE CARE ABOUT THE CLEARANCE, HEIGHT AND WIDTH AS WELL AS FUNCTIONAL PERFORMANCE.
4. LIGHTNING PROTECTION AND EARTHING SYSTEM IS NOT SHOWN AT THE DRAWINGS AND CONTRACTOR IS OBLIGED TO PERFORM DETAIL CALCULATION AND TO TAKE CARE ABOUT THE LIGHTNING PROTECTION AND EARTHING.
5. CIVIL FACILITIES BUILDINGS, FENCES AND GATES, ROADS, TRANSFORMER BASED AND OIL PIT, GANTRIES AND SWITCHYARD FOUNDATIONS ARE SHOWN GENERALLY, CABLES TRENCHES, RAINWATER PIPES ETC ARE NOT SHOWN AT ALL.
6. THE CONTRACTOR'S RESPONSIBILITY IS TO PROVIDE THAT ALL PARTS OF THE WORKS TO BE COMPLETED IN EVERY RESPECT FOR OPERATION.
7. ALL DETAILS REQUIRED FOR THE COMPLETE INSTALLATION AND SATISFACTORY OPERATION OF THE WORKS ARE DEEMED TO BE INCLUDED IN THE CONTRACT PRICE.
8. THE CONTRACTOR RESPONSIBLE FOR ENSURING THAT ALL AND/OR ANY ITEM(S) OF WORK REQUIRED FOR THE SAFE, EFFICIENT AND SATISFACTORY COMPLETION AND FUNCTIONING OF THE WORKS, ARE INCLUDED IN THE BID PRICE.
9. CO-ORDINATES, WHICH ARE PRESENTED AT THE DRAWING AS CORNERS OF THE BOUNDARY LINE, ARE APPROXIMATE, FOR TENDER PURPOSE ONLY. FINAL CO-ORDINATES WILL BE DEFINED LATER. PROPERTY LINE IS APPROXIMATE ALSO. BETWEEN THE PROPERTY AND BOUNDARY LINE WILL BE A SLOPE. LAND DEVELOPMENT FOR COMPLETE AREA IS IN THE SCOPE OF WORKS.

TENDER PURPOSE ONLY

Purpose of Issue:	Rev	Date	Drawn	Approved
FOR TENDER	0	06/03/2016	MBB	VBC

EMPLOYER:

পাওয়ার গ্রীড কোম্পানী অব বাংলাদেশ লিঃ
POWER GRID COMPANY OF BANGLADESH LTD.
(An Enterprise of Bangladesh Power Development Board)

ENGINEER:

intec
GOPA International Energy Consultants

PROJECT:

DESIGN, SUPPLY, INSTALLATION,
TESTING & COMMISSIONING OF
230/132kV AND 132/33kV SUBSTATIONS, NORTHERN ZONE

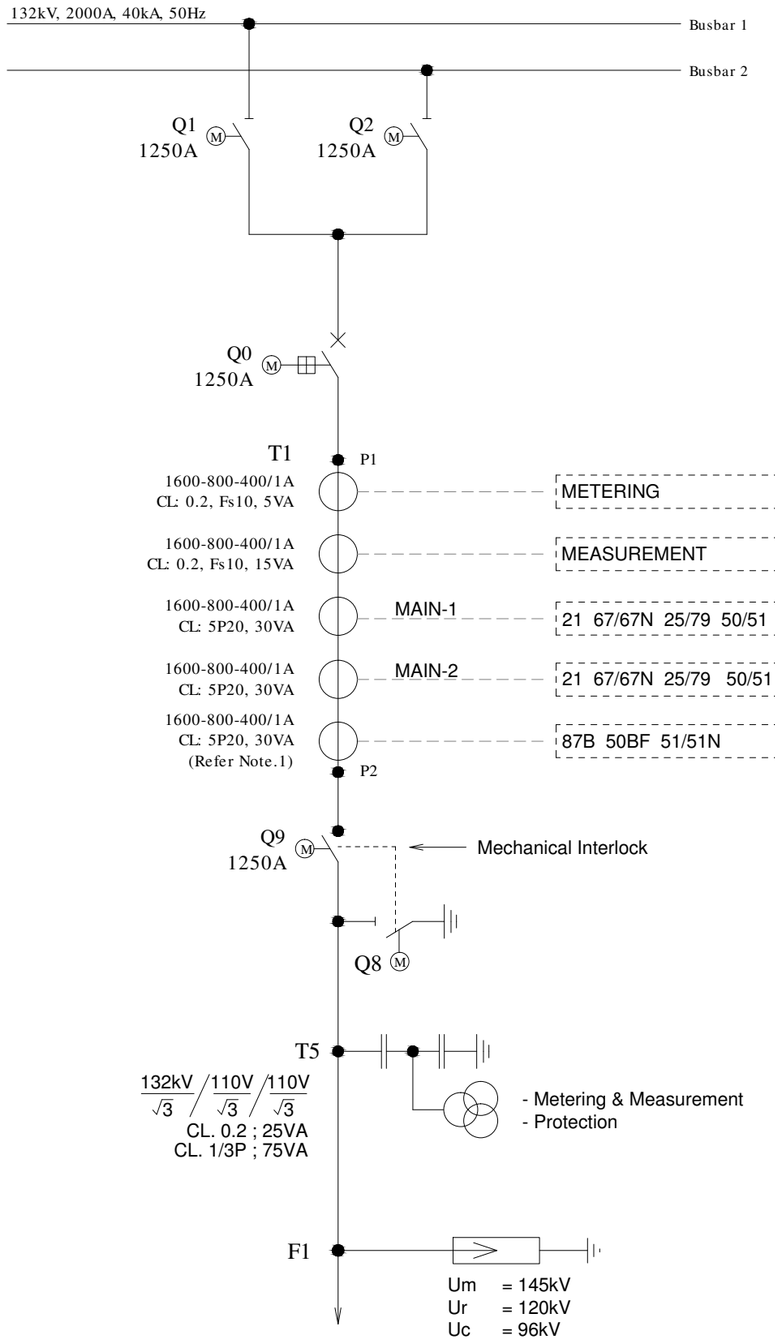
DRAWING TITLE:

NEW 132/33 kV SUBSTATION MITHAPUKUR
CROSS SECTIONS

Scale:	Drawn:	Checked:	Approved	Size:
1:100	MBB	BKP	VBC	A0

DRAWING NUMBER: PGCB/KfW/2012.66.436/SSNZ/4.3

Rev: 0



LEGENDS :-

Symbols	Description
Q1, Q2	Disconnectors
Q0	Circuit Breaker
Q8/Q9	Disconnector with Earth Switch
T1	Current Transformer
T5	Voltage Transformer
F1	Surge Arrester

NOTES:-

1. CHARACTERISTICS OF CURRENT TRANSFORMERS ARE PRELIMINARY. FINAL CHARACTERISTICS SHALL BE DEFINE DURING DESIGN STAGE.

TENDER PURPOSE ONLY

FOR TENDER	0	06/03/2016	MBB	VBC
Purpose of Issue:	Rev	Date	Drawn	Approved

EMPLOYER:

পাওয়ার গ্রীড কোম্পানী অব বাংলাদেশ লিঃ
POWER GRID COMPANY OF BANGLADESH LTD.
(An Enterprise of Bangladesh Power Development Board)

ENGINEER:

intec
GOPA International Energy Consultants

PROJECT:

DESIGN, SUPPLY, INSTALLATION,
TESTING & COMMISSIONING OF
230/132kV AND 132/33kV SUBSTATIONS, NORTHERN ZONE

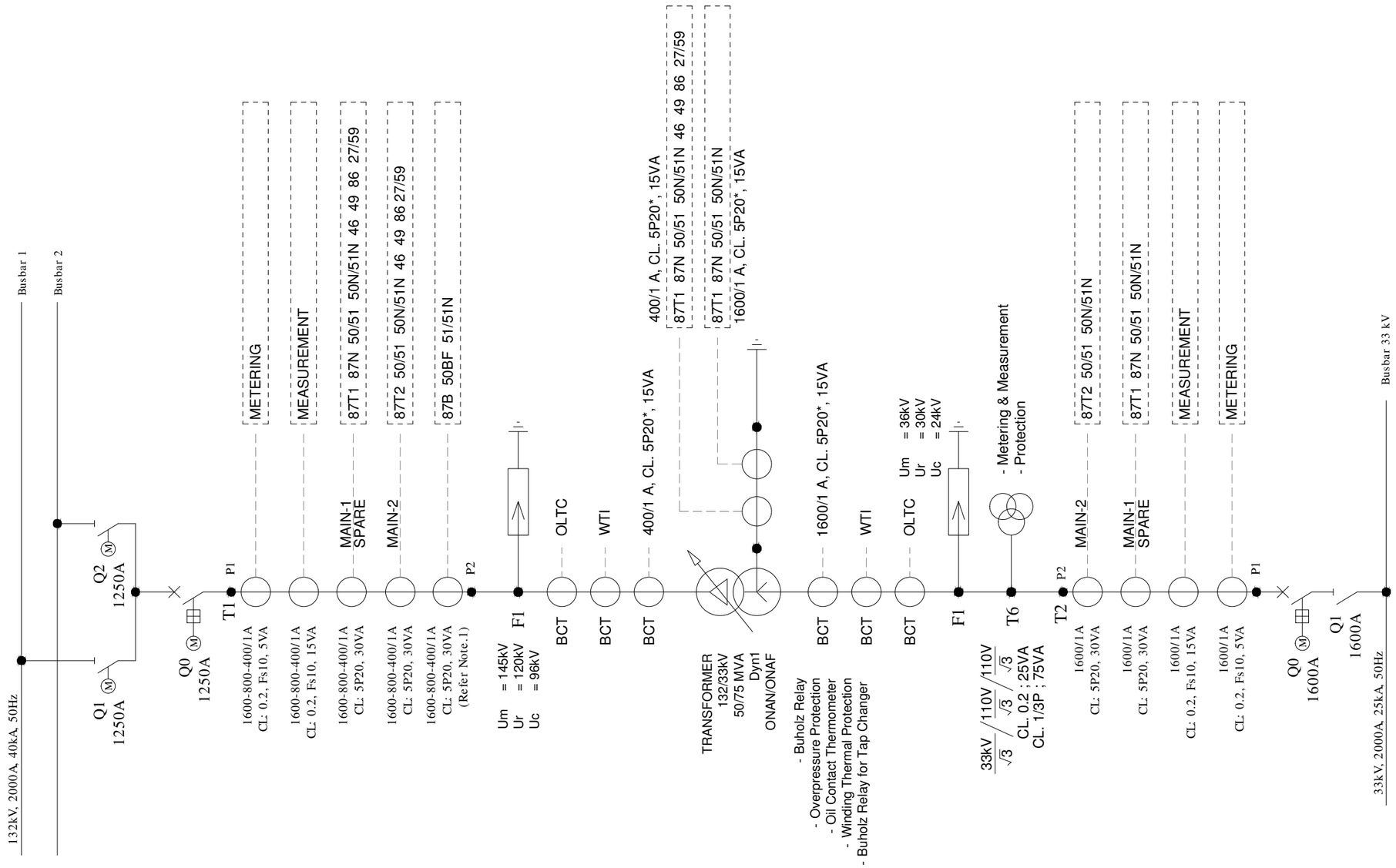
DRAWING TITLE:

NEW 132/33 kV SUBSTATION MITHAPUKUR
BLOCK DIAGRAM - LINE BAY 132kV

Scale:	Drawn:	Checked:	Approved	Size:
NTS	MBB	BKP	VBC	A3

DRAWING NUMBER: PGCB/KfW/2012.66.436/SSNZ/4.4

Rev: 0



TENDER PURPOSE ONLY

LEGENDS :-

Symbols	Description
Q1, Q2	Disconnectors
Q0	Circuit Breaker
T1, T2	Current Transformer
F1	Surge Arrester
T6	Voltage Transformer

NOTES:-

1. CHARACTERISTICS OF CURRENT TRANSFORMERS ARE PRELIMINARY. FINAL CHARACTERISTICS SHALL BE DEFINE DURING DESIGN STAGE.
2. ALL BUSHING SHALL BE EQUIPPED WITH CURRENT TRANSFORMERS, WITH THREE CORES, FOR PROTECTION, WTI,... CHARACTERISTICS ARE ONLY PRELIMINARY AND FINAL CHARACTERISTICS SHALL BE DEFINED DURING DESIGN STAGE.

Purpose of Issue:	Rev	Date	Drawn	Approved
FOR TENDER	0	06/03/2016	MBB	VBC

EMPLOYER:
পাওয়ার গ্রীড কোম্পানী অব বাংলাদেশ লিঃ
POWER GRID COMPANY OF BANGLADESH LTD.
(An Enterprise of Bangladesh Power Development Board)

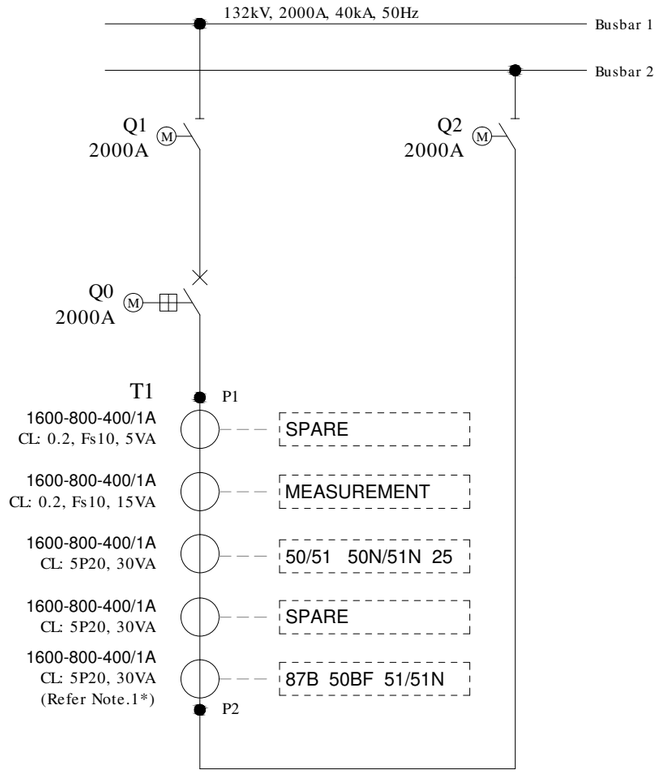
ENGINEER:
intec
GOPA International Energy Consultants

PROJECT:
DESIGN, SUPPLY, INSTALLATION, TESTING & COMMISSIONING OF 230/132kV AND 132/33kV SUBSTATIONS, NORTHERN ZONE

DRAWING TITLE:
NEW 132/33 kV SUBSTATION MITHAPUKUR
BLOCK DIAGRAM - TRANSFORMER BAY 132kV

Scale:	Drawn:	Checked:	Approved	Size:
NTS	MBB	BKP	VBC	A3

DRAWING NUMBER: PGCB/KfW/2012.66.436/SSNZ/4.5
Rev: 0



LEGENDS :-

Symbols	Description
Q1, Q2	Disconnectors
Q0	Circuit Breaker
T1	Current Transformer

NOTES:-

1. CHARACTERISTICS OF CURRENT TRANSFORMERS ARE PRELIMINARY. FINAL CHARACTERISTICS SHALL BE DEFINE DURING DESIGN STAGE.

TENDER PURPOSE ONLY

Purpose of Issue:	Rev	Date	Drawn	Approved
FOR TENDER	0	06/03/2016	MBB	VBC

EMPLOYER:

পাওয়ার গ্রীড কোম্পানী অব বাংলাদেশ লিঃ
POWER GRID COMPANY OF BANGLADESH LTD.
(An Enterprise of Bangladesh Power Development Board)

ENGINEER:

intec
GOPA Internationale Energy Consultants

PROJECT:

DESIGN, SUPPLY, INSTALLATION,
TESTING & COMMISSIONING OF
230/132kV AND 132/33kV SUBSTATIONS, NORTHERN ZONE

DRAWING TITLE:

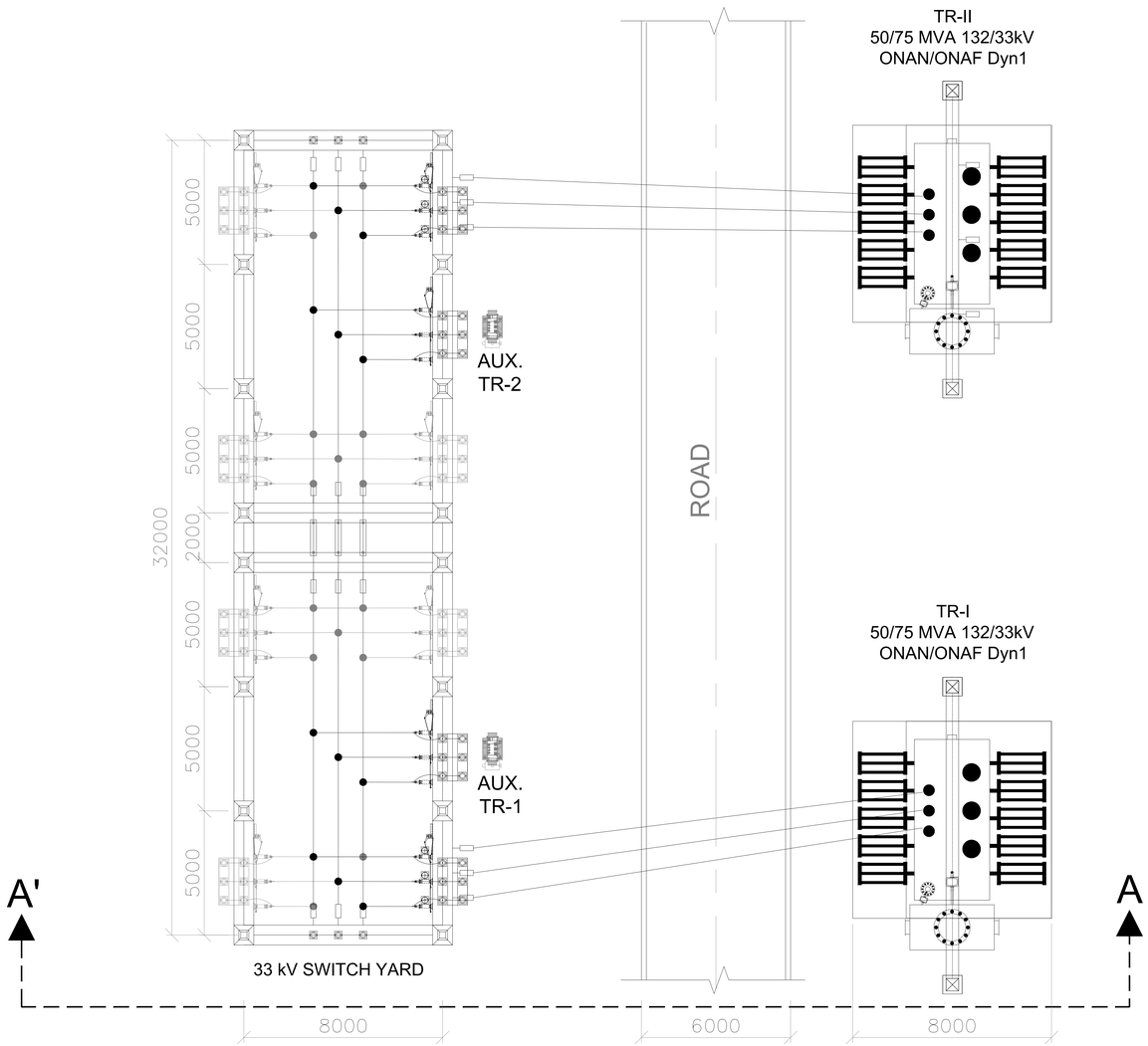
NEW 132/33 kV SUBSTATION MITHAPUKUR
BLOCK DIAGRAM - BUS COUPLER BAY 132kV

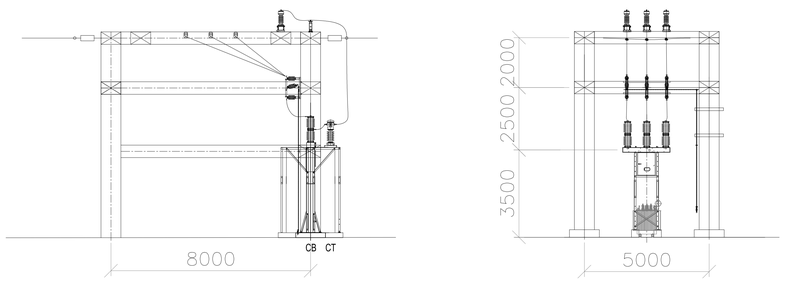
Scale:	Drawn:	Checked:	Approved	Size:
NTS	MBB	BKP	VBC	A3

DRAWING NUMBER:

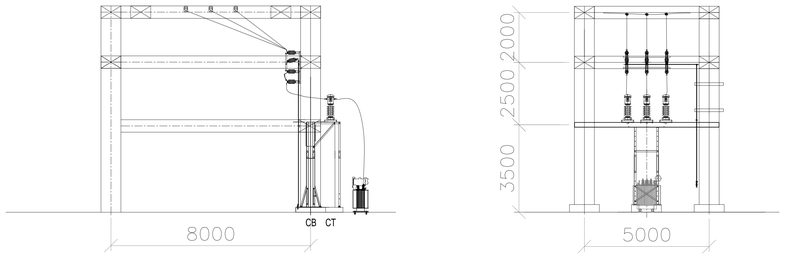
PGCB/KfW/2012.66.436/SSNZ/4.6

Rev: 0

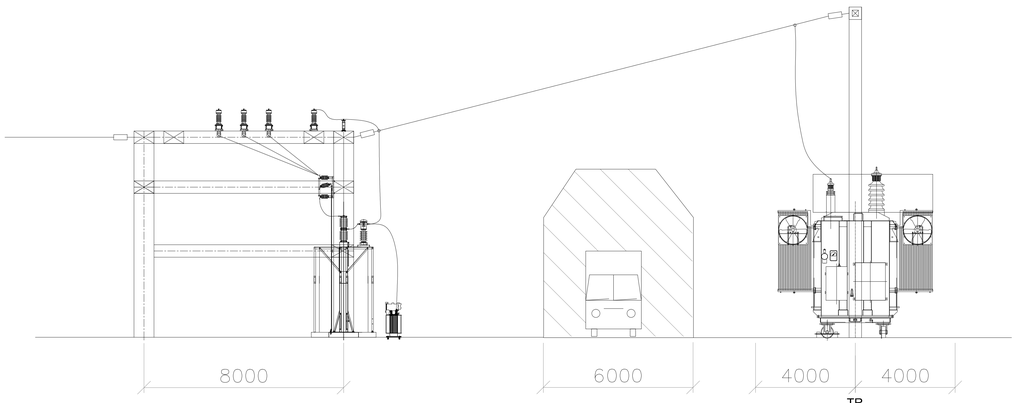




TRANSFORMER BAY



AUX. TRANSFORMER BAY



SECTION A'-A

TENDER PURPOSE ONLY

FOR TENDER	0	03/03/2016	MBB	VBC
Purpose of Issue:	Rev	Date	Drawn	Approved

EMPLOYER:

পাওয়ার গ্রীড কোম্পানী অব বাংলাদেশ লিঃ
POWER GRID COMPANY OF BANGLADESH LTD.
(An Enterprise of Bangladesh Power Development Board)

ENGINEER:

intec
GOPA International Energy Consultants

PROJECT:

DESIGN, SUPPLY, INSTALLATION,
TESTING & COMMISSIONING OF
230/132kV AND 132/33kV SUBSTATIONS, NORTHERN ZONE

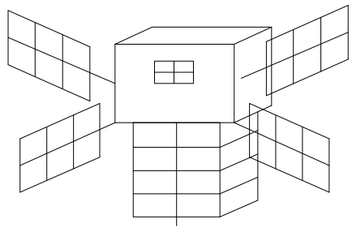
DRAWING TITLE:

33 kV SWITCHYARD (AIS SUBSTATION)
PLAN & SECTIONS

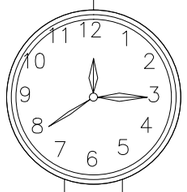
Scale:	Drawn:	Checked:	Approved	Size:
1:100	MBB	BKP	VBC	A0

DRAWING NUMBER: PGCB/KfW/2012.66.436/SSNZ/5.1

Rev: 0



GPS



GPS CLOCK

TIME Sync.

SERVER 1

SERVER 2

HMI 1

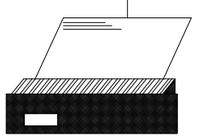
HMI 2

REMOTE ACCESS

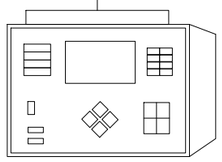
TELECOMMUNICATION

W/S

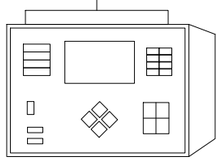
ETHERNET IEC 61850



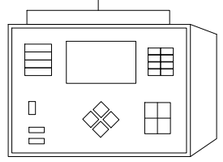
IED ENGINEER TOOL



IED



IED



IED

TENDER PURPOSE ONLY

FOR TENDER	0	03/03/2016	MBB	VBC
Purpose of Issue:	Rev	Date	Drawn	Approved

EMPLOYER:

পাওয়ার গ্রীড কোম্পানী অব বাংলাদেশ লিঃ
POWER GRID COMPANY OF BANGLADESH LTD.
(An Enterprise of Bangladesh Power Development Board)

ENGINEER:

intec
GOPA International Energy Consultants

PROJECT:

DESIGN, SUPPLY, INSTALLATION,
TESTING & COMMISSIONING OF
230/132kV AND 132/33kV SUBSTATIONS, NORTHERN ZONE

DRAWING TITLE:

SUBSTATION AUTOMATION SYSTEM
ARCHITECTURE

Scale:	Drawn:	Checked:	Approved	Size:
NTS	MBB	BKP	VBC	A0

DRAWING NUMBER: PGCB/KfW/2012.66.436/SSNZ/6.1

Rev: 0

LV AC DISTRIBUTION PANEL

LV AC DISTRIBUTION PANEL

3Ph. RECTIFIER
AC 415V / DC110V

3Ph. RECTIFIER
AC 415V / DC110V

INTERLOCK

SILICON DROPPER

SILICON DROPPER

DC 110V Bus 500A

DC 110V Bus 500A

2P

STORAGE BATTERY
DC 110V,
400Ah,
NICd TYPE

STORAGE BATTERY
DC 110V,
400Ah,
NICd TYPE

230KV SWITCH GEAR
132KV SWITCH GEAR
33kV SWITCHGEAR
EMERGENCY LIGHTING SYSTEM
SECURITY SYSTEM
CONTROL & PROTECTION
FIRE ALARM SYSTEM
SPARE
SPARE
DC / DC CONVERTER

DC / DC CONVERTER
230KV SWITCH GEAR
132KV SWITCH GEAR
33kV SWITCHGEAR
EMERGENCY LIGHTING SYSTEM
SECURITY SYSTEM
CONTROL & PROTECTION
FIRE ALARM SYSTEM
SPARE
SPARE

DC/DC CONVERTER
DC 110V / DC 48V
1500VA

DC/DC CONVERTER
DC 110V / DC 48V
1500VA

DC 48V Bus 100A

DC 48V Bus 100A

SUBSTATION COMPUTERS
MONITORS & PRINTERS
TELEPHONE SYSTEM
COMMUNICATION SYSTEM
SPARE
SPARE

SUBSTATION COMPUTERS
MONITORS & PRINTERS
TELEPHONE SYSTEM
COMMUNICATION SYSTEM
SPARE
SPARE

TENDER PURPOSE ONLY

LEGENDS :-

SYMBOLS	DESCRIPTION
	CIRCUIT BREAKER
A	AMMETER
V	VOLTMETER
	BATTERY
	RECTIFIER
	DC/DC CONVERTER

FOR TENDER	0	03/03/2016	MBB	VBC
Purpose of Issue:	Rev	Date	Drawn	Approved

EMPLOYER:

পাওয়ার গ্রীড কোম্পানী অব বাংলাদেশ লিঃ
POWER GRID COMPANY OF BANGLADESH LTD.
(An Enterprise of Bangladesh Power Development Board)

ENGINEER:

intec
GOPA International Energy Consultants

PROJECT:

DESIGN, SUPPLY, INSTALLATION,
TESTING & COMMISSIONING OF
230/132kV AND 132/33kV SUBSTATIONS, NORTHERN ZONE

DRAWING TITLE:

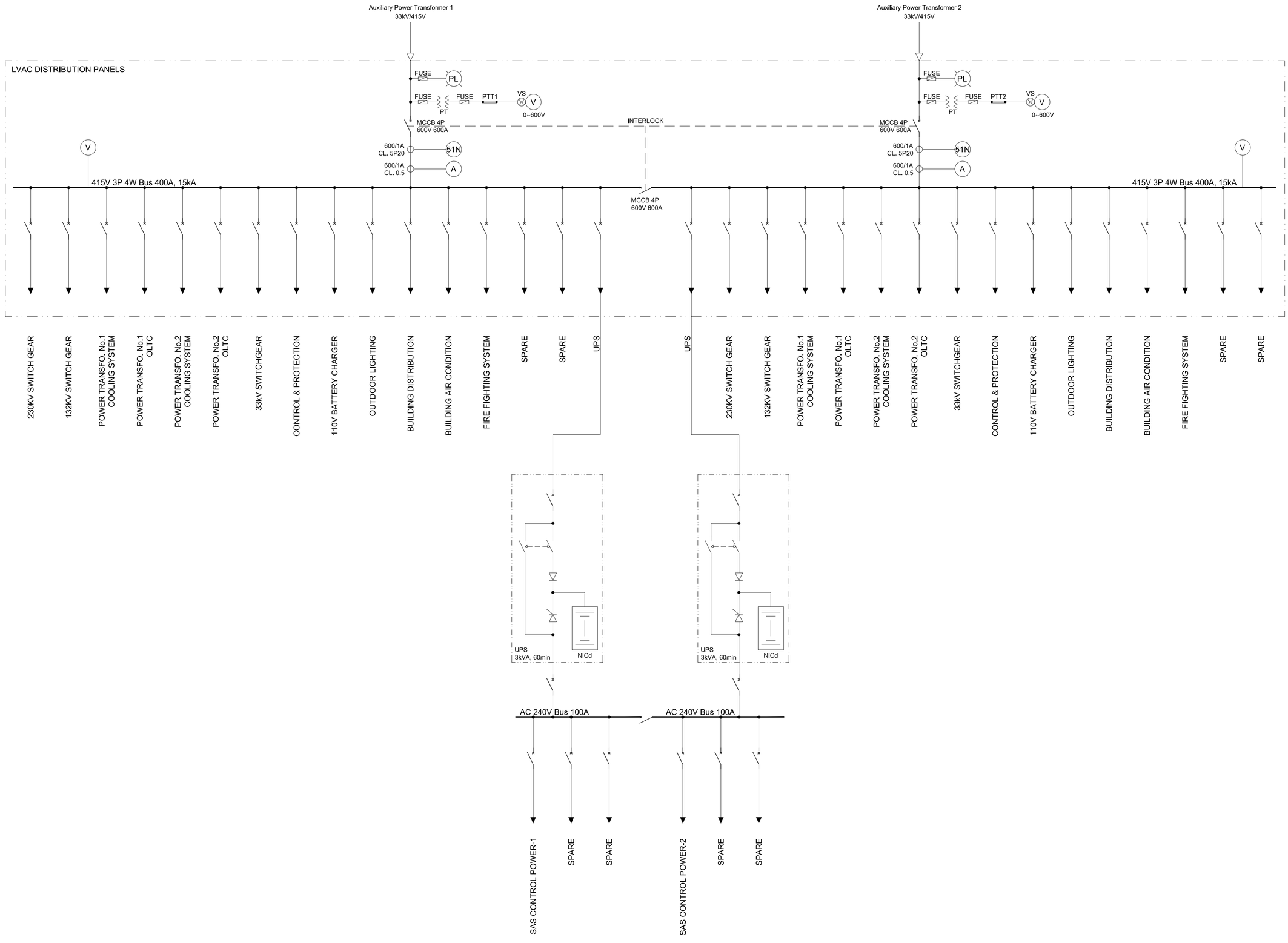
SINGLE LINE DIAGRAM FOR
110V & 48V DC DISTRIBUTION

Scale:	Drawn:	Checked:	Approved	Size:
NTS	MBB	BKP	VBC	A0

DRAWING NUMBER:

PGCB/KfW/2012.66.436/SSNZ/7.1

Rev: 0



LEGENDS :-

SYMBOLS	DESCRIPTION
	AUX. POWER TRANSFORMER
	CURRENT TRANSFORMER
	CIRCUIT BREAKER
A	AMMETER
V	VOLTMETER

TENDER PURPOSE ONLY

FOR TENDER	0	03/03/2016	MBB	VBC
Purpose of Issue:	Rev	Date	Drawn	Approved

EMPLOYER:

পাওয়ার গ্রীড কোম্পানী অব বাংলাদেশ লিঃ
POWER GRID COMPANY OF BANGLADESH LTD.
(An Enterprise of Bangladesh Power Development Board)

ENGINEER:

intec
GOPA International Energy Consultants

PROJECT:

DESIGN, SUPPLY, INSTALLATION,
TESTING & COMMISSIONING OF
230/132kV AND 132/33kV SUBSTATIONS, NORTHERN ZONE

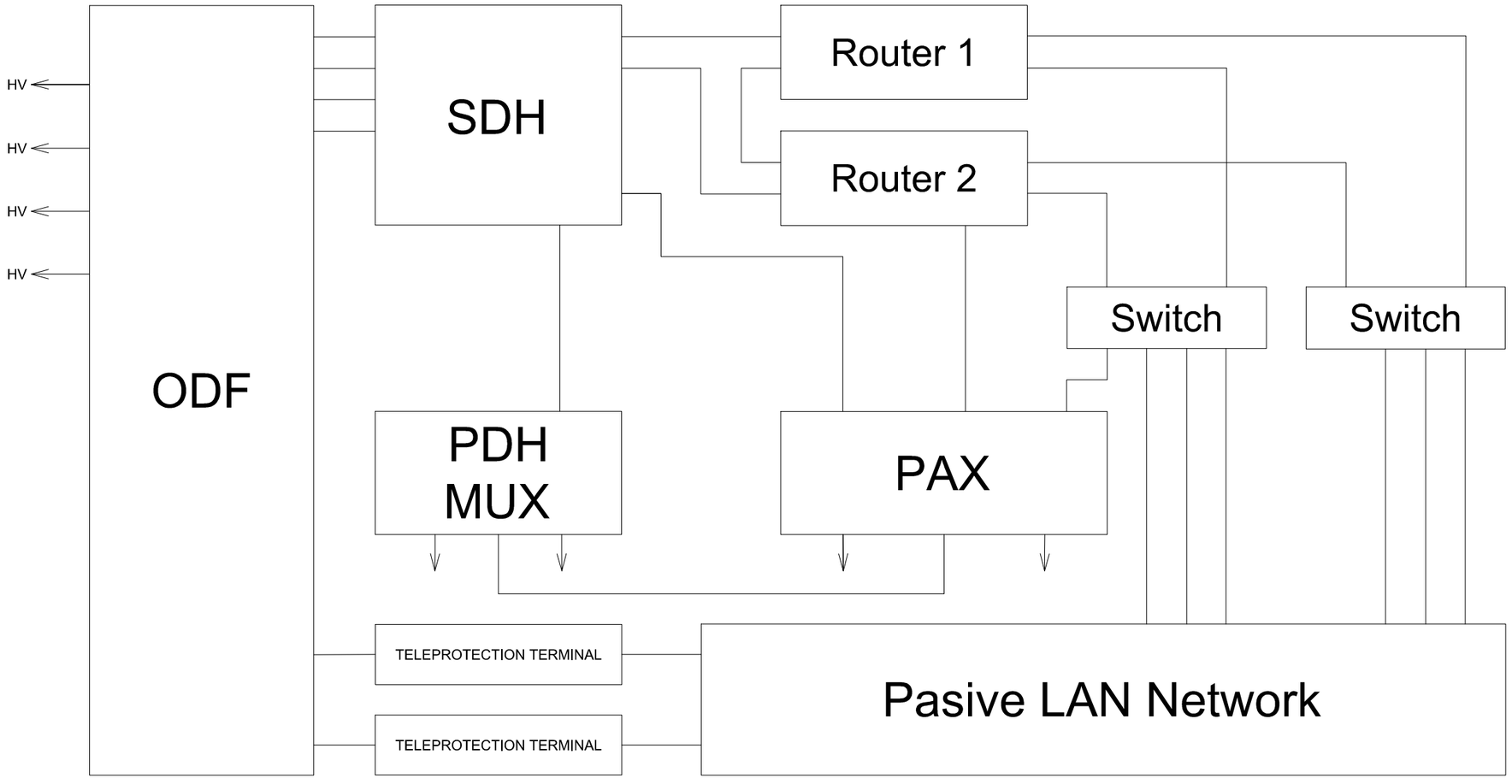
DRAWING TITLE:

SINGLE LINE DIAGRAM FOR
LV AC & UPS DISTRIBUTION

Scale:	Drawn:	Checked:	Approved	Size:
NTS	MBB	BKP	VBC	A0

DRAWING NUMBER: PGCB/KfW/2012.66.436/SSNZ/7.2

Rev: 0



TENDER PURPOSE ONLY

FOR TENDER	0	03/03/2016	MBB	VBC
Purpose of Issue:	Rev	Date	Drawn	Approved

EMPLOYER:

পাওয়ার গ্রীড কোম্পানী অব বাংলাদেশ লিঃ
POWER GRID COMPANY OF BANGLADESH LTD.
(An Enterprise of Bangladesh Power Development Board)

ENGINEER:

intec
GOPA Internationale Energie Consultants

PROJECT:

DESIGN, SUPPLY, INSTALLATION,
TESTING & COMMISSIONING OF
230/132kV AND 132/33kV SUBSTATIONS, NORTHERN ZONE

DRAWING TITLE:

SUBSTATION TELECOMMUNICATION SYSTEM
BLOCK DIAGRAM

Scale:	Drawn:	Checked:	Approved	Size:
NTS	MBB	BKP	VBC	A0

DRAWING NUMBER: PGCB/KfW/2012.66.436/SSNZ/8.1

Rev: 0

OPGW

SDH

ODF

PDH

GSM GW

LAN

TELEPROTECTION :
TERMINAL

SERVER

PAX

SIP PHONE

ANALOG
PHONE

DISP.
CONZOLE

COMPUTER

TENDER PURPOSE ONLY

FOR TENDER	0	03/03/2016	MBB	VBC
Purpose of Issue:	Rev	Date	Drawn	Approved

EMPLOYER:

পাওয়ার গ্রীড কোম্পানী অব বাংলাদেশ লিঃ
POWER GRID COMPANY OF BANGLADESH LTD.
(An Enterprise of Bangladesh Power Development Board)

ENGINEER:

intec
GOPA International Energy Consultants

PROJECT:

DESIGN, SUPPLY, INSTALLATION,
TESTING & COMMISSIONING OF
230/132kV AND 132/33kV SUBSTATIONS, NORTHERN ZONE

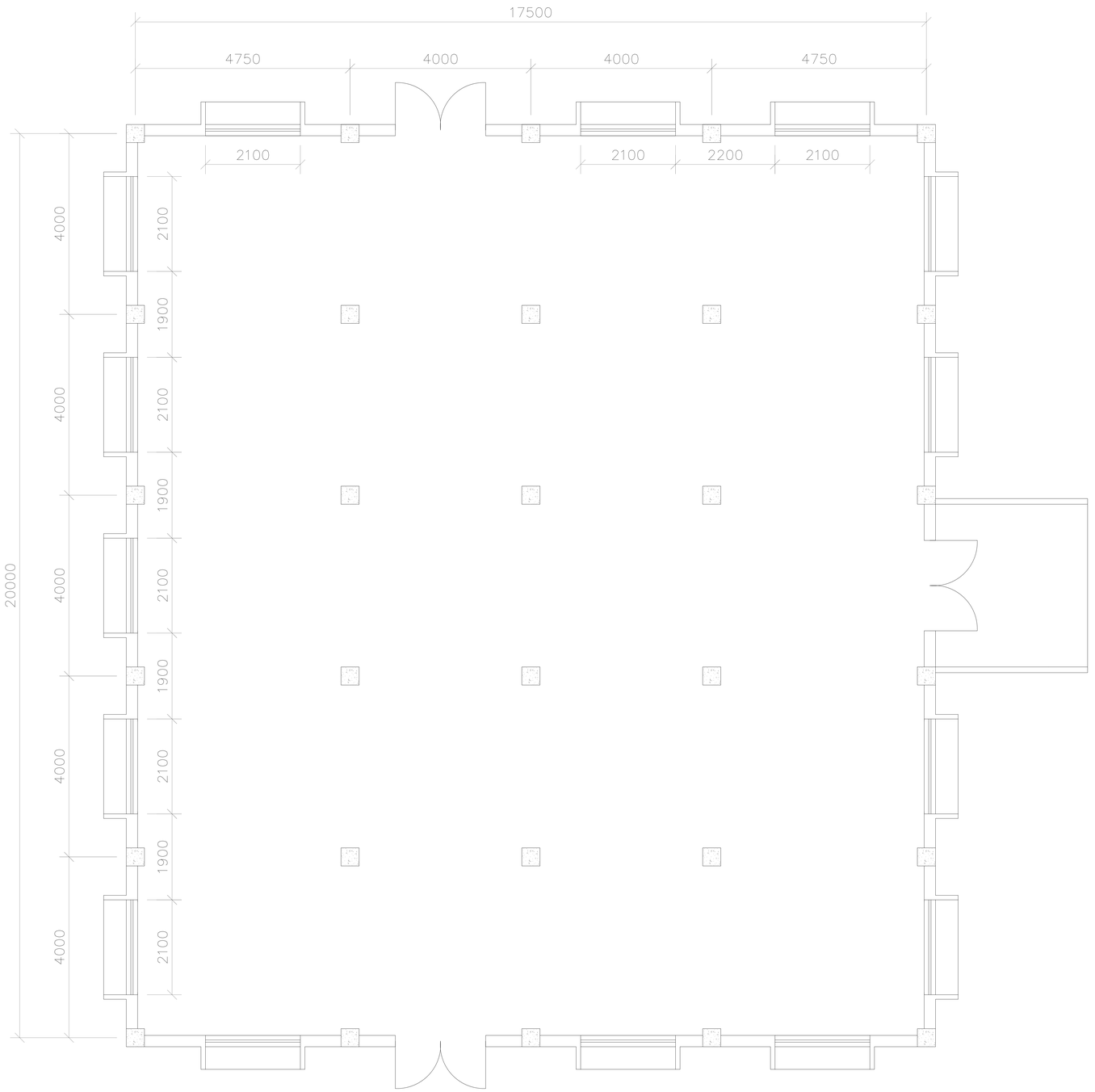
DRAWING TITLE:

SUBSTATION TELECOMMUNICATION SYSTEM
ARCHITECTURE

Scale:	Drawn:	Checked:	Approved	Size:
NTS	MBB	BKP	VBC	A0

DRAWING NUMBER: PGCB/KfW/2012.66.436/SSNZ/8.2

Rev: 0



GROUND FLOOR PLAN

TENDER PURPOSE ONLY

FOR TENDER	0	03/03/2016	MBB	VBC
Purpose of Issue:	Rev	Date	Drawn	Approved

EMPLOYER:

পাওয়ার গ্রীড কোম্পানী অব বাংলাদেশ লিঃ
POWER GRID COMPANY OF BANGLADESH LTD.
(An Enterprise of Bangladesh Power Development Board)

ENGINEER:

intec
GOPA International Energy Consultants

PROJECT:

DESIGN, SUPPLY, INSTALLATION,
TESTING & COMMISSIONING OF
230/132kV AND 132/33kV SUBSTATIONS, NORTHERN ZONE

DRAWING TITLE:

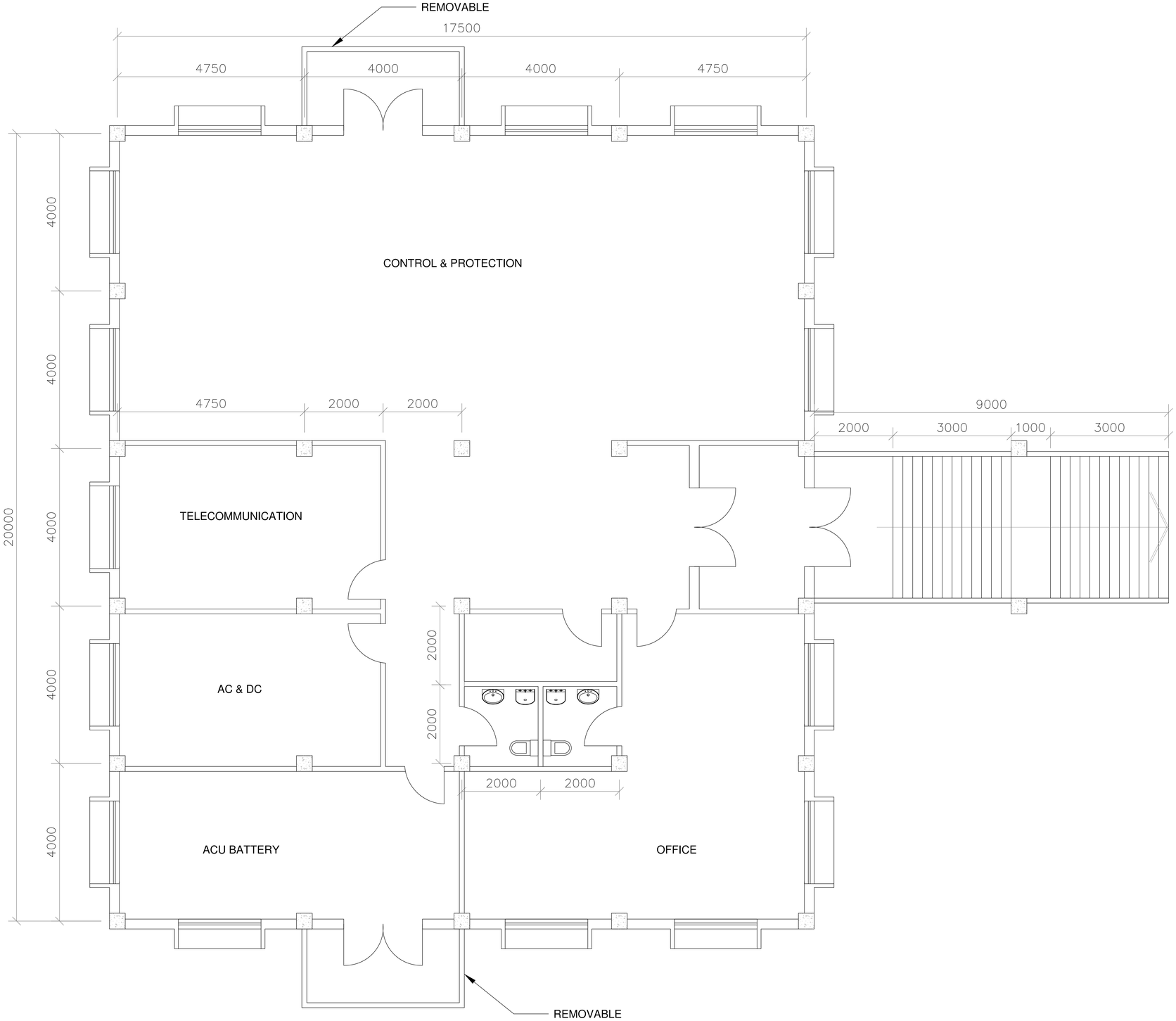
132/33 kV SUBSTATION
CONTROL BUILDING - GROUND FLOOR PLAN

Scale:	Drawn:	Checked:	Approved	Size:
1:50	MBB	BKP	VBC	A0

DRAWING NUMBER:

PGCB/KfW/2012.66.436/SSNZ/9.1

Rev: 0



FIRST FLOOR PLAN – VERSION–I

TENDER PURPOSE ONLY

FOR TENDER	0	03/03/2016	MBB	VBC
Purpose of Issue:	Rev	Date	Drawn	Approved

EMPLOYER:

পাওয়ার গ্রীড কোম্পানী অব বাংলাদেশ লিঃ
POWER GRID COMPANY OF BANGLADESH LTD.
(An Enterprise of Bangladesh Power Development Board)

ENGINEER:

intec
GOPA International Energy Consultants

PROJECT:

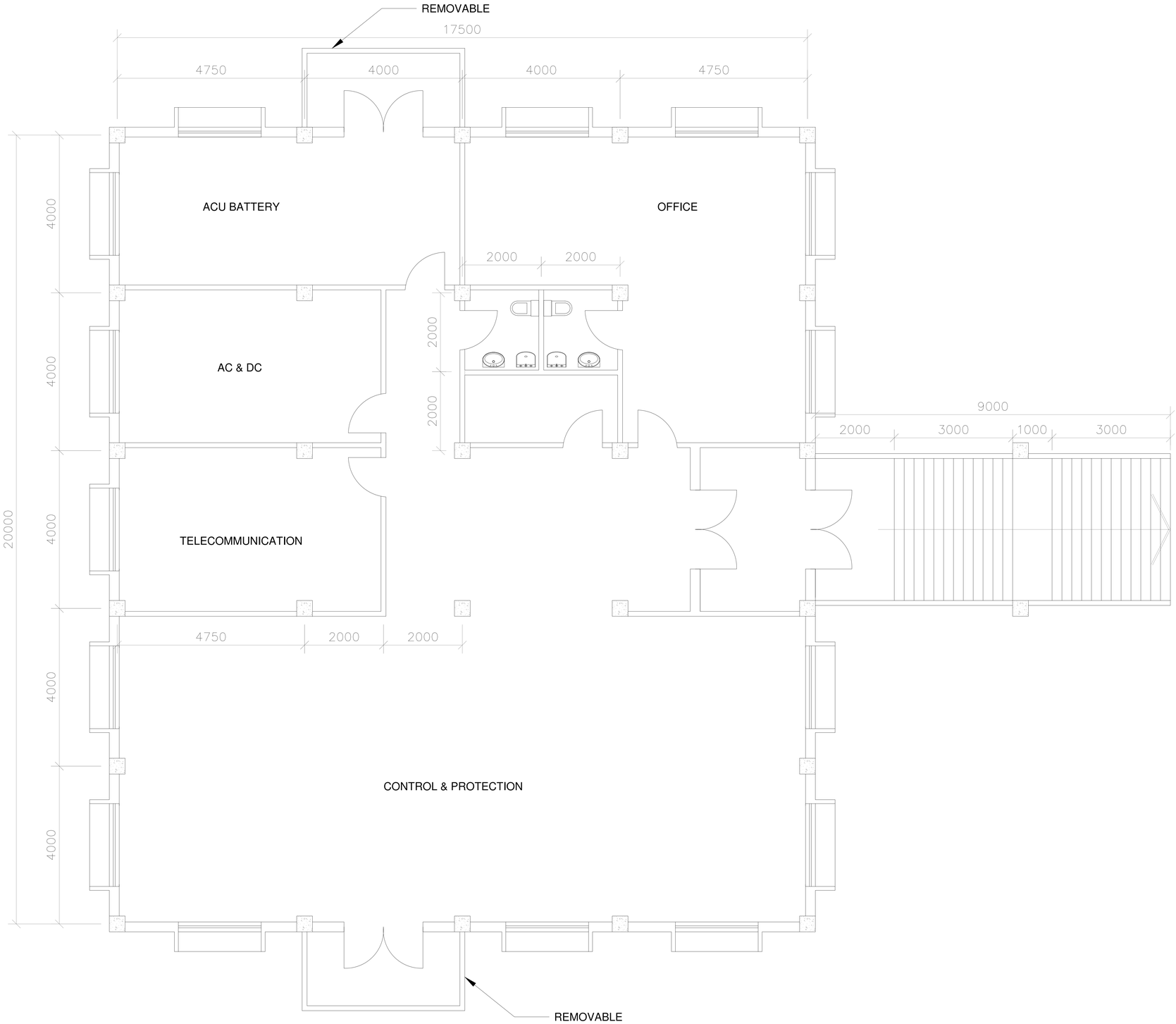
DESIGN, SUPPLY, INSTALLATION,
TESTING & COMMISSIONING OF
230/132kV AND 132/33kV SUBSTATIONS, NORTHERN ZONE

DRAWING TITLE:

132/33 kV SUBSTATION
CONTROL BUILDING - FIRST FLOOR PLAN (VERSION-I)

Scale:	Drawn:	Checked:	Approved	Size:
1:50	MBB	BKP	VBC	A0

DRAWING NUMBER: PGCB/KfW/2012.66.436/SSNZ/9.2 — Rev: 0



FIRST FLOOR PLAN – VERSION–II

TENDER PURPOSE ONLY

FOR TENDER	0	03/03/2016	MBB	VBC
Purpose of Issue:	Rev	Date	Drawn	Approved

EMPLOYER:

পাওয়ার গ্রীড কোম্পানী অব বাংলাদেশ লিঃ
POWER GRID COMPANY OF BANGLADESH LTD.
(An Enterprise of Bangladesh Power Development Board)

ENGINEER:

intec
GOPA International Energy Consultants

PROJECT:

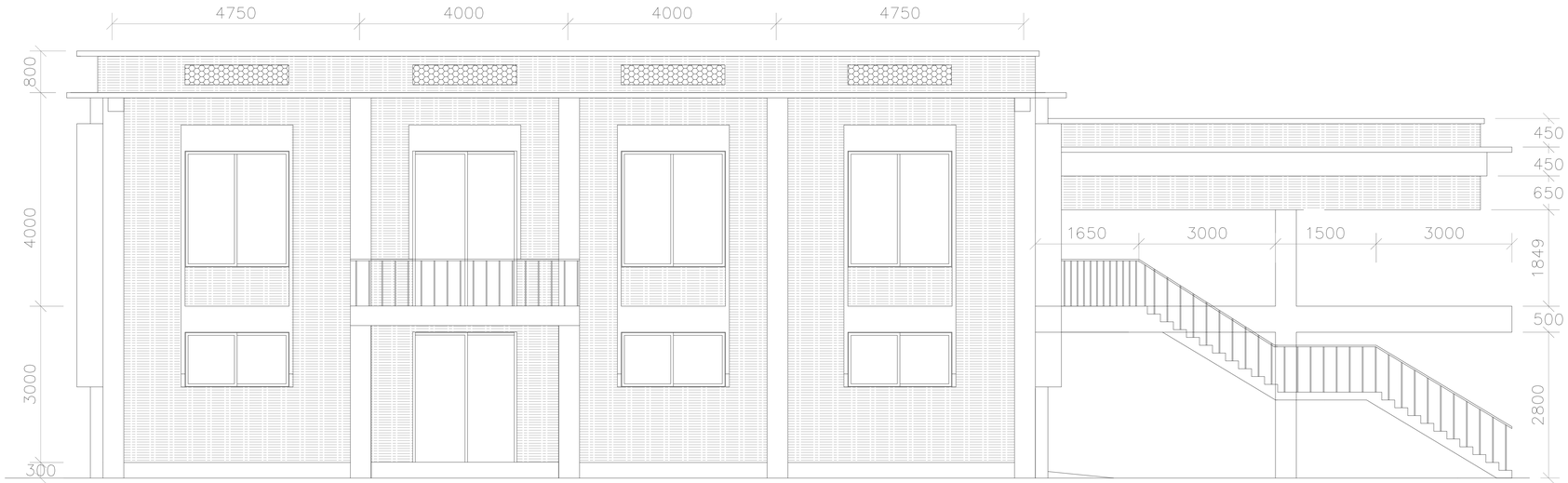
DESIGN, SUPPLY, INSTALLATION,
TESTING & COMMISSIONING OF
230/132kV AND 132/33kV SUBSTATIONS, NORTHERN ZONE

DRAWING TITLE:

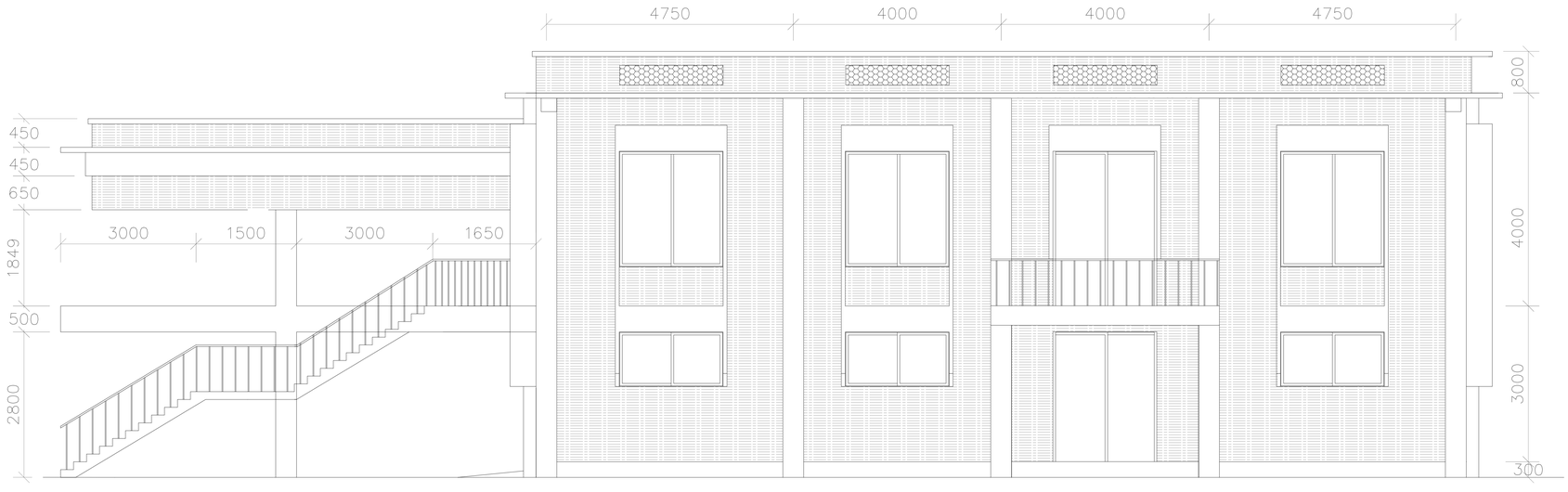
132/33 kV SUBSTATION
CONTROL BUILDING - FIRST FLOOR PLAN (VERSION-II)

Scale:	Drawn:	Checked:	Approved	Size:
1:50	MBB	BKP	VBC	A0

DRAWING NUMBER: PGCB/KfW/2012.66.436/SSNZ/9.3 — Rev: 0



RIGHT ELEVATION



LEFT ELEVATION

TENDER PURPOSE ONLY

FOR TENDER	0	03/03/2016	MBB	VBC
Purpose of Issue:	Rev	Date	Drawn	Approved

EMPLOYER:

পাওয়ার গ্রীড কোম্পানী অব বাংলাদেশ লিঃ
POWER GRID COMPANY OF BANGLADESH LTD.
(An Enterprise of Bangladesh Power Development Board)

ENGINEER:

intec
GOPA International Energy Consultants

PROJECT:

DESIGN, SUPPLY, INSTALLATION,
TESTING & COMMISSIONING OF
230/132kV AND 132/33kV SUBSTATIONS, NORTHERN ZONE

DRAWING TITLE:

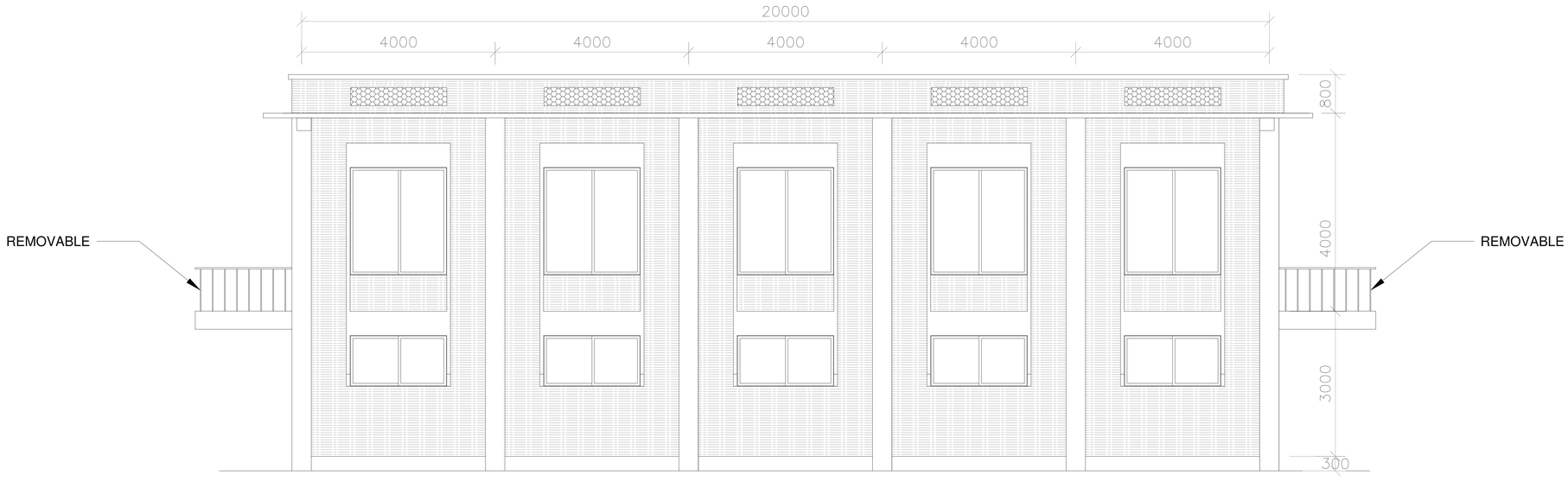
132/33 kV SUBSTATION
CONTROL BUILDING - ELEVATIONS (RIGHT & LEFT)

Scale:	Drawn:	Checked:	Approved	Size:
1:50	MBB	BKP	VBC	A0

DRAWING NUMBER: PGCB/KfW/2012.66.436/SSNZ/9.4

Rev: 0

FRONT ELEVATION



BACK ELEVATION

TENDER PURPOSE ONLY

FOR TENDER	0	03/03/2016	MBB	VBC
Purpose of Issue:	Rev	Date	Drawn	Approved

EMPLOYER:

পাওয়ার গ্রীড কোম্পানী অব বাংলাদেশ লিঃ
POWER GRID COMPANY OF BANGLADESH LTD.
(An Enterprise of Bangladesh Power Development Board)

ENGINEER:

intec
GOPA International Energy Consultants

PROJECT:

DESIGN, SUPPLY, INSTALLATION,
TESTING & COMMISSIONING OF
230/132kV AND 132/33kV SUBSTATIONS, NORTHERN ZONE

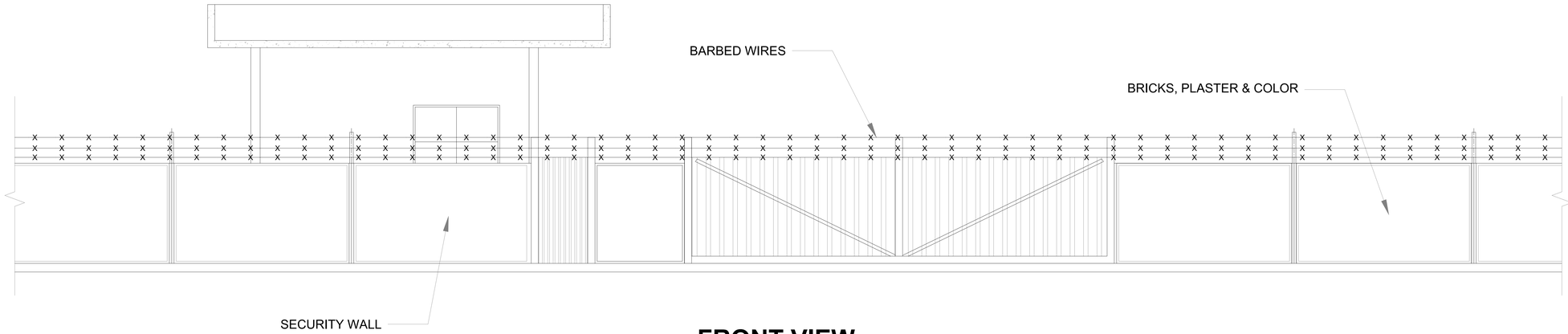
DRAWING TITLE:

132/33 kV SUBSTATION
CONTROL BUILDING - ELEVATIONS (FRONT & BACK)

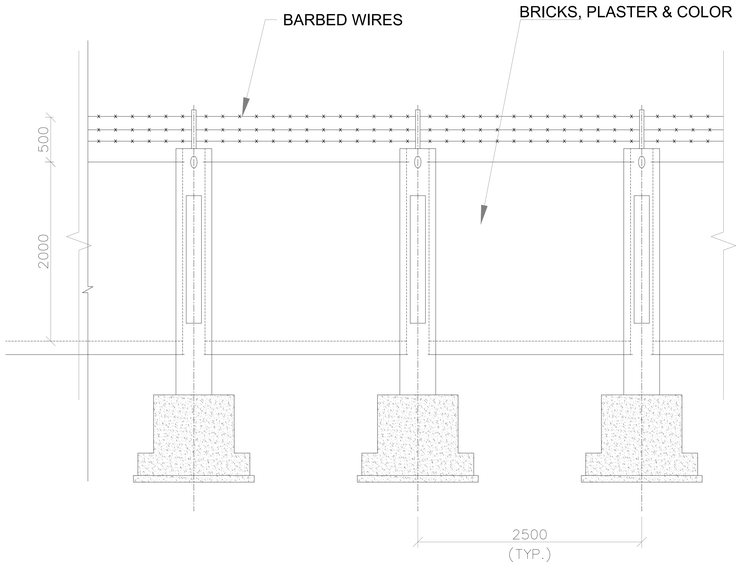
Scale:	Drawn:	Checked:	Approved	Size:
1:50	MBB	BKP	VBC	A0

DRAWING NUMBER: PGCB/KfW/2012.66.436/SSNZ/9.5

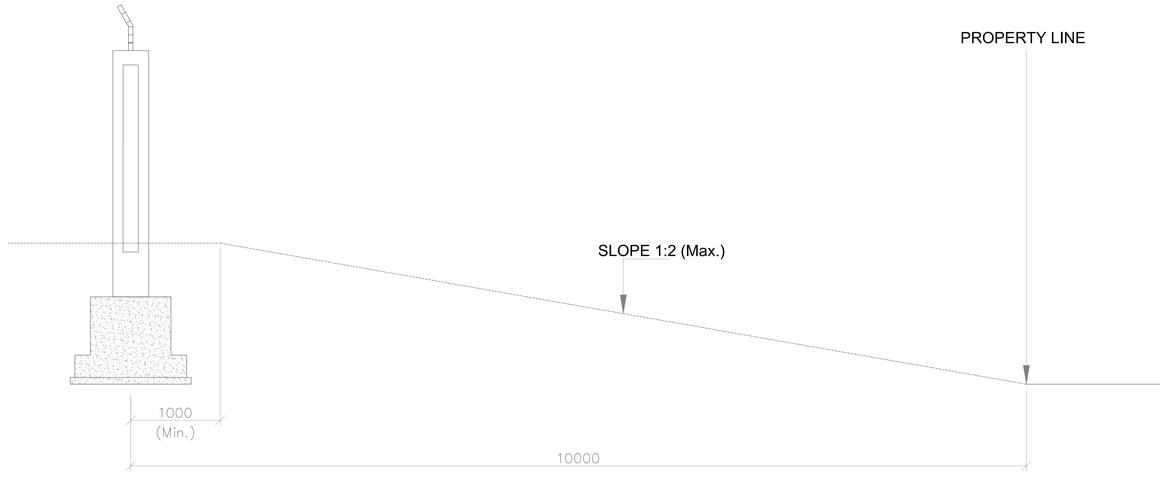
Rev: 0



FRONT VIEW



BOUNDARY / SECURITY WALL ELEVATION



BOUNDARY / SECURITY WALL SIDE VIEW

TENDER PURPOSE ONLY

FOR TENDER	0	03/03/2016	MBB	VBC
Purpose of Issue:	Rev	Date	Drawn	Approved

EMPLOYER:

পাওয়ার গ্রীড কোম্পানী অব বাংলাদেশ লিঃ
POWER GRID COMPANY OF BANGLADESH LTD.
(An Enterprise of Bangladesh Power Development Board)

ENGINEER:

intec
GOPA International Energy Consultants

PROJECT:

DESIGN, SUPPLY, INSTALLATION,
TESTING & COMMISSIONING OF
230/132kV AND 132/33kV SUBSTATIONS, NORTHERN ZONE

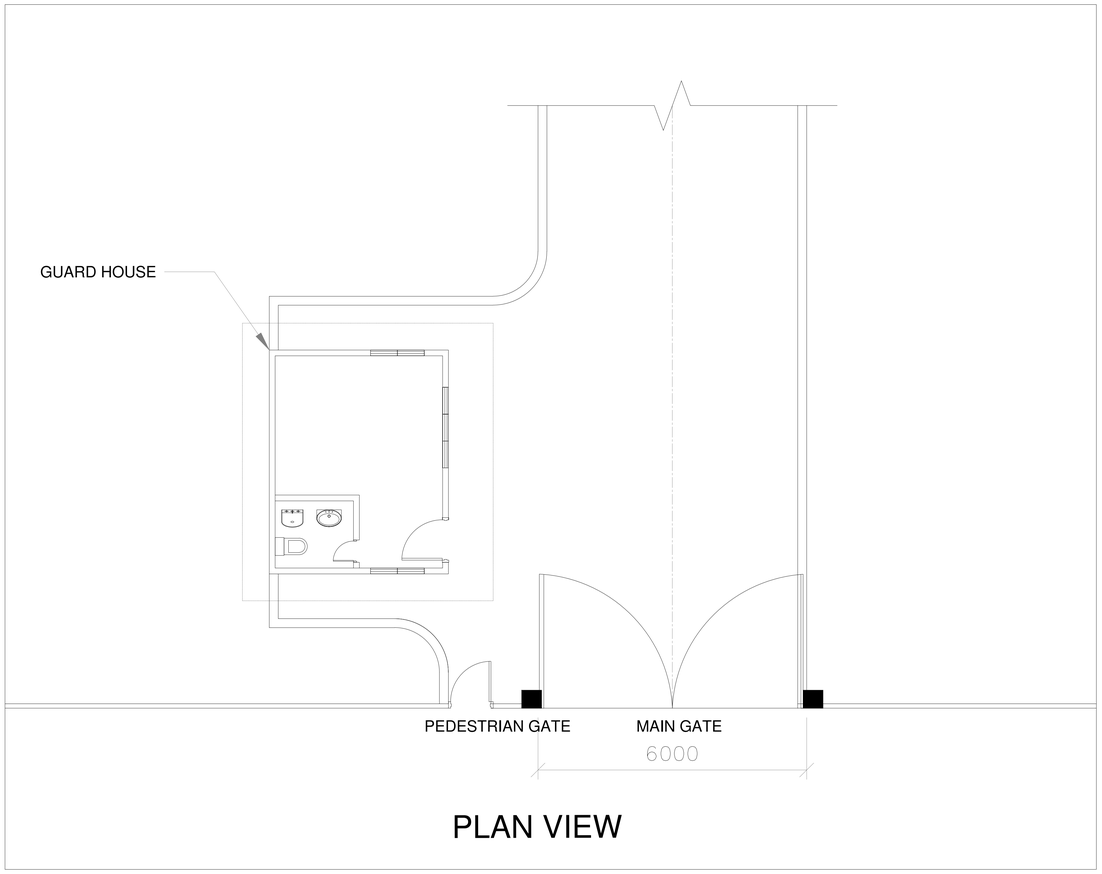
DRAWING TITLE:

132/33 kV SUBSTATION
PROPERTY LINE, BOUNDARY LINE & SECURITY WALL

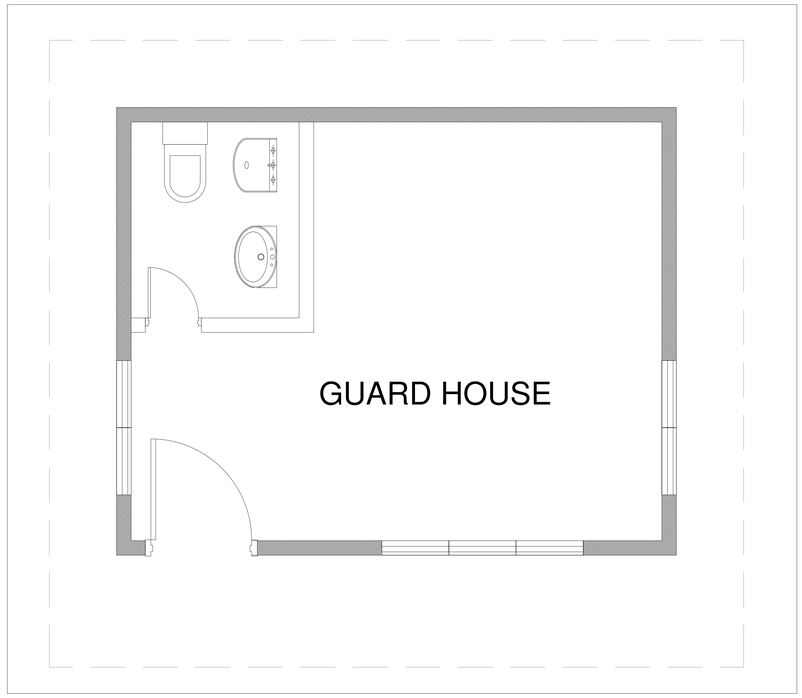
Scale:	Drawn:	Checked:	Approved	Size:
1:50	MBB	BKP	VBC	A0

DRAWING NUMBER: PGCB/KfW/2012.66.436/SSNZ/9.6

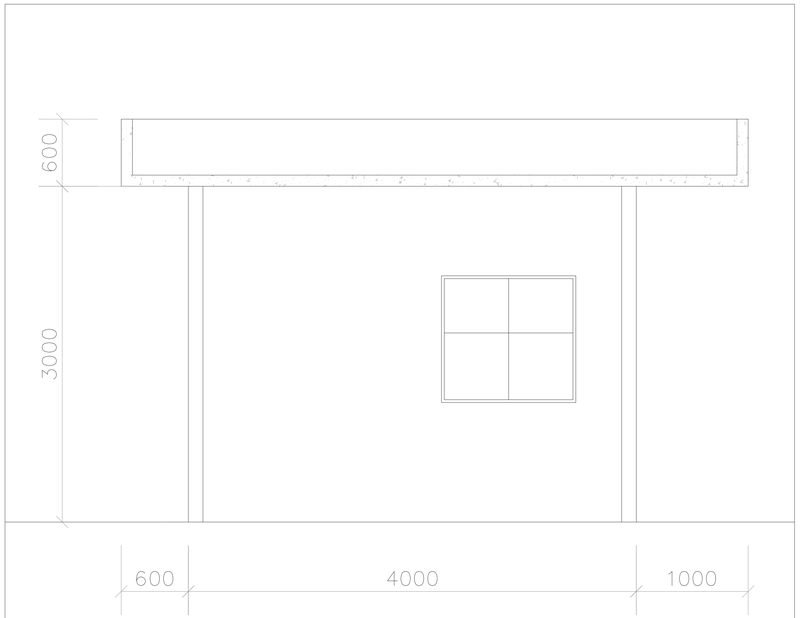
Rev: 0

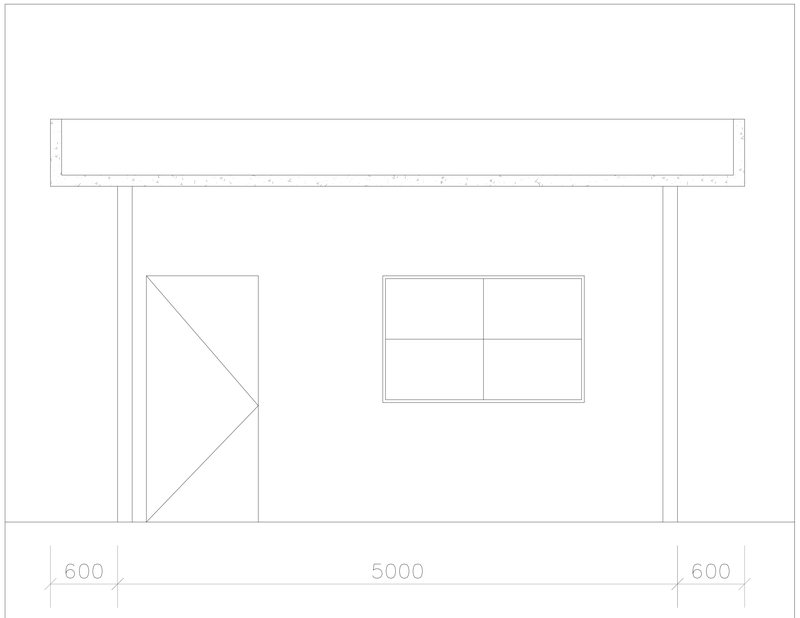


PLAN VIEW



NOTES:-





TENDER PURPOSE ONLY

FOR TENDER	0	03/03/2016	MBB	VBC
Purpose of Issue:	Rev	Date	Drawn	Approved

EMPLOYER:

পাওয়ার গ্রীড কোম্পানী অব বাংলাদেশ লিঃ
POWER GRID COMPANY OF BANGLADESH LTD.
(An Enterprise of Bangladesh Power Development Board)

ENGINEER:

intec
GOPA International Energy Consultants

PROJECT:

DESIGN, SUPPLY, INSTALLATION,
TESTING & COMMISSIONING OF
230/132kV AND 132/33kV SUBSTATIONS, NORTHERN ZONE

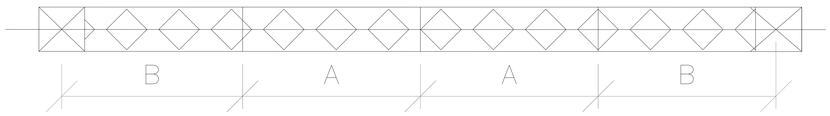
DRAWING TITLE:

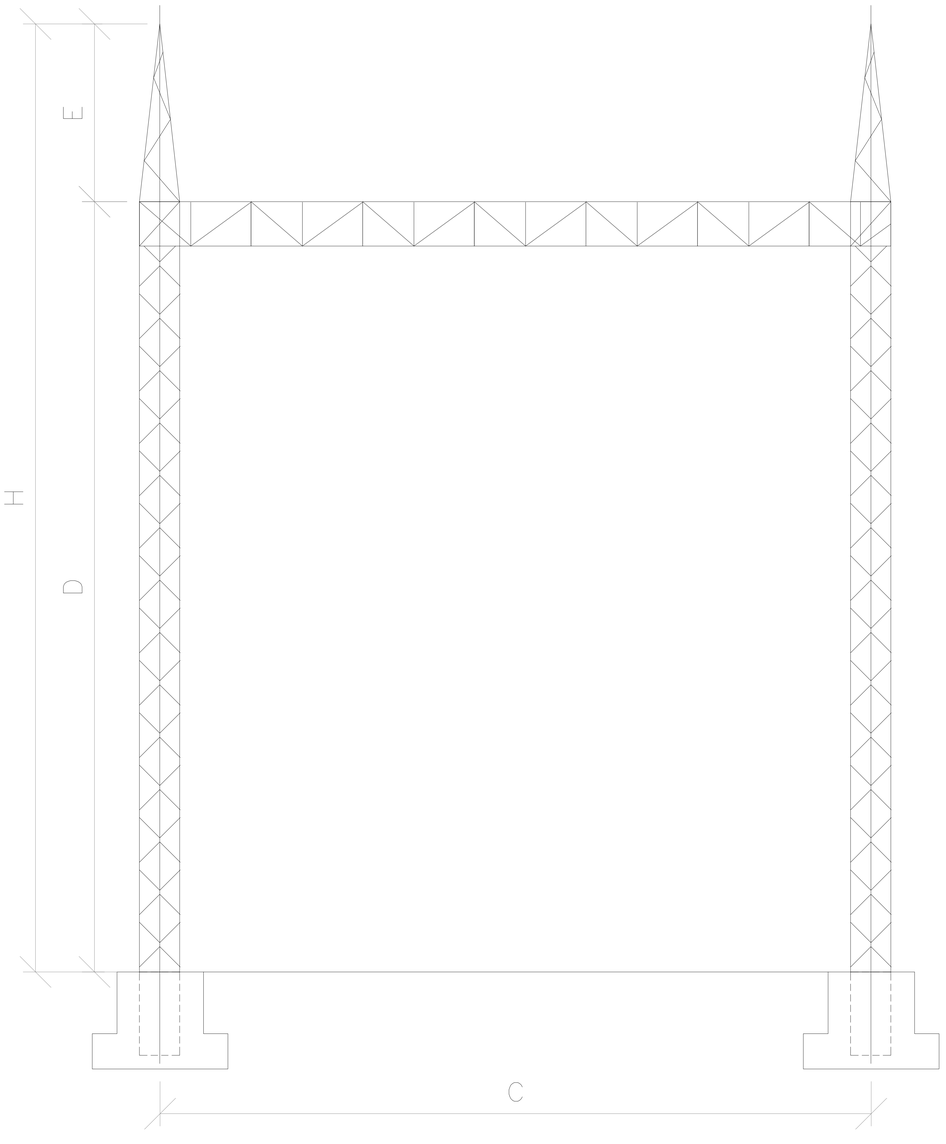
132/33 kV SUBSTATION
GUARD HOUSE AND CROSS SECTIONS

Scale:	Drawn:	Checked:	Approved	Size:
1:20	MBB	BKP	VBC	A0

DRAWING NUMBER: PGCB/KfW/2012.66.436/SSNZ/9.7

Rev: 0





	132kV		230kV	
	BAY	BUSBAR	BAY	BUSBAR
A	3.00	3.00	4.00	4.00
B	3.00	3.00	4.00	4.00
C	12.00	12.00	16.00	16.00
D	13.00	10.00	18.00	12.00
E	3.00	-	6.00	-
H	16.00	-	24.00	-

TENDER PURPOSE ONLY

NOTES:-

FOR TENDER	0	03/03/2016	MBB	VBC
Purpose of Issue:	Rev	Date	Drawn	Approved

EMPLOYER:

পাওয়ার গ্রীড কোম্পানী অব বাংলাদেশ লিঃ
POWER GRID COMPANY OF BANGLADESH LTD.
(An Enterprise of Bangladesh Power Development Board)

ENGINEER:

intec
GOPA International Energy Consultants

PROJECT:

DESIGN, SUPPLY, INSTALLATION,
TESTING & COMMISSIONING OF
230/132kV AND 132/33kV SUBSTATIONS, NORTHERN ZONE

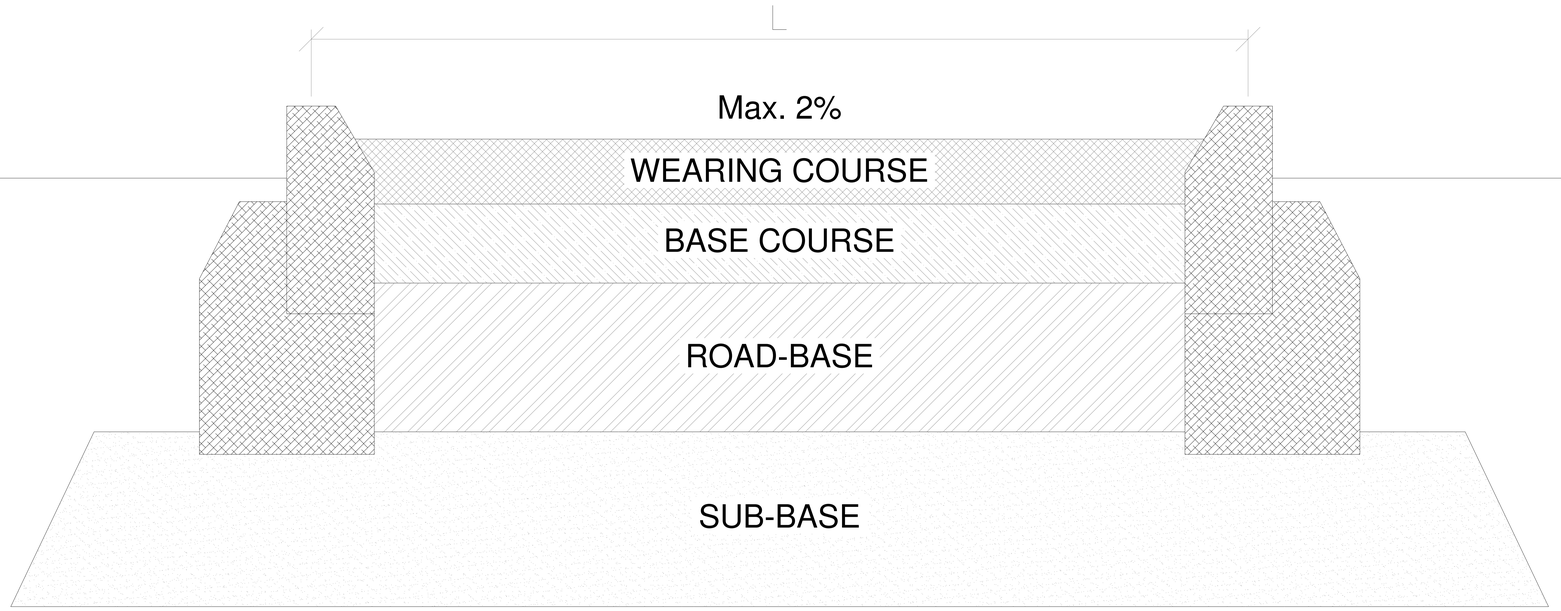
DRAWING TITLE:

132/33 kV SUBSTATION
GANTRY & CABLE TRENCH

Scale:	Drawn:	Checked:	Approved	Size:
1:100	MBB	BKP	VBC	A0

DRAWING NUMBER: PGCB/KfW/2012.66.436/SSNZ/9.8

Rev: 0



	L
MAIN ROAD	6.00
OTHER ROADS	3.00

WEARING COURSE	Min. 50
BASE COURSE	Min. 70
ROAD - BASE	Min. 150
SUB - BASE	Min. 200

TENDER PURPOSE ONLY

NOTES:-

FOR TENDER	0	03/03/2016	MBB	VBC
Purpose of Issue:	Rev	Date	Drawn	Approved

EMPLOYER:

পাওয়ার গ্রীড কোম্পানী অব বাংলাদেশ লিঃ
POWER GRID COMPANY OF BANGLADESH LTD.
(An Enterprise of Bangladesh Power Development Board)

ENGINEER:

intec
GOPA International Energy Consultants

PROJECT:

DESIGN, SUPPLY, INSTALLATION,
TESTING & COMMISSIONING OF
230/132kV AND 132/33kV SUBSTATIONS, NORTHERN ZONE

DRAWING TITLE:

132/33 kV SUBSTATION
ROAD

Scale:	Drawn:	Checked:	Approved	Size:
NTS	MBB	BKP	VBC	A0

DRAWING NUMBER: PGCB/KfW/2012.66.436/SSNZ/9.9

Rev: 0