



Technology Training that Works

Practical Power Distribution

Contents

Chapter 1—Overview	1
1.1 Introduction	1
1.2 History and growth of power distribution	2
1.3 Benefits of 3-phase AC power system	3
1.4 Typical characteristics of an industrial distribution system	6
1.5 Main components of an industrial distribution system	6
1.6 Main equipment types in an industrial distribution system	7
1.7 Electrical safety and power security	8
1.8 Summary	8
<hr/>	
Chapter 2— Distribution System Alternatives	9
2.1 Voltage classification	9
2.2 Multiple voltage levels in power distribution	10
2.3 Types of distribution arrangements and redundancy	14
2.4 Expandability	19
2.5 Summary	20
<hr/>	
Chapter 3— Distribution System Planning	21
3.1 The need for system planning	21
3.2 Approach to system planning	22
3.3 Data collection	22
3.4 Protection of future growth of electricity demand	24
3.5 Location of key assets	25
3.6 Selection of basic system parameters	26
3.7 Planning of electrical system configuration	27
3.8 Equipment ratings/sizing	28
3.9 Selection of appropriate equipment	29
3.10 Maintainability and expandability	29
3.11 System studies needed for planning	30
3.12 Software packages used for system studies	32
3.13 Summary	33



Technology Training that Works

Chapter 4— Faults in Electrical Systems	35
4.1 What is a fault	35
4.2 Effects of a fault	35
4.3 Types of faults	36
4.4 Limiting the damaging effects of a fault	38
4.5 Need to know the magnitude of fault current	42
4.6 Fault current calculations and system studies	44
4.7 Summary	44

Chapter 5— In-plant Generation and its Integration with Plant Power Systems	47
5.1 Why in-plant generation	47
5.2 Cost of power interruptions in critical processes	48
5.3 Types of in-plant generation	50
5.4 Parallel operation of in-plant generator with external source	51
5.5 In-plant power generation sources	57
5.6 Integrating in-plant generation with plant distribution	58
5.7 Summary	63

Chapter 6—Transformers	65
6.1 Introduction	65
6.2 Transformer theory	66
6.3 Transformer construction	69
6.4 Transformer cooling	73
6.5 Transformer voltage control	74
6.6 Power transformers and distribution transformers	78
6.7 Installation of transformers	78
6.8 Special aspects in installation of large power transformers	83
6.9 Fire protection measures for large transformer installations	89
6.10 Transformer troubleshooting	89

Chapter 7— Circuit Breakers	93
7.1 Role of a circuit breaker in a distribution system	93
7.2 Disconnectors/Isolator	94
7.3 Circuit breakers and their operating principle	94
7.4 Air circuit breakers	96
7.5 Oil Circuit Breakers (OCB)	97
7.6 Minimum (small volume) Oil Circuit Breakers - MOCB	103
7.7 Air blast circuit breakers	104



Technology Training that Works

7.8	SF ₆ circuit breakers	107
7.9	Vacuum circuit breakers	110
7.10	Comparison of relative features and applications	112
7.11	Circuit breaker operating mechanisms	112
7.12	Circuit breaker ratings	113
<hr/>		
Chapter 8—	Medium Voltage Switchgear	115
8.1	Switchgear options	115
8.2	Outdoor MV switchgear	116
8.3	Indoor MV switchgear	117
8.4	MV switchgear panel configurations	121
8.5	MV switchgear auxiliary devices	122
8.6	MV switchgear ratings	123
<hr/>		
Chapter 9—	Low Voltage Networks	129
9.1	Introduction	129
9.2	Air circuit breakers	130
9.3	Moulded case circuit breakers	131
9.4	Application and selective co-ordination	142
9.5	Miniature circuit breakers	148
<hr/>		
Chapter 10—	Protection of Electrical Power Systems	149
10.1	Need for protective apparatus	149
10.2	Basic requirements of protection	150
10.3	Basic components of a protection system	151
10.4	Protection of distribution systems	152
10.5	Types of faults in electrical systems	152
10.6	Detection of fault currents	155
10.7	Fuses for protection	156
10.8	Protective relays	157
10.9	Electromechanical protection relay	158
10.10	Electronic protection relays	163
10.11	Coordination of protection	169
<hr/>		
Chapter 11—	Electrical Cables	179
11.1	Introduction	179
11.2	Types and construction of cables	180
11.3	Basic design and selection	182



Technology Training that Works

11.4	Insulating materials for LV and HV cables	183
11.5	Accessories for cable installation	184
11.6	High voltage power transmission using cables	184
11.7	New technologies – superconductivity for high capacity cables	184
11.8	Failure of cables	185
11.9	Fault detection	189
11.10	Summary	194

Chapter 12—DC Power Supply Equipment	197
---	------------

12.1	Need for DC power	197
12.2	Battery principles	198
12.3	Battery charger	202
12.4	Construction of battery chargers	204
12.5	Battery charger maintenance guide	204
12.6	Arrangement of DC supplies	206
12.7	Grounding of DC supplies	207
12.8	Tip circuit supervision	208
12.9	Reasons why breakers and contactors fail to trip	209
12.10	Capacity storage trip units	211

Chapter 13—Electrical Safety and Role of Earthing	213
--	------------

13.1	Overview	213
13.2	Hazards posed by electrical equipment	214
13.3	Electrical shock hazard - definitions	216
13.4	Electrical shock by direct and indirect contact	219
13.5	Role of protective earthing	222
13.6	Indirect contact hazard – importance of protection	226
13.7	Sensing of earth faults	227
13.8	Equipotential bonding for safety against indirect contact	228
13.9	Use of Personal Protective Equipment (PPE)	231
13.10	Arc flash danger in electrical equipment	232

Chapter 14—Power Quality Problems and Solutions	235
--	------------

14.1	Introduction	235
14.2	Limits on electrical parameters	236
14.3	What is power quality?	238
14.4	Power quality indicators	239



Technology Training that Works

14.5 Power quality improvement measures	246
14.6 Need for improving power quality	252
14.7 Summary	253
<hr/>	
Chapter 15—New Era of Power System Automation	255
15.1 Definition of the term	255
15.2 What is power system automation?	255
15.3 Power system automation architecture	257
<hr/>	
Chapter 16—Asset Management of Power Distribution Equipment	261
16.1 Overview	261
16.2 Maintenance of electrical switchgear	262
16.3 Insulation deterioration	269
16.4 Switchgear diagnostic techniques	271
16.5 Substation battery condition and monitoring	282
16.6 Circuit breakers measurements	284
16.7 Switchgear maintenance procedures	293
16.8 Problems that may be found during switchgear maintenance	298
16.9 Defect management	299
16.10 Case studies of switchgear defects	301
<hr/>	
Appendix A—Fault calculations in electrical systems	305
Appendix B—Power Factor Compensation	325