



Technology Training that Works

Practical Power Cabling and Earthing

Contents

1	Introduction	1
1.1	Role of Power Cables in Electrical Systems	1
1.2	Trouble-free Operation of Cables	3
1.3	Earthing and Its Importance	3
1.4	System and Protective Earthing	6
1.5	Summary	7
2	Cables and Accessories	9
2.1	Low and High Voltage Cables	9
2.2	Advantages over Overhead Transmission Lines	10
2.3	Disadvantages of Cables in Power Transmission	10
2.4	Various Types of Cables	11
2.5	Cable Jointing (splicing) Accessories	11
2.6	Need for Termination Kits	12
2.7	Installation of Cables	13
2.8	Summary	14
3	Construction of cables	15
3.1	Basic Constructional Aspects	15
3.2	Insulation	19
3.3	Application Areas	29
3.4	Cable Standards	30
3.5	Summary	31
4	Selection and Installation of Cables	33
4.1	Selection Criteria	33
4.2	Sizing	36
4.3	Installation	41
4.4	Special Locations	46
4.5	Fire Prevention and Fire Protection for Cable Installations	46
4.6	Summary	50
5	Practical aspects of cable jointing and termination	51
5.1	Kits for Joints and Terminations	51
5.2	Shelf Life	55
5.3	Issues with Prefabricated Kits	56
5.4	Preparation of Cable for Termination and Jointing	56
5.5	Connection and Reconstitution of Cable Properties	61
5.6	Continuity and Earthing Aspects	65



Technology Training that Works

5.7	Sealing, Healthiness of Joint/Termination & Repairs	65
5.8	Basics of Equipment Terminations	68
5.9	Termination to Indoor Switchgear	69
5.10	Termination to Electrical Machines	73
5.11	Termination of outdoor HV installation	74
5.12	Terminations to GIS Installation	76
5.13	Importance of Correct Orientation of Terminations	77
5.14	Installation Aspects for Cable Joints and Terminations	78
5.15	Safety Issues and Access for Repairs	79
5.16	Summary	81
6	Failure Modes and Fault Detection	83
6.1	Types of Failures	83
6.2	Reasons for Failures	84
6.3	Fault Location	89
6.4	Electrical Tests for Detection of Cable Faults	90
6.5	Safety Issues in Fault Location	93
6.6	Analysis of Failures	94
6.7	Documentation of Work	97
6.8	Documentation of Failures	98
6.9	Summary	98
7	New Trends	101
7.1	Increasing use of underground Cables	101
7.2	New Technologies for Very High Capacities and Voltages	104
7.3	EHV XLPE Cable Systems	105
7.4	High Temperature Superconductivity in cables	106
7.5	Summary	111
8	Earthing of Power Supply Systems	113
8.1	Types of System Earthing and Comparisons	113
8.2	Unearthed Systems	116
8.3	Solidly Earthed Systems	119
8.4	Resistance Earthing Systems	119
8.5	Reactance Earthing	121
8.6	Impedance Earthing Using Neutral Reactor	121
8.7	Resonant Earthing Using Neutral Reactor	121
8.8	Impedance Earthing Through Neutral Resistance	122
8.9	Point of Earthing Without a Neutral Point	123
8.10	Summary	125
9	Equipment (Protective) Earthing	127
9.1	Shock Hazard	127
9.2	Earthing of Equipment	130
9.3	Operation of Protective Devices	131



Technology Training that Works

9.4	Thermal Capability	132
9.5	Touch Potential during Ground Faults	133
9.6	Induced Voltage Problem	133
9.7	Mitigation by Multiple Ground Connection	134
9.8	Mitigation by Reduction of Conductor Spacing	134
9.9	EMI Suppression	135
9.10	Metal Enclosures for Earthing Conductors	135
9.11	Earthing Connections for Surge Protection Equipment	136
9.12	Sensing of Ground Faults	137
9.13	Equipotential Bonding	138
9.14	Summary	140
<hr/>		
10	Ground Electrode Systems	141
<hr/>		
10.1	Earthing Electrodes	141
10.2	Soil Resistance	142
10.3	Measurement of Soil Resistivity	144
10.4	Resistance of a Single Rod Electrode	146
10.5	Current Carrying Capacity of an Electrode	148
10.6	Use of Multiple Ground Rods in Parallel	148
10.7	Measurement of Ground Resistance of an Electrode	149
10.8	Concrete Encased Electrodes	150
10.9	Corrosion Problems in Electrical Earthing Systems	152
10.10	Maintenance of Earthing System	152
10.11	Chemical Electrodes	152
10.12	Summary	154
<hr/>		
11	Cabling and Earthing: Convergence	155
<hr/>		
11.1	Inter-relation between Cabling and Earthing	155
11.2	Influence of System Earthing on Cable Voltage Rating	155
11.3	Cable as Part of a Protective Earthing System	156
11.4	Need to Earth Insulation Screens in Cables	158
11.5	Earth Continuity in Cable Joints	160
11.6	Use of Armor in Providing Earth Continuity	160
11.7	Earthing of Cable Screen/Armor in Cable Terminations	164
11.8	Summary	169
11.9	Appendices	169
<hr/>		
	Appendix A	171
<hr/>		
A.1	USA- National Electrical Code (NEC) Regulations Relating to Earthing Practices	171
A.2	South Africa- Earthing Practices as per SABS Standards	172
A.3	Earth Electrode Recommendations By Different National Codes	177
A.4	Measurement of Earth Electrode Resistance- Recommended Practice by South African Standard SCSASAAL9	182



Technology Training that Works

Appendix B		189
B.1	Common Neutral Earthing Practices in Low Voltage Consumer Installations as per UK Code BS: 7671:2000 (IEE Wiring Regulations)	189
B.2	More on TN-C-S systems	192
B.3	Installations Where Use of TN-C-S System Is Prohibited	193
Appendix C		197
Appendix D		199
D.1	Glossary	199
D.2	Introduction	199
D.3	Alphabetical Listing of Terms Used in this Recommended Practice	199
D.4	Words Avoided Because of No Single Technical Definition	205
D.5	Abbreviations and Acronyms	205
D.6	References	206
Appendix E		207
Appendix F		
Appendix G		
Appendix H		
Appendix I		