

HIGHER TECHNICAL INSTITUTE

ELECTRICAL ENGINEERING DEPARTMENT

DIPLOMA PROJECT

DESIGN AND DESCRIPTION OF THE OPEN AIR AND GAS INSULATED SUBSTATIONS OF E.A.C

E/1098

BY: STYLIANOU STAVROS

JUNE 1997

a contraining of	and it has to be a state of the second se
MOWER	PROJECT
TOUNICAL	9(00
TITUTE	2690
States and an and a state of the state of the states	and the second second second

DESIGN AND DESCRIPTION OF THE OPEN AIR AND GAS INSULATED SUBSTATIONS OF E.A.C

BY; STYLIANOU STAVROS

PROJECT REPORT SUBMITTED TO THE DEPARTMENT OF ELECTRICAL ENGINEERING OF HIGHER TECHNICAL INSTITUTE NICOSIA-CYPRUS

IN PARTIAL FULLFILMENT OF THE REQUIREMENTS FOR THE DIPLOMA OF TECHNICIAN ENGINEER IN ELECTRICAL ENGINEERING

JUNE 1997

PROJECT SUPERVISOR: Mr. CH.CHRYSAFIADES



TO MY F&MILY.

CONTENTS

•	Acknowledgements	IV
•	Summary	v
•	Chapter 1: Introduction	1
•	Chapter 2: Definitions	5
•	Chapter 3: Description of the Open Air substation	9
	3.1.0 Site selection	10
	3.2.0 Substation components	10
	3.3.0 Support structures	10
	3.4.0 Substation busbars	11
	3.4.1 Busbar Protection	11
	3.5.0 Transformers	11
	3.5.1 Current Transformers	- 11
	3.5.2 Power Transformers	12
	3.5.3 Capacitor Voltage Transformers	12
	3.6.0 Protection	12
	3.6.1 Transformer protection	12
	3.6.1.1 Transformer overheating protection	13
	3.6.2 Back-up protection	13
	3.6.3 Circuit breaker protection	14
	3.6.4 Line protection	14
	3.6.5 Disconnecting and earthing switches	15
	3.7.0 Surge Arresters	16
	3.8.0 Shunt capacitors-shunt reactors	16
	3.9.0 Substation earthing	17
	3.10.0 Batteries and battery chargers	17
	3.11.0 11kV Switchgear	18
•	Chapter 4: Design of the Open Air substation	19
	4.1.0 Switching arrangements	20
	4.1.1 Service continuity	20

4.1.2 (Choice of switching arrangements	21
4.2.0 Busbar co	nnection and structures	22
4.2.1 I	Design parameters	22
4.2.2 F	Force due to short-circuit	23
	4.2.2.1 Force between parallel conductors	23
	4.2.2.2 Forces between rigid conductors	23
	4.2.2.3 Forces between flexible conductors	24
4.2.3	Force due to wind loading	24
4.2.4	Force due to deadweight	25
4.3.0 Insulators	5	25
4.3.1	Post-type insulators for use as busbar	25
	or connection supports	25
4.3.2	Tension insulators	25
4.4.0 Busbars	and connections	25
4.5.0 Terminal	fittings and clamps	26
4.6.0 Supporti	ng structures	26
4.7.0 Main swi	itching equipment	27
4.7.1	Circuit breakers	27
4.7.2	Disconnectors	27
4.7.3	Current Transformers	27
4.7.4	Capacitive couplers and Voltage Transformers	28
4.7.5	Earthing Transformer on 132kV system	29
4.7.6	Transformer sizing	30
4.7.7	Transformer split	31
4.7.8	Surge arresters	32
4.7.9	Layout	32
	4.7.9.1 Clearances	33
4.8.0 Battery	systems	33
4.9.0 Earthing		34
4.9.1	Earth electrodes	34
4.9.2	Materials of earth electrode	35
4.9.3	Joint of earth electrodes	35
4.9.4	Fencing	35

	4.9.5 Incoming overhead lines	36
	4.9.6 Services	36
	4.9.7 Cable sheathes	37
	4.9.8 Surge arresters	37
	4.9.9 Operating mechanism and control kiosks	37
	4.9.10 Fixings	37
4.10.0	Control, Indication and Interlocking	38
	4.10.1 Control	38
	4.10.2 Indication	38
	4.10.3 Interlocking	39
	4.10.3.1 Principles	40
4.11.0	Marking and identification	40
	4.11.1 Phase marking of busbars and main connections	40
	4.11.2 Equipment identification	41
4.12.0	Insulation co-ordination	41
4.13.0	Transformer tab changer	42
Chapter 5:	Design and Description of Gas Insulated Substation	43
5.1.0	Introduction	44
5.2.0	Substation Components	45
5.3.0	Rated insulation level	45
5.4.0	SF6 gas and gas monitoring	45
5.5.0	Operating times	46
	5.5.1 Circuit Breaker	46
5.6.0	Hydraulic Operating system	47
	5.6.1 Closing and opening releases	48
	5.6.2 Auxiliary switches	48
5.7.0	Local control cabinet	48
5.8.0	Motor drive	48
5.9.0	Circuit Breaker	49
	5.9.1 External design	49
	5.9.2 Internal design	50
	5.9.2.1 Interrupter unit	51

5.9.2.2 Arc quenching	52
5.10.0 Corner gears	52
5.11.0 Switching with the manual device	52
5.12.0 Hydraulic unit	53
5.12.1 Hydraulic operating mechanism	53
5.12.1.1 Valve unit with auxiliary switch on/off indicate	or 53
5.12.1.2 Hydraulic cylinder	55
5.12.1.3 Oil tank	55
5.12.2 Hydraulic storage cylinder	56
5.13.0 Disconnectors	56
5.13.1 Construction	56
5.13.1 Operating	57
5.14.0 Work-in-progress earthing switches-Knife earthing switches	57
5.14.1 Construction	57
5.14.2 Operating mechanism	58
5.15.0 High-speed earthing switches	58
5.15.1 Spring stored-Energy mechanism	59
5.16.0 On-Off indicator	59
5.16.1 On-Off indicator with pointer	60
5.16.2 Additional on-off indicators	60
5.17.0 Motor operating mechanism	61
5.17.1 Construction and function	61
5.18.0 Busbars	62
5.18.1 Busbar module	62
5.18.2 Phase changing	63
5.19.0 Connection modules	63
5.20.0 Expansion joints	63
5.20.1 Cable termination	64
5.21.0 Current Transformers	66
5.22.0 Voltage Transformers	67
5.23.0 Surge arresters	68
5.24.0 Inspection and Maintenance services	69
5.25.0 Design considerations	70

	5.26.1 Minimizing and lightening Gas Insulated Switchgear	73
	5.26.2 Improving service quality	74
	5.27.0 Testing	75
	5.27.1 Material tests	76
	5.27.2 Work tests	76
	5.27.3 Site tests	76
•	Chapter 6: Load Flow Studies	77
	6.1.0 Load flow	78
	6.1.1 Data for load flow studies	79
	6.1.2 The Gauss-Seidel method	80
•	Chapter 7: Conclusions	81
•	References	83
•	Appendices	
	Appendix A: Drawings for the transmission system	
	Appendix B: Drawings for the Open-Air substation	
	Appendix C: Pictures of the Open-Air substation	
	Appendix D: Drawings for the Gas Insulated substation	
	Appendix E: Pictures of the Gas Insulated substation	

72

ACKNOWLEDGEMENTS

I would like to express my sincere thanks to my project supervisor Mr. Ch Chrysafiades, Senior Lecturer in the Electrical Engineering Department at the Higher Technical Institute and to my external assessor Mr.Evangelos Anastassiades PE, Electrical Engineer at the Electricity Authority of Cyprus, for their help and guidance throughout the project.

I would also like to thank all the staff of Electricity Authority of Cyprus at Nicosia for their assistance and cooperation during my training there.

Finally, I would like to thank Mr.Christos Christou and Mr.Costas Gavrielides for their useful help in every way.

Stavros Stylianou.

SUMMARY

Design and description of the Open Air and Gas Insulated Substations of E.A.C.

by

Stavros Stylianou

The project deals with the methods used by E.A.C for designing Open Air and GIS type of substations. In order to get acquainted with the design procedures of substations and in general with the whole subject we had to carry out the following tasks.

- Explain the role of each equipment in the substations and be able to describe it.
- Carry out the design of each equipment in order to comply with the relevant Standards.
- Carry out some design considerations which must be taken into account in the designing of a substation.
- Briefly explaining of the load flow studies and their importance in power systems.