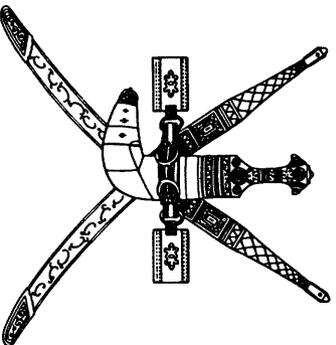


SULTANATE OF OMAN
MINISTRY OF ELECTRICITY AND WATER



STANDARD - OES 24
33/11KV INDOOR SUB STATION (TYPICAL)

FIRST EDITION - MAY 1991

C O N T E N T S

CLAUSE	DESCRIPTION	PAGE
1.0	GENERAL	1
1.1	Scope	
1.2	Major Equipment	
1.3	Building and Foundations	2
1.4	Main Electrical Systems	
1.5	Site Conditions	
1.6	Tools and Appliances	3
1.7	General Specifications	
2.0	OUTDOOR EQUIPMENT	
2.1	Overhead Line Incomer	
2.2	Cable Incomer	4
3.0	11KV, SWITCHGEAR	
4.0	10/20MVA 33/11.5KV TRANSFORMER AND ASSOCIATED EQUIPMENT	
5.0	CABLES	
6.0	EARTHING	5
6.1	General	
6.2	Earthing Points	
6.3	Earthing Conductor Connections	6
6.4	Earthing Conductors	
6.5	Earth Bars	
6.6	Tests at Site	
7.0	PORTABLE FIRE EXTINGUISHERS	
8.0	LIGHTING & SMALL POWER SYSTEM - GENERAL	7
8.1	Specifications and Drawings	
8.2	Electricity Supply	
8.3	Description of Installation	
8.4	Drawings	

8.5	Types of Light Fittings	8
8.6	Lighting Requirements	
8.7	Emergency Lighting	
8.8	Conduit and Fittings	9
8.9	Interior and Exterior Installations	
8.10	Earthing and Bonding	
9.0	AIR CONDITIONING AND VENTILATION	
10.0	500KVA 11KV/433V STATION TRANSFORMER	10
11.0	30V BATTERY SWITCH TRIPPING UNIT	
12.0	11.5KV 5X1 MVAR CAPACITOR BANKS	
13.0	SITE TESTS	
13.1	General	
13.2	Civil Works	
13.3	Lighting and Small Power Installation	11
13.4	Transformers	
13.5	Cables	
13.6	11KV Switchgear	12
13.6.1	Interlocks	
13.6.2	Current Transformers	
13.6.3	Switchgear HV Test	
13.6.4	Secondary Injection	
13.6.5	Primary Injection	
13.7	Ventilation and A/C System	13
13.8	Battery Charger and DC Systems	
13.9	Earthing	
13.10	Indicating Instruments	
13.11	DC Control Circuit Functional Checks	
13.12	Capacitor Bank Associated Control Equipment	
14.00	DRAWINGS	
	1. PL/SLD - E/63	Single Line Diagram
	2. PL/SLD - E/62	For 33/11KV Substation Typical with Cable
		Single line diagram for 33/11 KV
	3. MEW/OH-GA/33	Substation (Typical) - Over Head line Incomer
		Site Layout Plan
	4. MEW/OH-GA/34	33/11KV 10/20 MVA Outdoor Equipment
	5. MEW/OH-GA35/	Earthing layout for 33/11KV 20/10 MVA Substation yard
		General Arrangement Of 33/11KV
	6. MEW/OH-GA/41	10/20 MVA Primary Substation. (Detailed layout)
		33/11KV Substation layout Cable Feeders (Typical)

SULTANATE OF OMAN
MINISTRY OF ELECTRICITY & WATER

OES 24

33/11KV INDOOR SUB STATION (TYPICAL)

1.0 GENERAL

1.1 SCOPE

The specification covers complete supply, erection and commissioning of all electrical and mechanical plant, equipment and construction of building, also all civil works for a typical 33/11KV substation in accordance with the following layouts and single line diagrams:

- a) PL/SLD-E/62
- b) MEW/OH-GA/33
- c) PL/SLD-E/63
- d) MEW/OH-GA/34
- e) MEW/OH-GA/41
- f) MEW/OH-GA/35

The scope of work shall include the complete design, construction, manufacture, shop testing, packing and marking, shipment insurance, delivery to site, loading and unloading, complete erection, start-up, commissioning, initial operation, trial run, acceptance testing, putting into commercial operation, maintenance guarantee for a period of twelve months including construction services during guarantee period until final acceptance of complete plant and equipment.

1.2 MAJOR EQUIPMENT

Major equipment for the substation include:

- a) 14 panel, 11KV, 350MVA single busbar, metalclad indoor switchboard with its associated control and relay equipment.
- b) 2 Nos. 33/11.5KV, 10/20MVA transformers, vector group Dyn. 11
- c) 30V Battery switch tripping unit.
- d) 500KVA, 11KV/433V DYn11 Sm. Tx.
- e) 2 Nos. 3/5MVVAR (in multiples of 1MVVAR) capacitor banks with associated control and protection equipment accommodated in outdoor metal clad panels.
- f) Two fault throw switches with associated foundation and structure.
- g) 2 Nos. Spring opening disconnect with associated foundation structure.

The substation shall be complete with control and relay equipment, alarm facilities, auxiliary DC supplies with battery and charger, 500KVA station transformer and auxiliary LV switchboard, small power and lighting, earthing and all necessary equipment for the safe and efficient operation of the substation.

The scope shall however, include supply and installation of all equipment necessary to enable the supervisory system to be installed at a later date without the necessity of carrying out modifications to the equipment supplied.

The scope shall, therefore, include all local/remote/supervisory selector switches, auxiliary contacts on circuit breakers, isolators etc. for position indication, additional contacts on protection, tripping and alarm relays etc. necessary for a central supervisory control system.

This scope provides for all parts of the work to be completed in every respect for commercial operation to MEW requirements. Notwithstanding that any details, accessories etc. required for the complete installation and satisfactory operation of the plant are not specifically mentioned in this specification, such details shall be considered as included in the contract price.

1.3 BUILDING AND FOUNDATIONS

All civil works are to be as per OES 32 unless otherwise specified. All foundation walls, roof covering, concrete floor fittings, ducts and pipework embedded in the foundations, trenches with cover plates for cables, sleeves etc. shall be provided.

All special epoxy resin and non-shrinking grout necessary for erection of the plant shall be supplied under this contract.

1.4 MAIN ELECTRICAL SYSTEMS

The material and equipment shall be suitable in all respects for use and operation on the MEW 33KV, 11KV and 415V systems as the case may be. The characteristics of the MEW systems are as follows:

Description	33KV	11KV	415 Volts
Rated Voltage	33	11	415/240
Highest System Voltage	36	12.5	3
Number of Phases	3	3	3
Frequency	50 cps	50 cps	50 cps
Design fault level	1500 MVA	350 MVA	31 MVA
Earthing system	Earthed through 12.5 Ohm Resistance	Solidly earthed	Solidly earthed
Impulse level	170KV	75KV	

1.5 SITE CONDITIONS

Climatic conditions are very severe in the Sultanate of Oman. Dust storms are prevalent and the atmosphere is saline, humid and corrosive. Humidity is high, maximum relative humidity being 100% and periods of high humidity are long and continuous. Temperatures are high in summer.

Max. peak ambient shade temperature	: 50 Deg. C
Min. ambient temperature	: 5 Deg. C
Max. temperature of metal surfaces in direct sunlight	: 80 Deg. C
Altitude	: 50 Meters
Max. wind velocity	: 125 KM/Hr
Average annual rainfall	: 100mm

1.6 TOOLS AND APPLIANCES

Switchboard at the substation shall be provided with a complete set of tools housed in a floor/wall mounting cabinet with double leaf doors fitted with handle, locking bar and lock with two keys. The tool cabinet shall also house all switchgear loose handles, spare fuses and bulbs etc. A list of tools to be provided must be included in the tender and their prices itemized separately.

A separate list of spares which the Contractor considers necessary for three years maintenance of the Plant shall be included in the Schedule of Spares.

The Employer may order all or any of the spares recommended at his discretion. Those ordered shall be delivered to the Employer's store or on the site not later than the date of issue of the taking over certificate for the item of plant or equipment in question.

These spares will be charged against the Provisional Sum included in the Schedule of Prices and shall be supplied at the prices listed in the Schedule of Spares.

All spares supplied shall be strictly interchangeable with the spare parts for which they are intended to be replacements and shall be treated and packed for long storage under the climatic conditions prevailing at the site. Each spare shall be clearly marked or labelled on the outside of its packing with its description and purpose and, when more than one spare part is packed in a single case or other container, a general description of its contents is to be shown on the outside of such case or container and a detailed list enclosed inside. All cases, containers and other packages shall be suitably marked and numbered for purposes of identification.

All cases, containers or other packages are liable to be opened at the site for such examination as MEW may consider necessary and all such opening and subsequent repacking is to be at the expense of the Contractor.

1.7 GENERAL SPECIFICATIONS

The material, equipment and accessories supplied and installed shall be in accordance with Standard OES-11 : General Specifications for Electrical Distribution Materials and Equipment issued by the Ministry of Electricity and Water (MEW).

2.0 OUTDOOR EQUIPMENT

2.1 Outdoor equipment for overhead line 33KV feeder shall be generally as per Drawing No. MEW/OH-GA/35 and consists of the following:

OVERHEAD LINE INCOMER

i) I. Section Structure 200 x 100mm for supporting incomer and lightning arrestors. This shall be galvanized to BS 729 in accordance with Clause 011 of OES-11.

ii) Busbar Support Insulator

Station post insulator shall be with aerodynamic open profile type with creepage of 40mm/KV.

iii) 33KV On-load Isolator

They shall be as per OES-18.

iv) 33KV Lighting Arrestors

Three nos. of lighting arrestors conforming to OES 9.

v) TUBULAR COPPER BUSBARS AND BUSBAR CONNECTION

"The busbar should be of tubular type and made of tinned copper of high conductivity 50 mm dia. 8 SWG closed at both ends to prevent ingress of moisture or foreign material, suitable for 400 A continuous rating at Oman site conditions."

33KV Fault Throw Switch

Two Nos. of fault throw switch in accordance with OES-16A.

vii) 33KV Spring Opening Disconnect

Supply of two numbers 33KV spring opening disconnect complying to OES-16B and installed as shown in the layout drawing.

2.2 CABLE INCOMER

In the case of 33KV incomer cable feeder, pilot wire protection to be provided. 3 Sets of 33KV C.T's 400/1 Class X shall be provided in the 33/11KV transformer cable box and characteristics of C.T's matching with C.T's at other end. Pilot wire supervision equipment and associated relay and isolation transformer shall be provided on the 11KV switchgear panel of the incomer.

3.0 11KV SWITCHGEAR

Type

11KV Switchgear generally shall be in accordance with Ministry of Electricity and Water Standard OES-14 except that in case of initial installation of 10MVA transformer, C.T. switchgear on incomer shall have dual ratio 1200/600/1.

4.0 10/20MVA 33/11.5KV TRANSFORMER AND ASSOCIATED EQUIPMENT

The two 10/20MVA/33/11.5KV transformers and associated equipment shall be in accordance with MEW's Standard OES-6.

5.0 CABLES

All cables installed shall be in accordance with MEW Standard OES-2, copy of which can be obtained from the Ministry on payment of the prescribed fee.

The following cables and terminations shall be supplied and installed as necessary for the complete works:

1) 33KV 3C x 300sq. mm XLPE cable from terminal structure to transformer.

2) 11KV single core 500 sq. mm copper cables one/two per phase between 10 – 20MVA transformers and 11KV switchboard.

3) 1000V cables from the substation main distribution board to transformer fan motors, tap changer motors, battery charger, 11KV switchgear auxiliaries etc. Sizes shall be to the approval of MEW.

- 4) 11KV single core 500 sq. mm XLPE cable to fault throw switch.
- 5) Multi core cables for control, alarm, indication metering circuits including cables to 11 KV switchgear for transformer differential, earth fault protection, inter trips etc.
- 6) 11KV 3 core 50 sq. mm copper cable between 500 KVA 11KV/433V transformer and 11KV switchgear.
- 7) 1000 volt cables single core copper 630 sq. mm cables between 500 KVA 11KV/433V transformer and LT main distribution board.
- 8) 11KV cable between capacitor banks and switchgear.

6.0 EARTHING

6.1 GENERAL

Neutrals of the 10/20MVA and 500KVA transformers shall be solidly earthed.

The 11KV neutral bushing of the 20MVA transformer shall be connected to the station earthing system by a 11KV single core XLPE insulated and PVC sheathed cable.

Earthing electrodes and connections at the substation shall be in accordance with the recommendations in the British Standard Code of Practice CP 1013 : 1965. Earthing system shall consist of groups of earthing electrodes buried in the ground in suitable locations as close to the electrical plant as is feasible. The groups of earthing electrodes shall be interconnected with each other and connected via links.

A main hand drawn high conductivity earth bar, area not less than 300 sq. mm shall be provided to which the frames of all electrical apparatus and structural steel work shall be connected by branches of the same cross sectional area to this main bar or to subsidiary bars running to a group of equipment.

Each piece of equipment shall be connected at two defined points by separate subsidiary bars to the station earthing system.

The Contract shall include for the provision and installation of all equipment necessary to provide a complete earthing installation including electrode chambers and covers, positioning of all earth electrodes, installation and connection of all earthing conductors and testing of each earth point, to the satisfaction of the Employer.

The tenderer shall include a layout of the tenderer's proposals. The Contractor shall be responsible for preparing detailed layout drawings, and details of the earthing installation and supports for approval by the Employer and shall provide final record drawings of the earthing installation.

6.2 EARTHING POINTS

The Contractor shall be tests at site after the award of the Contract, determine the number of earthing points required but a minimum of four earthing points shall be provided. A number of rods and earthing points finally determined shall be to the Employer's approval.

Each earthing electrode shall consist as required of clusters of 16mm diameter copper rods, each at least 3.5 meters long driven into undisturbed soil. Each rod electrode shall be complete with approved non ferrous clamps for the

connections of earthing conductors and with a hardened steel tip and cap for driving by means of a power hammer. Each cluster or group of electrodes shall comprise at least four electrodes. The Contract shall include boring if necessary for the installation of electrodes.

Electrode link chambers and concrete covers shall be provided to facilitate ready inspection of the connection. The prices in this Contract shall include the driving of all earthing electrodes, connecting to earthing conductors etc.

6.3 EARTHING CONDUCTOR CONNECTIONS

Connections between the main earthing conductors and the main earth bars shall be made with lugs compressed on to the 300 sq.mm copper strand. The lugs shall then be tinned and riveted to the main earth bars.

The Contractor shall ensure that the resistance between any point of each system and the related earthing electrodes does not exceed 0.1 Ohm and that the overall resistance between the earthing installation and general body of the earth shall, if possible be less than one ohm and shall not exceed 3 Ohms under any climatic conditions.

6.4 EARTHING CONDUCTORS

Earthing conductors 300 sq. mm shall be of annealed high conductivity copper and shall be stranded in accordance with IEC 55. They shall be protected with an extruded PVC sheath of 1000 volts grade.

Earthing conductors shall be buried directly in the ground between the electrode chambers and buildings. Inside buildings they shall be cleated to walls and ceiling or fixed to cable racks or laid in the cable trenches as convenient.

6.5 EARTH BARS

Substation fencing shall be provided with an independent system and it shall be inter connected to the main earthing system only with the approval of the Employer/Engineer.

The size of the copper earthing strip or conductor to the various items of equipment shall be to the Employer's approval and shall be adequate for the maximum earth fault current likely to be encountered.

6.6 TESTS AT SITE

The Contractor shall provide all necessary test equipment for soil resistivity testing and for proving that the earthing system complies with this Specification. The Contractor shall also be responsible for measuring the resistance of each electrode installation and of the complete earthing system to the general body of earth without additional charge.

7.0 PORTABLE FIRE EXTINGUISHERS

The portable apparatus is to be used for the control of fires in the switchgear chambers and outside the substation building.

All apparatus shall be suitable for operation by one person alone and is to be easily recharged. The discharge is to be non-corrosive and free of chemicals prone to give off toxic gases when heated.

The extinguishers shall be manufactured to BS 1721.

The Contract shall include for the supply and installation of all wall brackets and fittings for small units and the provision of wheeled trolleys for units which cannot be carried easily.

Operating instructions shall be clearly printed on each unit.

Two "recharge" units shall be provided for each type and size of equipment at substation.

8.0 LIGHTING AND SMALL POWER SYSTEM – GENERAL

The completed installation shall comply with MEW Standard OES-4 Regulations for Electrical Installations.

All materials shall comply with the latest requirements of the aforementioned codes or standard whether these are mentioned or not and shall be suitable for the climatic conditions at site.

All lamp fittings, plugs, sockets, circuit breakers and general accessories of the same size and types shall be similar and interchangeable throughout the specified installations.

All supports, connections, accessories and other items necessary for the satisfactory completion of the installation shall be supplied and erected whether specifically mentioned or not in the Specification.

8.1 SPECIFICATIONS AND DRAWINGS

Detailed descriptions and drawings of all light fittings, distribution boards, switches, socket outlets, poles, glands etc. comprising the offer shall be submitted with the tender.

The tender price shall be based on the specification. Any variation proposed by the Tenderer shall be stated and alternative price rates shall be quoted separately.

8.2 ELECTRICITY SUPPLY

At the substation, the 415/240V auxiliary supplies shall be obtained from the LV side of the 11/0.415 KV auxiliary transformer.

The LV supplies shall be 415/240V, 3 phase, 4 wire, 50Hz systems with the neutrals solidly earthed.

8.3 DESCRIPTION OF INSTALLATION

AC supplies for lighting small power, air conditioning units etc. shall be supplied from a main distribution board located in the battery AC/DC room.

The main distribution board shall be of the single busbar air insulated metal clad type incorporating air break manually operated switch fuse units for incoming circuit from the 11/0.415KV transformer.

A voltmeter and an ammeter shall be provided for the incoming from the auxiliary transformer.

8.4 DRAWINGS

Drawings showing the lighting and power installations shall be submitted to the Employer for approval once the Plant layout has been finalized.

The Contractor shall when preparing drawings showing the respective design, use a code to identify each light fitting and sock outlet.

8.5 TYPES OF LIGHT FITTING

Each light fitting shall be the Manufacturer's nearest standard type.

Light fittings for interior and exterior use to be manufactured and tested in accordance with the appropriate code or standard and together with all components shall be suitable for service and operation in the tropical climate stated. Each fitting shall be complete with all lamp holders, control gear, internal wiring, fused terminal blocks, earth terminal and reflectors or diffusers. The design of each fitting shall be such that the ingress of dust, vermin and insects is prevented and where open type fittings are used it should not be possible for insects to become lodged therein. The control gear for fluorescent and discharge lamps shall incorporate power factor correction and interference suppression capacitors and be suitable for use on the 240V 50Hz system. Chokes shall be manufactured to restrict the third harmonic component to a minimum.

Internal connections shall comprise stranded conductors not less than 0.75 sq.mm covered with a heat resistant insulation such as neoprene or asbestos compound. All internal wiring shall be adequately cleated to the fitting chassis with an approved form of cleat. The finish of fittings for interior use shall have a vitreous enamel, natural aluminium, or galvanized finish according to the manufacturer's stranded product.

Fittings for housing tungsten lamps exceeding 150W rating shall be provided with an approved method of dissipating heat from the lamp cap and terminal housing. Lamp caps as applicable shall be:

Tungsten lamps upto and including 150 Watts : Standard Bayonet Cap BC

Tungsten lamps above 150W : Edison screw caps (E.S.)

Fluorescent Tubes : Bi Pin

Mercury Lamps : G.E.S.

8.6 LIGHTING REQUIREMENTS

The lighting installations shall be designed to give the illuminations levels for the respective areas set out in the following schedule. The installations shall also meet the limiting glare index requirements as set out in the approved code. The schedule also gives proposals for type of control to be employed, and type of mounting expected to be suitable for the respective areas.

The word "Remote" under the heading type of control indicates that it is proposed that the lighting fittings be switched by the contactors controlled from ON/OFF push button switches or time switches located at suitable positions in the area of the lighting circuit.

The word "Local" indicates the lighting fittings shall be switched by 5 Amp. single pole switches positioned in the area to be lighted.

8.7 EMERGENCY LIGHTING

Emergency lighting system inside the substations shall be supplied from 30V DC supply from 30V battery and charger installed in substation.

4 lamps permanently fitted to ceiling : Two in front of the switchboard and two in the rear shall be provided.

SCHEDULE OF REQUIREMENTS

Area	Lighting Level (lux)	Type of Mounting	Type of Control
Switchgear rooms	400	-	Local
Battery room	100	-	Local
Toilet	100	-	Local
External road ways	10	8 M pole	Remote

8.8 CONDUIT AND FITTINGS

Conduits shall be manufactured in accordance with the appropriate code or standard and shall be high impact heavy gauge polyvinyl chloride.

PVC conduit fittings shall be of the plain bore pattern suitable for 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 Employer.

8.9 INTERIOR AND EXTERIOR INSTALLATIONS

Wiring in the substation building shall comprise PVC insulated cables drawn into conduits, attached to walls, ceilings or steel work by an approved fixing. Where straight runs of lighting fitting occur, cable trunking attached to the building structure may be used. The trunking shall also accommodate the wiring to the lighting fittings.

Cables to outdoor installations shall be PVC insulated (upto 16 sq.mm) PVC sheathed and armoured types laid direct in ground, drawn into ducts, laid in trenches or cleated to walls or steel work as appropriate.

Cables laid direct shall be buried to a depth of 0.6M. Excavation, backfilling and consolidation shall be carried out by the Contractor to the satisfaction of the Employer. Cable trenches shall include racks for laying cables.

8.10 EARTHING AND BONDING

All equipment being supplied under this Section of the Contract such as fittings, socket, outlets, distribution boards etc. shall be effectively bonded to ensure earth continuity throughout the system. Where available armouring of cables can be used for this purpose. In cases where cable glands are secured to a removable plate and secured by means of backnuts, a separate earth bond from the cable sheath to the frame work of casing or the apparatus is to be provided. The earth continuity conductors shall as far as possible be in the one continuous length to the furthest part of the installation from the controlling switchboard, the ground conductors connecting all metal cases housing electrical equipment. The branches shall be connected to the main conductor by permanently soldered or mechanically claped joints.

9.0 AIR CONDITIONING AND VENTILATION

Window type air conditioners shall be installed for substation buildings and shall be capable of maintaining the following internal conditions:

22 to 25 Deg. C D.B. – 40 to 60% R.H.

The external conditions for calculation of duties of air conditioners shall be as follows:

Summer – 40 Deg. C D.B; 34 Deg. C wet bulb

The following areas shall be mechanically ventilated to a minimum 10 air changes per unit.

- 1) Toilet
- 2) Battery

Air shall be extracted from each of the room by wall mounted extract fans discharging to atmosphere.

10.0 500KVA 11KV/433V STATION TRANSFORMER

The 500KVA 11KV/433V station transformer shall be in accordance with MEW standard OES-5.

11.0 30V BATTERY SWITCH TRIPPING UNIT

The 11KV switchboard shall be supplied and installed complete with its own 30V battery switch tripping unit (housed in the battery room). The unit shall comply with OES-12.

12.0 11.5KV 5 x 1 MVAR CAPACITOR BANKS

The 11.5KV 5MVAR capacitor bank shall be in accordance with MEW standard (OES-13).

13.0 SITE TESTS

13.1 GENERAL

Before any part of the plant or equipment provided is commissioned for commercial use it shall be subjected to mechanical, electrical, operational and other tests as may be directed by the Engineer to prove its compliance with the Specifications.

The results of all such tests carried out, including any tests carried out independently shall be recorded in writing and four copies handed over to the Engineer, within 7 days of the test.

The Contractor shall provide all necessary apparatus, instruments, equipment and labour to carry out the tests, the costs of which shall be included in the Contract Price. All materials, plant and equipment which fail to pass the tests due to or arising from faulty design, material or workmanship or due to incorrect erection, shall be replaced, repaired or adjusted to the satisfaction of the Engineer and further tests carried out at the Contractor's expenses. The onus of proving that any defect is due to causes other than those referred above will lie with the Contractor.

Taking over certificates will be issued only when the individual system has been completed, energized and after all tests and adjustments have been carried out. A Taking Over Certificate will not be issued for parts of the system except where circumstances beyond the Control of the Contractor prevent the completion, testing and commissioning of any particular section of the system.

13.2 CIVIL WORKS

As soon as practical after the Contract has been awarded, the Contractor shall carry out soil tests, using approved methods and instruments to determine the load bearing quantities of the soil, to ensure that the foundation design is suitable for the building and equipment to be placed thereon.

During the course of the building construction work, tests on concrete mixes and other materials shall be carried out in accordance with the specification and as directed by the Employer/Engineer from time to time.

13.3 LIGHTING AND SMALL POWER INSTALLATION

The complete installation of any part thereof shall be tested, both before and after connection for service to the requirements of the Site Engineer.

Each completed section of the installation shall be subjected to the following tests using a 500V megger or approved instrument.

1. insulation resistance to earth and between conductors before and after running of lamps.
2. Insulation resistance tests on any electrical apparatus supply erected under this Contract before and after connected such apparatus to the supply circuit.
3. Polarity test for single pole switches and socket outlets.
4. Earth continuity tests as required by the Engineer.

The standard of acceptance for insulation tests shall be as recommended in the Regulation for the Electrical Installation OES-4.

13.4 TRANSFORMERS

All apparatus, instruments and connections for the tests after the completion of the erection work on site shall be provided by the Contractor, but the carrying out of other contracts, permit the Contractor to use for any tests on the Site any instruments and apparatus which may be provided permanently on the Site, conditional upon the Contractor accepting liability for any damage which may be sustained by the Employer's equipment during the test. The following tests shall be performed:

- a) Insulation resistance tests
- b) Insulation resistance test at 500 V between core and core clamping structure.
- c) Voltage withstand tests on transformer oil to BS 148
- d) Ratio
- e) Phase relationship
- f) Magnetization characteristics of current transformers of winding temperature devices
- g) Calibration of winding temperature devices
- h) Tap selector and diverter switch alignment
- i) Calibration of automatic voltage control equipment
- j) Magnetization characteristics and polarity tests on current transformers where provided and installed in terminal bushings under this Contract.

13.5 CABLES

1. Conductor Resistance Test

When the installation of cables and associated jointing accessories has been completed, the DC resistance of each conductor shall be measured and recorded and, when corrected to 20 Deg. C., shall not exceed the guaranteed value given in the Schedule of Particulars and Guarantees.

2. High Voltage Test

After the conductor resistance test, each cable shall be subjected to a DC voltage of $2E$ (where E is the rated voltage) applied for a period of 15 minutes between the conductor and the core screens which shall be connected to earth. To test voltage shall be raised gradually to the specified value at which point the test period shall begin. There shall be no breakdown of the electrical insulation.

3. Voltage Test on Outer Covering

The outersheath of each cable length shall be tested after laying but prior to jointing and backfilling above concrete slabs. The DC voltage shall be equal to 4KV for each mm of thickness of outersheath with a maximum of 10KV.

After completion of the installation, all insulating provisions, including external joint insulation, terminal base insulation, bonding leads etc. shall withstand a high voltage DC test equal to 2KV for each mm thickness of oversheath with a maximum of 5KV D.C. The test voltages shall be calculated on the minimum average thickness stated in the Schedule of Particulars and Guarantees. The duration of tests shall be one minute and the leakage current recorded for each cable.

The test shall be repeated every six months during the maintenance period.

13.6 11KV SWITCHGEAR

All equipment shall be operated to prove that the operating gear, tripping devices etc. are operating satisfactorily over the auxiliary voltage limits.

For adjacent equipment forming part of the complex switchboard, a 'Ducter' or similar continuity test shall be carried out to prove the connections made on site and vacuum checks to all appropriate circuit breakers.

Visual checks on all circuit breaker panels.

13.6.1 Interlocks

Check lists to be drawn up to form an operational test on all interlocks.

13.6.2 Current Transformers

Test of all cores of all current transformers as mentioned herein.

13.6.3 Switchgear H.V. Test

HV power frequency test on 11KV switchgear. Insulation resistance before and after test. Tests to include R-RBE, R-RYE with C/B closed and RYB-R'Y'B'E' across C/B open.

13.6.4 Secondary Injection Test

Required on all relays:

- a) IDMT type relays with settings provided by Engineer.
- b) All other protection relays –

Tests to prove characteristics of relay and to include upper and lower settings of instantaneous relays and tests at setting – if know or selected on site. Bias differential relay tests required at all bias settings. All tests to be to approval of the Engineer and recommendations unless otherwise approved shall be in accordance with manufacturer's recommendations.

- c) AVR (Auto T/C relays)

In accordance with manufacturer's recommendation.

13.6.5 Primary Injection Test

Primary injection test is required on all Ct circuits except for WTI thermal image and LVAC circuits (continuity check with ohm meter only).

Primary injection required to prove ratio and polarity (w.r.t. other phases) and to include:

- R – E (Red phase only)
- R – Y (Polarity and interconnection check)

All unit protection CT to be checked as a complete scheme

- Bias Diff – Compare HV and LV CT's
- REF – Compare any one phase and neutral CT

During primary injection all test points, short circuiting features and ammeters to be checked for correct operation. All values of current through interposing CTs to be monitored.

Operation of the protection relays is not required but sufficient current (25%) shall be used to overcome magnetizing current error affecting the interpretation of results.

Diagrams shall be produced for each primary injection indicating expected current distribution and values (for checking during test – these shall be made available prior to commencing any testing).

Insulation resistance of CT secondary circuits shall be performed prior to primary injection and all earth links shall be proved.

Current shall be monitored to all protection relays by means of the relay test plug. All stability resistors shall be short circuited during Primary Injection. All test and CT short circuiting features to be proved.

Prior to primary injection and after all secondary wiring is complete, the total loop resistance of all CT circuits shall be recorded including the CT internal resistance and relay (excluding stabilizing resistors in REF scheme).

13.7 VENTILATION AND A/C SYSTEM

Functional and temperature.

13.8 BATTERY CHARGER AND DC SYSTEMS

Record of initial charge.

Insulation resistance, charger operation on all float boost setting etc. and battery capacity test in accordance with the specification.

13.9 EARTHING

- a) Check list and catalogue of all joint prior to back-filling.
- b) Earth electrode resistance check.

13.10 INDICATING INSTRUMENTS

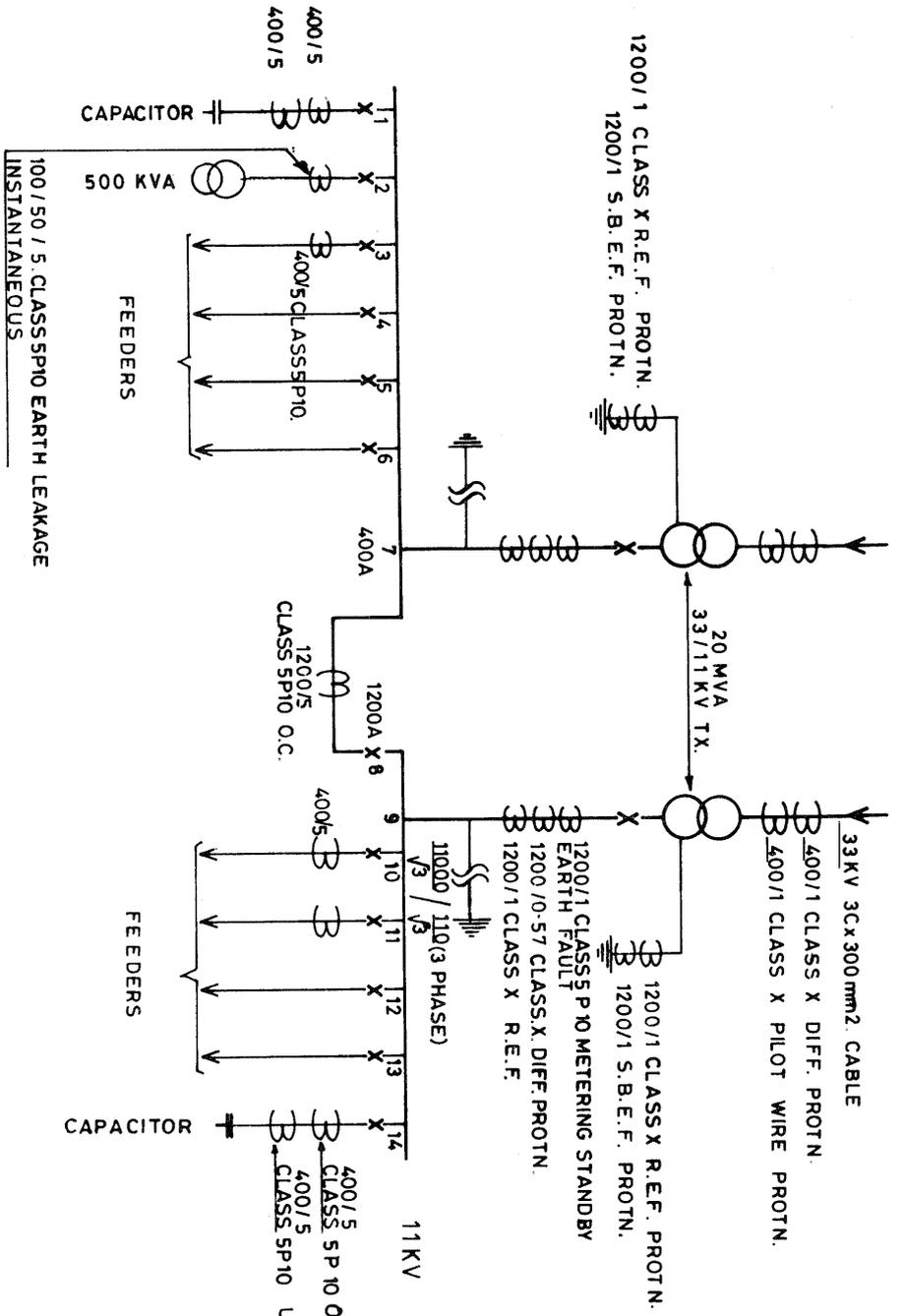
Calibration of all indicating ammeters and voltmeters at 0, 1/2 FS and FS.

13.11 DC CONTROL CIRCUIT FUNCTIONAL CHECKS

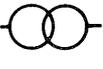
Checks shall be performed on all circuits to prove correct operations to the approved schematic and wiring diagrams.

13.12 CAPACITOR BANK ASSOCIATED CONTROL EQUIPMENT

Functional Tests.

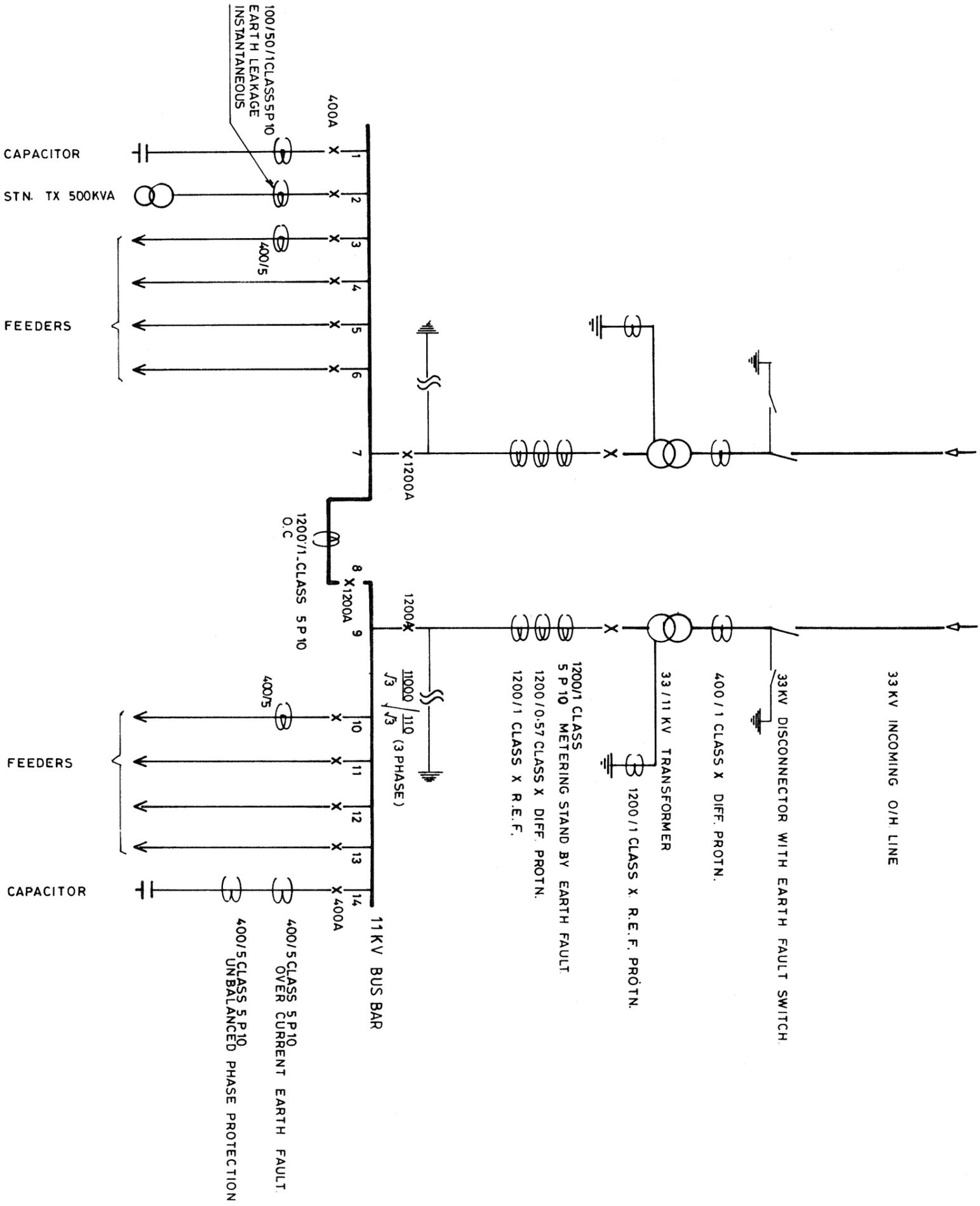
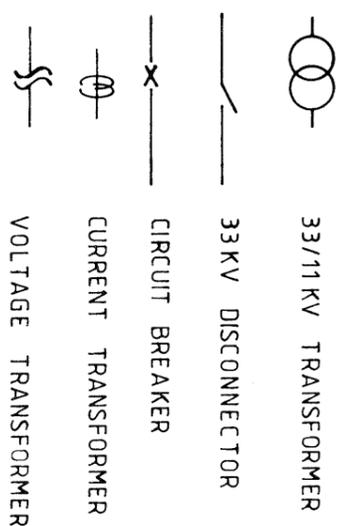


LEGEND

-  TRANSFORMER
-  CIRCUIT BREAKER
-  CURRENT TRANSFORMER
-  VOLTAGE TRANSFORMER

MINISTRY OF ELECTRICITY & WATER		
SINGLE LINE DIAGRAM FOR 33/11KV SUBSTATION (TYPICAL) WITH CABLE		
DRAWN FRANCIS	CHECKED	APPROVED
DRAWING NO: PL/SLD - E/63		
SCALE -		DATE - 30 / 08 / 1989

LEGEND



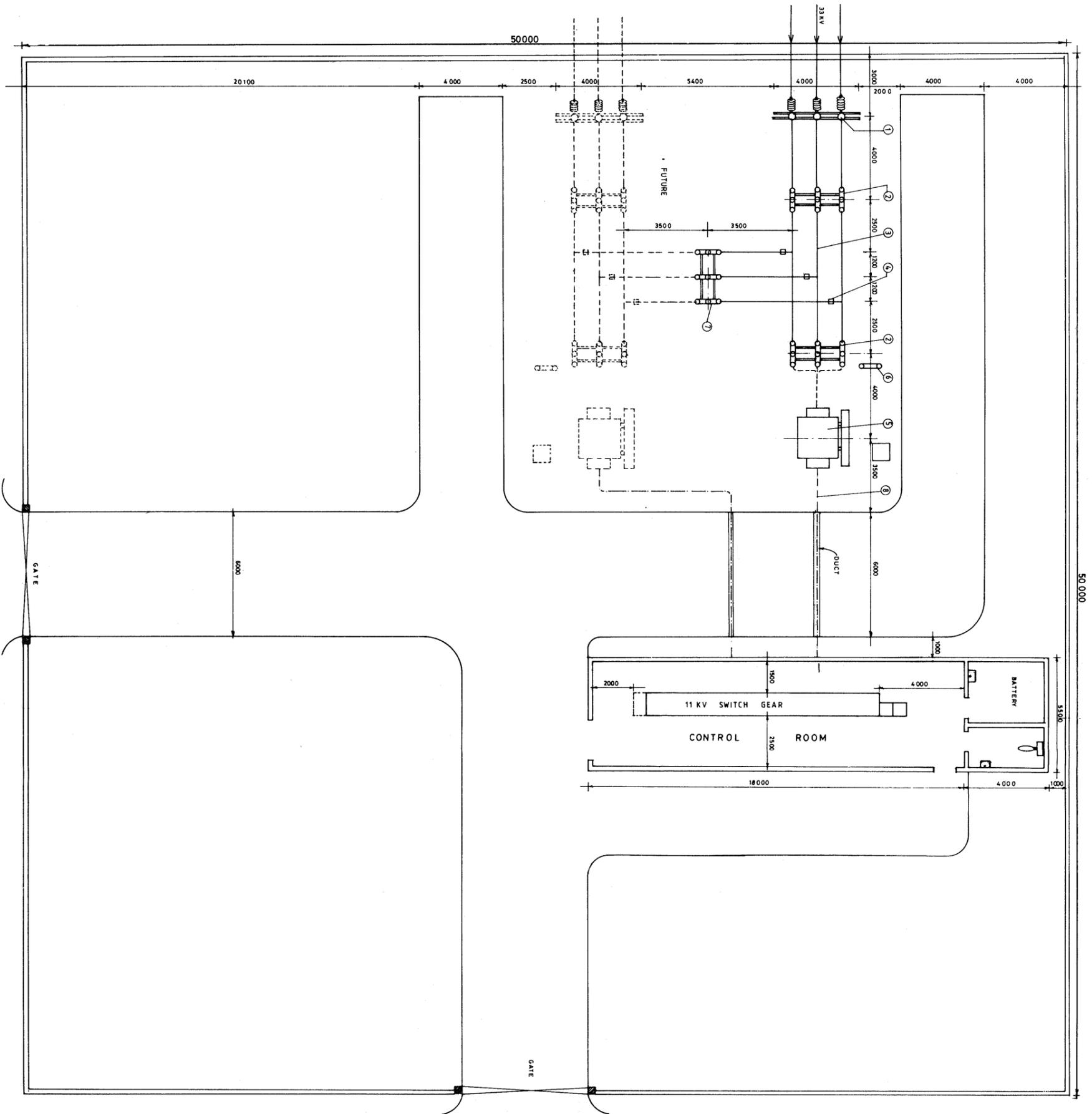
MINISTRY OF ELECTRICITY AND WATER

SINGLE LINE DIAGRAM FOR 33/11KV
SUBSTATION (TYPICAL) OVER HEAD
LINE INCOMER

DRAWN	CHECKED	APPROVED
FRANCIS		

DRAWING NO: PL/SLD-E/62

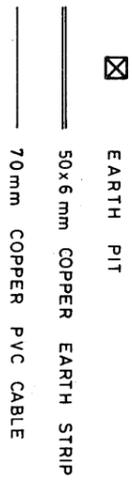
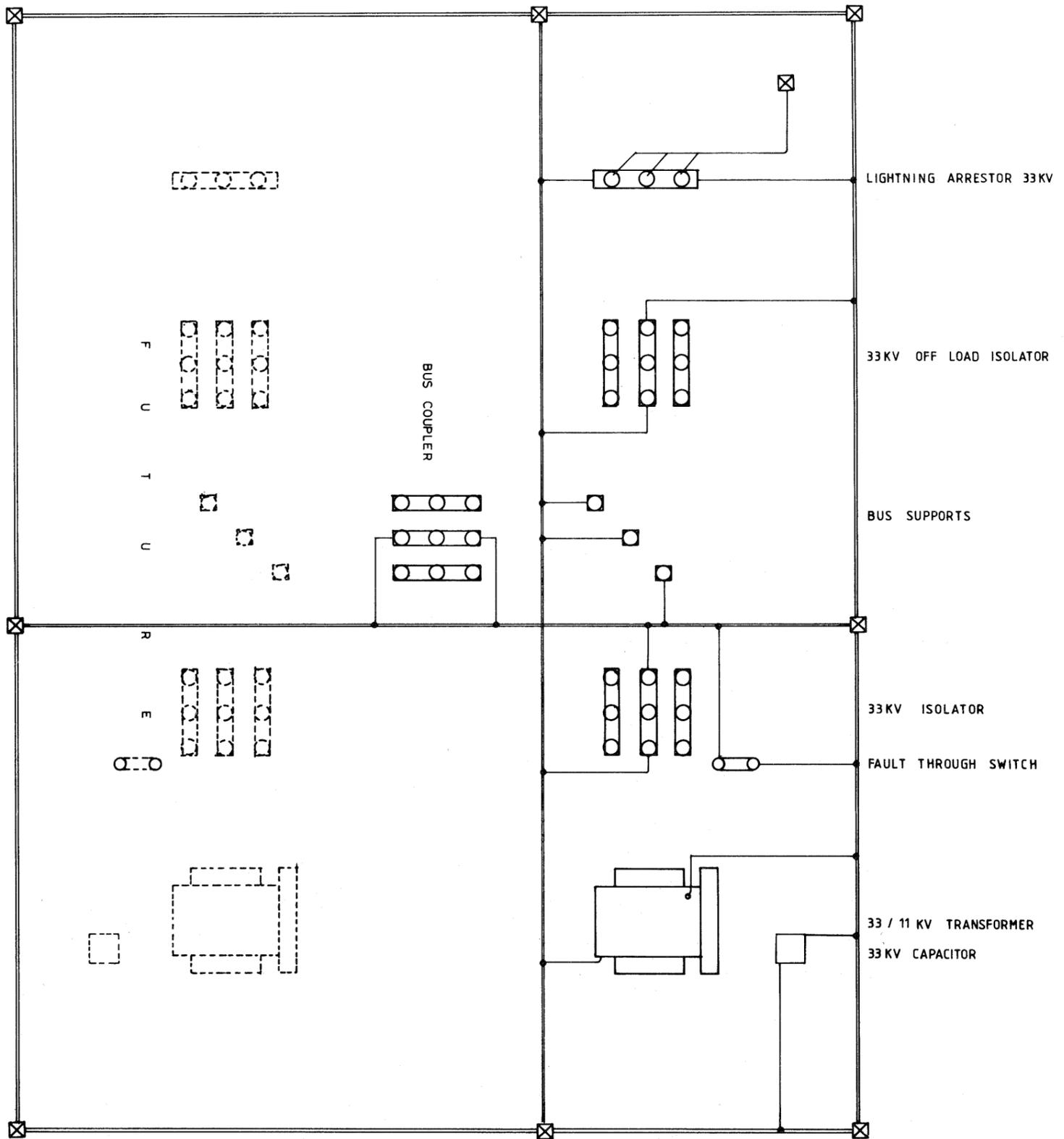
SCALE DATE 29 - 08 - 1989.



- LEGEND**
- ① 33 KV LIGHTNING ARRESTOR
 - ② 33 KV ISOLATOR
 - ③ 33 KV BUS BAR
 - ④ BUS SUPPORT INSULATOR
 - ⑤ 33 / 11 KV TRANSFORMER
 - ⑥ FAULT THROW SWITCH
 - ⑦ 33 KV BUS COUPLER

SULTANATE OF OMAN
 MINISTRY OF ELECTRICITY & WATER
 33/11 KV, 10/20 MVA OUTDOOR
 EQUIPMENT AND SUBSTATION
SITE LAYOUT PLAN

DRAWN	FRANCIS	CHECKED	APPROVED
DRAWING NO.	HEW/OH-GA/33	SCALE	1 : 100
		DATE	21-10-1989

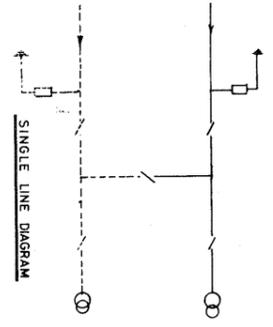
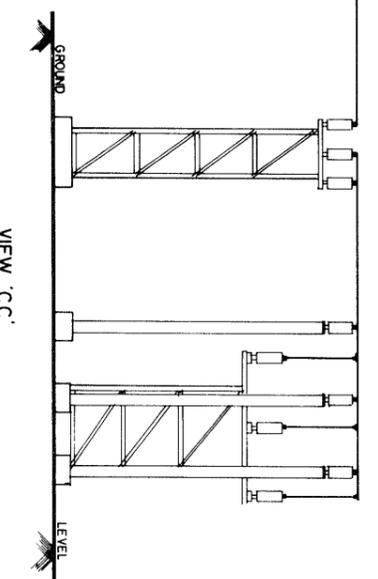
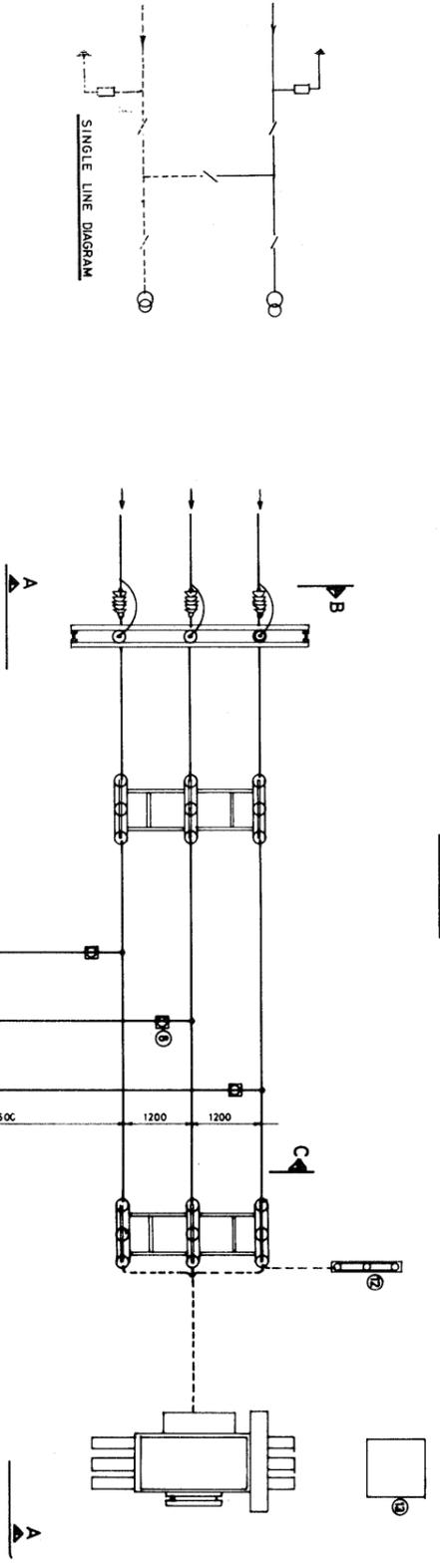
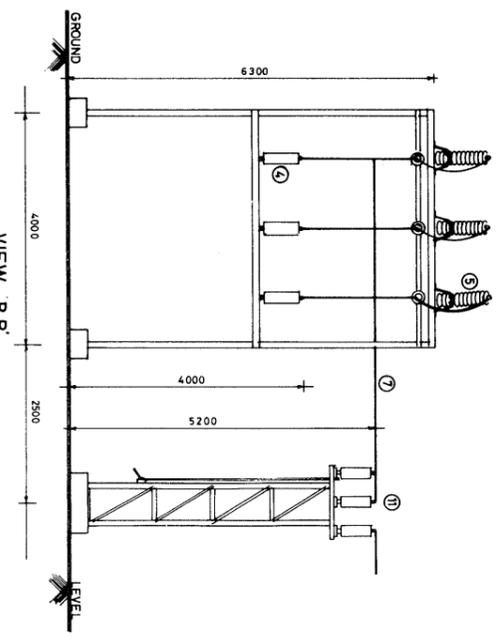
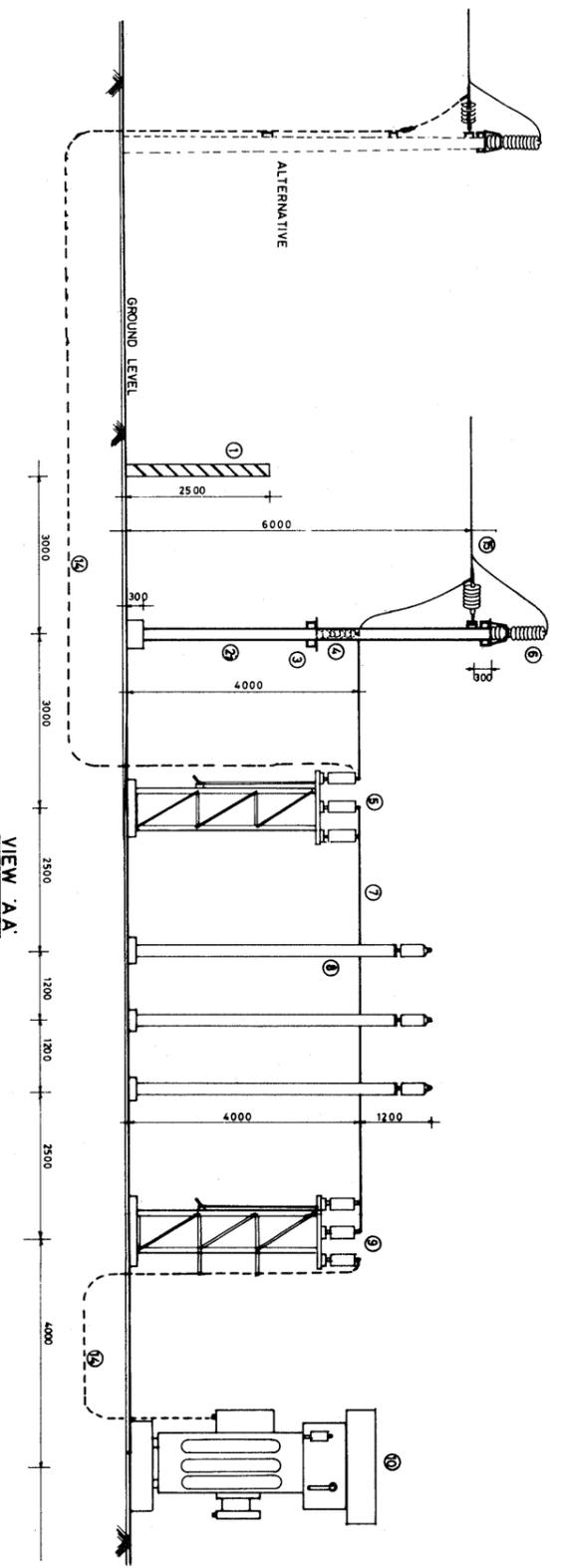


SULTANATE OF OMAN
 MINISTRY OF ELECTRICITY AND WATER
 EARTHING LAYOUT FOR 33/11KV
 20/10MVA SUBSTATION YARD.

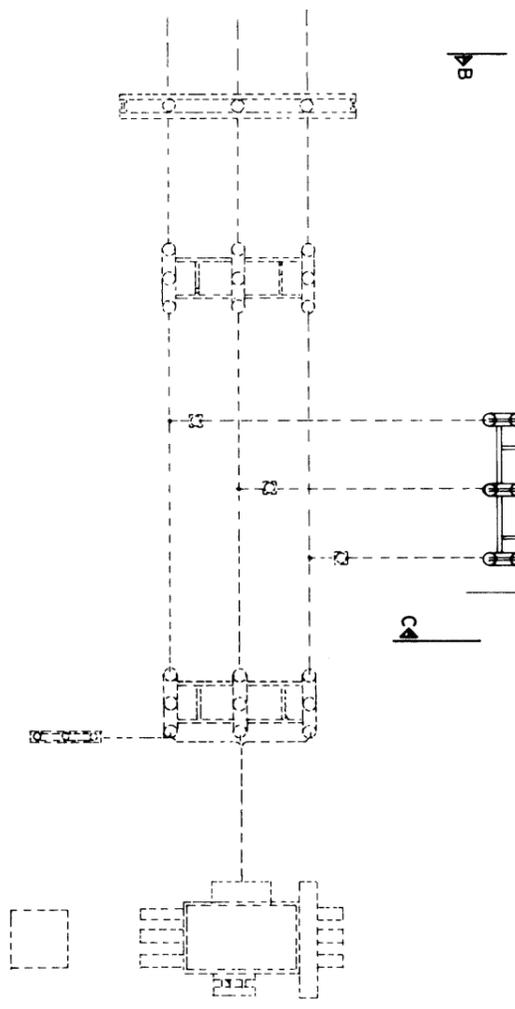
DRAWN FRANCIS. CHECKED APPROVED

DRAWING NO: MEW / OH - GA / 34

SCALE N T S. DATE. 04 - 07 - 1989



- LEGEND**
- 1 COMPOUND WALL
 - 2 R S JOIST 200 x100mm
 - 3 R S CHANNEL 100x50x 5mm
 - 4 BUS SUPPORT INSULATOR
 - 5 33KV OFF LOAD INSULATOR
 - 6 33 KV LIGHTNING ARRESTOR
 - 7 TUBULAR COPPER BUSBAR 38mm
 - 8 BUS SUPPORT WITH INSULATOR
 - 9 33 KV SPRING OPENING DISCONNECTOR
 - 10 33 / 11KV TRANSFORMER
 - 11 BUS COUPLER
 - 12 FAULT THROUGH SWITCH
 - 13 CAPACITOR BANK
 - 14 33 KV U/G CABLE
 - 15 33 KV INCOMING O/H LINE

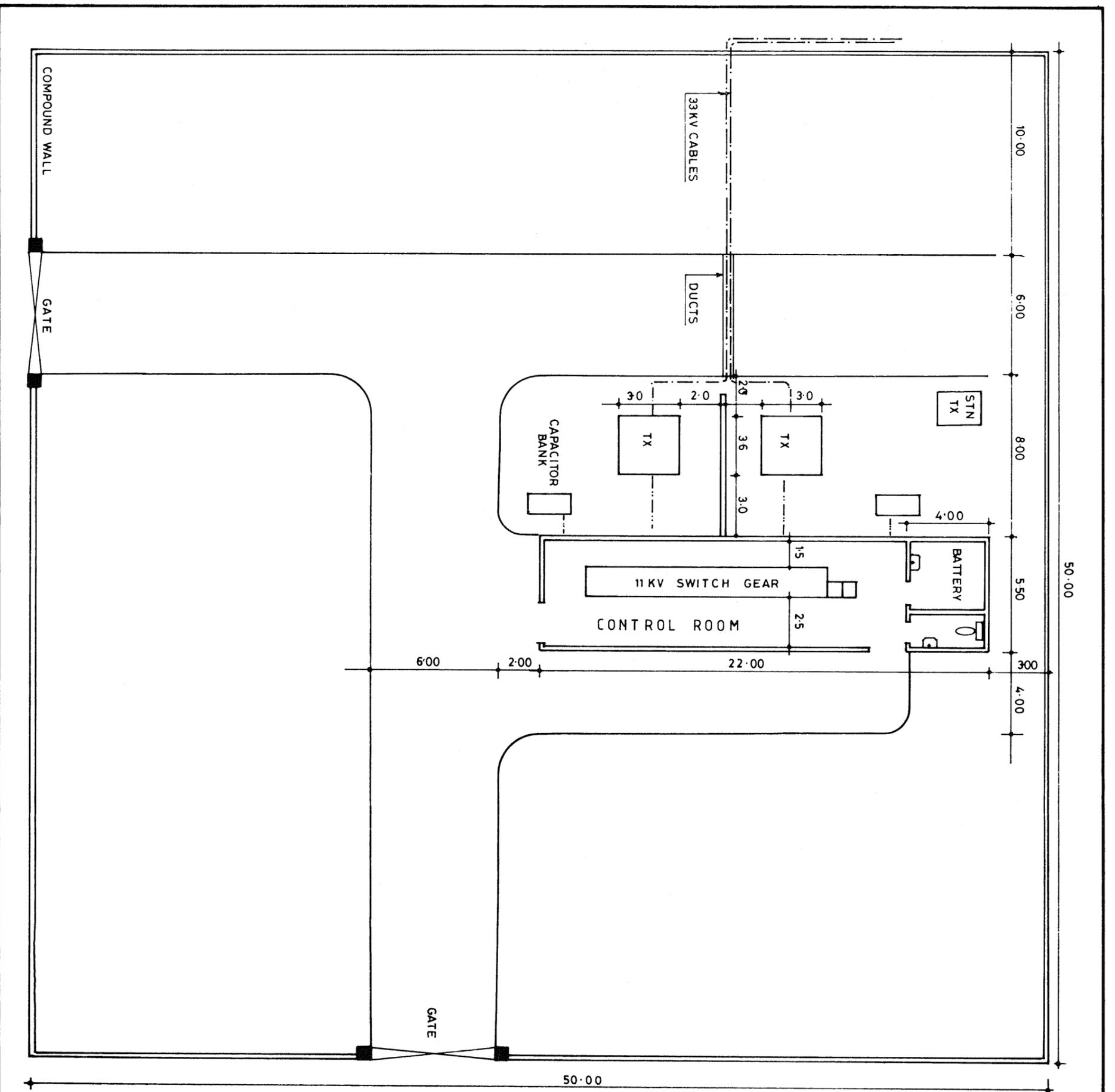


SULTANATE OF OMAN
 MINISTRY OF ELECTRICITY AND WATER

**GENERAL ARRANGEMENT OF
 33 / 11 KV 10 to 20 MVA PRIMARY
 SUBSTATION (DETAILED LAYOUT)**

DRAWN FRANCIS	CHECKED	APPROVED
SCALE 1 : 50	DATE 06-07-'98	

DRAWING NO. MEW/OH-GA/35



SULTANATE OF OMAN MINISTRY OF ELECTRICITY AND WATER 33/11 KV SUBSTATION LAYOUT CABLE FEEDERS (TYPICAL)		
DRAWN	CHECKED	APPROVED
FRANCIS		
DRAWING NO: MEW/OH - GA/41.		
SCALE : 1 : 200	DATE : 23-10-1989.	