KING FAHD UNIVERSITY OF PETROLEUM & MINERALS

COLLEGE OF SCIENCE ENGINEERING
ELECTRICAL ENGINEERING DEPARTMENT

Summer Training Report

by

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INTRODUCTION:

The college of science engineering gives a chance to their students to spend 8 weeks in industrial companies. This training gives the student the opportunity to see what they studied and how to deal with practical live. My training program was in the period from 3 July 2010 to 25 Augusta 2010 at Saudi Electricity Company – Eastern Region Branch (SEC-ERB).

During my summer training I worked in Operation Areas (Distribution System) in Customer Services Office. I attended in the medium voltage which are the Maintenance, Operation, Engineering, and Planning and Construction Division. The planning and construction division was a good start which I spent the most of period of my training with them.

The Planning and Construction Division deals with the power supply and the system improvement. Also, this division is responsible for providing bulk customers with relay settings for their switchgears.

The Engineering Division deals with the distribution of substations and mini pillars among a new region. This includes also the exemption from a substation or a mini pillar when customers objecting to have a substation or a mini pillar to be funded in their lots.

The Maintenance Division concerns maintaining some of electrical equipment in the medium voltage. It deals with substations and their contents like transformers, ring main units/ switchgears, and low voltage panels. This includes checking the fuses of the ring main units, oil level in oil switches, and SF_6 gas level in SF_6 switches.

The Operation Division concerns maintaining mini pillars, shutdown operations, and breakers readings. Moreover, it deals with cable faults comprehensively and there are a special department for it having special equipment and cars concerning cable faults.

DIVISIONS OF SEC ACCORDING TO THE POWER:

- **Power Planet (Generation System):**

Energy is converted at the generating station from one of its basic forms, such as fossil fuels, hydro, and nuclear into electric energy. Power plants generate electricity to switching stations where step up transformers are located to raise the voltage to transmission levels.

- **Power Transmission:**

This is the part of the system that transfers generated electricity from the power plants to the main supply points throughout the eastern province by using transmission lines which are the connecting links between the generating stations and the distribution systems.

The transmission network consists of:

1. Transmission lines: 69KV, 1155KV, 230KV, and 380KV.
2. Switching stations: Bulk supply points (B.S.P.) and Grid Stations.

The Grid Station receives 69KV and steps it down to 13.8 KV and the Grid Station is the final link in the transmission network.

- **Operation Areas (Distribution System).**

The objective of Power Distribution System is to deliver the Electrical power to Customers in safe, reliable and most economical way. This means that a Customer receives a supply of Electrical power required by him at the time and place at which he can use it. Several parameters of an Electricity supply such as frequency, continuity of supply, voltage level, etc. should be within allowable limits to ensure that the Customer obtains satisfactory performance for his electrical equipment while ensuring that the demands of the Customers continue to be met, the capital and operating costs of doing so should be reduced minimum as possible.

1.BACKGROUND:

Fig.1.1 shows the transmission of power starting from the power planet until reaching the customer. The power transmission starts from the power plant by providing a standard voltage of 13.8 KV. After that, the 13.8 KV is converted to 230 KV and 380 KV using step up transformers in the bulk supply point. The 230 KV is used in the near cities whereas the 380 KV is provided if necessary to be transmitted to far cities. This means that the 230 KV most exist in each bulk supply point. After the transmission, the 230 KV is then converted to 69 KV using step down transformers. In the grid station, the 69 KV is converted to 13.8 KV and in turn it is transmitted to substations through Breakers. The substation has a transformer which converts the 13.8KV to low voltages of 220V/380V or 127V/220V. The low voltage is distributed from the low voltage panel. Finally, the low voltage is delivered to the customer by using a mini pillar.

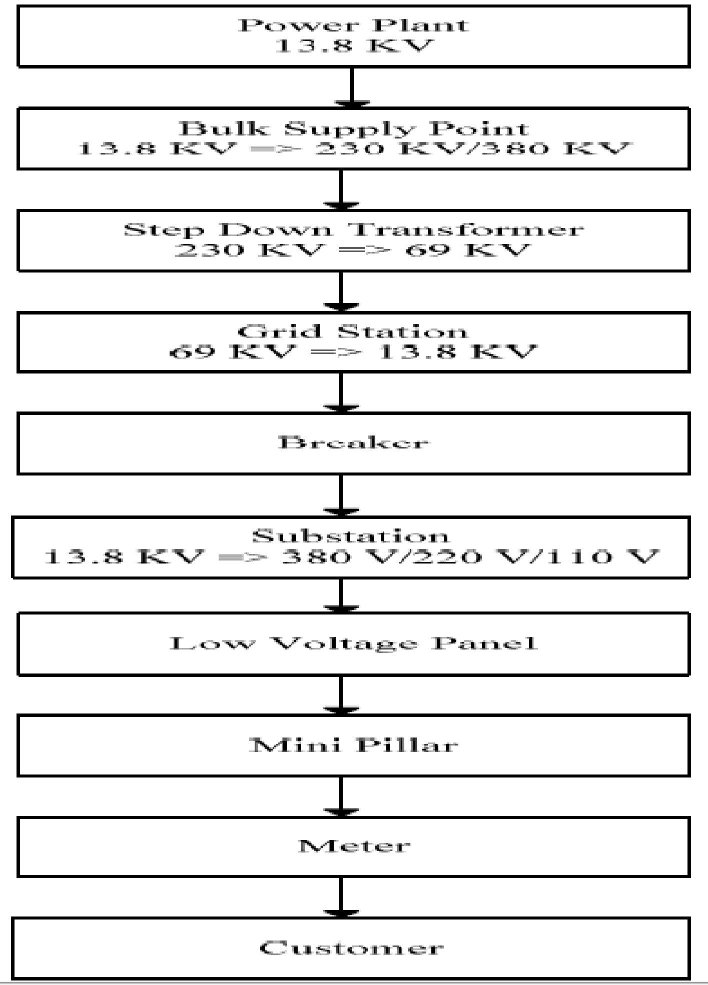


Fig.1.1

2. MEDIUM VOLTAGE UNTIL LOW VOLTAGE

The medium voltage (13.8 KV) starts from the grid station (G/S) in which it has a number of breakers (B) that depend on the transformers used in the grid station. The feeders/cables that are coming from the breakers are of 13.8 KV and distributed in the company network. This 13.8 KV is distributed to substations in which they have step down transformers. The low voltage starts just after the transformer in the substation. The substation uses a step down transformer that transform the 13.8 KV to low voltages. In the next sections, it is important to mention the 13.8 KV/ medium voltage electrical equipment in which it starts from the substation, through the low voltage panel, mini pillars, and until reaching meters.

2.1 Substations

Substation (S/S) is formed by the ring main unit, transformer, the low voltage panel, and the earth fault indicator. The transformer output voltage is distributed through the low voltage panel. There is an indoor substation, an outdoor substation and the pole mounted transformer substation. The three differ from another in their appearance not in how they are composed of. The indoor substation is a locked substation inside a room whereas the outdoor substation is a locked substation that is out in the open, and the pole mounted transformer substation is a substation that has the transformer hanged in two poles. There is another type of substations which is the street light substation where the company has no relationship with maintaining the substation because it is owned by the municipality. Fig2.1 shows the four types of substations with their transformers and low voltage panels. The substation is named by the transformer used on it, i.e. when the transformer used in the substation is 300 KVA transformer; the name of the substation is a 300 KVA 5 substation. Also, when the transformer is packed with the low voltage panel, the substation is called a unit substation.

(1) (2) (3) (4)

Figure 2.1: Substation types ;(1) the outdoor substation, (2) indoor substation, (3) pole mounted transformer substation, and (4) the street light substation.

2.1.1 Ring Main Unit

The ring main unit (RMU) is a switchgear that takes the 13.8 KV cable, links it to the transformer in the substation, and also links the 13.8 KV cable to another substation. This means that the ring main unit has an incoming 13.8 KV cable, an outgoing 13.8 KV cable, and a local cable. The incoming cable is a cable linked to the substation by another substation whereas the outgoing cable is a cable linked from the substation to another substation. The local cable is used by the substation from the incoming cable. There are two types of switchgears used at the company network. They differ in the used insulation substances which are the oil switch, and the Sulfur Hexafluoride (SF6) switch. Fig2.2. shows the two types of switchgears including the substance level in each one. The most popular one used in the company network is the oil switch even though that the SF6 is better in insulation and the insulation substance last more than 6 that in the oil switch. But, the SF6 switch cheats operators who are responsible of the inspection because the SF6 gas shrinks at winter and the operators who check the gas level do not know whether the gas level is actually low or because of the cold weather.

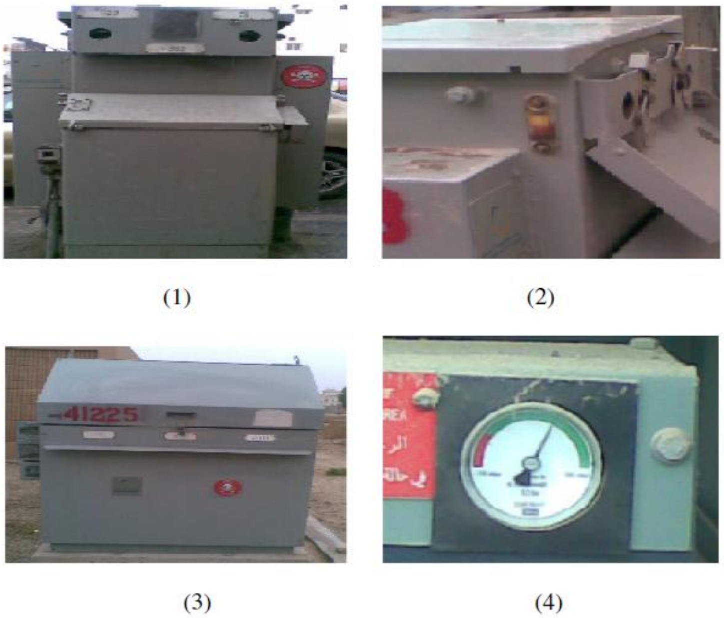


Figure 2.2: Switchgear types;(1) the oil switch, (2) the oil level in an oil switch, the SF6 switch, and (4) an SF6 level in a switch.

There is an automatic change over switch which is another type of oil switch shown in Fig2.3 that has three input feeders and one output feeder. This switch is used for high class of customers because when one feeder is damaged, it is automatically and very fast changes to another feeder.

Figure 2.3: Automatic change over switch.

Also, there is another type of oil switch used to change a feeder locus. This switch has an input feeder and an output of one, two, or three feeders. If there is multi number of oil switches that are linked together by bus caps, they all have a single number, i.e. three oil switches using one as an input and the others as outputs are known as an oil switch with three legs. Fig.2.4 shows three oil switches, i.e. an oil switch with three legs that has one input feeder and two output ones. There is also another type of switches called a load break switch used for high class of customers. The job of this switchgear is the same as the automatic change over switch except that the locus of a feeder is changed manually.

Figure 2.4: An oil switch with three legs.

2.1.2 Transformers

The transformers in the company underground network are of four types which are the 300 KVA, 500 KVA, 1000 KVA, and the 1500 KVA transformer. All these transformers transform the 13.8 KV to their nominal KVA. Fig.2.5 shows a transformer in an outdoor substation.

Figure 2.5: The transformer in an outdoor unit substation.

The input for the substation is the 13.8 KV where it is of three phases and Δ- configuration. When the 13.8 KV come to the transformer through the RMU/switchgear, it is transformed to the nominal KVA and the output will be in Y-configuration. As mentioned earlier that the company uses transformers that differ in their output KVA. Each transformer has a different output number of cables and the output cables are of three phase which are; the red, yellow, and the blue in addition to the neutral which is the black cable. table2.1 gives the transformers' number of output cables and the description of them.

Table2.1: Output cables of the SEC transformers for the 127V/220V low voltage.

Transformer	LVP Output cables / circuits	Description
300 KVA	4	One 3 phase & one neutral
300 KVA	8	Two 3 phase & two neutrals
300 KVA	12	Three 3 phase & three neutrals
300 KVA	16	Four 3 phase & four neutrals

Moreover, there is an auxiliary transformer that is used inside the grid station to energize the equipment used there like the air conditioners, lamps, and any other necessary equipment. The auxiliary transformer is energized from an existing breaker in the grid station.

2.1.3 Low Voltage Panel

The low voltage panel (LVP) is a panel that distributes the output cables/circuits of the transformer. Each circuit from the low voltage panel contains the red phase, yellow, and the blue phase in addition to the neutral cable which is black. The low voltage panel output number of circuits depends on the transformer used in the substation. The transformer output cables are connected to the bus bar of the low voltage panel and from the bus bar, the low voltage circuits are provided such that each circuit has a circuit breaker of 400A for each phase in the circuit. This means that the maximum amperage that a circuit from the low voltage panel withstands is 400A and beyond this current the cable may be damaged. Fig.2.6. shows a low voltage panel including the bus bars and the output circuits without showing the circuit breakers because they are covered.

(1)

(2)

Figure 2.6: The low voltage panel; (1) outside look, (2) inside look.

2.1.4 Earth Fault Indicator

The earth fault indicator (EFI) is used in every substation because it indicates that the ring main unit is not energized and declares that there is a cable fault. Fig 2.7 shows the EFI when the substation is under normal condition and when the substation is not energized.

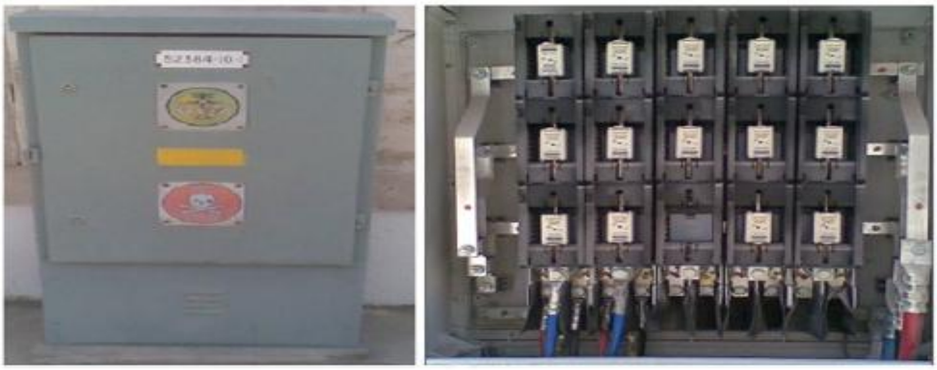
(1) (2)

Figure 2.7: The earth fault indicator; (1) when no cable fault, (2) when cable fault is indicated.

When the substation is not energized, the locus of the incoming feeder is having a cable fault. The cable fault is not necessary just before the substation and of course will not be after. When the EFI indicates a fault, operators check the single line diagram to indentify the substations in the feeder locus and go back to check each substation in the locus one by one. When, a substation in the locus does not declare a fault, the fault must be between the one that does not declare and the other one that declares a fault.

2.2 Mini Pillars

The mini pillar (MP) is a panel that takes one cable/circuit from the low voltage panel and provides at most six circuits to divide them among at most six customers. Fig.2.8 shows a mini pillar which has five circuits and two bus bars. One bus bar is used as an input whereas the other one is used if necessary to be connected to another mini pillar. The circuit breakers of the mini pillars are of 200 A for each phase in a circuit. Sometimes one customer needs two circuits from the mini pillar also when customers need higher ampere, a circuit from the low voltage panel is provided without using the mini pillar. There are at most two mini pillars that can be connected together and there is two phase and one neutral cables in each circuit, that are connected from the mini pillar to a meter because each customer needs this specification to be energized in the low voltage.



(1) (2)

Figure 2.8: The mini pillar ;(1) outside look, (2) inside look.

2.3 Meters

Meters are the SEC interface with customers. There are two types of meters for low voltage customers, one is the regular meter and the other is the service box shown in Fig.2.9. The regular meter and the service box give the electrical consuming in kilowatt hour (KWH). The regular meter circuit breakers range from 30A to 160A. When dealing with higher than that, a service box meter is used up to 400A. The service box contains a current transformer that transforms the high current that is impossible to be read by the regular meter, into a low current in which the meter can read without being damaged. Also, each service box has a multiplying factor where the operator takes the reading from the meter and multiplies it by the multiplying factor to give the actual reading.

(1) (2)

Figure 2.9: Types of low voltage meters; (1) regular meter and (2) service box.

For high voltage customers, upper than 400A circuit breakers, SEC uses a metering unit shown at Fig 2.10. Its method for reading the consumed electricity does not differ from that in the service box. However, the metering unit differs from the service box that it has a relay.

Figure 2.10: Metering unit with a multiplying factor of 13800/115.

The regular meter takes the input circuit from a mini pillar but the service box usually takes it directly from the low voltage panel. The meter is a meeting point between the customer and the company. The normal customers are provided with two phases of cables in addition to one neutral cable in one circuit. In the case when the service is of 220V/380V, connecting phase to phase gives 380V and connecting phase to neutral gives 220V, and in the case of 127V/220V, connecting phase to phase gives 220V and phase to neutral gives 127V. Meters cab be connected in parallel not in series because customers need their voltage to be fixed to operate their applications.

3. ESTIMATION OF THE LOAD

Bulk customer submit connected load details to SEC. Planning engineer will consider the submitted load detail and verify according to SEC rules of calculating demand load.

These customer can be supplied either:
(a) On medium voltage with an agreed MV switching room at the boundary of the project
Or
(b) On low voltage customers according to the existing service rules with number of substation with attached metering rooms at agreed location on the boundary of the project on roadside not less than 6 meters wide. These meters will be connected to the system through normal substation connection.

3.1 Demand Load

To calculate the demand load of the customer the planning engineer should use the following formula:

$DL = CL \times DF$ for one circuit breaker.

where:

DL: demand load ....CL: connected load .... DF: demand factor

Where the demand factor is according the following Table 3.1:

Table – 3.1
(Demand Factor)

Class of customer	Demand Factor	Type of construction
Residential Customer	0.5	Villas, Houses, Palaces, Istrahat
Commercial Customer	0.6	Shops, Workshops, Stores, Offices, Petrol pumps, Supermarkets, Malls, Motels, Furnished flats.
	0.8	Government buildings Hospitals, Schools, Clubs
	0.9	Mosque, Gold shops, Hajj Load, Street Lights
Industrial Customer	0.9	Industries, Factories
Agriculture Customer	0.9	Big Farms, Livestock and Dairy Farms, Production Farms, Greenhouses

3.2 Diversity Factor

when calculating the demand load for a group of one circuit breaker it should divided by diversity factor (DvF), the formula of demand load will be as following:

$DL = \frac{n \times CL \times DF}{DvF}$ where n: number of circuit breaker.

Where the diversity factor is according the following Table 3.2:

Table – 3.1
(Demand Factor)

Number of circuit breaker	diversity factor	Number of circuit breaker	diversity factor
1	1.000	9	1.603
2	1.383	10	1.615
3	1.453	11-15	1.656
4	1.497	16-20	1.681
5	1.529	21-30	1.712
6	1.553	31-50	1.745
7	1.572	50-100	1.798
8	1.590	Above 100	1.800

4. CASE STUDY

4.1 Substation Design

The main reason to design a new unit substation for customer is that he need current load more than 400A.

The problem:

A customer asked the company to connect electricity service to his new house and he need 10 breakers 60A and 2 breakers 30A for appendix and 1breaker for shops.

The solution:

we went outside to see the location of customer's house and we sow the location it was as following in Fig 4.1:

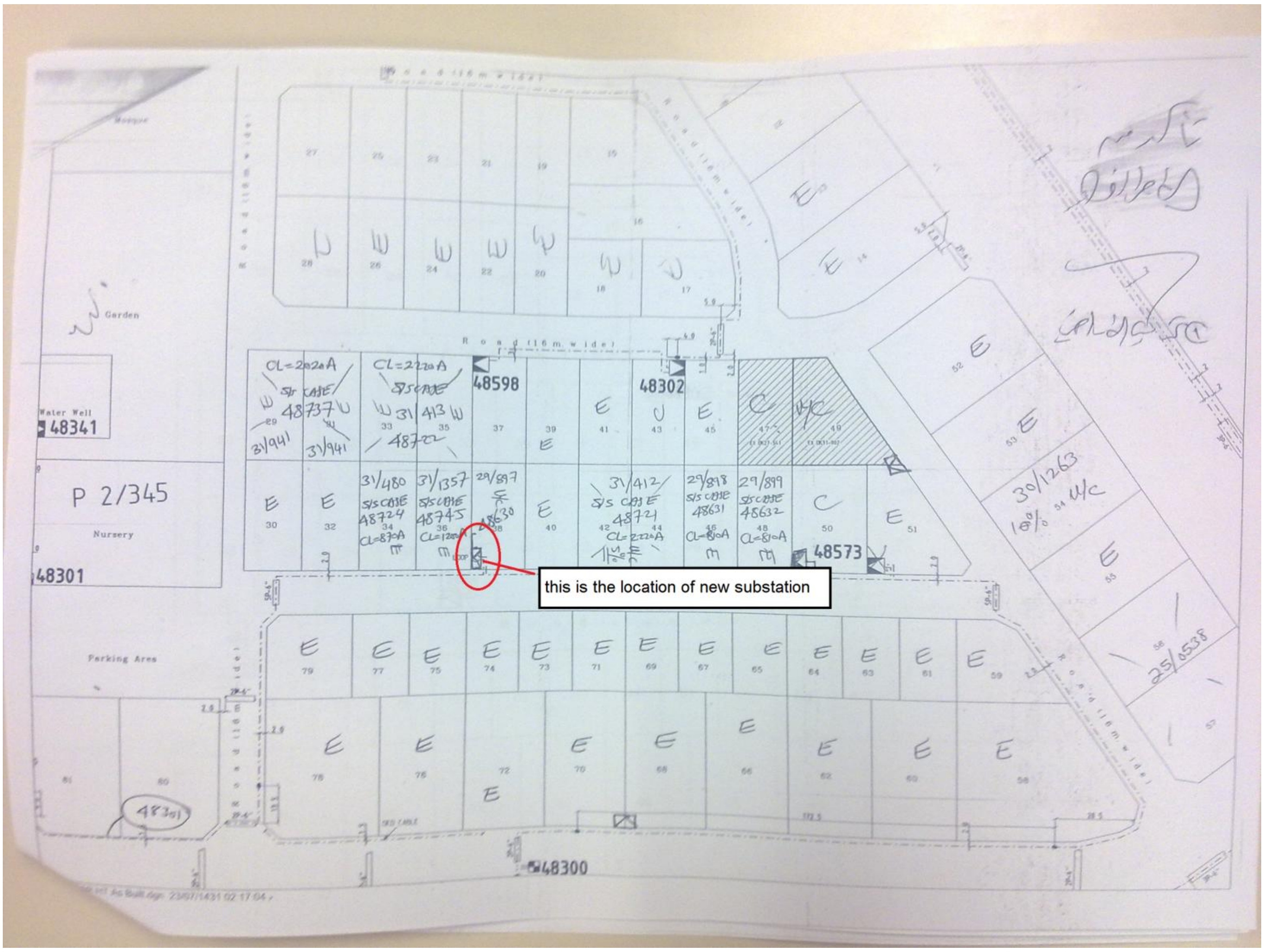


Fig 4.1: Layout

calculation of customer load:

$I=[(10\times 60)+(2\times 30)+150]=810A$ which is greater than 400A

V=220v

$\Rightarrow s=\sqrt{3}VI=\sqrt{3}\times 220\times 810=309KVA$

Demand load:

Residential

the floor:

$$DL=\frac{n\times I\times DF}{DvF}$$

$$DL=\frac{10\times 60\times 0.5}{1.615}=185.7$$

appendix:

$$DL=\frac{2\times 30\times 0.5}{1.383}=21.69$$

Commercial

$$DL=n\times I\times DF$$

$$DL=1\times 150\times 0.6=90$$

*Total Demand load:

DL=185.7+21.69+90=297.39 A

$\Rightarrow s=\sqrt{3}\times 220\times 297=113.2KVA$

we needed cable size 4x300 which can carry 310A.

and we decided to put 500KVA transformer for future and empty area.

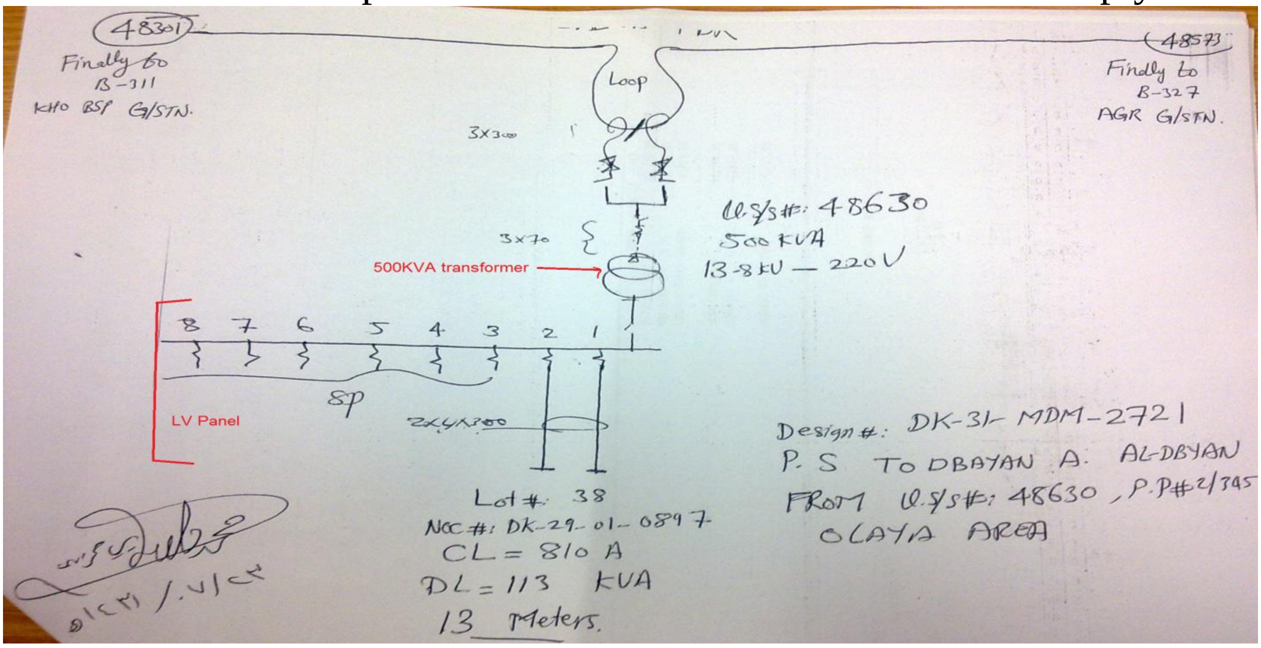
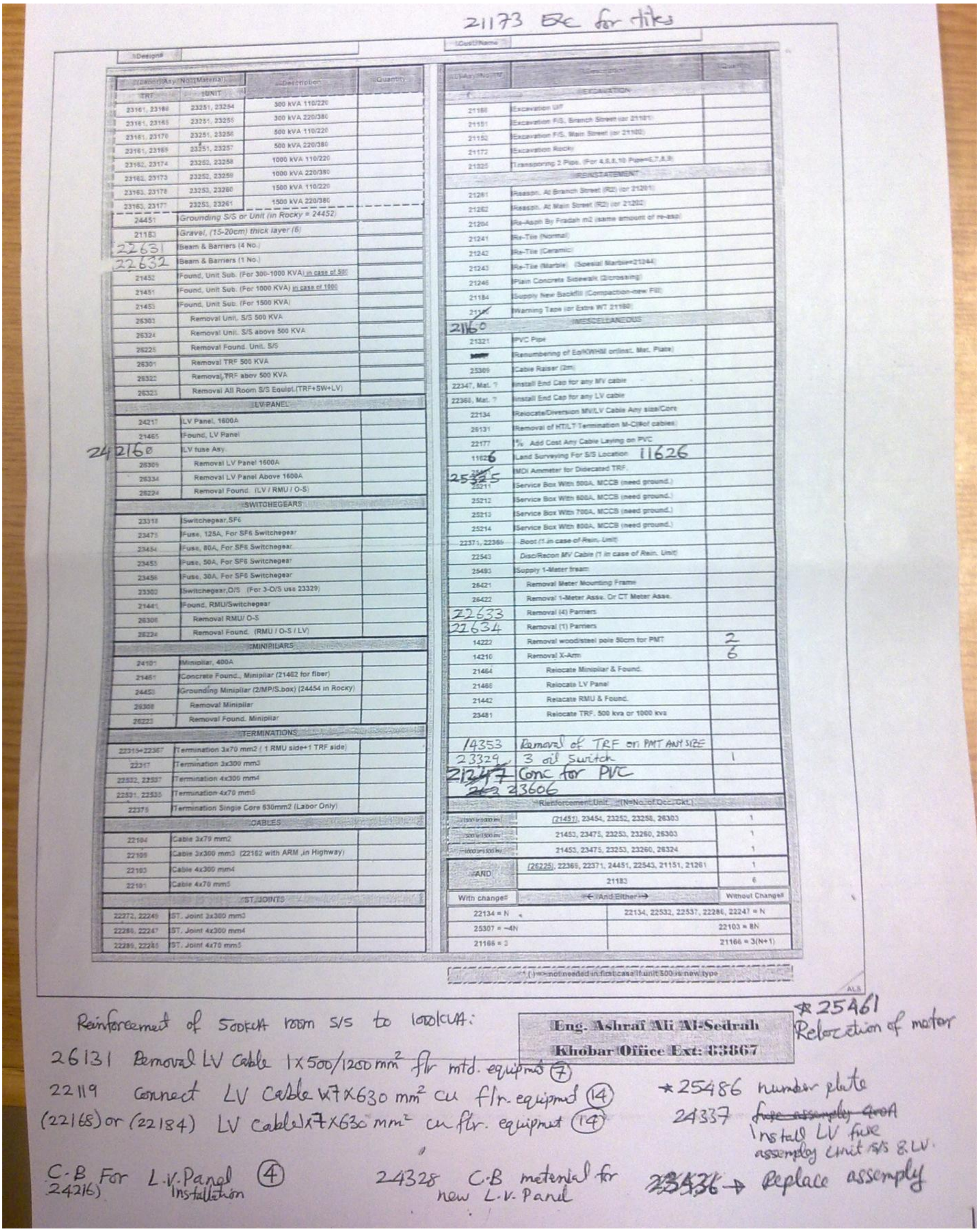


Fig 4.2: Single Line Diagram

The Cost:

The cost was about 120,000 SR. We calculated the cost from materials sheet Fig 4.3:



21173 Exc for tiles

Design#	

Asy. No. (Material) TRF	UNIT	Description	Quantity
23161, 23166	23251, 23254	300 kVA 110/220	
23161, 23165	23251, 23255	300 kVA 220/380	
23161, 23170	23251, 23256	500 kVA 110/220	
23161, 23169	23251, 23257	500 kVA 220/380	
23162, 23174	23252, 23258	1000 kVA 110/220	
23162, 23173	23252, 23259	1000 kVA 220/380	
23163, 23178	23253, 23260	1500 kVA 110/220	
23163, 23177	23253, 23261	1500 kVA 220/380	
24451		Grounding S/S or Unit (in Rocky = 24452)	
21183		Gravel, (15-20cm) thick layer (6)	
22631		Beam & Barriers (4 No.)	
22632		Beam & Barriers (1 No.)	
21452		Found, Unit Sub. (For 300-1000 KVA) in case of 500	
21451		Found, Unit Sub. (For 1000 KVA) in case of 1000	
21453		Found, Unit Sub. (For 1500 KVA)	
26303		Removal Unit. S/S 500 KVA	
26324		Removal Unit. S/S above 500 KVA	
26225		Removal Found. Unit. S/S	
26301		Removal TRF 500 KVA	
26322		Removal TRF abov 500 KVA	
26323		Removal All Room S/S Equipt.(TRF+SW+LV)	
		LV PANEL	
24217		LV Panel, 1600A	
21465		Found, LV Panel	
242160		LV fuse Asy.	
26309		Removal LV Panel 1600A	
26334		Removal LV Panel Above 1600A	
26224		Removal Found. (LV / RMU / O-S)	
		SWITCHEGEARS	
23318		Switchegear,SF6	
23475		Fuse, 125A, For SF6 Switchegear	
23454		Fuse, 80A, For SF6 Switchegear	
23453		Fuse, 50A, For SF6 Switchegear	
23456		Fuse, 30A, For SF6 Switchegear	
23302		Switchegear,O/S (For 3-O/S use 23329)	
21441		Found, RMU/Switchegear	
26306		Removal RMU/ O-S	
26224		Removal Found. (RMU / O-S / LV)	
		MINIPILARS	
24101		Minipillar, 400A	
21461		Concrete Found., Minipillar (21462 for fiber)	
24453		Grounding Minipillar (2/MP/S.box) (24454 in Rocky)	
26308		Removal Minipillar	
26223		Removal Found. Minipillar	
		TERMINATIONS	
22315+22367		Termination 3x70 mm2 (1 RMU side+1 TRF side)	
22317		Termination 3x300 mm3	
22532, 22537		Termination 4x300 mm4	
22531, 22535		Termination 4x70 mm5	
22375		Termination Single Core 630mm2 (Labor Only)	
		CABLES	
22104		Cable 3x70 mm2	
22109		Cable 3x300 mm3 (22162 with ARM ,in Highway)	
22103		Cable 4x300 mm4	
22101		Cable 4x70 mm5	
		ST. JOINTS	
22272, 22249		ST. Joint 3x300 mm3	
22288, 22247		ST. Joint 4x300 mm4	
22289, 22248		ST. Joint 4x70 mm5	

Cust. Name	

Asy. No.	Description	Quantity
	EXCAVATION	
21166	Excavation U/F	
21151	Excavation F/S, Branch Street (or 21101)	
21152	Excavation F/S, Main Street (or 21100)	
21172	Excavation Rocky	
21325	Transporing 2 Pipe. (For 4,6,8,10 Pipe=6,7,8,9)	
	REINSTATEMENT	
21261	Reason. At Branch Street (R2) (or 21201)	
21262	Reason. At Main Street (R2) (or 21202)	
21204	Re-Asph By Fradah m2 (same amount of re-asp)	
21241	Re-Tile (Normal)	
21242	Re-Tile (Ceramic)	
21243	Re-Tile (Marble) (Special Marble=21244)	
21246	Plain Concrete Sidewalk (2/crossing)	
21184	Supply New Backfill (Compaction-new Fill)	
~~2118~~ 21160	Warning Tape (or Extra WT 21180)	
	MESCELLANEOUS	
21321	PVC Pipe	
[illegible]	Renumbering of Eq/KWHM or/inst. Met. Plate)	
25309	Cable Raiser (2m)	
22347, Mat. ?	Install End Cap for any MV cable	
22368, Mat. ?	Install End Cap for any LV cable	
22134	Relocate/Diversion MV/LV Cable Any size/Core	
26131	Removal of HT/LT Termination M-C(#of cables)	
22177	% Add Cost Any Cable Laying on PVC	
11626	Land Surveying For S/S Location 11626	
25325	MDI Ammeter for Didecated TRF.	
25211	Service Box With 500A, MCCB (need ground.)	
25212	Service Box With 600A, MCCB (need ground.)	
25213	Service Box With 700A, MCCB (need ground.)	
25214	Service Box With 800A, MCCB (need ground.)	
22371, 22366	Boot (1 in case of Rein. Unit)	
22543	Disc/Recon MV Cable (1 in case of Rein. Unit)	
25493	Supply 1-Meter fream	
26421	Removal Meter Mounting Frame	
26422	Removal 1-Meter Asse. Or CT Meter Asse.	
22633	Removal (4) Parriers	
22634	Removal (1) Parriers	
14222	Removal wood/steel pole 50cm for PMT	2
14210	Removal X-Arm	6
21464	Relocate Minipillar & Found.	
21466	Relocate LV Panel	
21442	Relocate RMU & Found.	
23481	Relocate TRF. 500 kva or 1000 kva	
14353	Removal of TRF on PMT ANY SIZE	
23329	3 oil Switch	1
21247	Conc for PVC	
23606		
	Rienforcement Unit (N=No. of Occ. Ckt.)	
1500 in 1000 kv	(21451), 23454, 23252, 23258, 26303	1
500 in 1500 kv	21453, 23475, 23253, 23260, 26303	1
1000 in 1500 kv	21453, 23475, 23253, 23260, 26324	1
AND	(26225), 22366, 22371, 24451, 22543, 21151, 21261	1
	21183	6

With change#	← And Either →	Without Change#
22134 = N		22134, 22532, 22537, 22286, 22247 = N
25307 = -4N		22103 = 8N
21166 = 3		21166 = 3(N+1)

( ) not needed in first case if unit 500 is new type

Eng. Ashraf Ali Al-Sedrah
Khobar Office Ext: 83867

Reinforcement of 500KVA room S/S to 1000KVA:

26131 Removal LV Cable 1X500/1200 mm² flr mtd. equipmt (7)

22119 Connect LV Cable W7X630 mm² cu flr. equipmt (14)

(22168) or (22184) LV cable 1x7X630 mm² cu flr. equipmt (14)

C.B For L.V. Panel (24216) Installation (4)

24328 C.B material for new L.V. Panel

*25461 Relocation of meter

*25486 number plate

24337 ~~fuse assembly~~ Install LV fuse assembly unit S/S & LV.

~~23436~~ → Replace assembly

Fig 4.3: materials sheet

CONCLUSION

Actually, my summer training was absolute interesting, because I could get great useful through that period. Such that, I could perform something that studied before in some courses. So, I could make good connection between work life and academic life. During that period, I took good knowledge about power planet, transmission lines, substations, emergency and maintenance unit and some devices and elements.

Finally, I thank the god first then everybody in company and university who help me to learn and get any information and I hope that you found and get the benefit by reading this report.