SUMMER PRACTICE REPORT

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SP company name: Empresa Nacional de Electricidade – E.P

Company division: Power electronics

Company location: Luanda/Angola
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1. INTRODUCTION

I had the chance to conduct my summer practice in ENE – E.P, Empresa Nacional de Electricidade, which is the biggest electric power producer and supplier in Angola. My internship started on 06 of July and ended on 04 of September. The purpose of my summer practice in ENE was to help me visualize in practice what I will be doing after graduating if I pursue a power engineering career, get familiar with work environment and also to help me decided on which area of expertise I should get myself into.

Since ENE is the biggest electric company in Angola, I always dream of working for it; therefore, I apply for my internship there, by sending a letter to the Director responsible for all the substations located in Luanda (capital of Angola), Eng. José Carlos and fortunately I was accepted in Cazenga substation.

During my internship in Cazenga substation, I was supervised by Eng. José Credo and Eng. Lucídio, both holding B.S. degree in Electrical engineering. Moreover, I was given the opportunity to work in three main areas of the substation which are: The Control room, Maintenance department and Power Reading sector.

In the control room, engineers and technicians control and monitor the electricity flowing in and out of the substation and the functioning of all the electric equipments, through several panels in the control room. While people working in the maintenance sector make regular maintenance, fix errors or malfunctioning on electromechanical equipments, replace them when needed, propose improvement on equipments in order to improve reliability, assist in the installation and commissioning of new equipments and contribute to any project as necessary. The last sector, power reading sector, technicians install power counters and take monthly readings on transformers of their clients in order to charge them according to what they have consumed. Basically, my work was to observe and then do everything engineers and technicians do in terms of practical work. For a better clarification, I will explain this in detail in the following sections.

My report starts with a detailed description of the company followed by the weekly description all the work I conducted and all things I have learned and observed within the company. Then there is a conclusion of my report followed by an appendix and reference list.

Attention: Some of the photos on my report have dates that do not match with the reality because I had to wait few days to get permission to take photos and
also because there were days I forgot the machine at home and had to take the photos in another day.

2. DESCRIPTION OF THE COMPANY

2.1 - Company name
Empresa Nacional de Electricidade (ENE) – E.P.

2.2 - Company location
Av. 4 de Fevereiro 124 – 1º andar – Luanda
Subestação do Cazenga - Tel. (02) 380029
Dep. Comercial – Tel. (02) 392096

2.3 - Brief history of the company
In 1956, the Portuguese empire decided to start a very ambitious project that result in the creation of a company named SONEFE which provided electricity in all its African colonies including Angola and Mozambique. As Angola claimed for independence, portugueses were asked to leave the country and leave the control of the company in the hands of the new Angolan government. Afterwards, later in 1980, the government decided to change the name of the company to ENE, however, continued cooperating with the Portuguese company SONEFE which is now extinguished. Moreover, ENE has passed through several challenges during the civil war times in which several electrical equipments and part of its electrical network were destroyed, causing a big financial crisis to the company. Fortunately, due to the hard work of its engineers and government support, ENE has recovered from its crisis and is now making huge profits which tend to keep growing over the years.

2.4 - Main Area of Business
ENE is a government company devoted on production, conveyance, distribution and commercialization of electric energy. ENE distributes and sells high, medium and low tension electricity in all 18 provinces of Angola and its customers are industries, steel mills, distributors of electricity and other companies located in Angola.
2.5 Number of People employed

ENE is divided in several organic units and has a huge number of workers as can be seen from the above table.

<table>
<thead>
<tr>
<th>ORGANIC UNITS</th>
<th>Nº OF WORKERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Directorate</td>
<td>519</td>
</tr>
<tr>
<td>Regional Directorate Center</td>
<td>812</td>
</tr>
<tr>
<td>Regional Directorate North</td>
<td>1,275</td>
</tr>
<tr>
<td>Regional Directorate South</td>
<td>779</td>
</tr>
<tr>
<td>Directorate of Exploration of Cabinda</td>
<td>227</td>
</tr>
<tr>
<td>Directorate of Exploration of Huambo</td>
<td>266</td>
</tr>
<tr>
<td>Directorate of Exploration of Kuanza- Sul</td>
<td>147</td>
</tr>
<tr>
<td>Center of Exploration of Bié</td>
<td>103</td>
</tr>
<tr>
<td>Center of Exploration of Lunda – Sul</td>
<td>24</td>
</tr>
<tr>
<td>Center of Exploration of Malanje</td>
<td>64</td>
</tr>
<tr>
<td>Center of Exploration of Moxico</td>
<td>13</td>
</tr>
<tr>
<td>Center of Exploration of Uíge</td>
<td>92</td>
</tr>
</tbody>
</table>

The company has several power substations and I had the chance to work in Cazenga substation, part of the Regional Directorate North, which has 100 employees, where 75 of them are technicians and 15 engineers. Among the engineers, 12 of them are EE and 3 ME. Furthermore, 4 of them hold Ms. and 2 PhD. degrees.
2.6 Organizational structure of the company

Administration Council

Administration’s council
Secretary Eng. Mateus Gaspar

CEO
Eng. Eduardo Nelumba

Juridical Office
Dr. Fernando Silva

Business Planning Office
Eng. Euclides Brito

Organization & Methods Office
Dr. Samuel da Silva

Marketing Office
Dr. Mariano de Almeida

Internal Audits Office
Dr. João Nsuka

Enterprise Security Office
Feliciano Samba

Directorate of Planning & Engineering
Eng. Kilele Wa Tshama

Directorate of Distribution & commercialization
Eng. Eurico Mand Lay

Directorate of Production & Transport
Eng. José Marinho

Directorate of Accounting & Supporting Services
Dr. Luís Filipe

Directorate of Supply
Eng. João da Silva

Directorate of Human Resources
Dr. António José Domingos

Directorate of Production & Transport
Eng. José Marinho

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Eng. José Marinho

Directorate of Accounting & Supporting Services
Dr. Luís Filipe

Directorate of Supply
Eng. João da Silva

Directorate of Human Resources
Dr. António José Domingos
3. FIRST WEEK

As in all power substations, there is a Control Room in Cazenga substation which serves to monitor and switch (on and off) all electric equipments taking part on the power reduction and distribution process. Since the control room is the most important area of the substation, workers (System Operators) have to work in shifts to keep 24 hours a day track of the system and try to fix or inform the maintenance crew in case of a malfunctioning.

In my first week, the head engineer of the substation, Eng. Veloso, sent me to work in the Control Room for me to have a general idea of what goes on or what is done in a power substation.

3.1 - Interpretation of the substation diagram

Very friendly and skilled technicians were assigned to teach me to interpret the power diagram of the substation in order to have a global idea of what goes on in the substation. As it can be seen from figure 1, there are three incoming power lines (Cambambe I, II and III), three phases each, in Cazenga substation with a tension of 220 KV each. Then, the three lines connect and energize the bus (in red, Barra – A 220KV), which conducts the power straight to the circuit breakers of 5 transformers with 60 MVA each.

The power transformers then reduce the incoming voltage of 220KV to 60KV and 15KV respectively. The 60 KV output energizes two buses (in yellow, Barra – A 60KV and Barra – B 60KV) that work in parallel with five Gas Turbines that provide also 60KV to both buses in order to prevent interruption in the power transmition in these two buses which provide power to transformers that supply electricity to some parts of the city of Luanda (Ngola Kiluanje and Quifangondo) and industries such as: oil refinery, steel mills, cement plan and etc.

However, the 15KV output supply power to transformers that supply electricity to schools, hospitals, government institutions, companies and to electricity sellers in suburban areas. Also, it is the 15KV line that powers up two transformers that supply electricity to the entire substation.
Figure 1 – Cazenga substation diagram
3.2 - Interpretation of panels in control room

After I successfully learnt to interpret the Cazenga substation diagram I was able to take the next step which was to learn about the electric panels’ configuration that they have in the control room. As I could see, the electric panels were presented pretty much in the same order the equipments were shown in the power diagram of the substation. The electric panels can be seen in figure 2.

I could observe that all the electrical equipments’ switches had two switching options: local & remote. When it is set to local, one of the operators has to go near the device, which is somehow distant from the control room, and turn it on/off there. While, if it is set to remote, the operator can turn the device on/off from the control room by just rotating and pressing a button. Furthermore, after a maneuver in the system one of the system operators must write down everything that has happened and fix a security card in a button if it is pressed in order to avoid accident. See fig 3.
It is extremely important for a system operator to fix the security card in a button referring to a breaker because sometimes there are parts of the power network that are not electrified so that electricians can install transformers, fix and upgrade the network. Therefore, if this rule is not followed, one of the system operators from a different shift may turn on the button and electrify this part of the network where work is being carried out and kill his coworkers, unintentionally.

3.3 - Reading on electric panels

During this week I was also taught to make readings of voltage, current, active & reactive power in the electric panels, shown in fig. 2 and fig. 4, of the power lines going out of the substation. System operators are supposed to record these system variables every hour. In addition to that, they have the duty of keeping a record of the power transformers’ oil and winding temperature in every two hours. It’s important to monitor these system variables because there is a limit for all of them in order to keep a balance in the system. For example, in a three-phase line supplying power to a certain institution, there cannot be a more than 10% of difference in consumption in one of the phases compared to the others. That would imply a problem in one of the equipments or an increase in the load, overloading the system. When such cases happen the clients are given a warning to reduce the load to the level agreed in the contract.

For the case of the transformers’ oil and winding temperature, a rise in these variables could be a result of a failure in the cooling system (fans), bad oil condition, low oil level or overload in the system.
4. SECOND WEEK

In my second week in the control room, I noticed that system operators don’t only work in the control room; they also do field work when a situation arises or just to check the condition of key equipments (power transformers) once in a while.

4.1 - Field work as system operator

I could see that the remote control of a circuit breaker doesn’t always work properly, forcing system operator to go in the local and switch it off or on. In some cases, it happens because high power circuit breakers have a spring that after several switching maneuvers, they lose compression which is the mechanical force need to move the piece of metal that closes or opens the circuit.
There are two ways of resetting the spring’s compression:

1. **Automatic way**: the automatic way is done by pressing a button that turns on a small electric engine with a torque high enough to compress the spring. The engine is located inside the control box of the breaker.

   Note: Not all high voltage circuit breakers have this option, specially the old ones.

2. **Mechanical way**: there is a metal stick that is used to turn a sprocket that is connected to a mechanical system which compresses the spring. This method is tiring but is the most trustable and that is the reason why all the high voltage circuit breakers have it, including the new models.

Figure 5 – Control box of a high voltage circuit breaker SF6
5. THIRD WEEK

At the beginning of my third week in Cazenga substation I was sent to the Maintenance department to learn about the functioning principle of all electrical equipments in the substation and their periodic maintenance. Below I will give a brief description of the main equipments according to their order in the substation diagram.

5.1 - Main Equipments Description

At Cambambe I, power line, we find a Wave Filter, see fig. 6, which is used to tune the telecommunication signal, transmitted through the power line with a given frequency. The Wave Filter enables communication among all the substations in the Angolan territory. However, optic fiber is also used and is preferable.

Figure 6 – Wave Filter

After the Wave Filter, current transformers are found in each phase of every input line (cambambe I, II and III). They have the task of step down the current flowing in the line so that it can be read by an ammeter in the control room. See an example in fig. 7.
An important equipment for reading is the voltage transformer which has the same function as the current transformer, but in this case voltage is the variable stepped down. See an example in fig. 8.

In order to disconnect one of the lines there are several earthed switches composed by a principal Bypass switch, which allows maintenance in some equipments without interruption of the power supply in the network.
For the purpose of protecting the equipments, especially power transformers, there are high voltage circuit breakers in all phases. There are two types of circuit breakers: oil (dielectric II) and gas (SF6 – Hexafluoride).

Nowadays, oil high voltage circuit breakers are not so popular due to its frequent breakdowns and oil leakage that results in a great accumulation of dust over it. Instead, gas circuit breakers are used. In fig. 10 an example of both can be seen.
Besides circuit breakers another protection device called over current discharger is used to protect transformers of currents higher than the value that transformers can stand. For example, these currents can appear during a lightning.

![Figure 11 – Over current discharger](image)

After the over current discharge we find the most important and expensive equipments in the substation that are the three – phase power transformers (fig. 12). Each of the five power transformers step down voltage from 220KV to 60KV and 15KV respectively and have a power capacity of 60MVA. Furthermore, these transformers have three windings; two of them having Y connection and one ∆ (Alpha) connection.

These transformers cooling mechanism is composed by oil and forced air using fans. From fig. 12 we can see in the top of the transformer four output terminals of 60KV (three phases and ground) and three 15KV terminals leaving the transformer and connecting to a reactance which limits the homopolar component of the short circuit current.
Connected to the 60KV bus I could see phase reactances and capacitor banks as in fig. 13. The capacitor banks are used to compensate the power factor, in other words, reduce the reactive power on the network and increase the active power.
6. FOURTH WEEK

After learning about the functioning principle of equipments I was given assignments with learning purposes.

6.1 - Transformer’s internal resistance measurements (“Megging”)

Figure 14 – Me testing a transformer’s internal resistance

Transformer’s internal resistance measurement is a test that is conducted to detect internal problems in a transformer or to check if coils are still insulated from one another and from the external metal structure. It is done by using a device called Megger (see fig. 15) that supplies a certain voltage, in this case 5KV, to its terminals and measures the resistance between the two terminals.

Figure 15 - Megger

I had the chance to perform this test on a transformer with the characteristic plate in fig. 16. And I did the following connections:
• Input terminals with external structure = $\infty$
• Output terminals with external structure = $\infty$
• Output terminals with input terminals = 6M$\Omega$
• Output terminal with output terminal = 5M$\Omega$

According to the engineers present, a transformer is considered to be good when there is a very high (minimum 5M$\Omega$) or infinite resistance between its coils and external structure or among terminals. Therefore the transformer I was testing passed the test.

Degradation of the material insulating internal conductors in the coil and poor oil conditions are factor that reduce the resistance values when “Megging” a transformer. I will give more information on oil conditions on the following section.

After conducting this test I spent the rest of the week on standby with the rest of the crew waiting for an event or failure in the system.
7. FIFTH WEEK

After spending some time on standby and getting to know the substation and people better I was given another task to perform and I will describe it below in details.

7.1 - Transformer’s oil test

High voltage transformers use Oil Dielectric II as a cooling component and as an insulator. This test serves to analyze the insulation capabilities of oil dielectric II.

To run this test, technicians use an oil test machine, which has two metallic contacts parallel to its recipient where the oil is inserted and has a voltage regulator that the operator can use to regulate the voltage applied to the oil being tested. In addition to that, the operator will have the chance to see how much voltage can be used to break the insulation barrier of the oil and with that voltage value check whether the oil is good or bad. For the oil to be good enough to be used, it must have an insulation capability of blocking a minimum value of 100KV.

I was given the same transformer I had worked the previous week to test its oil, so I removed a certain amount of it to be tested. I inserted the test subject into the machine’s recipient. Then I was told to conduct the experiment 5 to 6 times in every 10 minutes and take the average of it in order to get better result, due to the fact that, the more time the oil stays in the machine the hotter it gets and the more it approaches the real work conditions, when it is inside a transformer.

My results where the following:

<table>
<thead>
<tr>
<th>Time</th>
<th>Cm</th>
<th>KV</th>
</tr>
</thead>
<tbody>
<tr>
<td>9h30</td>
<td>40</td>
<td>140</td>
</tr>
<tr>
<td>9h40</td>
<td>40</td>
<td>140</td>
</tr>
<tr>
<td>9h50</td>
<td>40</td>
<td>140</td>
</tr>
<tr>
<td>10h00</td>
<td>54</td>
<td>180</td>
</tr>
<tr>
<td>10h10</td>
<td>60</td>
<td>200</td>
</tr>
<tr>
<td>10h20</td>
<td>60</td>
<td>200</td>
</tr>
</tbody>
</table>

Average: 166
Since the average I obtained was 166KV, which is higher than 100KV, the oil passed the test and was good enough to be used.

### 7.2 - Maintenance day

The maintenance day is the day that all the maintenance crew gets together to do the maintenance of all the equipments in the substation and this is done in every one month. Normally, the maintenance is supposed to be done in every two months, however, due to the tropical weather it is done every one month.

These are the steps the maintenance crew follows:

1. **Power transformers**
   - Check the color of the Silica gel. If 2/3 of the Silica gel happens to be orange/pink or very light blue, then it must be changed because the Silica gel is the component that helps remove the humidity inside the transformers. In the fig. 17 we can see an example of Silica gel that is in a good state. Since the majority of the Silica present on the picture is dark blue there is no need to change it. Moreover, Silica gel should be checked every 2 months.

![Figure 17 – Silica Gel](image)

- Check the level of the oil and oil leakages. After working for several years, some oil leakages show up and should be eliminated as quickly as possible.
• Check the refrigeration system or fans. It is important to clean the radiators and keep the water above the minimum level in order to have the transformer operating with good winding and oil temperatures.

• Check the contact terminal (inputs/outputs). Porcelain terminals should be cleaned in order to remove dust that accumulates on them.

2. Control boxes

• Control boxes should be checked for removing dust and insects inside of it and also for lubricate the joints of the doors.

3. All metal equipments

• Check the paint conditions of equipments to detect and eliminate corrosion.

4. Protection systems

• Protection systems should be checked every 2 years.

8. SIXTH WEEK

I have to admit that this week started full of adrenaline because we have been called to fix a problem in one of the poles of the high voltage circuit breaker of 220KV connected to transformer 4 (see fig. 18). The enjoyable thing was that we were told to perform this task as quick as possible because there was a small neighborhood connected to the 15KV output line of this transformer.

Figure 18 – Pole of a 220KV circuit breaker
8.1 - Fixing a pole of a 220KV circuit breaker

Problem: One of the poles of a 220kv oil circuit breaker had an oil pump (see fig. 20) that had a little crack allowing oil to leak out and consequently, the pump wouldn’t stop working after an order for it to switch off being given either from local or remote location. It was happening because the “block” (see fig. 19) could not reach 320 bar of pressure enough to excite the pressostat of the oil pump.

The block was considered to be the main reason for the problem due to the fact that it has the function of keeping the necessary pressure for the oil ascends to the inferior contact of the circuit breaker, which was not happening.

Solution: The solution proposed was the replacement of the central block and the oil pump.

9. SEVENTH WEEK

Fortunately, the maintenance crew was requested by another substation called Viana substation, which is the biggest substation in Luanda, for fixing a huge oil leakage in one of their transformers. We were called there because their crew was pretty busy with another failure that arisen as a result of a big explosion that damaged several components on the substation.
9.1 - Fixing oil leakage

The oil leakage was in one of the power transformers with input power of 220KV and output 60KV and 15KV. The transformer had the leakage on its top in one of the connections box as can be seen in fig. 21. The oil coming out of this box was flowing down the transformer attracting dust to it (see fig. 22) and the oil level was decreasing very fast causing the transformer to overheat.

Figure 21 & 22 – Oil leakage

The cause of this leakage was found to be the weakness of the three rubber retainers to block oil and allow the terminals to come out and connect to the fans. What we did was remove the cables connecting the metal terminals and substitute the old retainers for new ones and increased the oil level. The work done was simple but a more tiring work was carried out by the other crew on the following event that I’m going to describe below.

9.2 - System breakdown in Viana substation

During the night of 07 of August a great explosion happened in the substation and damaged several equipments and let many people without electricity in their homes. Maintenance and network teams were called to help solve the problem.

Two very old groups of porcelain insulators were the cause of the problem. The insulators were quite old and were cracked but since they are made of porcelain and have a dark color (brown) the cracks cannot be seen and also because they are connected in a place more than 5 meters high from the ground. Moreover, these insulators were connected to two phases each from the same line and once the electricity flowed across these cracks there was a short circuit between phases, originating the two by pass switches to explode, melt and fall down. See figure 23.
Some of the conductors blow and melt, and some insulators cracked completely. It can be seen from the figures how bad the incident was.

Figure 23 – Blown Bypass switches

Figure 24 – Broken components
The solution for the problem was the replacement of the porcelain insulator for new ones made of glass, which are better because when they crack they break completely and fall down, so workers can easily realize it and change it. Some conductors and bypass switches were also replaced in order to restore the electricity to the network.

10. EIGHTH WEEK

On my eighth week in the substation, I was sent to the Reading department to learn about power reading, methods company use to set the electricity tariff and installation of power counters.

10.1 - Monthly reading

In the reading department there is a week that serves for workers to take readings in all medium voltage transformers around the city of Luanda. Fortunately, this day coincided with my first week in this department and I had an enjoyable week traveling around Luanda taking readings in every single transformer. Actually, there are more than 100 transformers and I had the chance to see them. All the transformers have numbers and the numbers are related to its location; in addition to that, there is a map showing all location of these transformers. Unfortunately, I didn’t have the chance to take a photo of it.

The digital power counters have a GSM feature that allows real time remote readings without having to go to the location of the transformer but, unfortunately, the only GSM company operating in Angola, UNITEL, does not have features that support this kind of GSM devices yet.

In this task, we were supposed to take readings of the active power or power consumed until that moment (measured in kW.h) and reactive power.
11. NINTH WEEK

After a week of long travels I end up in the office to have some theoretical lessons about the installation of power counter.

11.1 - Installation lessons of power counters

A very skilled technician was assigned to teach me to install power counters and the tricks clients use in order to cheat electric companies.

It is very important to install power counter in every client’s transformer not only to be able to know how much power they have consumed and charge them accordingly, but also to help engineers know how much power is being lost during the power distribution and consequently take actions to reduce this power losses. The calculation is simple; it is just as the following:

\[
\text{Power lost} = \text{Power delivered in the medium voltage network} - \text{Power consumed by clients}
\]

The components used for this task are:

- Digital power counter
- Toroidal Current Transformer (CT)
- Voltage transformer (VT)
- Cables

Since in the installation plan of the company there was not any medium voltage counter, I could only see and participate in the installation of low voltage power counter. As a result, I will only show low voltage CT and digital power counter in Figure 25.

![Figure 25 – Digital power counter and two types of Toroidal Current Transformers](image-url)
The installation can be done in the input of the transformer (medium voltage, 15KV) or at the output (low voltage, 400V). For the medium voltage two voltage and two current transformers are needed, whereas, only two current transformers are needed for low voltage counter installation. Figure 25 show the interconnection.

Figure 26 – Diagram of interconnections

These CT and VT have the same function as the ones I described for high voltage.

One important point I was warned about was the choice of the capacity of the CT. The CT must be chosen according to the transformer’s power delivering capabilities. This is, for good reading the CT should have 50/5A more than the transformer’s capacity (KVA) otherwise the CT will burn.

Example: The Toroidal CT in fig. 27 should be installed on a 200KVA (minimum) power transformer.

Figure 27 – Toroidal CT
It is important to note that the greater the CT value is with respect to the transformer’s KVA value the less power the power counter will count. Actually, this is the trick clients use to cheat on electric companies. It allows clients to consume alot and pay less than they should. But of course, inspections in transformers are done once in a while to prevent such actitudes.

After learning the theoretical aspects of the installation, I was sent to the field to take part in the installation of one power counter in a Pension which has a 200KVA transformer shown in figure 28.

Figure 28 – Medium voltage power transformer

For this task we used 250/5A Toroidal CTs and during the installation I could realize that CTs have labels in each side (P1 & P2), meaning, P1 is the side were the current of the cable should enter and come out in P2.

We installed the counter in the box of the main circuit breaker which receives the power from the transformer and delivers to the network. The result of our installation can be seen in fig. 29.

Figure 29 – Installation of power counter
12. CONCLUSION

I conducted my nine weeks SP in one of the substations of ENE – E.P in Luanda/Angola. In ENE’s substation I had the chance to work in Control room, maintenance and reading department. These experience deepened my knowledge about issues related to power engineering which is one of the areas I plan to specialize myself on. Now I am sure about my choice on power engineering because it is such a fantastic field that for some moments while I was working I thought for myself that if I get a job in power engineering, I will be paid to have fun rather than work because I love it. In the substation all the workers were nice to me and did their best to teach me as much as they could and sometimes I also taught them small things that they gave so much value that I felt like a member of that family of workers. The work environment was the best due to strong friendship among workers and bosses.

During these nine weeks of work there I developed my team work, intrapersonal, analytical thinking and problem solving skills. What I liked most was the fact that senior and junior engineers treated me as an engineer too and allowed me to perform by myself all the tasks I described above and not just observe and take notes.

I have to confess that for some deep technical details about certain equipments I could not fully understand at first, because they are related to subjects I will cover this academic year, but I did several researches on their User Manuals and managed to understand with help of the staff. I believe that ENE benefited from my SP because I was a very active trainee and contribute a lot for the work carried out during my stay there. I would like to thank all the staff of ENE for being very nice to me and supported me more than I was expecting.
13. REFERENCES

- User Manual, EFACEC Power Transformers, 2004
- Possible Failures and solutions manual, done by ENE – E.P
- ABB user manual for protection devices