" I hereby declare that I have read through this report entitle "*Analyzing Effect Of Moisture Content In The Transformer Oil Using Weibull Technique*" and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Industrial Power)"

Signature : ....

Supervisor's Name : MR. IMRAN BIN SUTAN CHAIRUL.

Date : ……………………………………….

ANALYZING EFFECT OF MOISTURE CONTENT IN THE TRANSFORMER OIL USING WEIBULL TECHNIQUE

NURUL AFIZA BINTI ABU BAKRI

A report submitted in partial fulfilment of the requirements for the degree of Bachelor of Electrical Engineering (Industrial Power)

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2015

I declare that this report entitle "*Analyzing Effect Of Moisture Content In The Transformer Oil Using Weibull Technique*" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ....

Name : NURUL AFIZA BINTI ABU BAKRI

Date : ……………………………………………..

DEDICATION

To my beloved father and mother

ACKNOWLEDGMENT

Firstly, I would like to give my thanks to Allah for giving me strength and ability to complete the project from beginning until the end. Without His permission, I would not finish my final year project in successful.

The special thank goes to my helpful supervisor, Encik Imran bin Sutan Chairul. The supervision and support that he gave truly help the progression and smoothness in order to complete my final year project. I really appreciate for all the guidance and advice that have been given for me.

My grateful thanks also go to all my friend that never tired to support and help me to assemble the parts and gave suggestion about this research. Last but not least, many thanks go to my beloved family for supporting and encourage me through out of this project. I have to appreciate the guidance given by other supervisor as well as panel especially to improve my report final year project to be a more better.

ABSTRACT

Power transformer is an important electrical equipment in power system. Fault happen in transformer when insulation in a poor condition. Failure in insulation might be happen when moisture or air ingress in the insulation and its affect the insulating of transformer. The aim of this project is to determine the moisture level of in service transformer and to categorize the condition of moisture according to the standard IEEE C57.106-2006. By differ to determine the effect of moisture in liquid insulation and to analyze the data by using weibull method. Weibull method is used to analyze the data life with using various parameters. The research is to compare the weibull plot between excel, reliasoft and least regression. The technique was used in the research is a weibull in life data analysis. In this method, contain of data life is a failure and successful. The data is consists of age and the condition of the moisture level. From the age of transformer, it can obtain the value of median rank to plot graph. All of this parameter is considered to analyze the data and to determine whether the end life of transformer is depends on the quantity of the moisture. The consistency of each data is based on the interpretation made from the analysis of 33/11kV,15MVA & 30MVA power transformer.

ABSTRAK

Kuasa pengubah adalah peralatan elektrik yang penting dalam sistem kuasa. Kesalahan berlaku di transformer apabila penebat dalam keadaan miskin. Kegagalan dalam penebat mungkin berlaku apabila lembapan atau kemasukan udara di penebat dan yang memberi kesan kepada penebat pengubah. Tujuan projek ini adalah untuk menentukan tahap kelembapan dalam perkhidmatan dan pengubah untuk mengkategorikan keadaan kelembapan mengikut standard IEEE C57.106-2006. Oleh berbeza untuk menentukan kesan kelembapan dalam penebat cecair dan untuk menganalisis data dengan menggunakan kaedah Weibull. Kaedah Weibull digunakan untuk menganalisis data yang hidup dengan menggunakan pelbagai parameter. Kajian ini adalah untuk membandingkan plot Weibull antara excel, reliasoft dan kurangnya regresi. Teknik yang digunakan dalam kajian ini adalah Weibull dalam analisis data kehidupan. Dalam kaedah ini, mengandungi hidup data adalah kegagalan dan berjaya. Data adalah terdiri daripada umur dan keadaan tahap kelembapan. Dari usia pengubah, ia boleh mendapatkan nilai pangkat median untuk plot graf. Semua parameter ini dianggap menganalisis data dan untuk menentukan sama ada kesudahannya ialah hidup yang pengubah adalah bergantung kepada kuantiti kelembapan. Konsistensi setiap data adalah berdasarkan kepada tafsiran yang dibuat daripada analisis 33 / 11kV, 15MVA & 30MVA kuasa pengubah.

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LIST OF ABBREVIATIONS

UTEM	Universiti Teknikal Malaysia Melaka
FKE	Fakulti Kejuruteraan Elektrik
IEEE	Institute of Electrical and Electronics Engineer
KFT	Karl Fischer Titrators
MVA	Mega Volt Ampere
PPM	Parts per million

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Distribution transformer is required component that allows the delivery of electricity with a high degree of flexibility. Transformers as a static electrical device used to transfer power between circuits through the coil of the transformer. In a power plant, transformer is an essential thus it is important to take caution and to monitor its condition to avoid any problems. It should go through by monitoring the transformer's condition to reduce the damage and diminish the cost to fix it. In addition, the lifetime of the transformer will be longer with expectations. However, any fault still can occurs when the protection its not good enough. The most factor can affect the transformer through oil is effect of moisture to liquid insulation life. The existence of moisture in a transformer is a concern because it causes several detrimental effect on the insulation. Moisture in insulation cannot be directly measured but is reach by the moisture level in oil. Temperature is a factor effect on moisture because with increasing temperature, the moisture in oil goes up. Therefore, a protecting oil filtered at excessively high a temperature may lose a substantial rate of its dielectric quality on cooling on the grounds that the dissolved dampness is then changed to an emulsion. This project aim is to analyze the effect of moisture to liquid insulation life assessment for power distribution transformer by using weibull technique.

1.2 Problem Statement of Research

When there is a fault occurs in transformer by presence of moisture to liquid insulation, this is a critical for transformer life because the transformer life is highly dependent on its insulation condition. Transformer insulation can be deteriorates due to many factors such as temperature rise, high dissolved gases in oil and moisture content. Thus, this project will be carried out to analyze the distribution transformer oil condition based on transformer aged, and moisture content in the transformer oil by using weibull technique.

1.3 Project Objective

The objective of this study are:

i. To determine the moisture level of in service power distribution transformer.
ii. To determine the adequate moisture level in transformer oil according to C57.106-2006 IEEE Guide.
iii. To analyze life assessment for the effect of moisture content in transformer oil using Weibull method.
iv. To compare the weibull plot between excel, reliasoft software and least square method.

1.4 Project Scope

The scope of this research are:

i. Parameters levels were obtained from in-services transformer.
ii. Parameters obtained are moisture level and age of transformer.
iii. 33/11 kV, 15MVA & 30MVA power distribution transformer.
iv. Analysis using Weibull plot.

1.5 Project outline

Insulation is important in each transformer. There are many factors that cause of breakdown voltage which is causes by moisture content in oil. For this thesis, it contains of five chapters which is include of the parameter to be determined, method to be used, review on the previous researcher, discussion of the result regarding of this thesis. For the chapter 1 is view on the distribution power, aim of this thesis and scope of the thesis. Chapter 2 is review on the previous journal to compare and to find the similar or to make comparison on this thesis. From this chapter, it is more to find the literature review regarding to the moisture, insulation and the technique that will used in weibull analysis. In chapter 3, it is review on the project methodology. This part is to describe the methodology that applied for this thesis. The data will differentiate between failure and success according to the standard. Other than that, the parameter, formula and plotting regarding to analyze in weibull it will shows on this chapter. Chapter 4 the results are analyzed. End life of transformer is depends on moisture level. The weibull analysis is used in three method to get the same value of parameter. Chapter 5 consists of conclusion and recommendation for this thesis.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This chapter will describe of literature review for type of insulation, moisture present in a insulation, accelerates aging, temperature and water solubility. Other than that, it will discuss the Karl Fischer technique and Weibull method. This can be utilized to direct this venture and all the related data was focused around the past examination done by others.

2.1 Type of Insulation

Insulation is one of the most important elemental of a transformer. The strength and stability of the transformer depends upon the proper utilization of insulating materials in it. Transformer failures are normally due to degradation and aging of paper and oil. Life assessment of a transformer is crucial when it reaches the age of 20-25 years [1]. Transformer failure have related to the dielectric response of the insulation system. To determine the life expectation of transformer periodic insulation assessment based on condition monitoring is extremely important, in specific for an aged transformer or the one with distrustful behavior. According to a study transformer failure rate due to insulation related problem is 11% and is increasing [2]. Age levels of protection in a transformer is a mind boggling and unalterable phenomena. Pressure is due of the operation (ordinary to the great), situation and contamination help the crumbling of protection chain therefore shortening the life of the transformer plan.

The protection is all that much responsive in transformer serving closer to plan life. The condition of existing unit has been unerring assessed, when have are best formulated on strategic maintenance and operational procedures.

The presence of moisture in solid and liquid transformer insulation plays a critical role in transformer life [3]. Dielectric breakdown will happen when any increase in moisture content and it can reduce the insulating. This is of a certain importance with rise and fall temperature because as the transformer cools down, any dissolve water will get to be free, resulting in a poor insulating power and fluid degradation. In transformers, the most part for three insulating materials are utilized which is transformer oil, paper and pressboard. In these insulation, provides initial drying to a moisture content of 0.25% to 0.50% moisture by weight, and after processing, the insulation system will be sealed to prevent the ingress of air (oxygen) and moisture.

2.1.1 Insulating oil - Transformer oil.

Transformer oil is the main protecting material utilized as a part of transformer. It is one of the essential factors that determine the life and satisfactory operation of the transformer. Transformer oil serves fundamentally two reasons one it is fluid protection in electrical power transformer and two it dissipates heat high of the transformers act as coolant. Oil analysis is the key source to detect incipient faults, fast developing fault, insulation trending and aging [4]. Oil is the main factor of the transformer to prevent oxidation of the core. Oil surrounding core-coil assembly enhance the dielectric strength of the winding. Other than that, oil has a greater electrical withstand than air occur by dielectric improvement. The stress on the insulation is reduce at the point when oil replaces air in a dielectric system. Polar compounds found in transformer oil usually contain oxygen, nitrogen, or sulphur. Ionic compounds would typically be organic salts found only trace quantities [5]. Polar and ionic compound are some of minor element that found in oil which can greatly influenced the chemical and electrical properties. Polar compound can describe which the electric charge is not symmetrically distributed, there have positive and negative poles. It is different with ionic compound because it is conduct electricity when they dissolve in water. Mineral insulating transformer insulating oils are refined from predominantly naphthenic crude oils[3].

The "crude oil" pumped out of the ground is a black liquid called petroleum. There have two type of transformer oil used in transformer that is consist of paraffin and naphtha based transformer oil. Naphtha oil is more effortlessly oxidized than Paraffin oil. Therefore sludge of naphtha based oil is not brought about in base of the transformer. In our country is still used paraffin that have disadvantages because it easy availability.

2.1.2 Paper Insulation (cellulose)

Insulation paper is one of the most important in transformer. The function is same with oil transformer but the different between paper and oil is material. The insulation system of a power transformer is understand as the complete assembly of dielectric insulating material. Aging is a factor on this insulation paper. Ageing of cellulose is a function of temperature. Moisture and oxygen has significant influence on the aging [1]. Increasing the failure risk is due to the forces produce by fault current as well, tensile strength and insulation dielectric decrease with aging due to the increase in moisture and contaminants. If the temperature is decreased, the infused paper lost a part of tensile strength. Impregnation effect is occurs by the thickness of oil impregnated.

Oil impregnated papers gradually age due to thermal stress, moisture and acidity and their degradation affects the lifetime of the power transformer [6,7]. This is affect the electrical, mechanical and physical characteristic of oil impregnated paper. Paper was the first insulation applied for used in high voltages technologies. This paper insulation was used in high capacity cable and transformer. The thermal contraction of paper is low and flexible at a low temperature is sensible without leading to the mechanical issue. The dielectric strength of an oil cellulose insulation system rely on the period of voltage application, field improvement factor, its temperature and pressure, kind and degree of contamination of the oil, its temperature and pressure [8]. This transformer paper insulation designed must be prepared and careful with consideration of these aspect.

2.2 Moisture Presence in Insulation

Moisture content of oil and paper is important have an effect on the dielectric behavior of insulation. There are many factor affect this insulation such as raising temperature and the ageing of transformer. In general, the mechanical life of the insulation is reduced by half for each doubling in water content [9]. The presence of moisture in a transformer will become worse in quality or condition of the transformer insulation by diminishing both electrical and mechanical strength. The parameter moisture content of oil in parts per million (PPM). A major causes of failures by moisture is partial discharge, bubble formation, dielectric breakdown and deterioration of insulating liquid and paper.

2.2.1 Moisture in Oil Insulation

Insulating oil have a low affinity for water. Moisture like an oxygen, can enter the transformer from main tank through loss of integrity of mechanical seal. This will be leading to failure which is oil level drop, exposing the winding and moisture contamination. The moisture presence in oil system have been recognized since the 1920'. Knowing moisture in oil can also predict the steady state moisture content in transformer board in equilibrium with oil [10]. The main thing of parameter in oil moisture measurement is water solvability. If the moisture in oil exceeds the ability in temperature, so the free water will form. This table below show the temperature is place at 20C, since the temperature below 20C the rate of dispersion of water is so moderate it is not possible attain harmony in operational equipment. The study confirmed that moisture equilibrium process in oil-paper insulation system of a transformer highly temperature dependent and a clear knowledge about the state of equilibrium is necessary for accurate determination of oil and paper moisture content[11].

Table 2.1 Guidelines for interpreting data expressed in percent saturation[12]

Percent saturation water in oil, adjusted to 20C	Condition of cellulosic insulation
0 – 5 %	Dry Insulation
6 – 20 %	Moderate wet, low numbers indicate fairly dry to moderate levels of water in the insulation. Value toward the upper limit indicate moderately wet insulation.
21 – 30 %	Wet Insulation
>30 %	Extremely wet insulation

The migration of a small amount of moisture has been associated with flow electrification at paper/oil interfaces and is presumed to be due to charge accumulation on highly insulating interfacial dry zones [3,13]. Water in mineral oil transformer also bring the risk of bubble formation when desorption of water from the cellulose increase the local concentration of gases in the oil [14]. Water can originate from two sources such as atmospheric and internal sources it shows in table 2.2. The table 2.3 show acceptable water content for new and in-service fluid. There are consist of 3 type of value of voltage. Each type have a different value of water content.

Table 2.2: Origin of water

Atmospheric	Internal Sources
Via the silica gel breather (dry silica gel is always blue).	Paper degradation produces water.
Via leaks into the power equipment, i.e. bad gasket, cracked insulation, a loose manhole cover, a ruptured explosion diaphragm etc.	Oil degradation produces water.
(if oil can get out, water can get in).	Wet insulation contaminates the oil, (temperature dependent).

Table 2.3: water content for new oil in 3 different voltage class [15].

Test and method	**Value for voltage class**		
	≤69 kV	69 – <230 kV	>230 kV & above
Water content IEEE C57.106-2006 mg/kg maximum (ppm)	35	25	20
Oxidation inhibitor content Type II oil	0.09% minimum, if in original oil.		

2.2.2 Moisture Accelerates Aging

Insulation is important to keep the transformer in good condition within the range. There are many factor to take prevent and avoid to give a long lasting for the transformer.

Aging is the one factor can affect the insulation and water is the element to influence with the age. Once a device is put into operation, its insulation will deteriorate and produce certain amount of moisture, which then act as catalyst for further aging [16]. Figure describes life expectancy for the insulation at various temperatures and moisture content [3]. At 90°C, cellulose with 1% moisture has a life expectancy of about 12 years. At 3% moisture the life expectancy is only 3year.

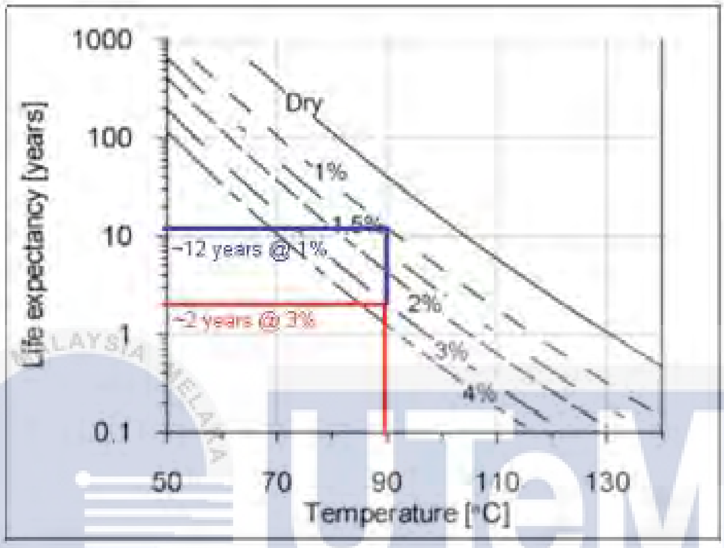


Figure2.1: Life expectancy for cellulose at different temperature and moisture content [17]

2.2.3 Water solubility

Solubility is a concept that sometimes is a quite difficult to understands, but this is essential when attempting to get to the drought or humidity of transformer. The water solubility known as the amount of water that can be dissolve in the insulation oil at particular temperature. The solubility of water is not fixed in insulating oil but it can change due to changes in temperature [18]. This is related, if the temperature is raise up, the amounts of water can be dissolve in insulating oil is increase. This increases is not a linear but exponential in a function. The calculation of solubility limits for oil at different temperatures are shown in Table 2.4.

The solubility can be calculated by using Arrhenius Equation 2.1 [18]:

$$\text{Log } S = -A/T + B \text{ equation} \qquad (2.1)$$

Where:-“S” is the solubility of water in mineral oil & “T” is the temperature in Kelvin (°C + 273)
“A” & “B” are constants. Here A= 1670 & B= 7.42

Table 2.4: water in oil solubility as function of temperature[18]

Oil Temperature	**Water Content in Oil, ppm**
0°C	20
10 °C	33
20 °C	53
30 °C	82
40 °C	122
50 °C	179
60 °C	255
70 °C	358
80 °C	491
90 °C	663
100 °C	880

2.3 Karl Fischer Method

Karl Fisher Titration is a technique for the measure existence of moisture content. This technique is used to measure the water level content in the transformer oil in the laboratory. It is based on a reagent which reacts with water and converts the water into a non-conductive chemical. Karl Fisher provides for the specific detection of water**.** The method are used to determine the amount of water in an oil sample on weight-to-weight (mg/kg) basic or what is commonly known as ppm (part per million)[18]. Most commonly the determination depends on measuring by using Karl Fischer, the mass of moisture presence in a sample taken from the equipment and interfering the relative humidity (%RH) – concentration relationship, typically presented as equilibrium plot at a given temperature [19,20,21]. There are two method use to perform the Karl Fischer titration test to determine the amount of water in oil using Volumetric or Coulometric Karl Fischer. Volumetric method determine is base the amount, or volume, of reagent used to convert the water. A reagent is added until the water was removed. For Coulometric is the capability to accurately measure small amounts of moisture.

Figure 2.2: KFT Test Setup[18]

2.4 Weibull Analysis

Weibull analysis is to gather all the data and analyze the data. There are many type of method to analyze the data such as degradation data analysis, warranty data analysis, reliability test design, repairable system analysis and monte carlo simulation. All the method have a specific reason to use it.

2.4.1 Life Data Analysis

In life information investigation, the objective is to model and comprehend the disappointment rate conduct of a specific thing, procedure or item. The models are assembled by taking the watched "life" information, which can be gotten either from the field then again from in-house testing. Since time is a typical measure of item life, the life information focuses are regularly called times-to-failure data. There are two general types of times-to-failure data complete and censored. Weibull analysis offers considerable insight into the life-time reliability of product [22]. The presents a method to transform the bus-motor time-between-failures (TBF) data of into the form of time-to-failure (TTF) data, and develop a normal process model to fit the TTF data [23].

2.4.2 Degradation Data Analysis

It is complex to acquire high reliability output in failure data. Analyzing the performance degradation data, analysis result of reliability will be more reasonable than through traditional approach [24]. The degradation model is create by on degradation data/ previous performance, and the parameter of the model are predict as the previous detailed of Bayesian method. In the 1980s, Kalbfleisch pointed out the performance degradation data was the abundant information source for reliability evaluation[25]. Yao Zhengqi questioned the hypothesis of traditional reliability theory, which considered that any components and systems have only two states of false and true [26]. Yao felt that there should be a continuous degradation process before the products fail absolutely, and put forward another reliability analysis method. Lu and Meeker thought about two reliability analysis methods, which were based on the failure time data and degradation data separately [27]. Figure below show the flow to plot the real time reliability by follow each method.

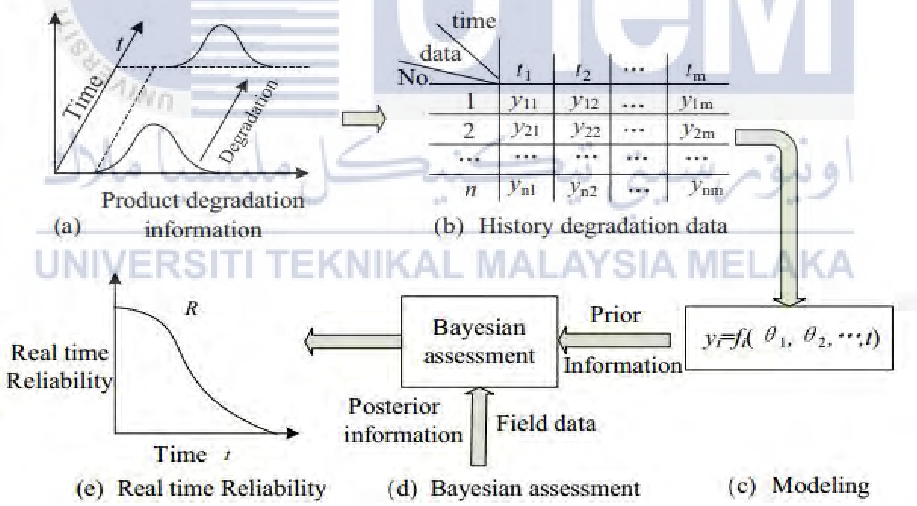


Figure 2.3: Real time reliability analysis procedure[22]

2.4.3 Median Rank Method

Rank method is determine the process to estimated unreliabilities are related with failure times. Median rank cannot be put into explicit form, by numerical techniques the value has to be determined[28]. The median rank technique is utilized to evaluate its sample part to develop the probability plot. This technique is usually to use for estimation the Y-axis plotting points. Y axis plot is represent of the unreliability or failure data that will calculate by using Benard's approximation which is as follow :

$$F(x) = \frac{O_i - 0.3}{n+4} \quad (2.2)$$

Where O_i= the failure order and N= the total number of specimens on test. There are example for sample data that consists of failure and success. There are have 8 sample data with 5 units that have failed at 10, 30, 45, 49, 82, 90, 96 and 100 minutes[29]. The unreliability estimation are shown in table 2.5

Table 2.5 Data with unreliability estimation

Rank	**Time**	**Failed / Success**	**Unreliability Estimation**
1	10	S	
2	30	F	9.8%
3	45	S	
4	49	F	25.5%
5	82	F	41.1%
6	90	F	56.7%
7	96	F	72.3%
8	100	S	

The y axis is represent of the unreliability and x axis represent of the time. This is refer to the table 2.5 to plot the graph. For the weibull probability plot, the range for the y axis is 1% to 99% that shown in figure 2.4. For the x axis, the range to plot the graph is 1 to 100 in hours or year or minutes depends on sample that need to estimated.

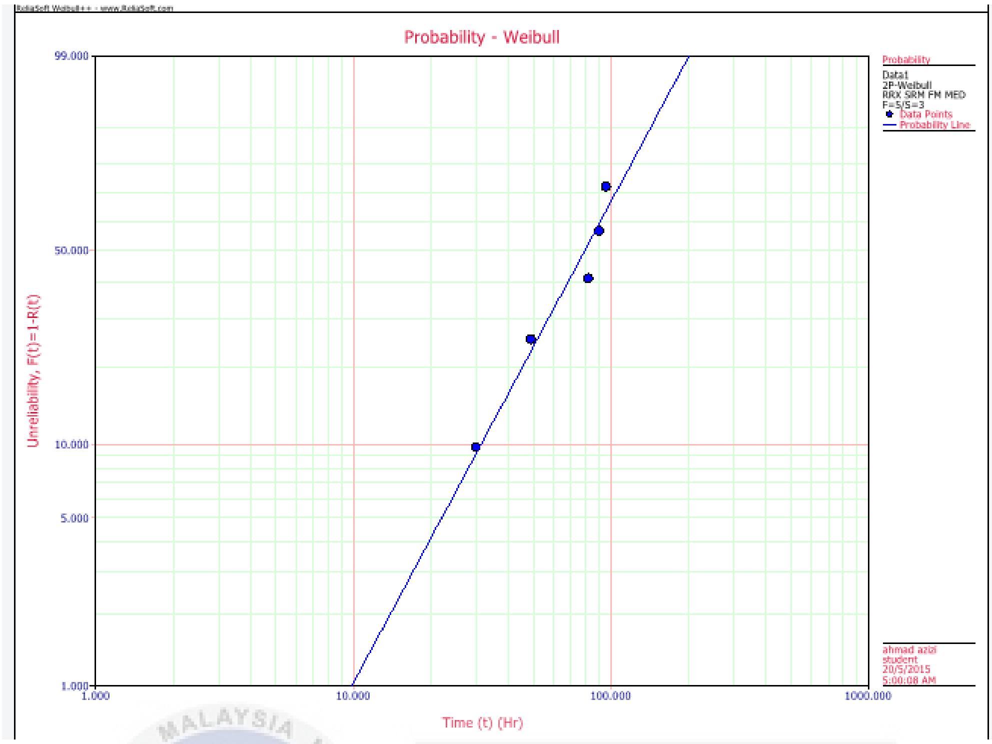


Figure 2.4 : probability – weibull

Refer to figure 2.4, it depicts that failure points against time(t) it fit a straight line for the probability weibull. It also can plot in excel to analyze by using weibull method. If The failure time against time plotted on probability weibull is linear, it indicates that two parameters that chosen for weibull distribution was valid. If the points is not seem to get a linear line, it would probably consider to use another lifetime distribution to review analysis the data. From that it can draw a best fit line from the points of failure.

2.4.4 Determining Parameter Estimation

In the weibull distribution, there are parameters that obtain in weibull probability plot which is the parameter estimation is consists of scale parameter (n) and shape parameter (β). Weibull distribution is widely known in analysis and reliability modeling. The Swedish professor waloddi Weibull was not the first use this expression [30], his paper, A statiscal distribution of Wide Applicability published in 1951. There a state about simplicity of formula give in (2.3), extreme flexibility to model services life distribution.

$$R(t) = 1 - F(t) \tag{2.3}$$

The parameter estimation can be derived on through the plotting graph. To estimate the beta with referring the plot, sketch a line parallel to the line by through the slope scale as shown in figure 2.5

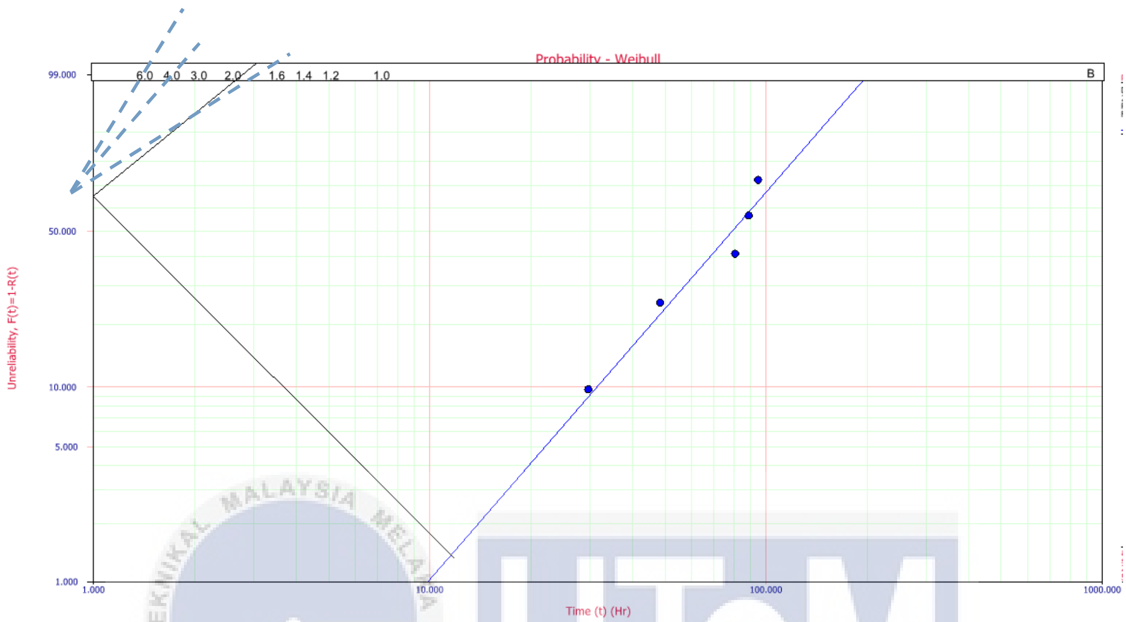


Figure 2.5 : Estimating beta (β) from probability-weibull

The scale parameter can define through the graph plot by drag the line from unreliability at 63.2% to the best fit line. When there are have intercept between fit line and dragging line, the value eta as shown in figure 2.6 below. Weibull distribution is represent by the quation below:

$$F(t) = 1 - e^{-\left(\frac{t}{n}\right)^{\beta}} \quad (2.4)$$

Where t=n

$$F(t) = 1 - e^{-1}$$

$$F(t) = 1 - 0.368$$

$$= 0.632 \text{ @ } 63.2\%$$

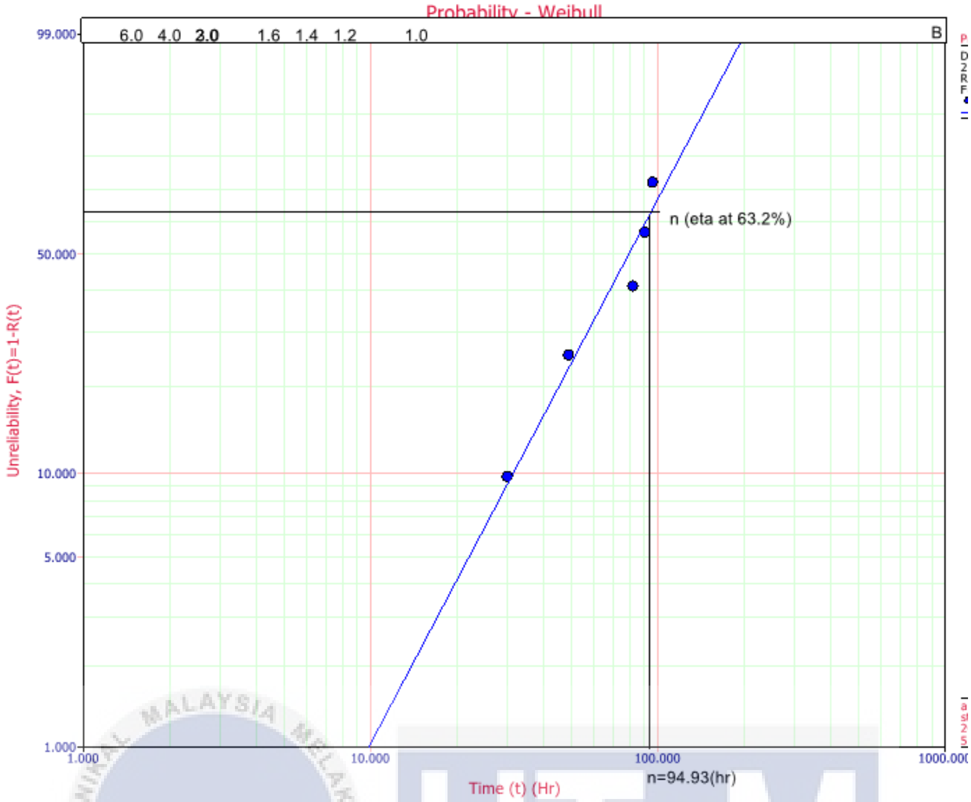


Figure 2.6: Estimating eta (n) from probability-weibull

Figure 2.6 indicates the value of eta by referring to the graph is 94.93 hour. This method can be acceptable if the data set contained suspensions because to plot the y-axis is from median rank.

2.4.5 Least Square Parameter Estimation Of The Weibull Distribution

This method is to estimated the parameters of weibull distribution, the empirical distribution function of life model is a key factor in accuracy[31]. This method is to plot the best fit line by using normal graph paper. It is different to the weibull using semi log paper. Even though it is different method, the value of beta and eta give a almost same with the previous method. For the least regression, it must measure one by one the value of x axis and y axis by using data median rank. In equation below, it show the formula for the least square parameter is [32]:

$$F(t) = 1 - e^{-\left(\frac{t}{n}\right)^{\beta}}$$

While is transformation equation is:

$$\frac{1}{1-F(t)} = exp\left[\left(\frac{t}{n}\right)^{\beta}\right] \quad (2.5)$$

Both sides takes twice of the logarithm, one has:

$$lnln\frac{1}{1-F(t)} = \beta(lnt - \ln(n)) \quad (2.6)$$

Let:

$$x = lnln\frac{1}{1-F(t)}; y = lnt \quad (2.7)$$

2.5 Summary of The Review

Insulating in a transformer consists of the paper and liquid insulation. Insulation is a cooling system but mostly it to insulate winding from the core. The advantages of this insulation is liquid dielectric performance and the disadvantages is contains of moisture or air that can affect the strength of insulation. However, the presence moisture in insulation is due to rise temperature, water solubility and the aging of transformer. A weibull analysis is used to evaluated the life assessment for the transformer for the effect of moisture contains in transformer oil. The statistical is using weibull++7 software, excel and regression method. Three method of this will get the same value of parameter.

CHAPTER 3

METHODOLOGY

3.1 Methods or Technique Used in The Previous Work

The purpose of the methodology to ensure that the project has guidelines and it can be done smoothly and well organized. This study was done in order to analyze the effect of moisture content in transformer oil using weibull technique. Moisture accelerates aging and water solubility in oil. Method to measure the water content in oil is by using Karl Fischer method that specific to evaluated and measure water content in oil. To analyze the data, Weibull method is used to show the result of data by using graph.

3.1.1 Weibull++ Analysis

Weibull++ is an intuitive, multipurpose and totally completely integrated work center designed around the Data Folio (it alike to an Excel worksheet). Weibull give all apparatuses that required to standard life information examination, this is incorporate adaptable alternatives for information sort, life time dispersion and parameter estimation system. All information sorts and usually utilized item lifetime circulation is backings by this product including the Exponential, Logistic, Lognormal, Normal, Bayesian-Weibull ,Generalized Gamma, Gamma, Logistic, Gumbel, and Competing Failure Modes,
In this software, there are 6 type the Complete Array of Related Analyses:

1. Degradation Data Analysis
2. Warranty Data Analysis
3. Life Data Analysis
4. Reliability Test Design
5. Repairable System Analysis
6. Monte Carlo Simulation

3.2 FLOW CHART

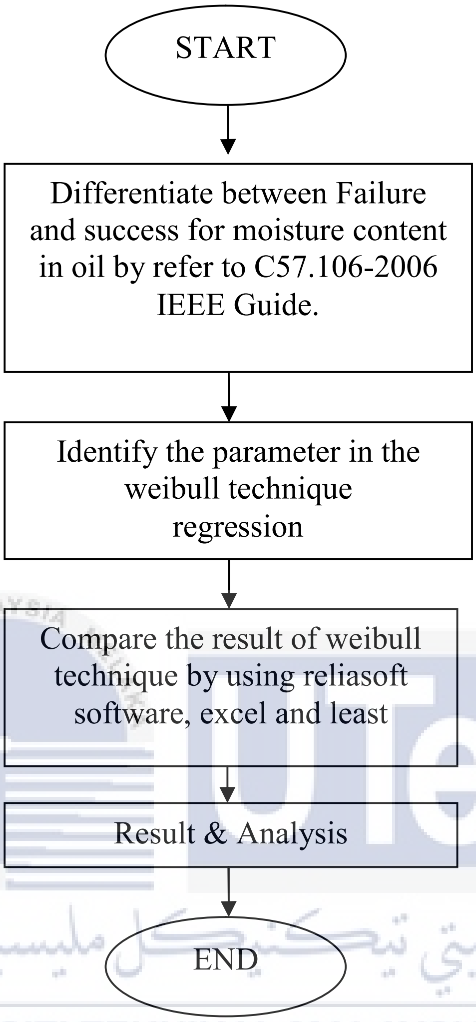


Figure 3.1: Project Power Flow

3.2.1 Weibull Concept- Unrealibilty versus age transformer

Life data analysis is call as weibull analysis. The specialist attempt to make forecasts about the life of all items in the community by fitting a accurate dispersion to life information from a envoy sample of units. Models is defines as line graph to estimate the failure rate of the product function of time as well as the probability of failure (or survival) of the product to a given age or period. There are 3concept to practitioner requires for life data analysis:

3.2.2 Life Data types

Life data can be refers to measurement of product life. The product life can be measured in cycles, hour, miles and some other parameter that applies to the times of successful operation in a specific item. There are two data type which is complete data and censored data.

i. Complete data is the exact time-to-failure for the unit is known. It consider that the product have not failed.

ii. Censored data is divide into 3 part which is have right censored(suspended), Interval censored and left censored.

Right censored data is the product have not failed and already failed during the test. Interval data can be describe the failure cannot be predict because it failed between maintenance and do not know exactly when it failed. Left censored data is a failure time is just known to be before a certain time.

For this project research, right censored data will be choose because this type will come out the result either failure or successful. The unit worked effectively for a known time of time and afterward proceeded with (or could have proceeded) to work for an extra obscure time of time. Figure 3.2 shows an example, if in this project have 5 units to test and only 3 is failed, the data set is composed of the three units that failed and the running time of the other two units without failure.

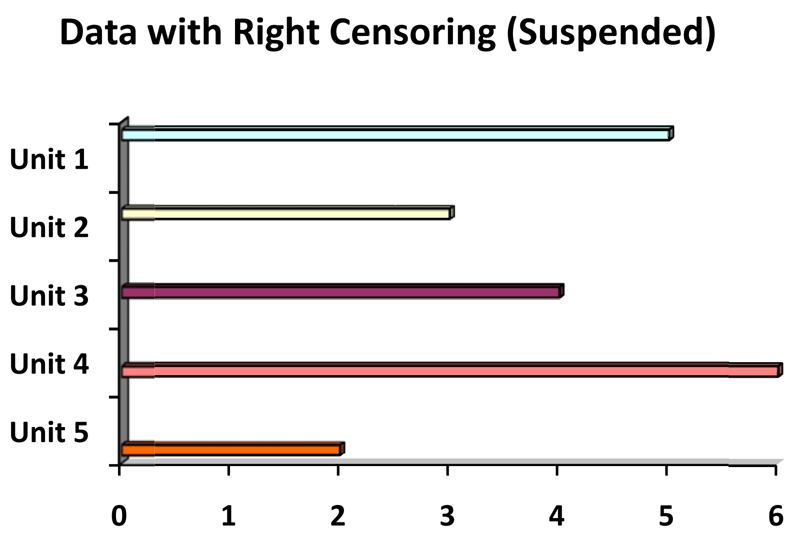


Figure 3.2: Example to show suspended data

3.2.3 Parameter Estimation

In this part, the table 3.2 shows to identify the failure and success of each data and the limit of the moisture content in transformer oil. This column is to identify which data is failure or success, according to the value that be appointed shows in table 3.1.

Table 3.1: The column of data and condition

	Site	Transformer	Age	Moisture Level	Condition
1	KL TOWN	T1	10	11	S
2	JALAN DUTA	T1	17	20	S
3	MSG	T1	20	16	S
4	AMPANG	T2	21	45	F
5	DESA PETALING	T1	21	41	F
6	DESA PETALING	T2	21	47	F
7	TAMAN SEGAR	T1	21	65	F

In this project, there are 2 condition to identify which liquid insulation content moisture more than 35 ppm and less than 35 ppm according to standard.

Table 3.2: Identify failure and success moisture content

State (F or S)	Condition
F	≥35 ppm moisture content in oil
S	<35ppm moisture content in oil

3.2.4 Evaluating the Weibull analysis by using three method

3.2.4.1 Weibull analysis by using reliasoft software.

Weibull++ software is use to calculated and determined the reliability and life data analysis which is to produce the probability plot instead by using graph paper, manually calculation as shown in below.

Age-to-failure data is the data will be measured to get significantly more exact information compares to others because there have related in each data point. Data that has been measured in accordance with accuracy so that the small sample size can be accepted. To determine failure time more detailed in weibull plot, there are 3 requirement should follow. Firstly, make sure time origin need to be clearly determined. Secondly is scale to measure the passage of time must be clarified and lastly is significance of failure must be completely clear.

Cumulative failure percentages is called unreliability, $Q(T)$ which is defined as :

$$Q(T) = 1 - R(T) \tag{3.1}$$

$$R(T) = e^{-\left(\frac{t}{n}\right)^{\beta}} \tag{3.2}$$

$R(T)$ is a reliability.

η (Eta), is characteristics life of an item, which defined 63.2% of the population has failed.

β (beta), the shape parameter is slope of the best-fit line through data points

t, represent the time of interest when solving equation (year age transformer)

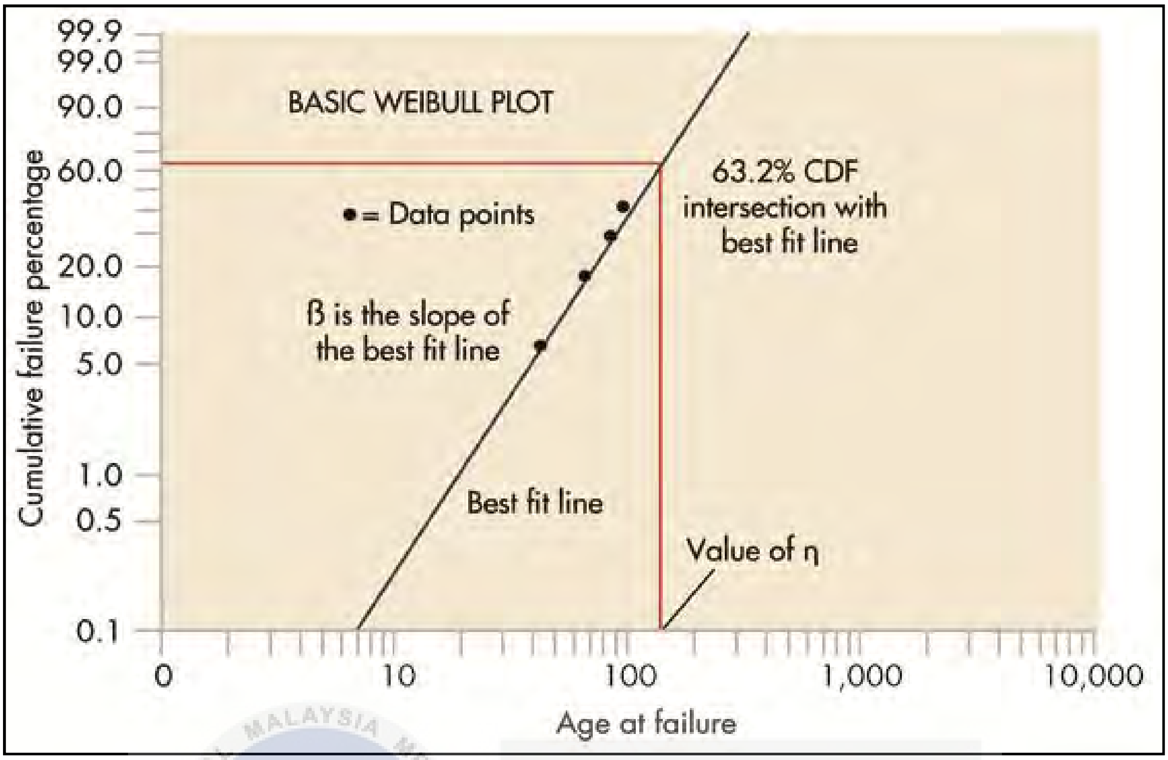


Figure 3.3: Weibull plot age at failure vs cumulative failure percentages [28]

This Weibull plot demonstrates a best-fit line with a slope of beta through four information focuses. The units of age rely on upon the part of usage and the failure mode. The value of eta will be taking at the 63.2% Cumulative density function intersection at the best-fit line. To get the best-fit line, there are using correlation coefficient to draw a straight line with the data given. The function of correlation coefficient is to linear model fits the data. For the life data analysis, it is measure between the median rank and the data. There a 3 different relationship to define the β. The table below show the condition of beta in Weibull plot.

$(\beta) < 1.0$ indicates infant mortality

$(\beta) = 1.0$ means random failures (independent of age)

$(\beta) > 1.0$ indicates wear out failures

i. Rank method

The rank method is one of the method considering the calculating unreliability estimates of the times-to-failure data. There are options available in rank method either median ranks or Kaplan-Meier. The median ranks method allocates unreliability estimates depends on the failure order number and the cumulative binomial distribution. Alternatively, the Kaplan-Meier estimator uses the product of the surviving fractions, producing a modified empirical distribution. In general, the median ranks method is better and comprehensive use for unreliability estimation. Hence, it is a smart thought to use median rank method except that one has a specific reason to use the Kaplan-Meier methodology.

To plot the graph, probability plotting is use to give a linear line. Probability plotting takes the cumulative distribution function (cdf) of the distribution and attempts to linear it by employing a specially constructed paper. In this project research of the two-parameter Weibull distribution, the cdf (and unreliability Q(t))

$$F(t) = Q(t) = 1 - e^{-\left(\frac{T}{n}\right)^{\beta}} \quad (3.3)$$

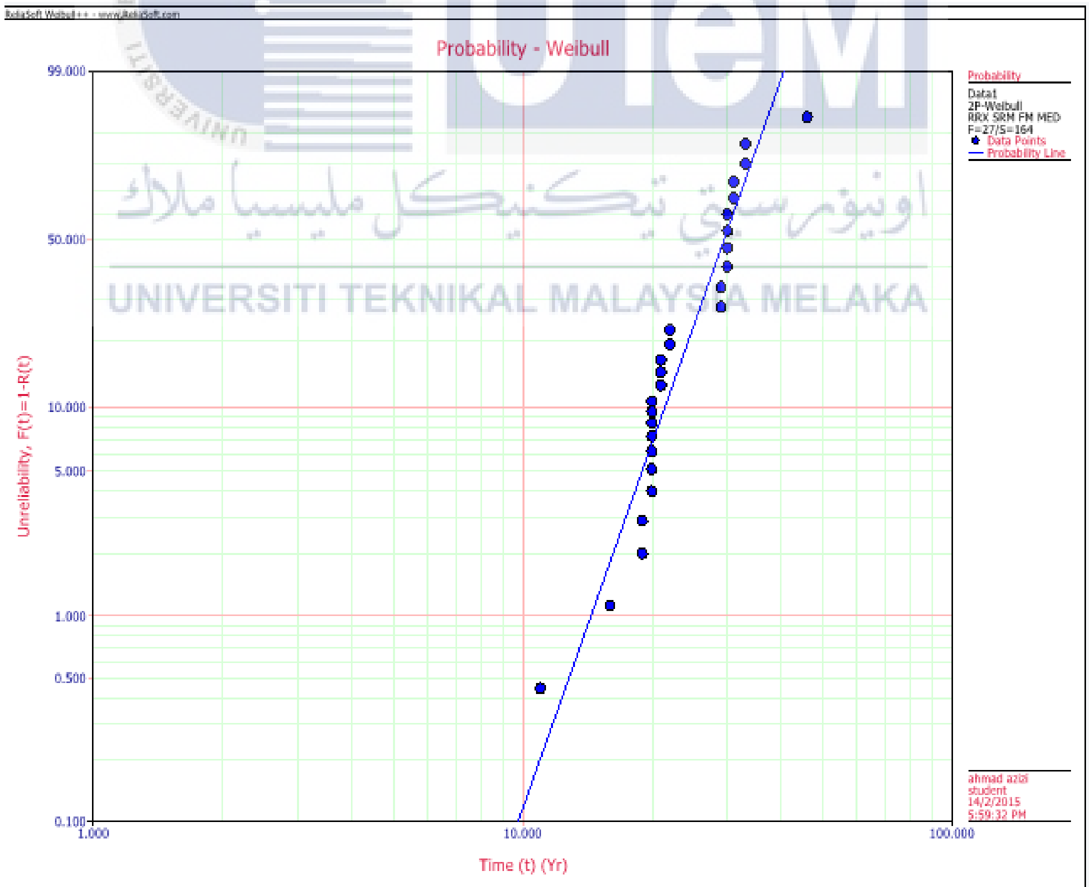


Figure 3.4: Probability plot graph Unrealibility Versus Age

To plot the graph probability – weibull, median rank is use for y axis and age (year) is used for x axis. There are two methods to calculate the median rank. Both methods can get the same answer median rank by using the weibull software.. The procedure of step by step by using reliasoft software shows at appendix A.

3.2.4.2 Weibull Analysis By Using Cumulative Distribution Function In Excel

The cumulative distribution function F(x), is usually estimated from the median rank.

$$F(x) = \frac{O_i - 0.3}{n+4} \tag{3.4}$$

O_i is the modified order or failure of the i_{th} data point. A modified order failure is only needed if censored data is involved.

This function can use to produce 5 percent or 95 percent, which are used for confidence limit. In other ways to find O_i is by using adjusted rank. By using adjusted rank, it directly calculate without to find I_i. This equation show below are used in Benard approximation to calculate median rank in excel.

Adjusted rank, $O_i = \frac{(Reverse\ rank)*(previous\ adjusted\ rank)+(N+1)}{(Reverse\ rank)+1}$

Table 3.3 : Template for procedure to calculate median rank

	Site	Transformer	Age	Moisture Level	Condition	Reverse Rank	Adjusted Rank	Median Rank
1								
2								
3								
4								

3.4.2.3 Weibull analysis by using Least square parameter estimation

Least square method is to find the best fitted data to get a straight line such that the total of the square of the vertical deviations from the point to the line is minimized, if the regression is on Y(RRY), or the line fitted to a set of data points such that the sum of the squares of the horizontal deviations from the points to the line is minimized, if the regression is on X(RRX). If the data shows a linear relationship between x and y, it called regression line.

$\hat{y} = a + bx$ or $\hat{y} = b_o + b_1 x$

$\hat{y}$ = read as predict y value

a/b_o = is the intercept (where it crosses the y-axis)

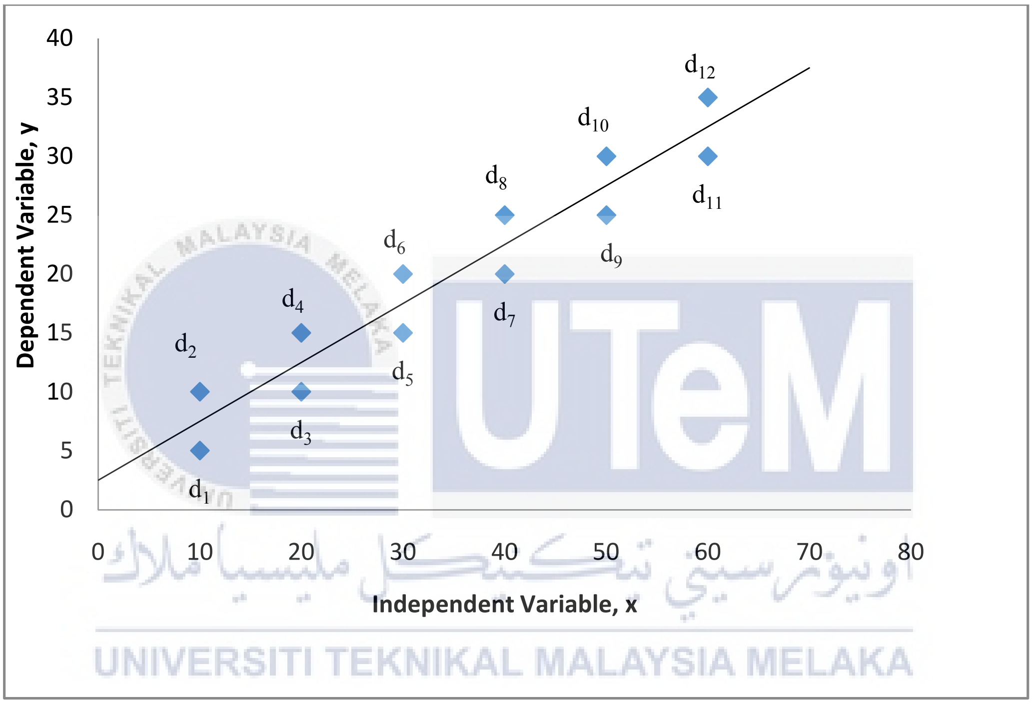


Figure 3.5: The regression line by using y =b_o+b_1 x

Figure 3.5 shows the best straight line is from the equations that consists of slope and the intercept of y-axis.

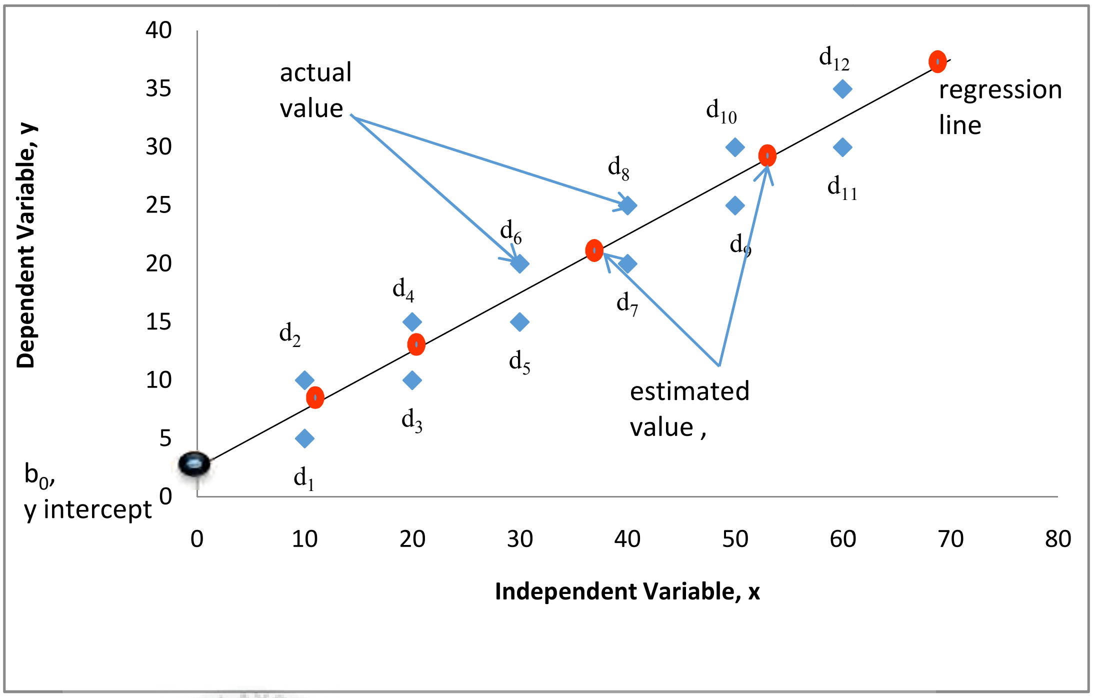


Figure 3.6: Difference between actual value and estimated value in graph

There are difference equation to determine the value of beta and eta by using the value of x-axis and y-axis. The value of x-axis and y axis is rearranging terms and taking natural logarithms from the cdf of the weibull distribution. This is equation for censored data in weibull.

$$y = \ln(T) \tag{3.5}$$

$$x = \ln(-\ln(1 - median\ rank)) \tag{3.6}$$

$$\text{Shape}, \beta = \frac{1}{slope(y,x)} \tag{3.7}$$

$$scale, n = \ exp\left(\frac{-x\ intercept}{slope}\right) \tag{3.8}$$

$$\text{Where, x intercept} = \left(\frac{-intercept\ (x,y)}{shape,\beta}\right) \tag{3.9}$$

3.3 Summary

The methodology is to investigating the solution with follow a procedure according to the flow chart. In this chapter is began by collecting data and follow by differentiate the condition of the data either the data in success(S) or failure(F). This condition will determine in Life Data Analysis using weibull reliasoft software, excel and least regression method.

CHAPTER 4

RESULT AND DISCUSSION

4.0 Introduction

The result is based on the analyze data using weibull reliasoft software. The steps of the calculation for each method are mentioned.

4.1 Data Analysis And Measurement

The data was obtained from TNB Selangor and Kuala Lumpur. The data is taken from 33/11KV, 15MVA & 30MVA power distribution transformer. All the data is take from main tank . From the data, it contains the level of moisture in the transformer oil. Moisture in oil will affect the condition in the transformer. Moisture is come from many different ways and the life expectancy of tx will be more damage quickly. Weibull is use to analyze the effect of moisture in transformer. There were contains of parameter that was used to differentiate failure rate, scale of the data and failure rate in 99% life.

Excel is use to compare the parameter by using the method of calculation. From that, it will observe the result obtain in excel is almost same in weibull. Other than that, from excel it can observe the regression line for the data. That is meant, the line can be more precise and the calculation will show in the discussion. In Appendix B and C was showed the data of moisture level and the category either failed or success. The status failed or success was depends on moisture level in transformer.

4.2 Data Measurement Using Median Rank Method

In general, the estimated median rank was used to calculated in distribution function. The result was shown in Table 4.1.

Table 4.1: Using adjusted rank to calculated median rank for 15MVA-KL data.

Count	Site	Transformer	Age	Moisture Level	Condition	Reverse Rank	Adjusted Rank	Median Rank
1	KL TOWN	T1	10	11	S	57		
2	JALAN DUTA	T1	17	20	S	56		
3	MSG	T1	20	16	S	55		
4	AMPANG	T2	21	15	F	54	1.055	1.315%
5	DESA PETALING	T1	21	41	F	53	2.109	3.152%
6	DESA PETALING	T2	21	47	F	52	3.164	4.989%
7	TAMAN SEGAR	T1	21	65	F	51	4.218	6.826%
8	TAMAN SEGAR	T2	21	27	S	50		
9	TAMAN SEGAR	T3	21	27	S	49		
10	BANDAR BARU SUNGAI BULUH	T1	22	20	F	48	5.316	8.738%
11	BANDAR BARU SUNGAI BULUH	T2	22	18	F	47	6.413	10.650%
12	D'VILLAGE	T1	22	10	S	46		
13	D'VILLAGE	T2	22	12	S	45		
14	SUNGAI PUSU	T1	22	18	S	44		
15	SUNGAI PUSU	T2	22	22	S	43		
16	TURF CLUB	T1	22	17	S	42		
17	TURF CLUB	T2	22	17	S	41		
18	JALAN DUTA	T2	26	22	S	40		
19	KL EAST	T1	28	40	F	39	7.703	12.897%
20	KL EAST	T2	28	38	F	38	8.993	15.144%
21	MALAWATI	T3	29	31	S	37		
22	BANK NEGARA	T1	30	46	F	36	10.317	17.452%
23	BANK NEGARA	T2	30	54	F	35	11.642	19.759%
24	KL TOWN	T2	30	83	F	34	12.966	22.067%
25	MINDEF	T1	30	37	F	33	14.291	24.374%
26	MINDEF	T2	30	31	S	32		

27	SELAYANG UTAMA	T1	30	28	S	31		
28	SELAYANG UTAMA	T2	30	34	S	30		
29	ULU KELANG	T1	30	19	S	29		
30	ULU KELANG	T2	30	27	S	28		
31	BUKIT BINTANG	T1	31	52	F	27	15.851	27.093%
32	BUKIT BINTANG	T2	31	60	F	26	17.412	29.813%
33	DAYA BUMI	T3	31	65	F	25	18.973	32.532%
34	MAS	T1	31	42	F	24	20.534	35.252%
35	MAS	T2	31	18	S	23		
36	AMPANG	T3	31	34	F	22	22.163	38.090%
37	PERNAS	T1	33	40	F	21	23.792	40.928%
38	PERNAS	T2	33	36	S	20		
39	MALAWATI	T1	33	29	S	19		
40	MALAWATI	T2	33	34	S	18		
41	DAYA BUMI	T3	33	34	S	17		
42	DAYA BUMI	T1	33	34	S	16		
43	SALAK SOUTH	T1	33	29	S	15		
44	SALAK SOUTH	T2	33	26	S	14		
45	KAMPUNG LANJUT	T1	34	64	F	13	26.236	45.184%
46	KAMPUNG LANJUT	T2	34	58	F	12	28.679	49.441%
47	KL NORTH	T1	35	15	S	11		
48	KL NORTH	T2	35	18	S	10		
49	AMPANG	T1	40	137	S	9		
50	CITY HALL	T1	40	9	S	8		
51	CITY HALL	T2	40	9	S	7		
52	CENTRAL	T1	46	38	F	6	32.868	56.738%
53	CENTRAL	T2	46	34	S	5		
54	BANGSAR	T1	47	40	F	4	37.894	65.495%
55	BANGSAR	T2	47	34	S	3		
56	BATU CAVES	T1	51	34	S	2		
57	BATU CAVES	T2	51	32	S	1		

Table above shows the column that consists of number of sample size, condition between failure or success depends on the moisture level. Other than that, the table above show the age of transformer in each of the sample. The fourth column is consists of adjusted rank and the fifth is a median rank. All the data above is needed to analyze the effect of moisture in transformer oil.

Adjusted rank was used for censored data to calculate the median rank. Adjusted rank is a previous failure that occurs in the system. It is also known as an increment for the previous failure. Median rank is use to plot the graph probability weibull. This mathematical equation statement is also known Bernard's approximation for median rank. It is adequately exact for practical usefulness. There are sample calculation for adjusted rank and median rank.

Adjusted rank, $I_j = \frac{(Reverse\ rank)*(previous\ adjusted\ rank)+(N+1)}{(Reverse\ rank)+1}$

$$Median\ rank = \frac{I_j - 0.3}{n+4}$$

Sample calculation: for n= 4,

adjusted rank = $\frac{(54)*(0)+(57+1)}{(54)+1}$ = 1.054545

$Median\ rank = \frac{1.054545-0.3}{57+4}$ x 100%=1.31454%

For n=3, no rank value because the data is a suspension and not failure. For n=5, the data was obtained is a failure and the formula is must to be used again to get the new increment.

Sample calculation: for n= 5, adjusted rank = $\frac{(53)*(1.054545)+(57+1)}{(53)+1}$ = 2.109091

$Median\ rank = \frac{2.109091-0.3}{57+4}\ x\ 100\%$ =3.15173%

Table 4.2 Using adjusted rank to calculated median rank for 30MVA-KL data.

Count	Site	Transformer	Age	Moisture Level	Condition	Reverse Rank	Adjusted Rank	Median Rank
1	Saujana triangle	T1	6	21	S	191		
2	Saujana triangle	T2	6	9	S	190		
3	Bangsar	T1	7	6	S	189		
4	Bangsar	T2	7	6	S	188		
5	Bukit bintang	T1	7	12	S	187		
6	Bukit bintang	T2	7	19	S	186		
7	Central	T1	7	9	S	185		
8	Central	T2	7	9	S	184		
9	Manjalara	T1	7	15	S	183		
10	Manjalara	T2	7	19	S	182		
11	Mid valley	T1	7	10	S	181		
12	Mid valley	T2	7	22	S	180		
13	Royal cendana	T2	7	10	S	179		
14	Jalan ampat	T1	8	9	S	178		
15	Jalan ampat	T2	8	12	S	177		
16	Jalan pahang	T2	8	8	S	176		
17	Royal cendana	T1	8	17	S	175		
18	Jalan pahang	T1	9	14	S	174		
19	Jalan roger	T1	9	7	S	173		
20	Jalan roger	T2	9	4	S	172		
21	Jalan sungai besi	T1	9	5	S	171		
22	Jalan sungai besi	T2	9	14	S	170		
23	Sri edaran	T2	9	9	S	169		
24	Sri endah	T1	9	10	S	168		
25	Sri endah	T2	9	10	S	167		
26	Kampung baru sungai buluh	T1	10	20	S	166		

27	Kampung baru sungai buluh	T2	10	21	S	165		
28	Hospital ampang	T2	11	42	F	164	1.16364	0.4512%
29	Damansara damai	T1	11	8	S	163		
30	Damansara damai	T2	11	10	S	162		
31	Hospital ampang	T1	11	25	S	161		
32	Hospital sungai buluh	T1	11	10	S	160		
33	Hospital sungai buluh	T2	11	9	S	159		
34	Prima damansara	T1	11	18	S	158		
35	Prima damansara	T2	11	9	S	157		
36	Seri endah	T1	11	12	S	156		
37	Seri endah	T2	11	14	S	155		
38	Magna park	T1	14	7	S	154		
39	Magna park	T2	14	7	S	153		
40	Maju perdana	T1	14	9	S	152		
41	Maju perdana	T2	14	11	S	151		
42	Ukay perdana	T1	14	10	S	150		
43	Ukay perdana	T2	14	12	S	149		
44	Great eastern	T1	15	26	S	148		
45	Great eastern	T2	15	28	S	147		
46	Pearl point	T1	15	13	S	146		
47	Pearl point	T2	15	16	S	145		
48	Hospital selayang	T1	16	23	F	144	2.47975	1.1388%
49	Low yat plaza	T1	16	27	S	143		
50	Low yat plaza	T2	16	31	S	142		

The data was determined for the condition success or failure. The determination is based on the moisture in oil is exceed according to the standard C57.106-2006 IEEE guide. The standard show if any of moisture content in oil transformer more than 35 ppm, it will consider as a failure. The condition in the table 4.2 is depends on the moisture level content in the transformer oil. The sample size for the 30MVA transformer is 191.

In this table only show 50 sample size from 191. The overall sample is shows in the appendix B. The sample calculation is same with the previous by using the formula adjusted rank and median rank. In the table 4.2 above, the sample size n=1 until n=27 and n=29 until n=47, the data is a suspensions. It is not require for rank value because it will not to be plotted on the weibull plotting. The sample size n=28 and n=48 is required to calculated the new increment between failures. The sample size for n=48, the previous adjusted rank depends on n=28 is 1.163636.

Table 4.3 Using adjusted rank to calculated median rank for 15MVA-Selangor data.

Count	Site	Transformer	Age	Moisture Level	Condition	Reverse Rank	Adjusted Rank	Median Rank
1	RAWANG BATU 16	T1	10	16	S	52		
2	SUNGEI WAY	T2	15	21	S	51		
3	SUNGAI LANG SABAK BERNAM	T1	16	29	S	50		
4	TANJUNG KARANG	T1	17	15	S	49		
5	BANGI LAMA	T1	18	30	S	48		
6	TANJUNG KARANG	T2	18	17	S	47		
7	BANDAR SEPANG	T1	19	25	S	46		
8	RAWANG BATU 16	T2	20	39	F	45	1.152174	1.62629%
9	TELUK PANGLIMA GARANG 2	T1	20	40	F	44	2.304348	3.82509%
10	KALUMPANG	T1	20	29	S	43		
11	SUNGEI WAY	T1	20	20	S	42		
12	KALUMPANG	T2	20	22	S	41		
13	TELUK PANGLIMA GARANG 2	T2	20	15	S	40		
14	SEK 9 BANGI	T2	21	53	F	39	3.571739	6.24378%
15	DAMANSARA UTAMA	T2	21	3	S	38		
16	MORIB	T1	21	23	S	37		
17	MORIB	T2	21	20	S	36		
18	SALAK TINGGI	T2	21	21	S	35		
19	SEK 9 BANGI	T1	21	28	S	34		

20	BERANANG	T1	21	33	S	33		
21	SERENDAH	T2	21	28	S	32		
22	SIME DARBY	T1	21	35	S	31		
23	SIME DARBY	T2	21	24	S	30		
24	BANDAR SEPANG	T2	22	18	S	29		
25	OLAK LAMPIT	T1	22	18	S	28		
26	OLAK LEMPIT	T2	22	27	S	27		
27	SERENDAH	T1	22	27	S	26		
28	SUBANG AIRPORT	T1	22	7	S	25		
29	SUBANG AIRPORT	T2	22	12	S	24		
30	SUNGAI LONG	T2	22	15	S	23		
31	TUDM	T2	22	15	S	22		
32	SUNGAI MANGGIS	T2	25	**32**	**S**	21		
33	TUDM	T1	26	29	S	20		
34	SUNGAI MANGGIS	T1	28	**31**	**S**	19		
35	NORTH KLANG STRAITS	T1	30	87	F	18	6.173227	11.20845%
36	PANDAMARAN	T2	32	38	F	17	8.774714	16.17312%
37	SALAK TINGGI	T1	32	27	S	16		
38	PANDAMARAN	T1	33	49	F	15	11.538794	21.44808%
39	TELUK PANGLIMA GARANG 1	T1	33	43	F	14	14.302875	26.72304%
40	PJ OLD OFFICE	T2	33	31	S	13		
41	PJ OLD OFFICE	T1	33	31	S	12		
42	TELUK PANGLIMA GARANG 1	T2	33	24	S	11		
43	SUNGAI LONG	T1	36	13	S	10		
44	TAMAN MAS	T1	36	25	S	9		
45	TAMAN MAS	T2	36	19	S	8		
46	UPM	T1	36	20	S	7		
47	UPM	T2	36	19	S	6		
48	AIR HITAM	T1	38	97	F	5	20.752396	39.03129%
49	NORTH KLANG STRAITS	T3	39	47	F	4	27.201916	51.33954%
50	NORTH KLANG STRAITS	T2	40	65	F	3	33.651437	63.64778%
51	DAMANSARA UTAMA	T3	42	48	F	2	40.100958	75.95603%
52	PJ OLD OFFICE	T3	50	53	F	1	46.550479	88.26427%

Table 4.3 above shows the sample size of the 15MVA transformer in Selangor. There are consists of 52 sample size with the number of failure is 12 and number of

suspension is 40. The previous adjusted rank is depends on the previous of the failure. For this sample, the failure is start from n=8 and the previous adjusted rank is zero because there have no number of increments for the previous failure. All of the median rank for the failure data will be plotted to analyze the failure rate will occurs in each transformer that consists of moisture

Table 4.4 Using adjusted rank to calculated median rank for 30MVA-Selangor data.

Count	Site	Transformer	Age	Moisture Level	Condition	Reverse Rank	Adjusted Rank	Median Rank
1	BUKIT RAJAH	T2	6	30	S	257		
2	DISTRE PARK	T2	6	7	S	256		
3	JAYA 33	T1	6	14	S	255		
4	KINRARA PERDANA	T1	6	11	S	254		
5	KINRARA PERDANA	T2	6	10	S	253		
6	KORAAYAT USJ	T1	6	7	S	252		
7	KORAAYAT USJ	T2	6	7	S	251		
8	LAGENDA MAS	T2	6	9	S	250		
9	SERDANG PERDANA	T2	6	7	S	249		
10	SUNGAI MAS	T1	6	4	S	248		
11	SUNGAI MAS	T2	6	4	S	247		
12	WORLD WIDE	T1	6	13	S	246		
13	WORLD WIDE	T2	6	9	S	245		
14	PERSIARAN RAJA MUDA MUSA	T2	7	58	F	244	1.0531	0.2926%
15	TAMAN INDUSTRI PUCHONG	T1	7	36	F	243	2.1061	0.7017%
16	TAMAN INDUSTRI PUCHONG	T2	7	11	S	242		
17	TAMAN INDUSTRI PUCHONG UTAMA	T1	7	9	S	241		
18	TAMAN INDUSTRI PUCHONG UTAMA	T1	7	19	S	240		
19	TAMAN INDUSTRI PUCHONG UTAMA	T2	7	25	S	239		
20	TOP GLOVE MERU	T1	7	9	S	238		
21	BUKIT RAJAH	T1	8	12	S	237		

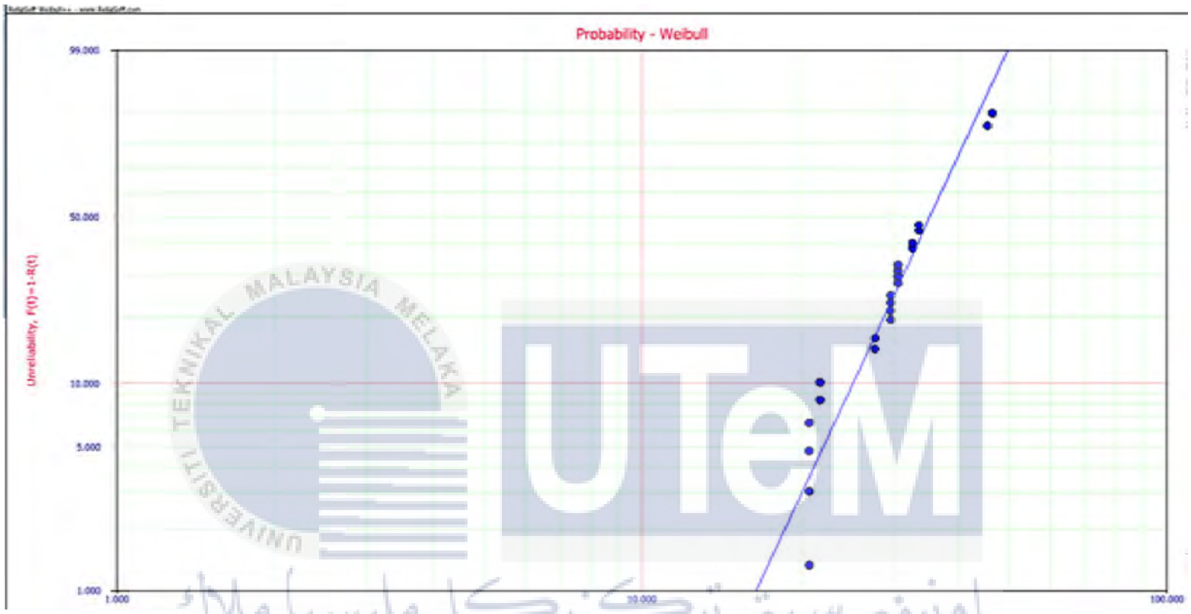
22	DISTRE PARK	T1	8	8	S	236		
23	JUSCO BALAKONG	T1	8	8	S	235		
24	JUSCO BALAKONG	T2	8	5	S	234		
25	LAGENDA MAS	T1	8	11	S	233		
26	PHELEO DAMANSARA	T1	8	8	S	232		
27	UPM	T1	8	6	S	231		
28	BANDAR RINCHING	T1	9	3	S	230		
29	BANDAR RINCHING	T2	9	8	S	229		
30	TAMAN MAS	T2	9	8	S	228		
31	TAMAN MAS TEMP	T2	9	6	S	227		
32	BANDAR BARU SULTAN SULAIMAN	T1	10	14	S	226		
33	BANDAR BARU SULTAN SULAIMAN	T2	10	12	S	225		
34	BUKIT LANCUNG	T1	10	8	S	224		
35	BUKIT LANCUNG	T2	10	6	S	223		
36	DESA COALFIELD	T1	10	5	S	222		
37	EQUINE PARK	T2	10	19	S	221		
38	SRI KEMBANGAN	T1	10	8	S	220		
39	BANGI RESORT	T1	11	19	S	219		
40	BANGI RESORT	T2	11	12	S	218		
41	LABU BENA	T1	11	21	S	217		
42	LABU BENA	T2	11	14	S	216		
43	MAHKOTA CHERAS	T2	11	13	S	215		
44	MAS SEPANG	T1	11	8	S	214		
45	MAS SEPANG	T2	11	14	S	213		
46	MUTIARA DAMANSARA	T1	11	8	S	212		
47	MUTIARA DAMANSARA	T2	11	11	S	211		
48	PETRONAS	T1	11	6	S	210		
49	PETRONAS	T2	11	9	S	209		
50	SAMTC	T3	11	17	S	208		

The table 4.4 shows the sample size of the 30MVA transformer in Selangor. For this data, sample size, n= 257 include with number of failure is 28 and number of success is 229. The table shows number of sample size n=1 until n=50. All of the result it shows in appendix C. Median rank is important to estimated the reliability value based on the failure number.

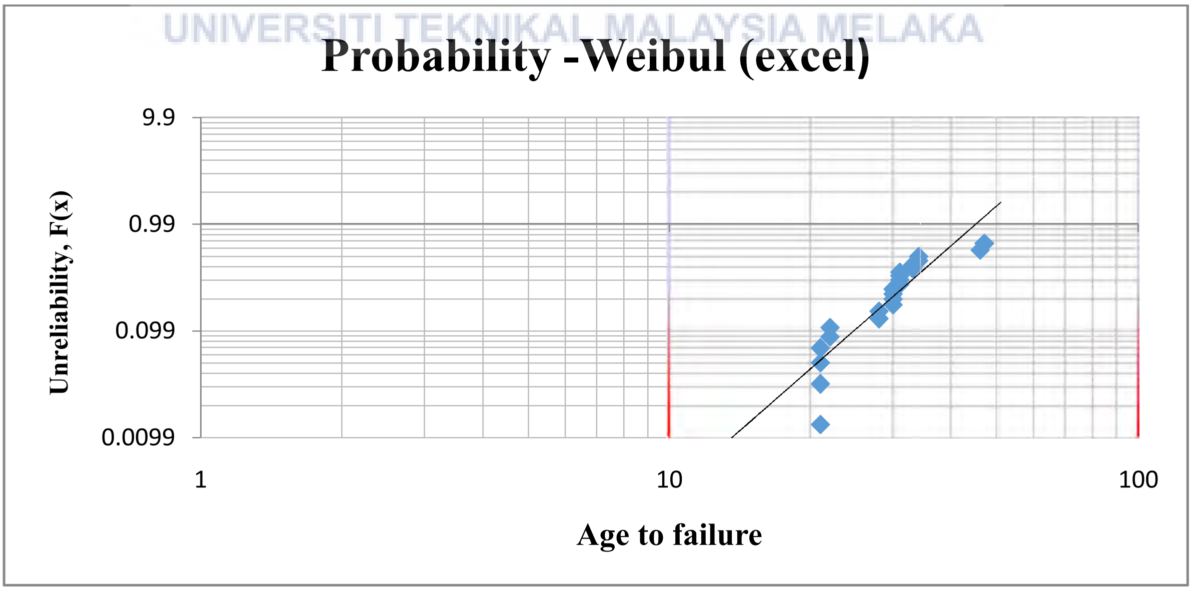
4.3 Median Rank data in the Probability Plot

Median rank is important to calculate and to determine for plotting graph in weibull analysis. This analysis is attempt to make expectation about the life of all items in the population by fitting measurable statistical to life information from sample units. From the probability plotting, it can be estimated the important parameter such as failure rate, mean life, and the probability of failure rate at a specific year.

1.



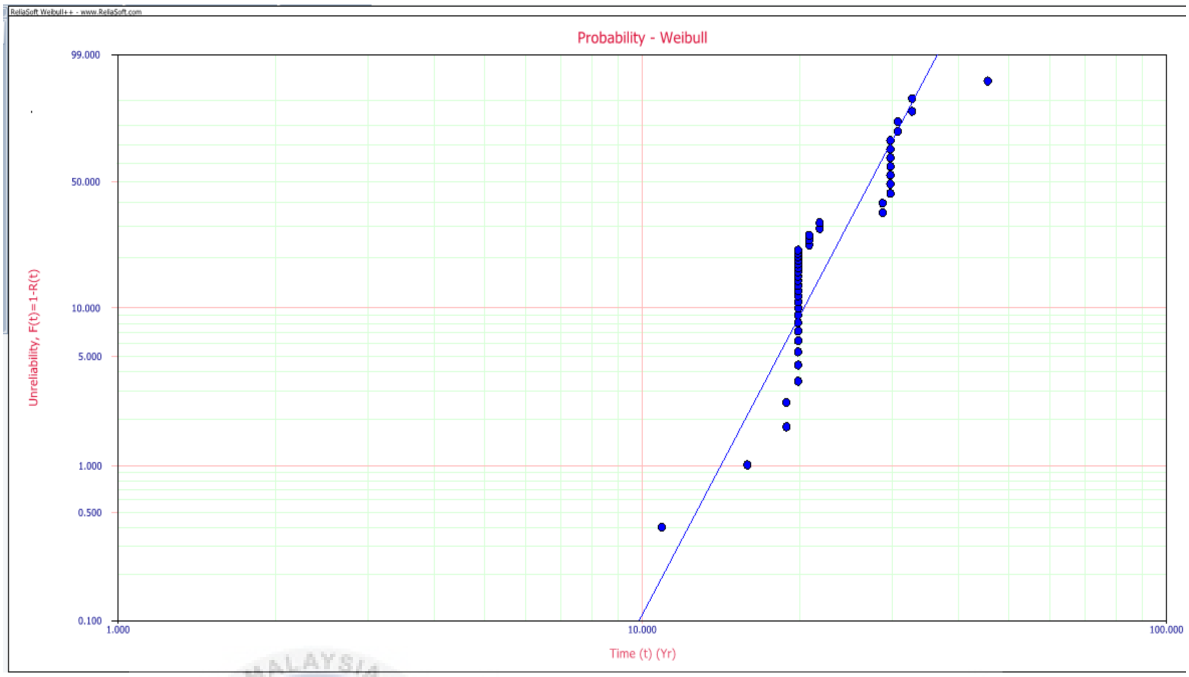
a)



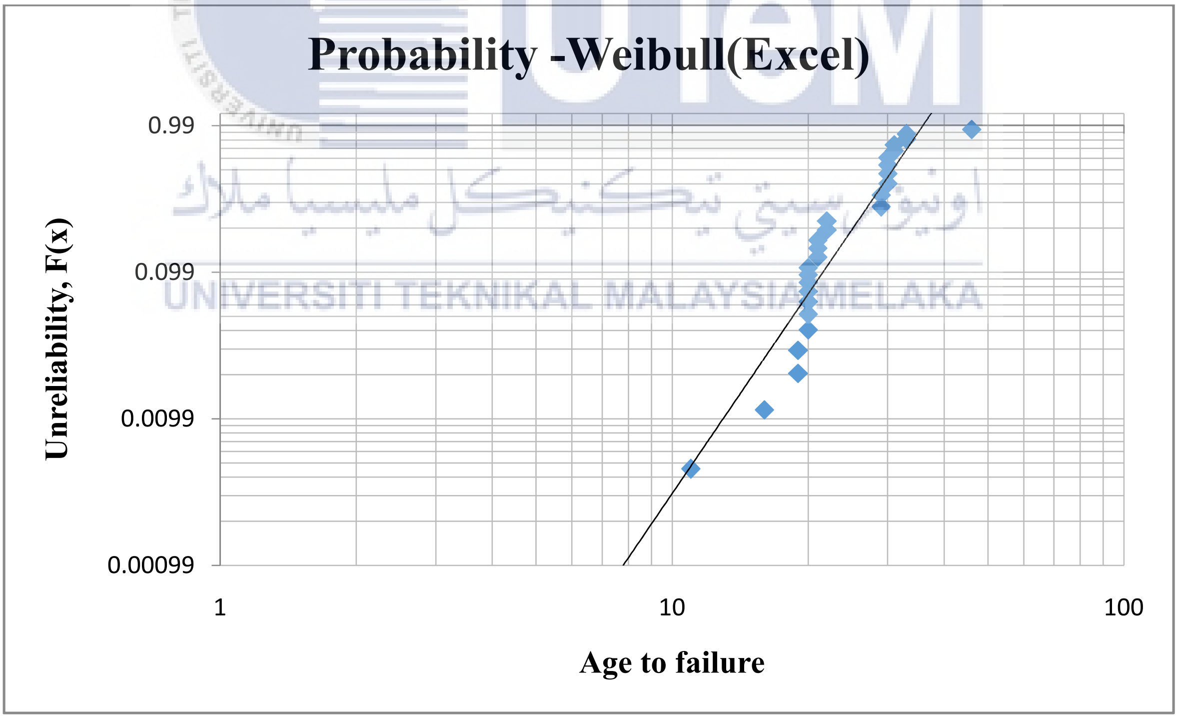
b)

Figure 4.1: the comparison weibull plotting for 15MVA transformer in Kuala Lumpur (a) graph plotting by using relia software, (b) graph plotting by using excel

2.



(a)



(b)

Figure 4.2: the comparison weibull plotting for 30MVA transformer in Kuala Lumpur (a) graph plotting by using relia software, (b) graph plotting by using excel

Figure 4.1 and 4.2 shows the probability plotting weibull analysis by using relia softwate and excel. The first data that obtained from measurement by using 15MVA transformer shown in figure 4.1 and the second data by using 30MVA transformer shown in figure 4.2.

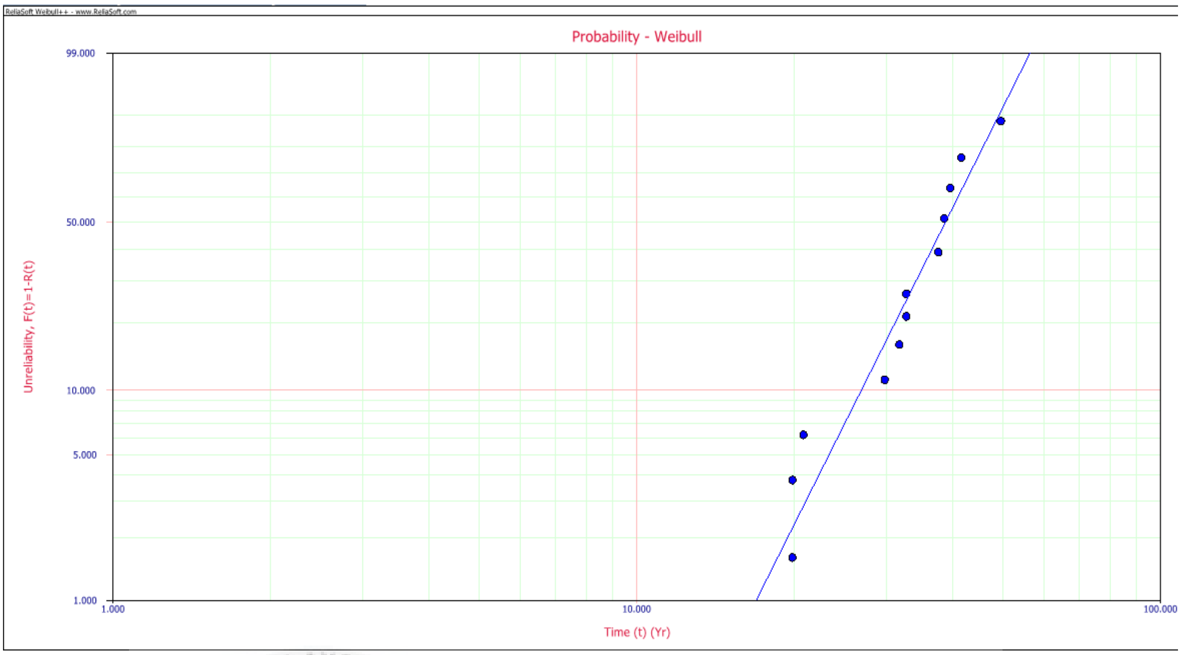
The graph indicate in the figure 4.1 and figure 4.2 consists of x-axis and y axis. X-axis represent of the time(year) of data and y axis is represent of the unreliability. Unreliability is data gather from failure sample and it calculate to produce median rank. From the graph, it may find the beta value and eta of which depends on the conditions of graph line. Beta is the slope of the graph and eta is taken 63.2% from the y-axis.

By using reliasoft to plot, the graph is automatically shows and the result is obtained. This is different to plot the graph by using excel. This is because by using excel, the median rank must be calculated to plotting the graph and done by manually.

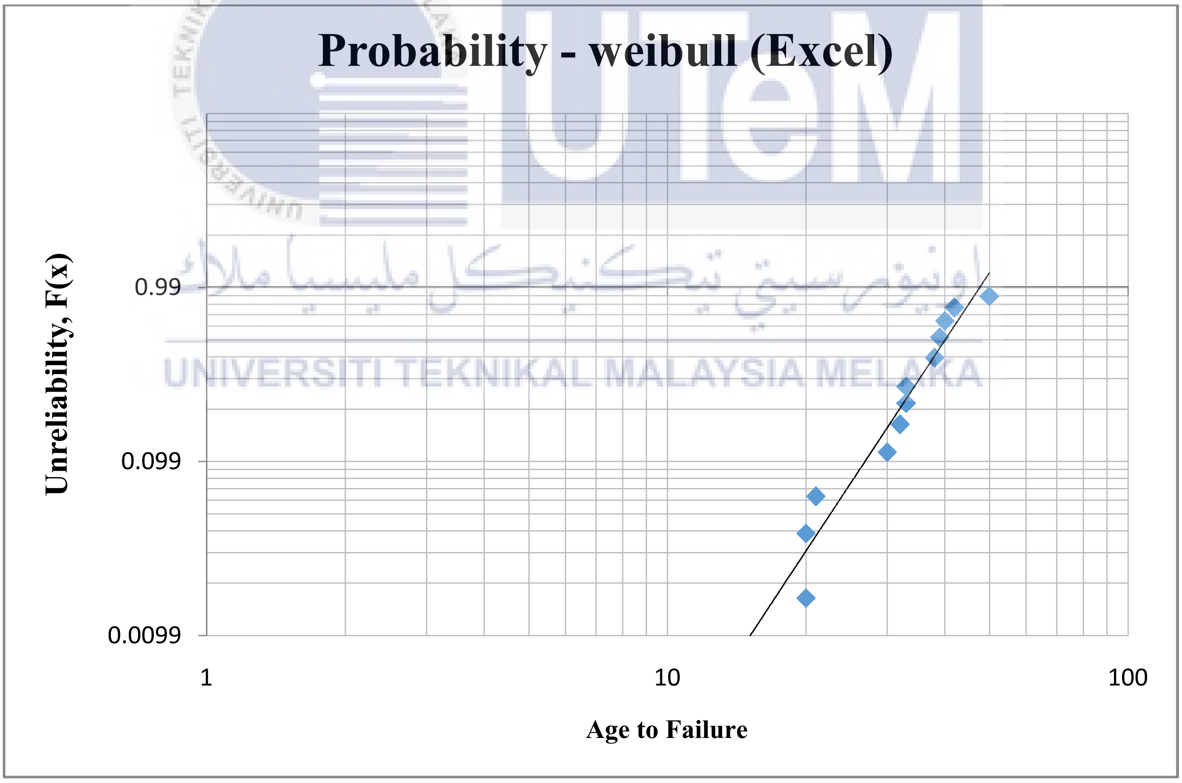
Each graph of weibull is contains of the specific parameters. In figure 4.1 a, the eta that obtained is 37.7985 yr and beta is 5.5416. In figure 4.2 (b), the eta indicates is 38.918 yr and beta is 5.249. There result is almost same but have some error in 3% to 5%. The 30MVA transformer data in figure 4.2 (a), the eta obtained was 31.338 yr and beta is 5.918. For the graph in 2.4(b), the eta was measure is 31.34 yr and beta is 5.9.Beta is important to find because if the slope is below 1.0, the reliability is increases at the unit ages.

By comparing of these two types of graph, there were reach almost same result. The value between each of value had some error 2% to 5%. The result is acceptable because it is still in the range because by using software it more precise and accurate.

3.



(a)

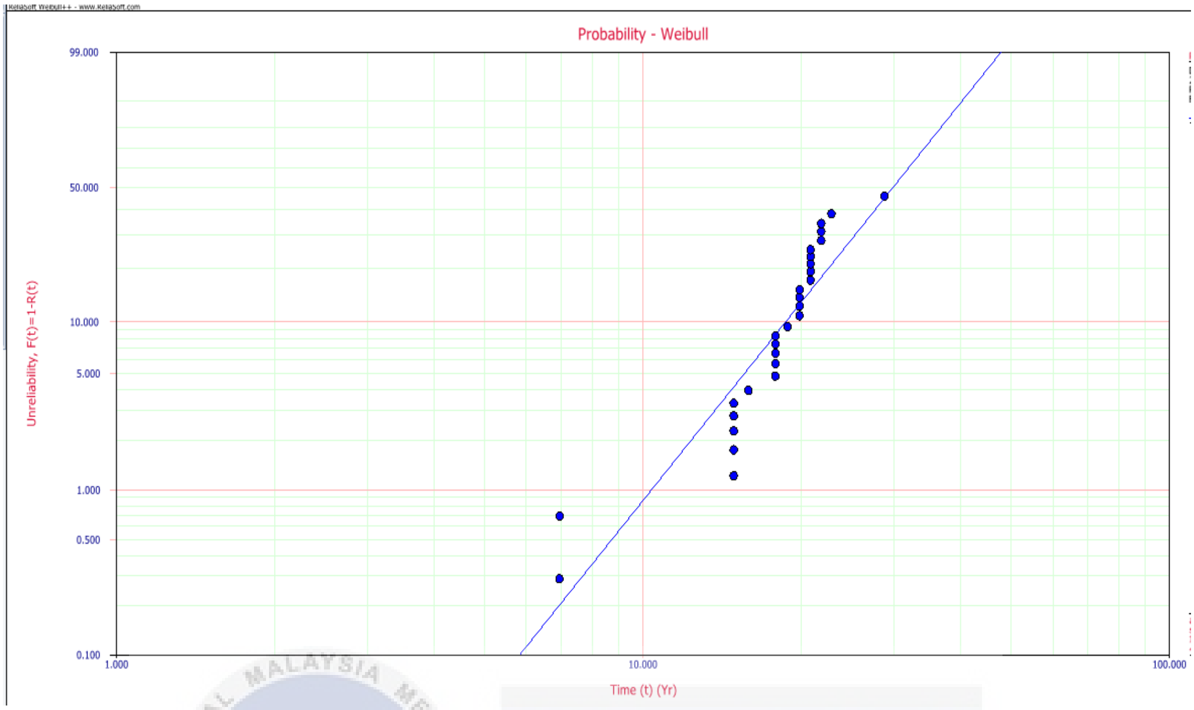


(b)

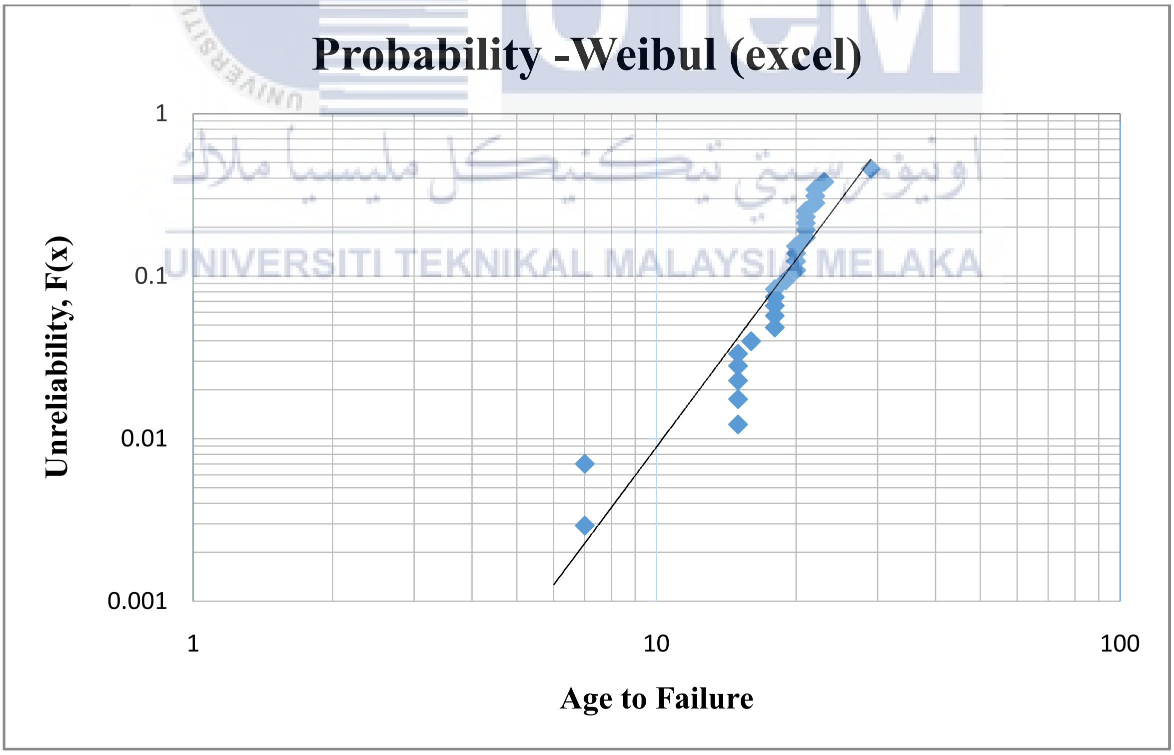
Figure 4.3: the comparison weibull plotting for 15MVA transformer in Selangor

(a) graph plotting by using relia software, (b) graph plotting by using excel

4.



(a)



(b)

Figure 4.4: the comparison weibull plotting for 30MVA transformer in Selangor (a) graph plotting by using relia software, (b) graph plotting by using excel

Refer to the figure 4.3 and 4.4, the figure were shown the graph from 15MVA and 30MVA respectively in selangor. The y-axis and x axis is same with previous graph. From the graph, it will shows the mesuremnt of its parameter. Basically, for the weibull analysis graph, it focus for the value eta and beta. Beta is shape parameter that obtained in one graph either it small or larger. Eta is characteristic life and to find the value of the failure in year. For this graph, refer to figure 4.3 (a), the value of eta is 41.73 year and beta is 5.09. Figure 4.3(b) indicates that the value of eta is 41.74 and the value of beta is 5.07.

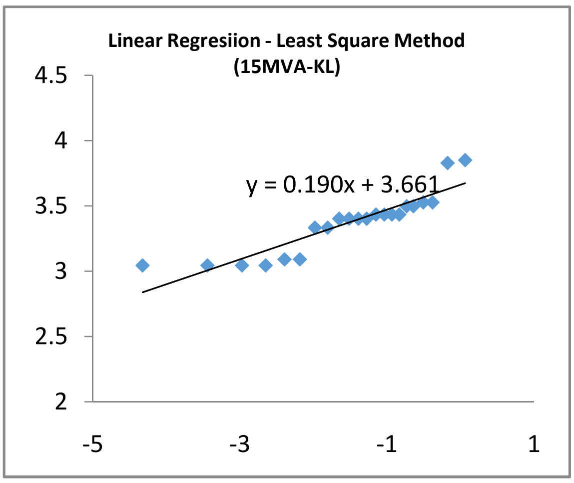
For the data transformer oil 30MVA, there were also have two value of eta and beta which is to compare the value by using reliasoft and excel. By using reliasoft thet obtained in figure 4.4 (a), the value of eta 29.62 yr and beta is 4.78. By using excel that shos in figure 4.4 (b), the value of eta obtained is 29.64 yr and beta is 4.77.

Based on this result that indicate for all graph, the value of eta by using excel were more higher than using reliasoft. It is vice with the value of beta because the value of beta by using reliasoft more higher than excel. Each value have 2% to 5% error.

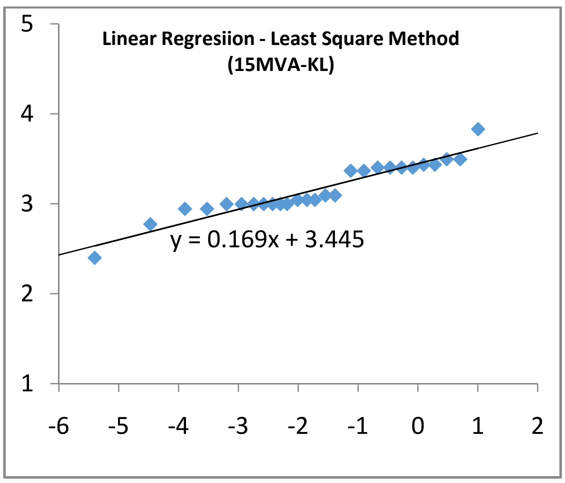
The value of eta in graph excel is obtained from 63.2% same to the graph in reliasoft. This is different for the value of beta in graph excel, this value of beta that obtained in graph excel is refer to calculation of regression method.

4.4 Estimating Parameter Using Least Regression Method

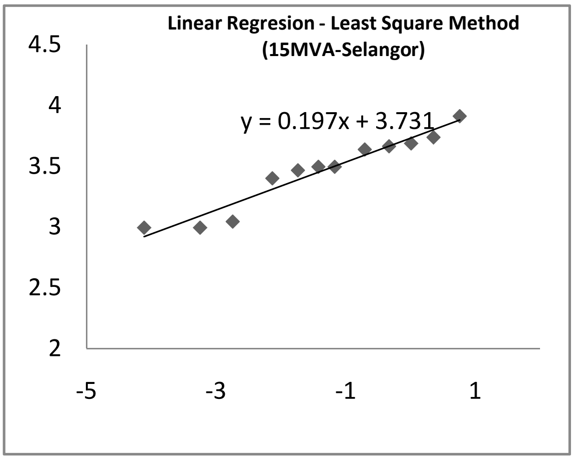
Least regression method is to find the best line with the precise value to calculated the parameter obtained in weibull analysis. This method is used in excel and the line is only to plot in normal paper graph.

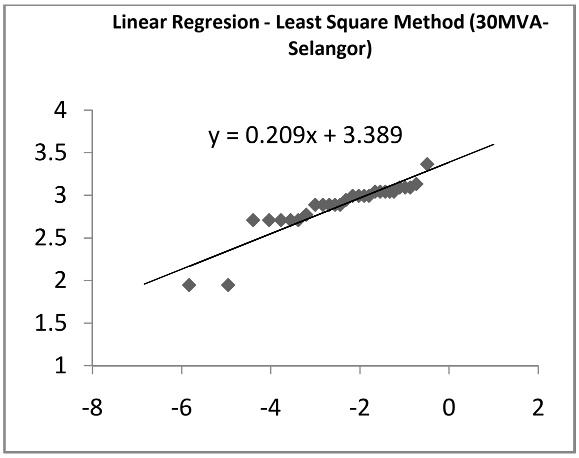


(a)



(b)





(c) (d)

Figure 4.5 : (a) The Median-rank method of the Least-squares 15MVA-Kl, (b) The Median-rank method of the Least-squares 30MVA-Kl, (c) The Median-rank method of the Least-squares 15MVA-Selangor, (d) The Median-rank method of the Least-squares 30MVA-Selangor

The figure 4.5 show the graph that using least square to analyse the effect of moisture in transformer oil. Refer to graph weibull in semi log paper, y axis is represent by median rank. For this method, y-axis is represent of transformation median rank to the ln(age). For the x-axis, is calculate by the LN(LN(1/(1-median rank.))). For this method, eta cannot be define through the graph compare with graph in semi log excel and reliasoft. To find the value of beta and eta for this method is all based on calculation. Table 4.5 shows the value of Y-axis and x axis for the transformer 15MVA in Kuala Lumpur for only 5 units instead of 52 units. Overall result was attached to appendix D,E,F and G.

Table 4.5 Value of x-axis and y-axis for regression line

Number Of Sample (N)	Condition	Age	Median Rank	Use This Date For X-Axis	Use This Date For Y-Axis
1	S	10			
2	S	17			
3	S	20			
4	F	21	1.31454%	-4.32508	3.044522
5	F	21	3.15173%	-3.44125	3.044522

i. Sample calculation to calculate Beta and eta by using least square method for 15MVA-kuala lumpur:

$$y = \ln(T)$$

$$x = \ln(-\ln(1 - median\,rank))$$

Shape,β = $\frac{1}{slope(y,x)}$

$$scale, n = \ exp\left(\frac{-x\ intercept}{slope}\right)$$

Where, x intercept = $\left(\frac{-intercept\ (x,y)}{shape,\beta}\right)$

N=4

$$y_{axis} = \ln(21) = 3.04452$$

$x_{axis} = \ln(-\ln(1 - \ 0.01314)\ ))$ = - 4.32508

Shape,β = $\frac{1}{slope\left(\frac{y_2-y_1}{x_2-x_1}\right)} = \frac{1}{0.190524}$ = 5.248695

Where, x intercept =

$\left(\frac{-intercept\ (Range\ in\ x\ axis\ From\ sample\ 1\ to\ 52, Range\ in\ y\ axis\ from\ n=1\ until n=52)}{5.248695}\right)$ = -0.69759

$scale, n = \ exp\left(\frac{-0.69759}{0.190524}\right)$= 38.91817

4.5 Transformer's life assessment

Table 4.6 : Bx life (for X% life)

State	MVA	B1% life (year)		B99% life (year)	
		Reliasoft	excel	Reliasoft	excel
Kuala Lumpur	15	16.5	14.5	49.80	46.5
	30	14.40	13.95	40.57	36.25
Selangor	15	16.90	16.14	56.3	49
	30	11.32	10.51	40.777	36

Bx life is information of failure in time which is time at X% of the units in a population will have failed. X% is refer to the y axis that represent of unreliability F(t).

Table 4.6 indicates the value in year that will failed in 1% or 99% respectively between reliasoft and excel. For example in the table 4.6 shows for the 15MVA Kuala Lumpur, refer to the value of reliasoft that B1% unreliability of 16.5 year, then 1% of the population will have failed by 16.5 year of operation.

That is meant, within 16.5 year of operation, there would have 1% failure if moisture content for the sample size of 52 units transformer. For the B99% life with the same state and power, it shows that 99% of the population would have failed by 49.8 year of operation. The end of life for this population is 49.8 years. There value of the year obtained between reliasoft and excel is almost same. There were have 1% to 10% error for the excel value because to find the unreliability in excel by refer to the formula, not automatically calculated.

4.6 Summary

In this thesis, the condition of moisture level had been categorized. The condition of failure and success are depends on the standard of the moisture level, which is when the moisture level that consists in transformer oil is below than 35ppm the condition of the transformer is considered success. For the moisture level above than 35ppm, the transformer will be categorized as a failure.

This thesis is to find the life assessment for the transformer if the moisture level contains in high quantity. This may affect the end life (BX%) of the transformer and the mean of a transformer for the life span. To analyze and to find the parameter for this thesis, weibull analysis was used. This is the comparison between excel and relia software to plot weibull probability. In excel method, there are two methods that can be used which is by using probability weibull and least regression method. Both methods show that the value of the parameter in weibull was the same. But the plotting graph and the calculation is different. For the reliasoft, the value is more precise and accurate because it is done by automatically but the software is expensive. This chapter will summarize that to analyze the analysis of effect of moisture contains in transformer oil by used linear regression will get the almost same of value with the software.

CHAPTER 5

CONCLUSION & RECOMMENDATION

5.1 Conclusion

In power transformer, there are two types of insulation that consists of liquid and paper insulation. The function of the insulation is same for the both types, to prevent electrical shorting. Both for this type is an environmental protection that actually protects from moisture and dust. This is because to prevent the air in the transformer that can conduct electricity and heat and to provide strength. This project is to determine the moisture level of in service power distribution transformer. The data are collected from TNB to analyze the liquid insulation life assessment of effect of moisture in transformer oil. To analyze this data, there are two categories to differentiate between failure and success for the value of moisture. The categorized is according to the standard IEEE C57.106-2006 which determines it the value to be followed in order to analyze whether there is value in a failed or succeeded. To analyze the data, weibull analysis is used. Weibull++7 software, excel, and least regression method is used to compare the value of parameter to get the result almost same. It can be concluded that, the life of transformer depends on the amount of moisture inside the transformer oil. The failure rate can reduce if the amount of moisture is in the low quantity.

5.2 Recommendation and Future Work

There are a few recommendations for future work to be done for this project. The recommendation for the time ahead is to add the data of temperature and the service of a transformer for the liquid insulation. To improve this research to be more precise and accurate, the data must be measure for how many time of service on transformer is taken to compare with the effect of insulation oil if moisture and high temperature contains in transformer. Therefore, in the future work, there are new additional parameter to be analyze.

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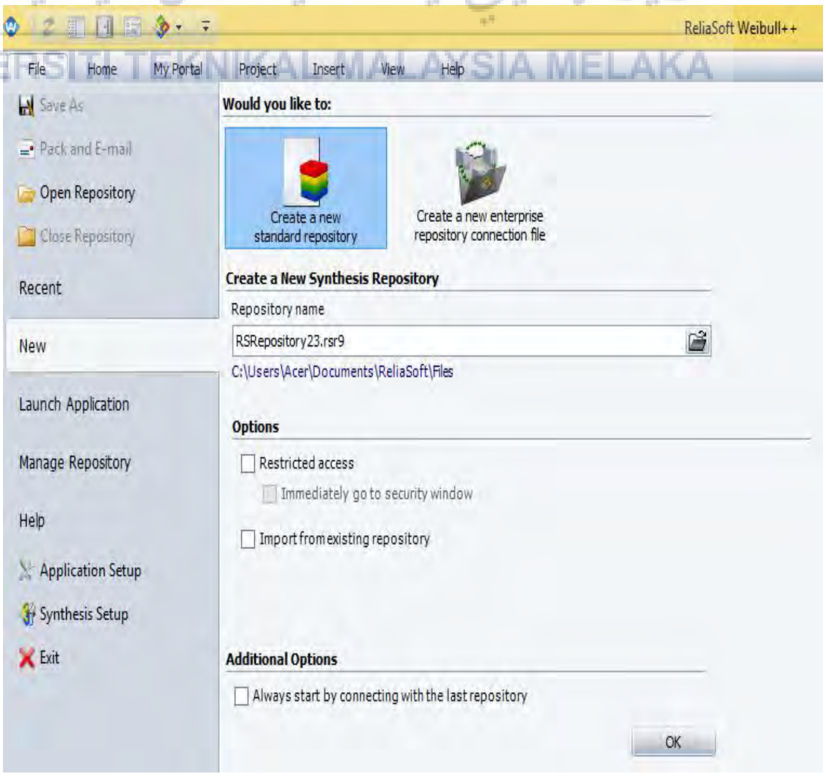
APPENDIX

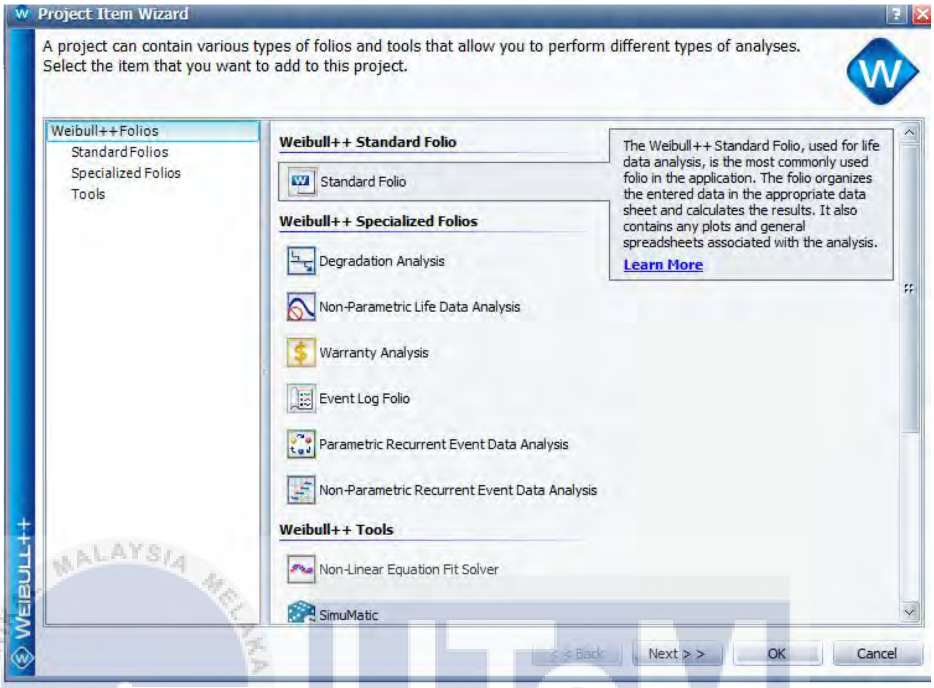
APPENDIX A

1. Clicking the " Weibull++" as in figure below.

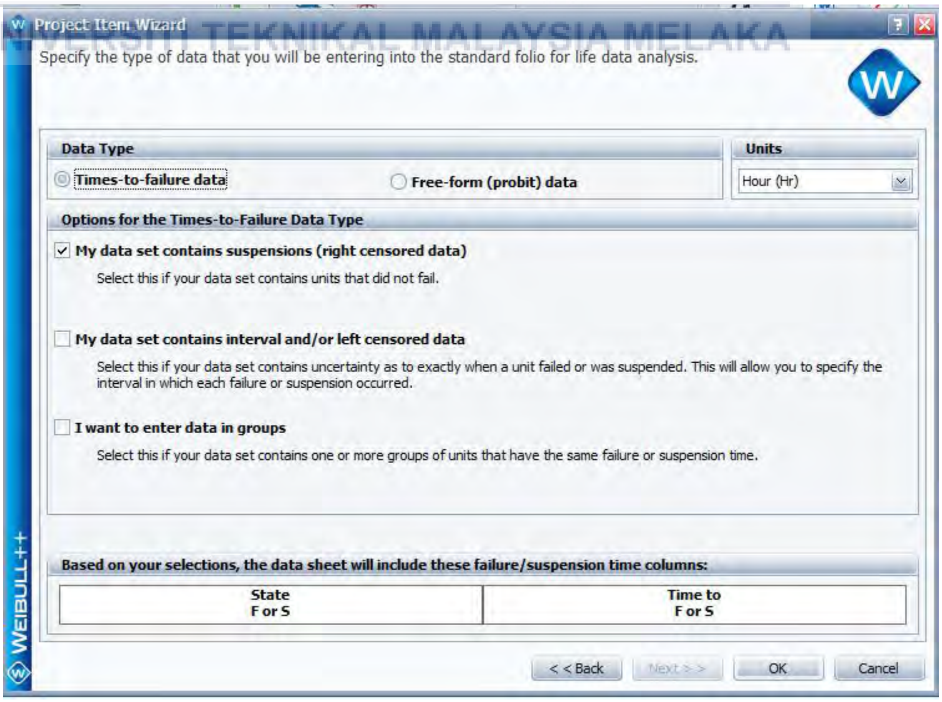
2. Select "new" for create new project.



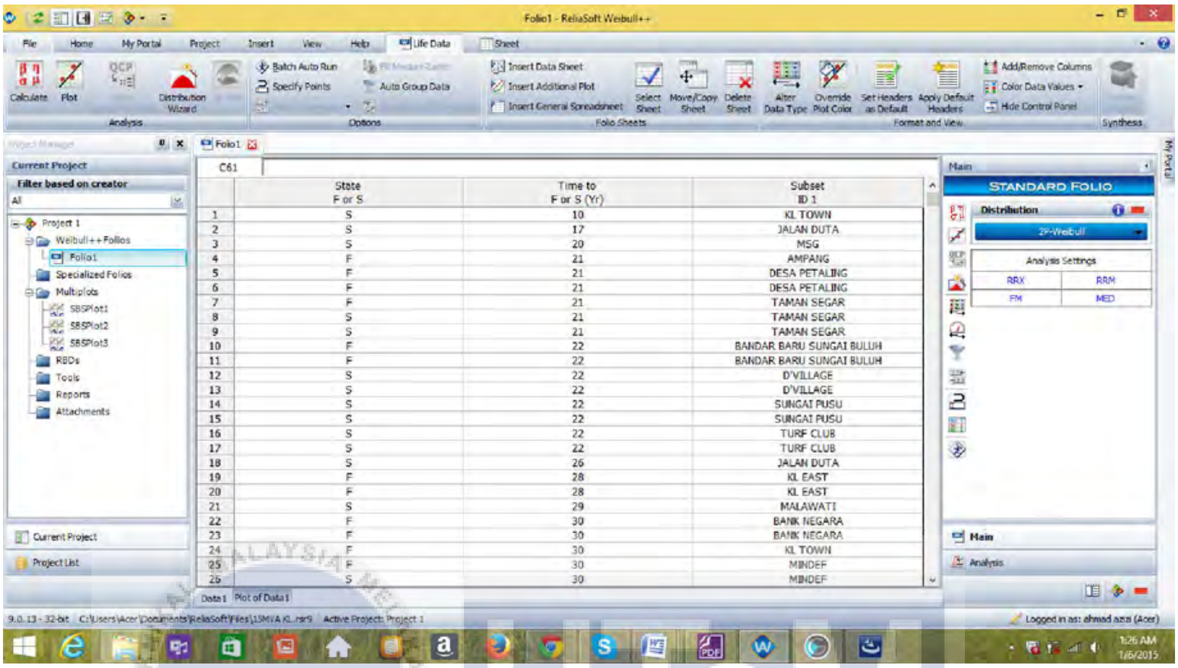
3. Select" standard folio" for life data analysis



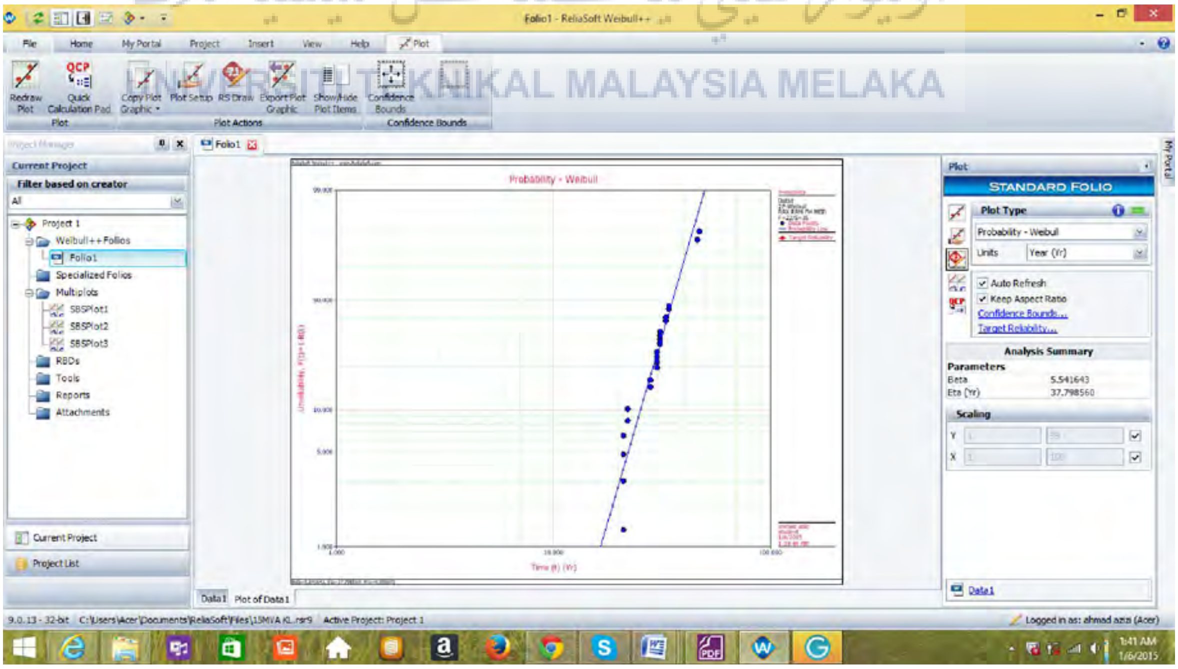
4. Select "time-to-failure data" for standard data type and select "my data set contains suspension (right censored data)" shown in figure below.



5. Set the data information which the condition is Failure(F) or Success(S) and the age of parameters can be inserted accordingly as figure below.



6. After entering the data the next step is to select “calculate” and “plot” from the data menu, result of probability-weibull will be displayed shown in figure below.



7. Repeat step 1 to 6 for different parameters and data.

APPENDIX B: DATA FOR TEANSFORMER 30MVA KUALA LUMPUR

Count	Site	Transformer	Age	Moisture Level	Condition	Reverse Rank	Adjusted Rank	Median Rank
1	Saujana Triangle	T1	6	21	S	191		
2	Saujana Triangle	T2	6	9	S	190		
3	Bangsar	T1	7	6	S	189		
4	Bangsar	T2	7	6	S	188		
5	Bukit Bintang	T1	7	12	S	187		
6	Bukit Bintang	T2	7	19	S	186		
7	Central	T1	7	9	S	185		
8	Central	T2	7	9	S	184		
9	Manjalara	T1	7	15	S	183		
10	Manjalara	T2	7	19	S	182		
11	Mid Valley	T1	7	10	S	181		
12	Mid Valley	T2	7	22	S	180		
13	Royal Cendana	T2	7	10	S	179		
14	Jalan Ampat	T1	8	9	S	178		
15	Jalan Ampat	T2	8	12	S	177		
16	Jalan Pahang	T2	8	8	S	176		
17	Royal Cendana	T1	8	17	S	175		
18	Jalan Pahang	T1	9	14	S	174		
19	Jalan Roger	T1	9	7	S	173		
20	Jalan Roger	T2	9	4	S	172		
21	Jalan Sungai Besi	T1	9	5	S	171		
22	Jalan Sungai Besi	T2	9	14	S	170		
23	Sri Edaran	T2	9	9	S	169		
24	Sri Endah	T1	9	10	S	168		
25	Sri Endah	T2	9	10	S	167		
26	Kampung Baru Sungai Buluh	T1	10	20	S	166		

27	Kampung Baru Sungai Buluh	T2	10	21	S	165		
28	Hospital Ampang	T2	11	42	F	164	1.16364	0.4512%
29	Damansara Damai	T1	11	8	S	163		
30	Damansara Damai	T2	11	10	S	162		
31	Hospital Ampang	T1	11	25	S	161		
32	Hospital Sungai Buluh	T1	11	10	S	160		
33	Hospital Sungai Buluh	T2	11	9	S	159		
34	Prima Damansara	T1	11	18	S	158		
35	Prima Damansara	T2	11	9	S	157		
36	Seri Endah	T1	11	12	S	156		
37	Seri Endah	T2	11	14	S	155		
38	Magna Park	T1	14	7	S	154		
39	Magna Park	T2	14	7	S	153		
40	Maju Perdana	T1	14	9	S	152		
41	Maju Perdana	T2	14	11	S	151		
42	Ukay Perdana	T1	14	10	S	150		
43	Ukay Perdana	T2	14	12	S	149		
44	Great Eastern	T1	15	26	S	148		
45	Great Eastern	T2	15	28	S	147		
46	Pearl Point	T1	15	13	S	146		
47	Pearl Point	T2	15	16	S	145		
48	Hospital Selayang	T1	16	23	F	144	2.47975	1.1388%
49	Low Yat Plaza	T1	16	27	S	143		
50	Low Yat Plaza	T2	16	31	S	142		
51	Pkns Sungai Buluh	T1	16	28	S	141		
52	Pkns Sungai Buluh	T2	16	27	S	140		
53	Telekom Pantai	T1	16	18	S	139		
54	Telekom Pantai	T2	16	24	S	138		
55	Angsana Setia	T2	17	23	S	137		
56	Bintang Buana	T1	17	7	S	136		

57	Bintang Buana	T2	17	12	S	135		2.0229%
58	Hospital Selayang	T2	17	21	S	134		
59	Kompleks Mahkamah	T1	17	8	S	133		
60	Kompleks Mahkamah	T2	17	30	S	132		
61	Kompleks Sukan Bukit Jalil	T1	17	16	S	131		
62	Kompleks Sukan Bukit Jalil	T2	17	12	S	130		
63	Matrade	T1	17	11	S	129		
64	Matrade	T2	17	26	S	128		
65	Perkampungan Sukan Bukit Jalil	T1	17	15	S	127		
66	Perkampungan Sukan Bukit Jalil	T2	17	12	S	126		
67	Plaza Damaz	T1	17	12	S	125		
68	Plaza Damaz	T2	17	14	S	124		
69	Sentul Raya	T1	17	19	S	123		
70	Vision City	T1	17	17	S	122		
71	Vision City	T2	17	17	S	121		
72	Angsana Setia	T1	18	19	S	120		
73	Kepong	T1	18	30	S	119		
74	Kepong	T2	18	32	S	118		
75	Phileo	T1	18	27	S	117		
76	Phileo	T2	18	29	S	116		
77	Plaza Phoenix	T1	18	17	S	115		
78	Plaza Phoenix	T2	18	27	S	114		
79	Taman Dato Ahmad Razali	T1	18	22	S	113		
80	Taman Dato Ahmad Razali	T2	18	24	S	112		
81	Taman Teknologi	T1	19	50	F	111	4.17189	2.0229%

82	Taman Teknologi	T2	19	43	F	110	5.86404	2.9070%
83	Bskl	T1	19	18	S	109		
84	Bskl	T2	19	13	S	108		
85	Klcc	T1	19	16	S	107		
86	Klcc	T2	19	12	S	106		
87	Mbf Plaza	T1	19	24	S	105		
88	Mbf Plaza	T2	19	16	S	104		
89	Miel	T1	19	17	S	103		
90	Miel	T2	19	27	S	102		
91	Mpaj	T2	19	13	S	101		
92	Mpaj	T1	19	10	S	100		
93	Pandan Indah	T1	19	10	S	99		
94	Pandan Indah	T2	19	16	S	98		
95	Panggung Negara	T1	19	16	S	97		
96	Panggung Negara	T2	19	21	S	96		
97	Pasar Borong	T1	19	16	S	95		
98	Pasar Borong	T2	19	12	S	94		
99	Sentul Raya	T2	19	18	S	93		
100	Sri Gombak	T1	19	30	S	92		
101	Sri Gombak	T2	19	35	S	91		
102	Taman Desa	T1	19	25	S	90		
103	Taman Desa	T2	19	20	S	89		
104	Bandar Baru Selayang	T2	19	24	S	88		
105	Azabar	T1	20	46	F	87	7.97922	4.0121%
106	Berjaya Golf	T2	20	42	F	86	10.09440	5.1172%
107	Damansara	T2	20	45	F	85	12.20958	6.2224%
108	Sppk Bukit Damansara	T2	20	46	F	84	14.32476	7.3275%
109	Starhill	T1	20	50	F	83	16.43995	8.4326%
110	Union Square	T1	20	46	F	82	18.55513	9.5377%
111	Wangsa Maju	T1	20	62	F	81	20.67031	10.6428%
112	Bukit Maluri	T1	20	26	S	80		

113	Bukit Maluri	T2	20	7	S	79		
114	Cycle & Carriage	T2	20	21	S	78		
115	Damansara A	T1	20	33	S	77		
116	Danau Kota	T1	20	22	S	76		
117	Danau Kota	T2	20	34	S	75		
118	Desa Pantai	T1	20	23	S	74		
119	Desa Tun Razak	T2	20	20	S	73		
120	Farizar	T2	20	25	S	72		
121	Harta Kemuncak	T1	20	28	S	71		
122	Harta Kemuncak	T2	20	28	S	70		
123	Hukm	T1	20	13	S	69		
124	Hukm	T2	20	11	S	68		
125	Jalan Pudu	T1	20	18	S	67		
126	Jalan Pudu	T2	20	13	S	66		
127	Kelwaram	T1	20	15	S	65		
128	Kelwaram	T2	20	9	S	64		
129	Mont Kiara	T2	20	25	S	63		
130	Msg	T2	20	11	S	62		
131	Narajaya	T1	20	10	S	61		
132	Narajaya	T2	20	22	S	60		
133	Pkns Ampang	T1	20	15	S	59		
134	Spring Crest	T1	20	13	S	58		
135	Spring Crest	T2	20	33	S	57		
136	Sri Damansara	T3	20	35	S	56		
137	Sri Damansara	T4	20	15	S	55		
138	Sri Edaran	T1	20	19	S	54		
139	Sri Keladi	T1	20	22	S	53		
140	Sri Keladi	T2	20	33	S	52		
141	Starhill	T2	20	15	S	51		
142	Taman Kosas	T1	20	15	S	50		
143	Taman Kosas	T2	20	30	S	49		
144	Taman Miharja	T2	20	14	S	48		
145	Taman Shamelin	T1	20	10	S	47		

146	Taman Tun Dr Ismail	T1	21	62	F	46	24.31562	12.5473%
147	Insajaya	T2	21	40	F	45	27.96093	14.4519%
148	Mont Kiara	T1	21	38	F	44	31.60625	16.3565%
149	Pandan Jaya	T1	21	27	S	43		
150	Pandan Jaya	T2	21	11	S	42		
151	Salinas	T1	21	11	S	41		
152	Salinas	T2	21	14	S	40		
153	Sogo	T1	21	15	S	39		
154	Sogo	T2	21	30	S	38		
155	Sri Damansara	T1	21	30	S	37		
156	Sri Damansara	T2	21	26	S	36		
157	Taman Shamelin	T2	21	14	S	35		
158	Taman Tun Dr Ismail	T2	21	7	S	34		
159	Tasik Tambahan	T1	21	33	S	33		
160	Tasik Tambahan	T2	21	7	S	32		
161	Telekom Brickfield	T1	21	10	S	31		
162	Telekom Brickfield	T2	21	7	S	30		
163	Yow Chuan Plaza		21	9	S	29		
164	Yow Chuan Plaza		22	45	F	28	37.13707	19.2461%
165	Hotel Istana	T1	22	45	F	27	42.66788	22.1358%
166	Hotel Istana	T2	22	6	S	26		
167	Ampang	T2	22	14	S	25		
168	Cycle &Carriage	T1	22	28	S	24		
169	Metroplex	T1	22	23	S	23		
170	Metroplex	T2	22	8	S	22		
171	Pkns Ampang	T2	24	17	S	21		
172	Pudu Ulu	T1	24	20	S	20		
173	Pudu Ulu	T2	24	32	S	19		
174	Segambut	T1	24	32	S	18		
175	Segambut	T2	25	20	S	17		
176	Ampang Specialist	T1	25	18	S	16		

	Center							
177	Uda Bangsar	T1	25	18	S	15		
178	Uda Bangsar	T2	26	18	S	14		
179	Ampang Specialist Center	T2	29	37	F	13	53.33446	27.7087%
180	Bukit Mahkamah	T1	29	39	F	12	64.00104	33.2816%
181	Bukit Mahkamah	T2	29	18	S	11		
182	Dang Wangi	T1	29	20	S	10		
183	Dang Wangi	T2	30	40	F	9	76.80094	39.9691%
184	Uda Bukit Nanas	T1	30	54	F	8	89.60084	46.6567%
185	Uda Bukit Nanas	T2	30	62	F	7	102.4007	53.3442%
186	Umno	T1	30	47	F	6	115.2006	60.0317%
187	Umno	T2	31	58	F	5	128.0005	66.7192%
188	Pnb Luth	T1	31	49	F	4	140.8004	73.4067%
189	Pnb Luth	T2	33	47	F	3	153.6003	80.0942%
190	Damansara Height	T1	33	41	F	2	166.4002	86.7817%
191	Damansara Height	T2	46	38	F	1	179.2001	93.4692%

APPENDIX C: DATA FOR TRANSFORMER AT SELANGOR 30MVA

Count	Site	Transformer	Age	Moisture Level	Condition	Reverse Rank	Adjusted Rank	Median Rank
1	Bukit Rajah	T2	6	30	S	257		
2	Distre Park	T2	6	7	S	256		
3	Jaya 33	T1	6	14	S	255		
4	Kinrara Perdana	T1	6	11	S	254		
5	Kinrara Perdana	T2	6	10	S	253		
6	Koraayat Usj	T1	6	7	S	252		
7	Koraayat Usj	T2	6	7	S	251		
8	Lagenda Mas	T2	6	9	S	250		
9	Serdang Perdana	T2	6	7	S	249		
10	Sungai Mas	T1	6	4	S	248		
11	Sungai Mas	T2	6	4	S	247		
12	World Wide	T1	6	13	S	246		
13	World Wide	T2	6	9	S	245		
14	Persiaran Raja Muda Musa	T2	7	58	F	244	1.0531	0.2926%
15	Taman Industri Puchong	T1	7	36	F	243	2.1061	0.7017%
16	Taman Industri Puchong	T2	7	11	S	242		
17	Taman Industri Puchong Utama	T1	7	9	S	241		
18	Taman Industri Puchong Utama	T1	7	19	S	240		
19	Taman Industri Puchong Utama	T2	7	25	S	239		
20	Top Glove Meru	T1	7	9	S	238		
21	Bukit Rajah	T1	8	12	S	237		

22	Distre Park	T1	8	8	S	236		
23	Jusco Balakong	T1	8	8	S	235		
24	Jusco Balakong	T2	8	5	S	234		
25	Lagenda Mas	T1	8	11	S	233		
26	Pheleo Damansara	T1	8	8	S	232		
27	Upm	T1	8	6	S	231		
28	Bandar Rinching	T1	9	3	S	230		
29	Bandar Rinching	T2	9	8	S	229		
30	Taman Mas	T2	9	8	S	228		
31	Taman Mas Temp	T2	9	6	S	227		
32	Bandar Baru Sultan Sulaiman	T1	10	14	S	226		
33	Bandar Baru Sultan Sulaiman	T2	10	12	S	225		
34	Bukit Lancung	T1	10	8	S	224		
35	Bukit Lancung	T2	10	6	S	223		
36	Desa Coalfield	T1	10	5	S	222		
37	Equine Park	T2	10	19	S	221		
38	Sri Kembangan	T1	10	8	S	220		
39	Bangi Resort	T1	11	19	S	219		
40	Bangi Resort	T2	11	12	S	218		
41	Labu Bena	T1	11	21	S	217		
42	Labu Bena	T2	11	14	S	216		
43	Mahkota Cheras	T2	11	13	S	215		
44	Mas Sepang	T1	11	8	S	214		
45	Mas Sepang	T2	11	14	S	213		
46	Mutiara Damansara	T1	11	8	S	212		
47	Mutiara Damansara	T2	11	11	S	211		
48	Petronas	T1	11	6	S	210		
49	Petronas	T2	11	9	S	209		
50	Samtc	T3	11	17	S	208		
51	Sek 21 Shah Alam	T1	11	7	S	207		
52	Sri Kembangan	T2	11	5	S	206		

53	Taman Berjaya Klang	T1	11	22	S	205		
54	Taman Berjaya Klang	T1	11	29	S	204		
55	Labu Bena	T1	12	16	S	203		
56	Central Klang	T1	13	17	S	202		
57	Europlus Zon 7	T1	13	5	S	201		
58	Europlus Zon 7	T2	13	5	S	200		
59	Mahkota Cheras	T1	13	6	S	199		
60	Equine Park	T1	14	4	S	198		
61	Horsedale 2	T1	14	13	S	197		
62	Horsedale 2	T2	14	13	S	196		
63	Kuala Selangor	T2	14	15	S	195		
64	Maxilux	T1	14	3	S	194		
65	Maxilux	T2	14	9	S	193		
66	Pandamaran Jaya	T2	14	12	S	192		
67	Serdang Perdana	T1	14	13	S	191		
68	Sungai Manggis Temp	T1	14	6	S	190		
69	Taman Berjaya Klang	T2	14	16	S	189		
70	Axis	T1	15	39	F	188	3.4601	1.2277%
71	Axis	T2	15	41	F	187	4.8140	1.7537%
72	Bukit Hitam	T1	15	52	F	186	6.1679	2.2797%
73	Bukit Hitam	T2	15	53	F	185	7.5219	2.8057%
74	Commerce Square	T1	15	39	F	184	8.8758	3.3317%
75	Commerce Square	T2	15	22	S	183		
76	Damansara Intan	T2	15	22	S	182		
77	Istimewa Ria	T1	15	13	S	181		
78	Jalan Langat	T1	15	20	S	180		
79	Jalan Langat	T2	15	24	S	179		
80	Kajang Utama	T1	15	10	S	178		
81	Kajang Utama	T2	15	6	S	177		
82	Ladang Sungai Kapar	T1	15	34	S	176		
83	Ladang Sungai Kapar	T2	15	32	S	175		
84	Pj Bulk	T2	15	16	S	174		
85	Puncak Alam	T1	15	13	S	173		

86	Pusat Bandar Hicom Sek 27	T1	15	25	S	172		
87	Pusat Bandar Hicom Sek 27	T1	15	18	S	171		
88	Pusat Bandar Hicom Sek 27	T2	15	23	S	170		
89	Pusat Bandar Puchong	T1	15	45	S	169		
90	Samtc	T4	15	24	S	168		
91	Sek 19 Shah Alam	T1	15	29	S	167		
92	Sek 19 Shah Alam	T2	15	14	S	166		
93	Sek 23a Shah Alam	T1	15	21	S	165		
94	Sek 23a Shah Alam	T2	15	4	S	164		
95	Sek 7 Shah Alam	T1	15	25	S	163		
96	Sek 7 Shah Alam	T2	15	12	S	162		
97	Subang Jaya Main Town	T1	15	19	S	161		
98	Sungai Buaya	T1	15	10	S	160		
99	Sungai Buaya	T2	15	14	S	159		
100	Sunway Down Town	T1	15	8	S	158		
101	Sunway Down Town	T2	15	6	S	157		
102	Talu	T1	15	12	S	156		
103	Talu	T2	15	11	S	155		
104	Tasik Puteri	T1	15	19	S	154		
105	Tasik Puteri	T2	15	18	S	153		
106	Ultra Mine	T1	15	7	S	152		
107	Ultra Mine	T2	15	6	S	151		
108	Ladang Bukit Serdang	T2	16	36	F	150	10.5256	3.9727%
109	Central Klang	T2	16	22	S	149		
110	Damansara Intan	T1	16	20	S	148		
111	Dataran Prima	T1	16	16	S	147		
112	Dataran Prima	T2	16	14	S	146		
113	Istimewa Ria	T2	16	16	S	145		
114	Kayangan Height	T1	16	14	S	144		

115	Kayangan Height	T2	16	13	S	143		
116	Kuala Selangor	T1	16	23	S	142		
117	Ladang Bukit Serdang	T1	16	23	S	141		
118	Bandar Baru Klang	T1	16	11	S	140		
119	Pandamaran Jaya	T1	16	26	S	139		
120	Puncak Alam	T2	16	13	S	138		
121	Pusat Bandar Puchong	T2	16	27	S	137		
122	Sek 16 Shah Alam	T2	16	31	S	136		
123	Subang Jaya Main Town	T2	16	26	S	135		
124	Tiara Atika	T1	16	16	S	134		
125	Tiara Atika	T2	16	23	S	133		
126	Tudm	T1	16	15	S	132		
127	Wanderful	T1	16	24	S	131		
128	Wanderful	T2	16	18	S	130		
129	Bandar Baru Klang	T2	17	11	S	129		
130	Bcm Rawang	T1	17	13	S	128		
131	Bcm Rawang	T2	17	15	S	127		
132	Kompleks Sukan Shah Alam	T1	17	12	S	126		
133	Kompleks Sukan Shah Alam	T2	17	11	S	125		
134	Lembah Beringin	T1	17	12	S	124		
135	Lembah Beringin	T2	17	13	S	123		
136	Motorola	T1	17	28	S	122		
137	Pilmoor Saujana	T1	17	9	S	121		
138	Pilmoor Saujana	T2	17	7	S	120		
139	Seafield 2	T1	17	21	S	119		
140	Seafield 2	T2	17	26	S	118		
141	Seahousing	T1	17	31	S	117		
142	Seahousing	T2	17	25	S	116		
143	Sek 13 Shah Alam	T1	17	17	S	115		
144	Sek 13 Shah Alam	T2	17	22	S	114		

145	Selegie Tower	T1	17	17	S	113		
146	Taman Industri Pulau Indah	T1	17	10	S	112		
147	Taman Industri Pulau Indah	T2	17	9	S	111		
148	Ikatan	T1	18	38	F	110	12.7551	4.8388%
149	Saujana Impian	T1	18	46	F	109	14.9846	5.7050%
150	Saujana Impian	T2	18	57	F	108	17.2141	6.5711%
151	Taming Jaya	T1	18	44	F	107	19.4436	7.4373%
152	Bayu Perdana	T1	18	46	F	106	21.6731	8.3035%
153	Bukit Kemuning	T2	18	9	S	105		
154	Alcan 1	T1	18	21	S	104		
155	Ikatan	T2	18	34	S	103		
156	Kelana Centre Point	T1	18	10	S	102		
157	Kelana Centre Point	T2	18			101		
158	Kota Kemuning	T1	18	11	S	100		
159	Kota Kemuning	T2	18	19	S	99		
160	Mbf Spring Crest	T1	18	27	S	98		
161	Mbf Spring Crest	T2	18	32	S	97		
162	Melawangi	T1	18	16	S	96		
163	Melawangi	T2	18	26	S	95		
164	Mines Resort	T1	18	10	S	94		
165	Mines Resort	T2	18	17	S	93		
166	Bandar Tun Hussein Onn	T2	18	5	S	92		
167	Bandar Utama Damansara	T2	18	19	S	91		
168	Sunway Pyramid	T1	18	28	S	90		
169	Sunway Pyramid	T2	18	26	S	89		
170	Taman Bayu Perdana	T1	18	28	S	88		
171	Taman Industri Subang	T1	18	9	S	87		
172	Taman Industri	T2	18	10	S	86		

	Subang							
173	Bangi Lama	T1	18	26	S	85		
174	Termasya	T1	18	10	S	84		
175	Termasya	T2	18	12	S	83		
176	Dunlop	T1	19	42	F	82	24.5204	9.4096%
177	Alcan 1	T2	19	24	S	81		
178	Highland Lowland	T1	19	14	S	80		
179	Highland Lowland	T2	19	13	S	79		
180	Lion Town Complex	T1	19	20	S	78		
181	Lion Town Complex	T2	19	22	S	77		
182	Petaling Utama	T1	19	24	S	76		
183	Petaling Utama	T2	19	30	S	75		
184	Pj Bulk	T1	19	14	S	74		
185	Sek 23 Shah Alam	T1	19	28	S	73		
186	Selbourne Square	T1	19	16	S	72		
187	Selbourne Square	T2	19	13	S	71		
188	Selegie Tower	T2	19	16	S	70		
189	Sime Uep	T1	19	28	S	69		
190	Sime Uep	T2	19	16	S	68		
191	Subang Uda	T1	19	31	S	67		
192	Subang Uda	T2	19	23	S	66		
193	Taman Teknologi Bangi	T1	19	18	S	65		
194	Taman Teknologi Bangi	T2	19	13	S	64		
195	Tropicana	T1	19	12	S	63		
196	Tropicana	T2	19	12	S	62		
197	Bandar Baru Kajang	T1	20	42	F	61	28.2862	10.8727%
198	Kelana Jaya	T2	20	39	F	60	32.0520	12.3357%
199	Bandar Kinrara	T1	20	47	F	59	35.8178	13.7987%
200	Bandar Kinrara	T2	20	38	F	58	39.5836	15.2617%
201	Batu Tiga	T2	20	29	S	57		
202	Bukit Kemuning	T1	20	15	S	56		

203	Kelana Jaya	T1	20	18	S	55		
204	Bandar Baru Kajang	T2	20	34	S	54		
205	Mox P. Jaya	T1	20	7	S	53		
206	Mox P. Jaya	T2	20	8	S	52		
207	New Town Port	T2	20	22	S	51		
208	Paling Jaya	T1	20	19	S	50		
209	Paling Jaya	T2	20	24	S	49		
210	Pheleo Damansara	T2	20	16	S	48		
211	Pulau Indah	T1	20	15	S	47		
212	Pulau Indah	T2	20	15	S	46		
213	Sek 10 Bangi	T2	20	5	S	45		
214	Strong Crest	T1	20	10	S	44		
215	Strong Crest	T2	20	9	S	43		
216	Alcan 2	T1	21	39	F	42	44.6631	17.2351%
217	Sek 23 Shah Alam	T2	21	47	F	41	49.7425	19.2084%
218	Subang Hitech	T2	21	41	F	40	54.8220	21.1818%
219	Taman Klang Utama	T1	21	38	F	39	59.9014	23.1552%
220	Taman Klang Utama	T2	21	44	F	38	64.9809	25.1285%
221	Bukit Badong	T1	21	23	S	37		
222	Bukit Badong	T2	21	20	S	36		
223	Europlus Zon 2	T1	21	11	S	35		
224	Europlus Zon 2	T2	21	3	S	34		
225	Horsedale 1	T1	21	26	S	33		
226	Horsedale 1	T2	21	5	S	32		
227	Sek 10 Bangi	T1	21	10	S	31		
228	Sek 16 Shah Alam	T1	21	11	S	30		
229	Bandar Sunway	T1	21	28	S	29		
230	Subang Hitech	T1	21	21	S	28		
231	Bandar Sunway	T2	21	16	S	27		
232	Bandar Tun Hussein Onn	T1	21	7	S	26		
233	Batu Tiga	T1	21	14	S	25		
234	Alcan 2	T2	22	43	F	24	72.7017	28.1281%

235	New Town Port	T1	22	41	F	23	80.4224	31.1276%
236	Seafield 1	T1	22	51	F	22	88.1432	34.1271%
237	Dunlop	T2	22	32	S	21		
238	Hicom E	T2	22	35	S	20		
239	Seafield 1	T2	22	14	S	19		
240	Sek 21 Shah Alam	T2	22	7	S	18		
241	Tudm	T2	22	9	S	17		
242	Damansara Utama	T1	23	59	F	16	98.1348	38.0088%
243	Bayu Perdana	T2	23	24	S	15		
244	Lion Industrial Park	T1	23	13	S	14		
245	Lion Industrial Park	T2	23	15	S	13		
246	Motorola	T2	23	22	S	12		
247	Taman Bayu Perdana	T2	23	15	S	11		
248	Taman Bayu Perdana	T2	23	19	S	10		
249	Sri Alam	T1	26	34	S	9		
250	Sri Alam	T2	26	19	S	8		
251	Cheras Jaya	T2	29	58	F	7	118.1179	45.7723%
252	Cheras Jaya	T1	29	32	S	6		
253	Proton	T1	29	22	S	5		
254	Proton	T2	29	27	S	4		
255	Shah Alam South	T3	29	17	S	3		
256	Shah Alam South	T4	29	19	S	2		
257	Shah Alam South	T4	29	21	S	1		

APPENDIX D: Value of x-axis and y-axis for regression line Transformer 15MVA-KL

No Of Sample (N)	Condition	Age	Median Rank	Use This Date For X-Axis	Use This Date For Y-Axis
1	S	10			
2	S	17			
3	S	20			
4	F	21	1.31454%	-4.32508	3.044522
5	F	21	3.15173%	-3.44125	3.044522
6	F	21	4.98891%	-2.97247	3.044522
7	F	21	6.82610%	-2.64927	3.044522
8	S	21			
9	S	21			
10	F	22	8.73828%	-2.39209	3.091042
11	F	22	10.65045%	-2.18379	3.091042
12	S	22			
13	S	22			
14	S	22			
15	S	22			
16	S	22			
17	S	22			
18	S	26			
19	F	28	12.89725%	-1.97991	3.332205
20	F	28	15.14406%	-1.80658	3.332205
21	S	29			
22	F	30	17.45159%	-1.65138	3.401197
23	F	30	19.75912%	-1.5135	3.401197
24	F	30	22.06665%	-1.38903	3.401197
25	F	30	24.37418%	-1.27521	3.401197
26	S	30			
27	S	30			
28	S	30			

29	S	30			
30	S	30			
31	F	31	27.09377%	-1.15203	3.433987
32	F	31	29.81335%	-1.03842	3.433987
33	F	31	32.53294%	-0.9326	3.433987
34	F	31	35.25253%	-0.83316	3.433987
35	S	31			
36	F	33	38.09036%	-0.73502	3.496508
37	F	33	40.92819%	-0.64166	3.496508
38	S	33			
39	S	33			
40	S	33			
41	S	33			
42	S	33			
43	S	33			
44	S	33			
45	F	34	45.18494%	-0.50882	3.526361
46	F	34	49.44169%	-0.38266	3.526361
47	S	35			
48	S	35			
49	S	40			
50	S	40			
51	S	40			
52	F	46	56.73897%	-0.17684	3.828641
53	S	46			
54	F	47	65.49570%	0.062117	3.850148
55	S	47			
56	S	51			
57	S	51			

APPENDIX E: Value of x-axis and y-axis for regression line Transformer 30 MVA-KL

No Of Sample (N)	Condition	Age	Median Rank	Use This Date For X-Axis	Use This Date For Y-Axis
1	S	6			
2	S	6			
3	S	7			
4	S	7			
5	S	7			
6	S	7			
7	S	7			
8	S	7			
9	S	7			
10	S	7			
11	S	7			
12	S	7			
13	S	7			
14	S	8			
15	S	8			
16	S	8			
17	S	8			
18	S	9			
19	S	9			
20	S	9			
21	S	9			
22	S	9			
23	S	9			
24	S	9			
25	S	9			
26	S	10			
27	S	10			
28	F	11	0.4512%	-5.39871	2.397895

29	S	11			
30	S	11			
31	S	11			
32	S	11			
33	S	11			
34	S	11			
35	S	11			
36	S	11			
37	S	11			
38	S	14			
39	S	14			
40	S	14			
41	S	14			
42	S	14			
43	S	14			
44	S	15			
45	S	15			
46	S	15			
47	S	15			
48	F	16	1.1388%	-4.46943	2.772589
49	S	16			
50	S	16			
51	S	16			
52	S	16			
53	S	16			
54	S	16			
55	S	17			
56	S	17			
57	S	17			
58	S	17			
59	S	17			
60	S	17			
61	S	17			

62	S	17			
63	S	17			
64	S	17			
65	S	17			
66	S	17			
67	S	17			
68	S	17			
69	S	17			
70	S	17			
71	S	17			
72	S	18			
73	S	18			
74	S	18			
75	S	18			
76	S	18			
77	S	18			
78	S	18			
79	S	18			
80	S	18			
81	F	19	2.0229%	-3.89042	2.944439
82	F	19	2.9070%	-3.52333	2.944439
83	S	19			
84	S	19			
85	S	19			
86	S	19			
87	S	19			
88	S	19			
89	S	19			
90	S	19			
91	S	19			
92	S	19			
93	S	19			
94	S	19			

95	S	19			
96	S	19			
97	S	19			
98	S	19			
99	S	19			
100	S	19			
101	S	19			
102	S	19			
103	S	19			
104	S	19			
105	F	20	4.0121%	-3.19544	2.995732
106	F	20	5.1172%	-2.94641	2.995732
107	F	20	6.2224%	-2.74507	2.995732
108	F	20	7.3275%	-2.57573	2.995732
109	F	20	8.4326%	-2.42934	2.995732
110	F	20	9.5377%	-2.30022	2.995732
111	F	20	10.6428%	-2.18455	2.995732
112	S	20			
113	S	20			
114	S	20			
115	S	20			
116	S	20			
117	S	20			
118	S	20			
119	S	20			
120	S	20			
121	S	20			
122	S	20			
123	S	20			
124	S	20			
125	S	20			
126	S	20			
127	S	20			

128	S	20			
129	S	20			
130	S	20			
131	S	20			
132	S	20			
133	S	20			
134	S	20			
135	S	20			
136	S	20			
137	S	20			
138	S	20			
139	S	20			
140	S	20			
141	S	20			
142	S	20			
143	S	20			
144	S	20			
145	S	20			
146	F	21	12.5473%	-2.00937	3.044522
147	F	21	14.4519%	-1.85731	3.044522
148	F	21	16.3565%	-1.72257	3.044522
149	S	21			
150	S	21			
151	S	21			
152	S	21			
153	S	21			
154	S	21			
155	S	21			
156	S	21			
157	S	21			
158	S	21			
159	S	21			
160	S	21			

161	S	21			
162	S	21			
163	S	21			
164	F	22	19.2461%	-1.54288	3.091042
165	F	22	22.1358%	-1.38548	3.091042
166	S	22			
167	S	22			
168	S	22			
169	S	22			
170	S	22			
171	S	24			
172	S	24			
173	S	24			
174	S	24			
175	S	25			
176	S	25			
177	S	25			
178	S	26			
179	F	29	27.7087%	-1.12557	3.367296
180	F	29	33.2816%	-0.90463	3.367296
181	S	29			
182	S	29			
183	F	30	39.9691%	-0.67273	3.401197
184	F	30	46.6567%	-0.46455	3.401197
185	F	30	53.3442%	-0.27132	3.401197
186	F	30	60.0317%	-0.08656	3.401197
187	F	31	66.7192%	0.095482	3.433987
188	F	31	73.4067%	0.281043	3.433987
189	F	33	80.0942%	0.478814	3.496508
190	F	33	86.7817%	0.704863	3.496508
191	F	46	93.4692%	1.003805	3.828641

APPENDIX F: Value of x-axis and y-axis for regression line Transformer 15 MVA-SELANGOR

No Of Sample (N)	Condition	Age	Median Rank	Use This Date For X-Axis	Use This Date For Y-Axis
1	S	10			
2	S	15			
3	S	16			
4	S	17			
5	S	18			
6	S	18			
7	S	19			
8	F	20	1.62629%	-4.11068	2.995732
9	F	20	3.82509%	-3.24415	2.995732
10	S	20			
11	S	20			
12	S	20			
13	S	20			
14	F	21	6.24378%	-2.74152	3.044522
15	S	21			
16	S	21			
17	S	21			
18	S	21			
19	S	21			
20	S	21			
21	S	21			
22	S	21			
23	S	21			
24	S	22			
25	S	22			
26	S	22			
27	S	22			

28	S	22			
29	S	22			
30	S	22			
31	S	22			
32	S	25			
33	S	26			
34	S	28			
35	F	30	11.20845%	-2.12965	3.401197
36	F	32	16.17312%	-1.73491	3.465736
37	S	32			
38	F	33	21.44808%	-1.42126	3.496508
39	F	33	26.72304%	-1.16821	3.496508
40	S	33			
41	S	33			
42	S	33			
43	S	36			
44	S	36			
45	S	36			
46	S	36			
47	S	36			
48	F	38	39.03129%	-0.70358	3.637586
49	F	39	51.33954%	-0.32808	3.663562
50	F	40	63.64778%	0.011845	3.688879
51	F	42	75.95603%	0.354372	3.73767
52	F	50	88.26427%	0.761989	3.912023

APPENDIX G: Value of x-axis and y-axis for regression line Transformer 30 MVA-SELANGOR

No Of Sample (N)	Condition	Age	Median Rank	Use This Date For X-Axis	Use This Date For Y-Axis
1	S	6			
2	S	6			
3	S	6			
4	S	6			
5	S	6			
6	S	6			
7	S	6			
8	S	6			
9	S	6			
10	S	6			
11	S	6			
12	S	6			
13	S	6			
14	F	7	0.2926%	-5.83278	1.94591
15	F	7	0.7017%	-4.95593	1.94591
16	S	7			
17	S	7			
18	S	7			
19	S	7			
20	S	7			
21	S	8			
22	S	8			
23	S	8			
24	S	8			
25	S	8			
26	S	8			
27	S	8			

28	S	9			
29	S	9			
30	S	9			
31	S	9			
32	S	10			
33	S	10			
34	S	10			
35	S	10			
36	S	10			
37	S	10			
38	S	10			
39	S	11			
40	S	11			
41	S	11			
42	S	11			
43	S	11			
44	S	11			
45	S	11			
46	S	11			
47	S	11			
48	S	11			
49	S	11			
50	S	11			
51	S	11			
52	S	11			
53	S	11			
54	S	11			
55	S	12			
56	S	13			
57	S	13			
58	S	13			
59	S	13			
60	S	14			

61	S	14			
62	S	14			
63	S	14			
64	S	14			
65	S	14			
66	S	14			
67	S	14			
68	S	14			
69	S	14			
70	F	15	1.2277%	-4.39387	2.70805
71	F	15	1.7537%	-4.03462	2.70805
72	F	15	2.2797%	-3.76962	2.70805
73	F	15	2.8057%	-3.55932	2.70805
74	F	15	3.3317%	-3.38479	2.70805
75	S	15			
76	S	15			
77	S	15			
78	S	15			
79	S	15			
80	S	15			
81	S	15			
82	S	15			
83	S	15			
84	S	15			
85	S	15			
86	S	15			
87	S	15			
88	S	15			
89	S	15			
90	S	15			
91	S	15			
92	S	15			
93	S	15			

94	S	15			
95	S	15			
96	S	15			
97	S	15			
98	S	15			
99	S	15			
100	S	15			
101	S	15			
102	S	15			
103	S	15			
104	S	15			
105	S	15			
106	S	15			
107	S	15			
108	F	16	3.9727%	-3.20553	2.772589
109	S	16			
110	S	16			
111	S	16			
112	S	16			
113	S	16			
114	S	16			
115	S	16			
116	S	16			
117	S	16			
118	S	16			
119	S	16			
120	S	16			
121	S	16			
122	S	16			
123	S	16			
124	S	16			
125	S	16			
126	S	16			

127	S	16			
128	S	16			
129	S	17			
130	S	17			
131	S	17			
132	S	17			
133	S	17			
134	S	17			
135	S	17			
136	S	17			
137	S	17			
138	S	17			
139	S	17			
140	S	17			
141	S	17			
142	S	17			
143	S	17			
144	S	17			
145	S	17			
146	S	17			
147	S	17			
148	F	18	4.8388%	-3.0038	2.890372
149	F	18	5.7050%	-2.8346	2.890372
150	F	18	6.5711%	-2.68869	2.890372
151	F	18	7.4373%	-2.56027	2.890372
152	F	18	8.3035%	-2.44547	2.890372
153	S	18			
154	S	18			
155	S	18			
156	S	18			
157	S	18			
158	S	18			
159	S	18			

160	S	18			
161	S	18			
162	S	18			
163	S	18			
164	S	18			
165	S	18			
166	S	18			
167	S	18			
168	S	18			
169	S	18			
170	S	18			
171	S	18			
172	S	18			
173	S	18			
174	S	18			
175	S	18			
176	F	19	9.4096%	-2.31443	2.944439
177	S	19			
178	S	19			
179	S	19			
180	S	19			
181	S	19			
182	S	19			
183	S	19			
184	S	19			
185	S	19			
186	S	19			
187	S	19			
188	S	19			
189	S	19			
190	S	19			
191	S	19			
192	S	19			

193	S	19			
194	S	19			
195	S	19			
196	S	19			
197	F	20	10.8727%	-2.16192	2.995732
198	F	20	12.3357%	-2.02757	2.995732
199	F	20	13.7987%	-1.90727	2.995732
200	F	20	15.2617%	-1.79816	2.995732
201	S	20			
202	S	20			
203	S	20			
204	S	20			
205	S	20			
206	S	20			
207	S	20			
208	S	20			
209	S	20			
210	S	20			
211	S	20			
212	S	20			
213	S	20			
214	S	20			
215	S	20			
216	F	21	17.2351%	-1.66513	3.044522
217	F	21	19.2084%	-1.54507	3.044522
218	F	21	21.1818%	-1.43537	3.044522
219	F	21	23.1552%	-1.33415	3.044522
220	F	21	25.1285%	-1.23995	3.044522
221	S	21			
222	S	21			
223	S	21			
224	S	21			
225	S	21			

226	S	21			
227	S	21			
228	S	21			
229	S	21			
230	S	21			
231	S	21			
232	S	21			
233	S	21			
234	F	22	28.1281%	-1.1078	3.091042
235	F	22	31.1276%	-0.98641	3.091042
236	F	22	34.1271%	-0.87361	3.091042
237	S	22			
238	S	22			
239	S	22			
240	S	22			
241	S	22			
242	F	23	38.0088%	-0.73777	3.135494
243	S	23			
244	S	23			
245	S	23			
246	S	23			
247	S	23			
248	S	23			
249	S	26			
250	S	26			
251	F	29	45.7723%	-0.49106	3.367296
252	S	29			
253	S	29			
254	S	29			
255	S	29			
256	S	29			
257	S	29			