# CONDITION MONITORING OF ELECTRIC MOTOR

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To my caring and beloved husband,
*Amir,*

To my son,
*Afiq*

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## ABSTRACT

Condition monitoring on electric motor is a preventive maintenance in order to avoid problems and hazard from happening to the machinery, also to prevent personal injury with the major factor is insulation resistance. In this thesis, to further discuss this issue, the developed experiment with the measuring technique of the condition of electric motor on insulation resistance is used. Then, the experiment rig was developed applied to Thrige Odense Denmark 3-phase induction motor for case study to observe the condition monitoring on insulation resistance. The validity of the data was then taken using the megohmmeter and temperature indicator. The experiment is to monitor the Denmark manufactured motor condition of insulation whether is good, fair, poor or bad by following the IEEE standard procedure. This preventive maintenance test can be done on a monthly, semiannual or annual basis as conditions demand. The data from the test is plotted to graph to get the trended data of the insulation. The theoretical and experiment studies include the effect of the humidity and temperature to the insulation. Tests rig for the experimental work are developed using IEEE Standard 43-2000, *IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machinery* and *A Guide To Diagnostic Insulation Testing Above 1kV by* Megger Ltd, Second Edition 2002. The results have been compared to the standard and analyses are presented in graph. From the developed procedure and methods prove that the temperature affects the insulation winding at 3-phase induction motor (2 speed : 2 winding). For case study, the motor has been soaked for three days to apply flooded condition. The result shows that the motor insulation condition is even better after comparison with the standard manufactured data at 821 MΩ and 893 MΩ change to more than 999 MΩ for both winding condition after drying out experiment.

## ABSTRAK

Pengawasan keadaan ke atas motor elektrik merupakan penyenggaraan cegahan bagi mengelakkan masalah yang mengundang bahaya berlaku ke atas jentera serta mengakibatkan kecederaan ke atas manusia yang mana faktor penyumbang utama adalah rintangan penebatan. Dari itu. ujikaji dibangunkan berdasarkan teknik pengukuran keadaan rintangan penebatan motor elektrik. Pelantar ujikaji dijalankan ke atas motor aruhan 3 fasa Thrige Odense Denmark untuk kajian kes mencerap pengawasan keadaan terhadap penebatan rintangan. Data sah diambil menggunakan megohmmeter dan pengesan suhu untuk memantau keadaan penebatan motor buatan Denmark samada berkeadaan baik. memuaskan, lemah atau tidak memuaskan dengan mematuhi tatacara piawai IEEE. Ujian penyenggaraan cegahan boleh dilakukan samada sebulan sekali, enam bulan sekali atau setahun sekali. Data tersebut diplotkan ke dalam graf bagi mendapatkan '*trend*' terhadap penebatan. Pemelajaran dari ujikaji dan teori termasuklah kesan penebatan terhadap suhu dan kelembapan. Pelantar ujian bagi menjalankan kerja-kerja pengujian dibangunkan berdasarkan piawai IEEE 43-2000, *IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machinery* dan *A Guide To Diagnostic Insulation Testing Above 1kV* oleh Megger Ltd, edisi kedua 2002. Tatacara dan kaedah yang dibangunkan membuktikan bahawa suhu memberi kesan terhadap belitan penebatan pada motor aruhan 3 fasa (2 kelajuan:2 belitan).Untuk mengaplikasi keadaan banjir dalam kajian kes, motor telah direndam selama 3 hari. Hasil keputusan menunjukkan keadaan penebatan motor adalah lebih bagus selepas perbandingan dibuat dengan data piawai pengilang pada 821 MΩ dan 893 MΩ berubah lebih daripada 999 MΩ bagi kedua-dua keadaan belitan selepas ujikaji pengeringan.

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# NOMENCLATURE

| | |
|---|---|
| V | voltage |

**Greek letters**

| | |
|---|---|
| Ω | resistance, ohm |
| δ | loss angle |
| θ | phase angle |

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# CHAPTER 1

# INTRODUCTION

## 1.0 Background of the Study

The normally quiescent state of electrical transmission and distribution system plant does not draw attention to incipient faults which may develop from the gradual deterioration of equipment. This fault may be detected during routine maintenance, but the ability to have detailed information on the state-of-health of transmission and distribution system equipment prior to carrying out maintenance work or alterations becomes a significant asset and adds an element of preventive maintenance to the operation of such assets.

Condition monitoring is a technique which may be adopted to reduce non-planned downtime and increase plant availability. To be successful it must be self sufficient and did not require manual intervention or detailed analysis. It must be capable of detecting gradual or sudden deterioration and trends and have predictive capabilities to permit alarming insufficient time to allow appropriate action to be taken and avoid major failure. It must be reliable and not reduce the integrity of the system, it must not require undue maintenance itself and must be a cost effective solution.

Condition monitoring may be formally defined as a predictive method making use of the fact that most equipment will have a useful life before maintenance is required. It embraces the life mechanism of individual parts of or the whole equipment, the application and the development of special purpose equipment, the means of acquiring the data and the analysis of that data to predict the trends .Certain key words are useful to recall from this definition: p*redictive, useful life, maintenance, application and development of special purpose of equipment, acquiring the data, analysis of that data, predict the trends [1].*

In more practical terms, the initial stage of a condition monitoring programmed consists of establishing the baseline parameter and then recording the actual baseline or fingerprints values. The next stage is the establishment of routine tours of equipment observing the running condition and assessing the parameter previously determined for the baseline. These readings are then compared with the fingerprint and the trends determined. The state of the present equipment condition can be determined from the absolute figures. The rate of degradation and an assessment of the likely time to failure can be estimated from the trend. The resources committed to monitoring the condition of equipment will depend on the numbers and on the service experienced and reliability.

## 1.1 Statement of Problem

Most of the electric motor around the world exceeding their designed life. Insulation is the major component, which plays an important role in the life expectancy of the electric motor. To determine the performance and aging of the asset, insulation behavior is a main indicator. In the absence of insulation monitoring and assessment, good number of electric motor failed due to insulations problems, before reaching to their designed technical life. A good number of aged electric motor are still performing well, it is important to monitor the insulation behavior rather than replacing with new one.

**Table 1.1 : Specification for Thrige Odense Denmark 3-phase induction motor**

| | |
|---|---|
| Type | NAS 62 |
| Horse Power | 10 |
| Rotor V | 350 Y |
| RPM | 1440 |
| V | 400A |
| A | 14 |
| Frequency | 50Hz |

Insulation failure can cause electrical shocks, creating a real hazard to personal and machinery. While there are cases where the drop in insulation resistance can be sudden, such as when equipment is flooded, it usually drops gradually, giving plenty of warning if tested periodically. A regular program of testing insulation resistance is strongly recommended to prevent this danger, as well as to allow timely maintenance and repair work to take place before catastrophic failure. Not only motor but new equipment, transformers, switch gears and wiring also should be tested before being put into service. This test record will be useful for future comparisons in regular maintenance testing.

Without a periodic testing program all failures will come as a surprise, unplanned, inconvenient also quite possibly very expensive in time and resources, therefore, money to rectify. For instance, take a small motor that is used to pump material, which will solidify if allowed to stand, around a processing plant. Unexpected failure of this motor will cost tens maybe even hundreds of thousands of ringgit to rectify if downtime of the plant is also calculated. However, if diagnostic insulation testing had been included in the preventive maintenance program it may have been possible to plan maintenance or replacement of the failing motor at a time when the line was inactive thereby minimizing costs. Indeed, it may have been that the motor could have been improved while it was still running.

If advanced insulation degradation goes undetected there is an increase in the possibility of electrical shock or even death for personnel: there is an increase in the possibility of electrically induced fires; the useful life of the electric motor can be reduced and/or the facility can face unscheduled and expensive downtime. Measuring insulation quality on a regular basis is a crucial part of any maintenance program as it helps predict and prevent electric motor breakdown.

For most motors, the expected life of a stator winding depends on the ability of the electrical insulation to prevent winding faults. That is the need for a stator rewind is almost always determined by when the electrical insulation is no longer able to fulfill its purpose, rather than, for example, being determined by a problem with the copper conductors. This follows from the fact that the electrical insulation has a large organic content, a lower melting temperature and a lower mechanical strength that the copper and the core steel.

Therefore, to implement this project the Thrige Odense Denmark 3-phase induction motor ( Table 1.1) will be used as experiment rig to measure the insulation resistance. The insulation resistance test measures the resistance of the electrical insulation between the copper conductor and the core of the stator or rotor. Ideally the resistance is infinite. The purpose of the insulation is to block the current flow between the copper and the core. In practice, the insulation resistance is not infinitely high. Usually, the lower the insulation resistance, reveal more problem with the insulation.

Insulation resistance can be measured by nondestructive tests applied between the conductors and the framework of the apparatus. The resistance value can be read directly from a megohmmeter, called a megger or indirectly by calculation using the voltmeter-ammeter method. When properly made and evaluated, such tests assist in diagnosing impending trouble.

Moisture absorbed in the windings or condensed on the surface of insulation results in a decrease in the measured values of insulation resistance. Hence, for insulation measurements to be significant, the tests should be made immediately after shutdown. This avoids errors due to condensation of moisture on the windings. When the machine temperature is lower than the temperature of the surrounding air, moisture condenses on the windings and is gradually absorbed by the insulation. The insulation resistance values of DC machines are generally more sensitive to changes in humidity than are those of AC windings; this due to the greater number of leakage paths in the armature and fields of DC machines [1].

## 1.2 Objectives

The aims of this project are:

i. To understand the technique and to familiarize the measuring equipment in order to measure the insulation condition of electric motor.

ii. To develop the AC and DC method used for condition monitoring.

iii. To apply the learning technique and measurement method for case study using electric motor.

iv. To validate the condition of the electric motor being monitor using various testing.

## 1.3 Project Scope

The scopes that are set to achieve the main objectives are listed as follow:

i. To observe condition monitoring on insulation resistance of electric motor.

ii. It will be focused on AC and DC measurement method of insulation resistance test.

iii. To observe the validity of the data taken on electric motor using learning technique and measurement method.

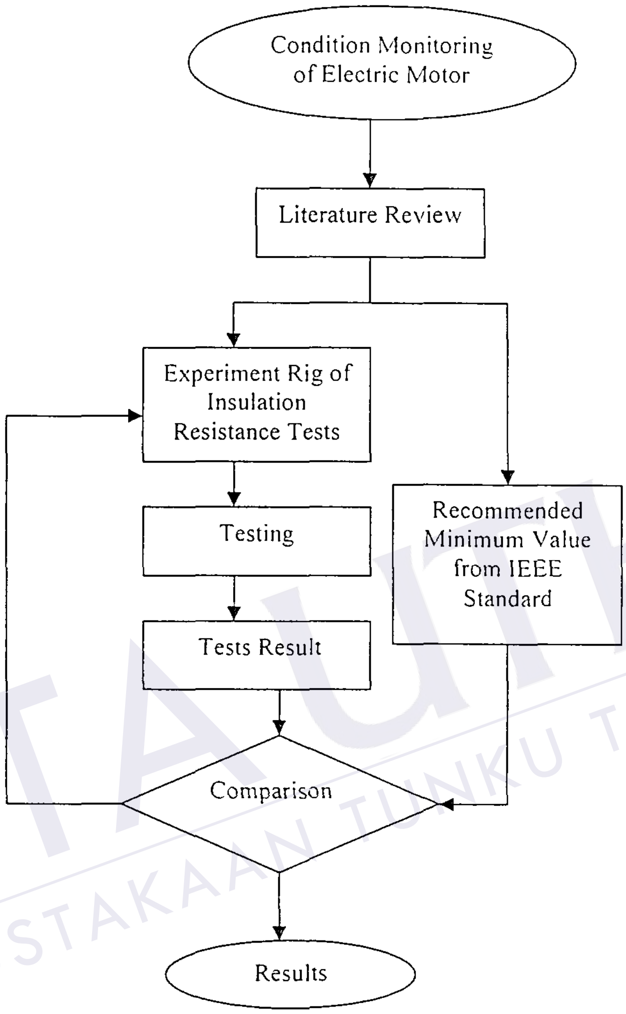


**Figure 1.1 : Flow Chart Of The Research Methodology**



Figure 1.1 shows a flow chart of the research methodology. For start, finding the project title is the most important thing. After the project title is fixed, objectives and scope of the project are identified. Next, proceed with the literature review. Using the information from the literature review, setup an experiment rig of insulation resistance tests. Then, continued with the testing followed the test procedures have been setup for experiment rig. From the tests result, comparison has been done with the recommended minimum value from IEEE standard. Finally, the test results are plotted in graphs. to get the trend of the insulation condition of the electric motor. Briefly explanation according to the experiments can be referred to Chapter 4 and 5.

## 1.4 Significance of the Study

The benefits of condition monitoring can be summarized as:

i. To reduce maintenance costs.

ii. The results provide quality control feature.

iii. Limiting the probability of destructive failures. this lead to improvements in operator safety and quality of supply.

iv. Limiting the severity of any damage incurred, elimination of the consequential repair activities and identifying the root causes of failures.

v. Information is provided on the plant operating life, enabling business decisions to be made either on plant refurbishment or replacement.

This study also useful as preventive maintenance from any hazardous to personnel and machinery.

# CHAPTER 2

# LITERATURE REVIEW

## 2.0 Introduction

This chapter discusses and reviews previous studies from other researchers on condition monitoring on insulation resistance of electric motor which helps to provide more information and explanation especially on insulation resistance measurement method.

## 2.1 Condition Monitoring In Rotating Machinery

One of the most important insulation deterioration mechanisms in rotating machines is thermo-mechanical stresses during the machines life due to on-off-operations or load changes. With this load changes the insulation is thermo-

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