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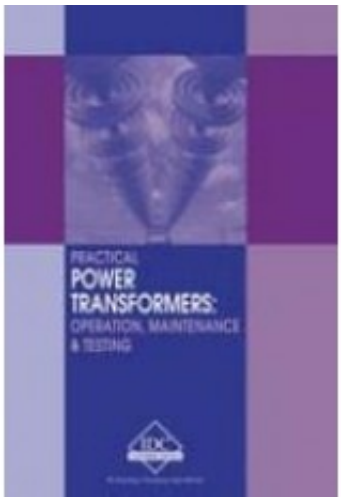
TF-E - Power Transformers Operation, Maintenance and Testing



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Short Description

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First Chapter

An Introduction to Practical Power Transformers, Operation, Maintenance & Testing

1 Introduction

1.1 Why transformers?

In today's world, the bulk of electrical power is generated in the form of AC using generators whether thermal, hydro, and nuclear or gas. However due to equipment sizing, insulation requirements, etc., the generating voltage in the present day power stations is limited in the order of 15 to 25 kV though the power generated is in hundreds of mega watts. It is impractical to distribute this much power at the generated voltage due to the magnitudes of currents, which are in the order of about 1000 amps for every 25 MVA at 15 kV.

If such high currents are to be transmitted over long distances, it will be necessary to overcome the following:

- The total power loss in a transmission/distribution system is proportional to I^2Z where I is the magnitude of current and Z is the impedance of the transmission/distribution system. The larger the current transferred, the larger will be the power loss and lower the transmission efficiency.
- The cross section of conductors required would increase as the value of current increases and it is impractical to install heavy conductors across a country to carry and transmit higher currents to remote parts.
- The voltage drop in a distribution system is proportional to I×Z and it is necessary to keep the value of I as low as possible to limit the voltage drops (since the value of Z cannot be reduced very much).

All the above factors necessitate that the transmission current is reduced as much as possible, which is achievable only by increasing the transmission voltage. A transformer is the answer to the above issues and today's AC distribution cannot be what it is without the use of transformers.

A transformer is an essential device in any Electrical AC power distribution system, which is used to convert (transform) AC voltage magnitudes of any value

obtained from a power source to any desired value. The development of power transformers dates back to the 19th Century. The main feature of a transformer is its constant VA rating whether referred to its primary or secondary side. With VA being constant (V refers to the voltage magnitude and A refers to the current magnitude in a transformer winding), it is just possible to get a higher V with lower A OR a lower V with a higher A, by choosing suitable turns ratio for the transformer windings.

It is to be noted that the transformers can be used only for changing the magnitudes of AC voltages. They cannot be used for varying DC voltages, without converting them to AC voltages.

1.2 About this manual

To make the full use of transformers it is necessary that a basic knowledge on the following is a must:

- Theory of transformers.
- Terminal markings and connection methods.
- Construction of a transformer and its parts
- Types of transformers based on application
- Test requirements
- Installation practices to be followed.
- Proper operation and maintenance to ensure continuous service.
- Protecting the transformers while in service to keep outages to a minimum.

1.2.1 Theory of transformers

Though the operation of a transformer may look simple, it is necessary to understand the basic functioning of a transformer and its components. The basic theory of transformers is mainly related to elementary electricity, magnetism and the magnetic properties of materials, behavior with different types of loads, and factors defining a transformer (such as its impedance, regulation, losses, efficiency, etc.).

1.2.2 Terminal markings and connections

Depending upon the method of connections inside a transformer, there are appreciable differences in the output phase voltages and currents with respect to the main source. It is necessary to know the method of connections employed inside transformer windings, so that there is a clear understanding on transformer

output and protections to be employed. It is internationally common practice to identify transformer connections by simple letters and also to show them in the nameplate. A section covering the connection methods and their identification is covered in this manual.

1.2.3 Construction of Transformers

A transformer basically comprises of a primary and a secondary winding with a magnetic core and is normally represented as per Figure 1.1. The study of transformer construction basically covers its windings, insulation, core materials, duty/application/type, standard/special accessories, etc. For example, it is necessary to keep the losses in a transformer to a minimum to ensure that the major portion of the power transferred is not dissipated in the transformer itself. Hence knowledge of the core and its construction is required and is covered in this manual.

Figure 1.1

Typical connection of a transformer

1.2.4 Types of Transformers

Though the basic principle of transformers is one, the applications which employ these transformers have different requirements based on the load requirements such as furnace loads, step up transformers, autotransformers, etc. The actual application could demand either a simple two winding single-phase transformer stepping up or stepping down the available voltage or it could also cover multiple winding three-phase transformers with some specific requirements to overcome harmonics, etc. The insulation could also be different. A small chapter is devoted to the types of transformers.

1.2.5 Testing Requirements

Before a transformer is accepted for installation or put in service after receipt at a site, it is necessary to ensure that it meets the basic functions/requirements expected of it. International standards are available which give the standard tests that are to be conducted on a transformer at various stages. The standards also differ region wise depending upon the developments in that region and local regulations. A section of this manual will cover the tests normally conducted on transformers and also briefly cover the comparison between IEC and NEMA

standards. These are mostly referenced transformer standards.

1.2.6 Installation Practices

A transformer needs to be installed at the right place to meet its objectives and it is vital that the best installation practices are followed while locating and erecting them. This could be related to safe clearances to be provided between transformers and other equipment, safety clearances to be maintained from live parts to the ground/operating personnel, cabling practices, provisions to drain out the oil to safe places during critical situations, etc. A part of this manual briefly covers the various guidelines to be followed for installing a transformer.

1.2.7 Operation and maintenance

The proper operation of a transformer is achieved by following good maintenance practices to keep the transformer and its components healthy and functional throughout its life. For example, it is very necessary to keep the insulation properties of a transformer almost constant to avoid internal and external flashovers, which are the major causes of transformer breakdowns. This manual will also briefly cover the best maintenance practices to be followed to keep the transformer healthy throughout its life.

1.2.8 Protection

The transformers shall be protected against possible failures due to external and internal faults. This is possible by having an understanding on the types of faults likely to occur and providing monitoring devices which continuously oversee the functioning of the transformers (like its voltage/current parameters through relays), the condition of its internal parts like oil (pressure, level, temperatures), windings (temperature), etc. These devices warn before any major failure of transformer occurs. A section of this manual covers a brief study and practices related to the protection of transformers.