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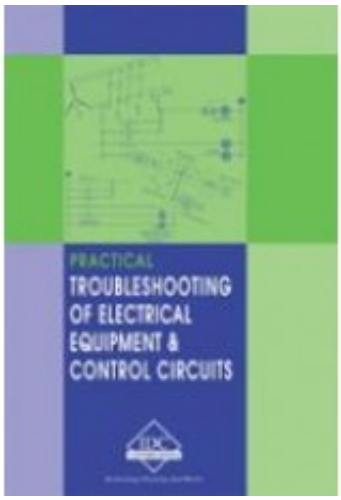
EL-E - Practical Troubleshooting of Electrical Equipment & Control Circuits



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Short Description

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Types of Problems

1.1 Introduction

Building electrical equipment or networks so as to completely eliminate the possibility of failure in service is neither a practical, nor a viable proposition. It is therefore a fact of life, that different types of problems do occur in electrical equipment and systems, however infrequently and at random locations.

However, it is imperative that the problems should be identified, diagnosed and solved as quickly as possible to avoid causing disturbance to the users, mitigate damage to equipment and prevent safety hazards. For example, problems involving electrical faults produce short circuit currents which release enormous amount of destructive heat energy capable of causing irreparable damage to insulators, conductors and equipment and produce violent magnetic forces that can twist and destroy conductors and bus-bars in the panels. Electrical faults in a hazardous area like a refinery can even cause explosions.

It is of major importance to prevent or mitigate problems in electrical systems because the cost of damage to life and property inflicted by major problems can be very huge and prohibitive. The cost of electrical failures is attributable to the following:

- Loss of revenue due to downtime
- Cost of labour for trouble shooting, repairing, restarting etc
- Cost of damaged equipment and material including repairs, replacements, scrapped material
- Cost incurred due to injuries suffered by personnel

Prevention or mitigation of problems have the tangible benefits of reduced repair costs and down time and the intangible benefits of improved safety, morale etc.

1.2 Problems and their genesis

Problems can arise on account of various reasons such as:

- Design deficiencies
- Quality of installed equipment
- Installation deficiencies
- Operation deficiencies
- Quality of maintenance carried out on the equipment
- Inherent ageing and deterioration of equipment

- External causes like hostile environment, malfunction of protection devices etc

1.3 Problem categories

Problems can be broadly classified into two categories, namely electrical problems and mechanical problems.

1.3.1 Electrical problems

Electrical problems can arise either in the electrical circuit or in the equipment and components connected in the electrical circuit.

Types of electrical equipment used in practical circuits

Equipment used in electrical circuits can be broadly divided into power equipment and control equipment.

Power and power electronic equipment

Power and power electronic equipment are used for handling the main electrical energy in electrical circuits. They are designed to carry relatively larger magnitudes of power.

Control equipment

Control equipment, as the name implies are used only for controlling the power handled by the main power circuits and equipment and hence are designed relatively to handle lesser power than what is handled by power equipment and circuits.

Electrical circuits

Electrical circuits are used for interconnecting different electrical devices together to enable the operation of electrical equipment and are generally classified as power circuits and control circuits. A power circuit consists of the main power device (motor, generator or some other power device) along with associated power conductors, contactors, protection devices etc. A control circuit consists of switches, field device contacts, timers, relay coils, relay contacts, protection devices and light power conductors. Power circuits invariably handle more power than control circuits.

Power circuits are required for carrying power to, or from large electrical equipment like motors, alternators or an electrical installation. They are used for performing the following functions:

- Circuit control using devices such as contactors, circuit breakers etc.
- Isolation of equipment or network using devices such as isolators, linked switches and circuit breakers
- Protection against overload and short circuits using thermal overload relays, electro-magnetic relays, circuit breakers, fuses etc.

Power circuits carry large magnitude of power and therefore consist of heavy conductors along with switching devices like contactors, breakers for switching the power on and off. Protection devices are also included in power circuits for resolving overload conditions or other faults. Figure 1.1 shows the typical power circuit of a DOL starter used for a 3-phase induction motor.

Figure 1.1

Power circuit for a motor

Control circuits are used for automatic control, safety interlocking and sequencing the operations of electrical equipment. Control circuit hardware consists of relay contacts, wires, timers, counters, relay coils etc. The circuit consists of input contacts representing various conditions and the coils at the output are energized or de-energized depending on the input conditions. A few simple control circuits are shown in Figure 1.2 to represent such logical conditions.

(a) **(b)** **(c)**

Figure 1.2

Simple control circuits

Electrical problems can be basically categorised as following:

- Open circuits and short circuits
- Active and passive faults
- Incipient and solid faults

Open circuits and short circuits

An ‘open circuit’ is a condition in which current fails to flow through its intended path due to disconnection or open circuiting of the current path. ‘Short circuit’ is a situation wherein the current in a circuit flows through an unintended path either between the phases or between phases and earth.

Active and passive faults

An ‘Active fault’ is one, where the fault current flows from one phase conductor to another (phase-to-phase) or alternatively from one or more phase conductors to earth (phase-to-earth). An active fault can be a ‘solid fault’ or an ‘incipient fault’. A solid fault occurs due to sudden and complete breakdown of insulation resulting in high fault currents and release of huge amounts of destructive energy. A solid fault must be cleared as quickly as possible due to the catastrophic damage it can cause to equipment. An ‘incipient’ fault is a fault that starts with a small magnitude and develops over an extended period of time, till the deterioration results in the occurrence of a ‘solid’ fault.

Passive faults on the other hand are not really faults but are rather conditions that stress the system beyond its design capacity and which may ultimately lead to occurrence of active faults. Typical examples for passive faults are:

- Overloading - Leading to overheating of conductors and insulation resulting in their premature failure
- Over voltage - Stressing insulation beyond its limits
- Under frequency - Impairing the performance of equipment
- Power swings – Causing generators to go out-of- synchronism with each other

While passive faults are not as severe as active faults in the short run, it is necessary to identify and clear these faults to prevent them developing into larger faults.

1.3.2 Mechanical problems

Mechanical problems, as the name implies are on account of mechanical causes like bearing defects, breakages, jamming of moving parts, lubrication problems etc. Mechanical problems can lead to electrical problems. A defective motor bearing can cause the rotor to foul with the stator of the motor causing an electrical flashover.