STUDY and RECOMMENDATIONS IN THE FIELD OF ELECTRICAL SAFETY IN ESCORTS AGRI MACHINERY

Final Year Project Report

Submitted by

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Under the guidance of

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Declaration

STUDY AND RECOMMENDATIONS IN ELECTRICAL SAFETY IN AN AGRI MACHINERY INDUSTRY

Acknowledgement

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Any omission in this brief acknowledgement does not mean lack of gratitude.

Manaswita.

UPES
THE NATION BUILDERS UNIVERSITY

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Abbreviations Used

1. EHS- Environment Health And Safety
2. HSE- Health Safety And Environment
3. CTLs- Creep Temperature Limits
4. HRC- High Rupturing Fuse
5. IER- Indian Electricity Rules
6. EMRs- Electro Magnetic Relays
7. SSRs- Solid-State Relays
8. ZSI- Zone Selective Interlocking
9. NESC- National Electrical Safety Code
10. OSHA- Occupational Safety And Health Administration
11. NFPA- National Fire Protection Association
12. AMG- Agri Machinery Group
13. IS- Indian Standards
14. BIS- Bureau Of Indian Standards
15. LOTO- Lock Out And Tag Out
16. PPEs- Personnel Protective Equipments
17. DG- Diesel Generator
18. ECCP- Electrical Change Control Procedure
19. MCB- Miniature Circuit Breaker
20. MCCB- Moulded Case Circuit Breaker
21. RCCB- Residual Current Circuit Breaker
22. HRC- High Rupture Capacity
23. PVC- Polyvinyl Chloride
24. ELE/ ELEC- Electric/ Electrical
25. ELCB- Earth Leakage Circuit Breaker
26. LT- Low Temperature
27. HT- High Temperature
28. HAC- Hazardous Area Classification
29. TRG- Training

Abstract

According to the Bureau of Labor Statistics Census of Fatal Occupational Injuries Research File, Electrocution is the cause of 7% of all workplace deaths among young workers aged 16–19, causing an average of 10 deaths per year. Therefore electrical safety has to be strictly followed. This report is a detailed study of the different hazards and risks associated with electricity in an automobile industry and audit conducted to make proper observations and recommendations to prevent the occurrence of potential accidents. The primary goal of the EHS (Environment, Health And Safety) management system is to minimize the risks associated with electricity and hence prevent accidents. Audit is one of the best ways to observe and identify the risks involved to prevent accidents by making a check if the operational activities comply with the statutory standards. This process involves study, observation, identification of the risks and possible hazards associated in the industry in the form of a risk matrix and make recommendations in accordance to different standards and safe engineering practices. Further these recommendations can be implemented to obtain a safe work place. Safety audit is normally carried out at different levels in the factory to check if the standards are being properly followed and to prevent potential accidents from happening

***Key words*:** Electrocution, Safety Audit, Environment, Health and Safety

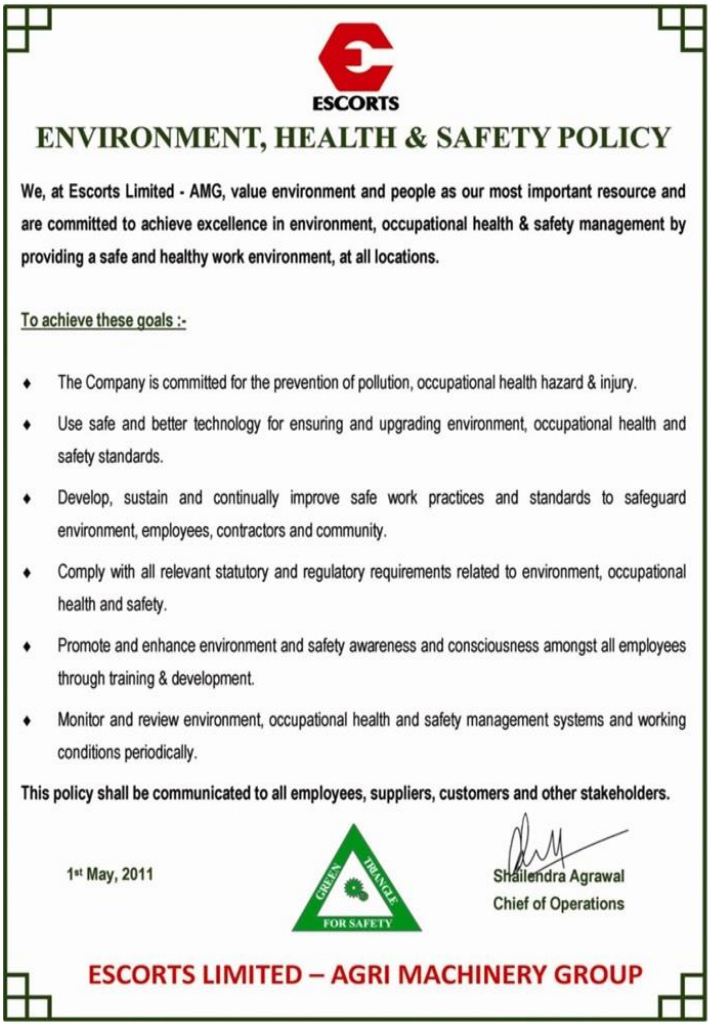
Chapter 1
Introduction

1.1 Background

According to the Bureau of Labor Statistics Census of Fatal Occupational Injuries Research File, Electrocution is the cause of 7% of all workplace deaths among young workers aged 16–19, causing an average of 10 deaths per year. Therefore electrical safety has to be strictly followed.

HSE functions & systems have been made as a part of the total management and work culture of ESCORTS AGRI MACHINERY. The system also provides structured paths for improvement of communication, accomplishment of goals, development of personnel and overall improvement of business process.

THE EHS POLICY OF ESCORTS



ESCORTS

ENVIRONMENT, HEALTH & SAFETY POLICY

We, at Escorts Limited - AMG, value environment and people as our most important resource and are committed to achieve excellence in environment, occupational health & safety management by providing a safe and healthy work environment, at all locations.

To achieve these goals :-

- The Company is committed for the prevention of pollution, occupational health hazard & injury.
- Use safe and better technology for ensuring and upgrading environment, occupational health and safety standards.
- Develop, sustain and continually improve safe work practices and standards to safeguard environment, employees, contractors and community.
- Comply with all relevant statutory and regulatory requirements related to environment, occupational health and safety.
- Promote and enhance environment and safety awareness and consciousness amongst all employees through training & development.
- Monitor and review environment, occupational health and safety management systems and working conditions periodically.

This policy shall be communicated to all employees, suppliers, customers and other stakeholders.

1st May, 2011

GREEN TRIANGLE FOR SAFETY

Shailendra Agrawal
Chief of Operations

ESCORTS LIMITED – AGRI MACHINERY GROUP

Fig 1: The EHS policy of Escorts Agri Machinery.

1.2 Project Objectives:

Vision: To study the procedures of electrical safety practiced in Escorts Agri Machinery and make proper recommendations wherever there is a scope for improvement.

Objectives:

1 To study the electrical safety procedures practiced in Power House (Plant 2)
2 To conduct an electrical safety audit on behalf of EHS department of Escorts Agri Machinery in the Power House
3 To make proper recommendations wherever a scope for improvement is observed in the Power House.

Chapter 2

Literature Survey

The following literature review on Study and Recommendations in the field of Electrical Safety in Escorts Agri Machinery includes the current knowledge on substantial findings, as well as theoretical and methodological contributions to Electrical Safety in the power house of any Automobile Industry. The table below describes the objectives and key findings of the papers that are considered in carrying out the project.

Table 1: List of Papers which were referred to during the project

Author's Name	Title of Paper	Objectives	Statement
PG Sreejith, Asst. manager (tech), Loss prevention Association of India Ltd	Electrical safety Auditing	To understand the necessity of Electrical Safety in any Work Place	According to the Bureau of Labor Statistics Census of Fatal Occupational Injuries Research File for 1992–2005, electrocution is the fifth leading cause of work-related deaths for 16- to 19-year-olds
A.A Hattangadi	Electrical failures and fires	Basics of Electrical Safety	Terminologies related to Electrical Safety
A.A Hattangadi	Electrical Fires And Failures (A prevention And Trouble Shooting Guide)	Availability of Electrical Hazards in work place and how to prevent these hazards	Study of all the electrical hazards
S. Rao, Prof. H.L. Saluja	Electrical Safety, Fire Safety Engineering and Safety Management	Procedures to check stress and to detect potential failures	The rate of growth of the fatigue cracks depends directly on the excess of peak stress over the endurance limit and the number of stress peaks per second.
Kimberly keller	Establishing an effective Electrical Safety Program	Benefits of Training and Safety Programs in any work place	The creep temperature limits (CTLs) for a few metals
Seyed Hamid salehi	Workplace Electrical	Electrocution and its	Electrocution is the

	Injury in Workers *Burns, Volume 39, Issue 4June 2013*	effects in any workplace	cause of 7% of all workplace deaths among young workers aged 16–19, causing an average of 10 deaths per year. Therefore electrical safety has to be strictly followed
Paul A. Erickson	Electrical safety Related work practices , *practical Guide to Occupational Health and Safety 1996*	Procedures to check voltage, current in any Power station	The Megger test is a combined test for both the insulation resistance and dielectric strength. If a 1000 volt Megger is used, the insulation resistance is measured and at the same time, a proof test is carried out at 1000 volts for one minute
Alex Albert, Matthew R. Hallowell	Safety Risk management for electrical transmission and distribution line , *Safety Science, Volume 51, Issue 1,January 2013*	Risk associated with electrical transmission and distribution	Most people do not realize that overhead power lines are usually not insulated. More than half of all electrocutions are caused by direct worker contact with energized power lines
J.D. Koustellis, C.D. Halevidis, A.D. Polykrati, P.D. Bourkas	Analysis of fatal Electrical Injury due to improper switch operation, *Safety Science, Volume 53,March 2013*	Fatal Electrical Hazards	An electrical hazard exists when the wire is too small a gauge for the current it will carry
Kimberley Keller	OSHAS regulation simplified, *Electrical Safety Code Manual ,2010*	All the safety codes that are to be followed in a workplace	OSHA Regulation, the NEC, NFPA 70E standard of electrical safety in work place, National Electrical Safety code (NESC) (Reference during Audit)
B.L. Prabhu	Electrical Safety Audit	Procedures that are to	Procedures and scope

		be followed while conducting a Safety Audit	of Electrical Safety.
C. Satish, Indian Drugs and Pharmaceutical Ltd, Hyderabad	Safety Related Electrical Maintenance	Different Protection Procedures available	Zone selective interlocking (ZSI) and bus differential protection
V.D. Vaidya, Chief Electrical Engineer. Dalal Mott Macdonald.	Detection of Incipient Earth Fault	Detection of different faults which is very helpful during a preventive maintenance	The resistance of earth and the conductor should be low enough
L. Martirano (St. M. IEEE), Electrical Engineering Dept. University of Roam, "La Spanienza" Via Eudossiana, 18-00184-Roam, Italy	Protection Against Electrical Shock And Fire Hazards, G Parise (M. IEEE)	Different Hazards and way to prevent these hazards	How to recognize hazards
BUREAU OF INDIAN STANDARDS, Electrical Installations Sectional Committee, ETDC 20, *Chairman* Shri M. L. Dongre	*Indian Standard* CODE OF PRACTICE FOR ELECTRICAL WIRING INSTALLATIONS ,Third Reprint MAY 2007	Standard practices for electrical wiring in any work place	All the IS Codes.

Chapter 3

Study of Electrical Safety And Methodology

Terminologies related to Electrical Safety:

3.1.Electrical Fire: The three main group of fire causes are accidental, natural and incendiary. Of the accidental causes electricity plays an important role. It occurs mainly in cases like

- Overheating and arcing
- Ignition and combustion of insulating material in equipment itself
- Combustible material in the building which houses the equipment.

Eg Fire on a switch board panel caused by a defective terminal connector.

3.2. Failure: The term failure will cover the cases in which the electrical equipment fail to perform it's normal functions as a result of electrical fault. In these cases also, there may be momentary arcing and local overheating, but there would have been no ignition and combustion.

3.3 Defect: It is the immediately preceding cause of failure. It may be detected during normal maintenance or inspection schedules or programs is to detect and eliminate defects before they develop into failures.

3.4. Seed- Defects: Defects which develop slowly or lie dormant harmlessly for years without causing any problem. Defects in protective devices should be considered as seed defect because they operate only when there is a fault. A defect in these devices will therefore remain undetected.

3.5. Modes of Failure: It covers the visible or measurable changes in the properties or appearance of the component which fails first during the process which precedes an equipment failure. In the initial stages of investigation, when it is not clear as to which equipment failed first, it is advisable to record observations on all components in the damaged zones.

3.6. Mechanisms of Failure: The term 'mechanism' refers to an internal physical or chemical process which ends in a failure of the material, component or equipment. For instance certain type of failure may involve physical processes thermal expansion, plastic deformation, elastic stress or fatigue in materials. There is a certain sequence of invisible processes, which may be either physical or chemical, the end point of which is failure. It is only when we determine or understand the sequence of processes, that we are able to take effective measures to prevent the failures from taking place.

3.7. Failure Rates: When the number of similar equipment or components installed in any plant are sufficiently large, ie in tens or hundreds or even more, it is important to maintain statistics of failure rates periodically.

The general formula for failure rate is as follows:

FRPCPY= (100 * f) / (P*t)

Where

FRPCPY- failure rate, per cent per year.

P- Equipment Population

f- Number of failures in period t years

t- Period under consideration, in years.

This formula is an approximation, but it is adequate for practical purposes. Failure statistics are always considered for same period. If the number of hours that different equipment have worked per year are widely different, failure rates can be calculated on a per hour or per thousand hour basis, instead of per year basis. In such a case hourly utilization statistics have to be maintained for all equipment.

3.8. Metal Fatigue: Whenever metal components like wires, hardware and switch gear components are subjected to alternating or fluctuating stresses, they are vulnerable to a phenomenon known as metal fatigue. When the peak stress exceeds a certain limit (endurance limit), the component develops metal fatigue. The component develops cracks which grow in size with every new peak of alternating stress.

The rate of growth of the fatigue cracks depends directly on the excess of peak stress over the endurance limit and the number of stress peaks per second.

If it happens while the component is carrying a heavy current, an electric arc may be produced and a fire may be the ultimate result.

3.9. Metal Creep: Creep temperature limit (CTL) varies from metal to metal and depends on melting point. The creep temperature limits for a few metals commonly used in electrical equipment are as follows:

Table 2: Creep temperature limits of some metals.

Metal	**CTLs**	**Remarks**
Copper	135	In case of copper , creep can be problem only in machines where conductor temperatures are high
Aluminum	**7**	Subjected to creep at normal operating temperatures(20 to

		80 degree C)
Lead	-70	Subjected to creep at normal operating temperatures(20 to 80 degree C)
Tin	-100	Subjected to creep at normal operating temperatures(20 to 80 degree C)

3.10. Elastic Deformation: The elastic deformation of metals which takes place initially as soon as the load is applied, remains constant for an indefinitely long time, and if at the end of the period the load is removed, the metal component will return to its original shape and size, which it had acquired initially.

3.11. Stress: The reactive force per unit area produced inside a material which has been subjected to an external load or force.

3.12. Strain: Deformation per unit length produced in any material as a result of external load. Mathematically,

Strain= (Change in Length)/ (Original Length)

3.13. Insulation Resistance: It is a measure of the leakage current across the entire insulation system and gives an indication of the general condition of insulation It is usually measured in **mega ohms**. Some installations may show 'infinity' as the insulation resistance. This is not quite correct. It only means that the insulation resistance is higher than what the instrument is capable of measuring.

3.14. Dielectric Strength: It is a measure of minimum voltage at which the insulation will break down and develop a short circuit. It is indicated in **kilo volts.** It depends on the weakest point in the system. Even if the general strength is very high , one weak point will reduce the dielectric strength of the entire system. Therefore high insulation resistance is necessary but not sufficient to ensure that there is no failure of insulation; the dielectric strength must also be satisfactory.

The Megger test is a combined test for both the insulation resistance and dielectric strength. If a 1000 volt Megger is used, the insulation resistance is measured and at the same time, a proof test is carried out at 1000 volts for one minute.

3.15. Fuse: A safety device consisting of a strip of wire that melts and breaks an electric circuit if the current exceeds a safe level. It is the simplest and the most common protective system. It can be used in installations. It consists of a wire of cross section smaller than the cross section of the wire to be protected. HRC (High Rupturing Fuse) are to be used where the fault level currents are high. If a normal fuse is used instead it will fail to clear the fault. It may explode and continue to arc and start a fire from the fuse board.

3.16. Circuit Breakers: A variety of circuit breakers are available –

- Miniature circuit breakers and moulded case circuit breakers for low current
- Oil Circuit breakers, Vacuum Circuit Breakers, Air Blast Circuit Breakers, SF6 Circuit Breakers for high current , high Voltage systems.

They may be operated either by hand or by means of electromagnetic or compressed air motors.

3.17. Earthing: IE Rules 61, 63(2) L, 67 & 68(2)

- The current carrying conductor should have enough capacity to deal with maximum fault current.
- The resistance of earth and the conductor should be low enough.
- Main station earthing system should be separated from earthing for lightning protection

3.18. Transformer:

- Transfers power from one circuit to another without change in frequency
- Works on mutual induction principle
- Comprises of two or more coils linked to a magnetic circuit
- Has one primary and one or more secondary windings
- Receives power at one voltage on the primary
- Delivers power on the secondary at another voltage

Some of the safety devices used in transformers:

3.18.1 Relays: Relays are electrical switches that open or close another circuit under certain conditions.

Some types of Relays are-

- Electromagnetic Relays (EMRs)

  EMRs consist of an input coil that's wound to accept a particular voltage signal, plus a set of one or more contacts that rely on an armature (or lever) activated by the energized coil to open or close an electrical circuit.

- Solid-state Relays (SSRs)

  SSRs use semiconductor output instead of mechanical contacts to switch the circuit. The output device is optically-coupled to an LED light source inside the relay. The relay is turned on by energizing this LED, usually with low-voltage DC power.

- Microprocessor Based Relays

  Use microprocessor for switching mechanism. Commonly used in power system monitoring and protection

Buchholz Relay is a very important type of relay which is used as a safety device in some oil filled power Transformers. The Buchholz relay working principle of is very simple. Buchholz relay function is based on very simple mechanical phenomenon. It is mechanically actuated. Whenever there will be a minor internal fault in the transformer such as an insulation faults between turns, breakdown of core of transformer, core heating, the transformer insulating oil will be decomposed in different hydrocarbon gases, CO_2 and CO. The gases produced due to decomposition of transformer insulating oil will accumulate in the upper part the Buchholz container which causes fall of oil level in it.

Fall of oil level means lowering the position of float and thereby tilting the mercury switch. The contacts of this mercury switch are closed and an alarm circuit energized. Sometime due to oil leakage on the main tank air bubbles may be accumulated in the upper part the Buchholz container which may also cause fall of oil level in it and alarm circuit will be energized. By collecting the accumulated gases from the gas release pockets on the top of the relay and by analyzing them one can predict the type of fault in the transformer.

More severe types of faults, such as short circuit between phases or to earth and faults in the tap changing equipment, are accompanied by a surge of oil which strikes the baffle plate and causes the mercury switch of the lower element to close. This switch energized the trip circuit of the circuit breakers associated with the transformer and immediately isolate the faulty transformer from the rest of the electrical power system by inter tripping the circuit breakers associated with both LV and HV sides of the transformer.

3.18.2 Silica Gel: Whenever electrical power transformer is loaded, the temperature of the transformer insulating oil increases, consequently the volume of the oil is increased. As the volume of the oil is increased, the air above the oil level in conservator will come out. Again at low oil temperature; the volume of the oil is decreased, which causes the volume of the oil to be decreased which again causes air to enter into conservator tank. The natural air always consists of more or less moisture in it and this moisture can be mixed up with oil if it is allowed to enter into the transformer. The air moisture should be resisted during entering of the air into the transformer, because moisture is very harmful for transformer insulation. A silica gel breather is

the most commonly used way of filtering air from moisture. Silica gel breather for transformer is connected with conservator tank by means of breathing pipe.

Zone selective interlocking (ZSI) and **bus differential protection** are two methods to detect bus faults and quickly clear the fault to minimize damage.

3.19. Zone Selective Interlocking: The zone selective interlocking (typically low voltage breaker only) uses a communications signal between zones of protection. For a through fault the downstream protection sends a blocking signal to the upper level breaker, allowing normal time selective operation. For an in zone fault, no blocking signal is sent and the time delay (usually for short time and ground fault protection only) is reduced to the minimum setting for the trip unit (typically 100 ms plus the breaker response). ZSI is not generally available as a field modification, and so cannot be used for installed systems.

3.20. Bus Differential Protection: Buss differential protection is faster than ZSI (2 cycles or less plus breaker response), but can be retrofit to existing systems. It is expensive to install due to the number of current transformers that must be installed.

Fig 2.1 Transformer

Fig2.2 Earthing Pit

Fig 2.3 Lighting Arrestor

3.21. Lighting Arrestor: A lightning arrester is a device used on electrical power systems and telecommunications systems to protect the insulation and conductors of the system from the damaging effects of lightning. The typical lightning arrester has a high-voltage terminal and a ground terminal. When a lightning surge (or switching surge, which is very similar) travels along the power line to the arrester, the current from the surge is diverted through the arrestor, in most cases to earth.

Importance of Electrical Safety.

According to the Bureau of Labor Statistics Census of Fatal Occupational Injuries Research File for 1992–2005, electrocution is the fifth leading cause of work-related deaths for 16- to 19-year-

olds. Electrocution is the cause of 7% of all workplace deaths among young workers aged 16–19, causing an average of 10 deaths per year. Therefore electrical safety has to be strictly followed.

Some of the electrical hazards are as follows:

3.22 Electrocution: An electrical shock is received when electrical current passes through the body. Current will pass through the body in a variety of situations. Whenever two wires are at different voltages, current will pass between them if they are connected. Your body can connect the wires if you touch both of them at the same time. Current will pass through your body.

3.23 Burns Caused by Electricity: The most common shock-related, nonfatal injury is a burn. Burns caused by electricity may be of three types: **electrical burns, arc burns, and thermal contact burns.** Electrical burns can result when a person touches electrical wiring or equipment that is used or maintained improperly. Electrical burns are one of the most serious injuries. Additionally, clothing may catch fire and a thermal burn may result from the heat of the **fire.**

3.24 Arc Blasts: Arc-blasts occur when powerful, high-amperage currents arc through the air. Arcing is the luminous electrical discharge that occurs when high voltages exist across a gap between conductors and current travels through the air. This situation is often caused by equipment failure due to abuse or fatigue. Temperatures as high as 35,000°F have been reached in arc-blasts.

There are three primary hazards associated with an arc-blast:

- Arcing gives off thermal radiation (heat) and intense light, which can cause burns. Several factors affect the degree of injury, including skin color, area of skin exposed, and type of clothing worn. Proper clothing, work distances, and overcurrent protection can reduce the risk of such a burn
- A high-voltage arc can produce a considerable pressure wave blast. A person 2 feet away from a 25,000-amp arc feels a force of about 480 pounds on the front of the body. In addition, such an explosion can cause serious ear damage and memory loss due to concussion. Sometimes the pressure wave throws the victim away from the arc-blast. While this may reduce further exposure to the thermal energy, serious physical injury may result. The pressure wave can propel large objects over great distances. In some cases, the pressure wave has enough force to snap off the heads of steel bolts and knock over walls
- A high-voltage arc can also cause many of the copper and aluminum components in electrical equipment to melt. These droplets of molten metal can be blasted great distances by the pressure wave. Although these droplets harden rapidly, they can still be hot enough to cause serious burns or cause ordinary clothing to catch fire, even if you are 10 feet or more away.

3.25 Electrical Fires: Electricity is one of the most common causes of fires and thermal burns in homes and workplaces. Defective or misused electrical equipment is a major cause of electrical fires.

OSHA Regulation, the NEC, NFPA 70E standard of electrical safety in work place, National Electrical Safety code (NESC) provide a wide range of safety information.

3.26 Inadequate wiring hazards: An electrical hazard exists when the wire is too small a gauge for the current it will carry. Normally, the circuit breaker in a circuit is matched to the wire size. However, in older wiring, branch lines to permanent ceiling light fixtures could be wired with a smaller gauge than the supply cable. When a wire is too small for the current it is supposed to carry, the wire will heat up. The heated wire could cause a fire. The kind of metal used as a conductor can cause an electrical hazard. Special care needs to be taken with aluminum wire. Since it is more brittle than copper, aluminum wire can crack and break more easily. Connections with aluminum wire can become loose and oxidize if not made properly, creating heat or arcing.

3.27 Exposed electrical parts hazards: Electrical hazards exist when wires or other electrical parts are exposed. Wires and parts can be exposed if a cover is removed from a wiring or breaker box. Older equipment may have exposed electrical parts. If our body comes in contact to exposed live electrical parts, it will experience shock. The risk from exposed live parts depends on our distance from the parts. **Three "boundaries"** are key to protecting ourselves from electric shock and one to protect us from arc flashes or blasts.

- The **limited approach boundary** is the closest an unqualified person can approach, unless a qualified person accompanies.
- The **restricted approach boundary** is the closest to exposed live parts that a qualified person can go without proper PPE
- The **prohibited approach boundary**—the most serious—is the distance one must stay from exposed live parts to prevent flashover or arcing in air.

To protect against burns, there's one more boundary: The **flash protection boundary** is where you need PPE to prevent incurable burns, if there's an arc flash.

3.28 Overhead power line hazards: Most people do not realize that overhead power lines are usually not insulated. More than half of all electrocutions are caused by direct worker contact with energized power lines. Power line workers must be especially aware of the dangers of overhead lines. In the past, 80% of all lineman deaths were caused by contacting a live wire with a bare hand. Due to such incidents, all linemen now wear special rubber gloves that protect them up to 36,000 volts. Today, most electrocutions involving overhead power lines are caused by failure to maintain proper work distances. Shocks and electrocutions occur where physical barriers are not in place to prevent contact with the wires. When dump trucks, cranes, work

platforms, or other conductive materials (such as pipes and ladders) contact overhead wires, the equipment operator or other workers can be killed. If proper clearance distance is not maintained one might get shock and might suffer death.

Fig 3.1 Electrical burn

Fig 3.2 Contact electrical burns

(The knee on the left was energized,

the knee on the right was grounded)

Fig 3.3 Electrical Fire

Fig 3.4 This hand-held sander has exposed wires and should not be used

Fig 3.5 Operating a crane near overhead wires is very hazardous

Methods for recognizing Hazards

The first step towards protecting ourselves is recognizing the hazards we face on the job. To do this, we must know which situations can place us in danger. Knowing where to look helps us to recognize hazards.

- Inadequate wiring is dangerous.
- Exposed electrical parts are dangerous.
- Overhead power lines are dangerous.
- Wires with bad insulation can give a shock.
- Electrical systems and tools that are not grounded or double-insulated are dangerous.
- Overloaded circuits are dangerous.
- Damaged power tools and equipment are electrical hazards.
- Using the wrong PPE is dangerous.
- Using the wrong tool is dangerous.
- Some on-site chemicals are harmful.
- Defective or improperly set up ladders and scaffolding are dangerous.
- Ladders that conduct electricity are dangerous.
- Electrical hazards can be made worse if the worker, location, or equipment is wet

Methodology

The study is conducted in two stages

First Stage – Making Observations.

Observations were noted down with the help of the following documents:

- Documents/records pertaining to electrical maintenance & operations test records
- Electrical breakdown /disturbance file
- Electrical inspector report file
- Work permits

- Physical examination of the power house

Second Stage – Provide Recommendations and form a preliminary Risk Matrix.

- By making a study of the electrical drawings
- By electrical protection study
- By condition monitoring of electrical equipments
- By study on the certification of contractor Equipment
- By study of accident report investigation
- By conducting thermography test
- By study of the earthing system

Audit (Assessment in Escorts):

Electrical Safety Audit of ESCORTS AMG group plant II was carried out by EHS Escorts. As part of the audit, documents/records pertaining to electrical maintenance & operations test records, electrical breakdown /disturbance file, electrical inspector report file, work permits, etc. were examined**.**

Scope:

- Verification of statutory compliance with respect to Indian Electricity rules 1956
- Physical inspection to identify electrical hazards (shock, fire, explosion, overloading) and to suggest electrical safety solutions
- Review of the Earthing system (installation & maintenance aspects) -IS 3043
- Review of electrical systems & procedures (work permits, interlocks, lockout tags, etc.)
- Review of electrical accidents and near-misses in the plant to identify the root causes
- Review of electrical preventive maintenance system (including tests, documentation, history cards, etc.)
- Review of static electricity hazards in the plant operations as per IS 7689

Chapter 4

Result and Discussion

After the Audit which was conducted by EHS Escorts the following recommendations were made:

Recommendations:

The priorities of recommendation have been denoted by the following colours:

	High
	Medium
	Low

Table 3: Recommendations according to their severity.

ELECTRICAL PREVENTIVE MAINTENANCE	
Plant II has a maintenance schedule for the electrical equipment and the shop floor equipment of various types. Equipment history cards are not maintained which is a legal requirement also. Present maintenance practices of transformer are not adequate**.** Transformer maintenance practices need to be aligned with the guidelines prescribed by IS 10028**.** An oil maintenance management program needs to be formulated and followed. Estimated life of a transformer is 40- 50 years. It is not uncommon to hear transformers serving more than 50 years. A well-oiled transformer management program coupled with transformer oil management program will go a long way in achieving the full life of transformer**.** Measurement of contact resistance and carbon impressions of Air circuit breakers to be recorded.. HV breakers should be maintained properly. However the records of maintenance by them were not available during audit. Audit team recommends adoption of following Indian standards (listed below) in the	

schedules and checklists in the respective areas. Some of the standards that can be adopted are given below.

IS 732 – Code of Practice of Electrical Wiring Installations

IS 900 – Code of Practice for Installation & maintenance of Induction Motors

IS 2309 – Protection of buildings and allied structures against lightning code of practice

IS 1255 – Code of Practice for Installation and maintenance of power cables up to and including 33 kV rating

IS 3043 – Code of Practice for Earthing

IS 5216 – Guide for Safety Procedures and Practices in Electrical Work

IS 7689 - Guide for control of Undesirable Static Electricity

IS 10118 – Code of Practice for the installation, selection, and maintenance of switchgear and control gear

IS 10028 – Code of practice for selection, installation & maintenance of transformers Of transformers.

NFPA 70E – Standard for Electrical Safety in the workplace

NFPA 70B – Recommended practice for electrical equipments

- History cards for the equipments needs to be maintained.
- Feedback between breakdown and preventive maintenance schedule should be developed.
- Equipment specific checklists need to be developed. .

ELECTRICAL DRAWINGS	

- Approved copy of Master single line diagram is not available for inspection. . It is recommended to display the authorized copy in all substations with relevant portions

- Drawings of the underground cable network are not available for reference during any earth excavation works.

- Lightning protection drawings was not available since detailed study is not done.

ELECTRICAL PROTECTION STUDY

- It is recommended to paste the relay settings near the relay as a good engineering practice**.**

- IS 9124- 1996- Recommends testing of relays every year. For dusty environments testing every six months is recommended. For less critical backup protections, once in two years is sufficient. However the frequency may be modified in accordance with the manufacturer's advice and operating experience

- Equipment protection schemes should be tested by simulating fault conditions wherever possible (for example – Buchholz relay actuation by injecting air inside Buchholz relay and tripping the breaker).Records of such tests should be maintained for back reference

- A master register of relay settings employed should be kept. For the digital relays if possible software set parameters may be copied in a digital media like CDs, DVDs and kept stored in a secure place. The relay set values before and after the calibration should be compared before energizing the feeders

ELECTRICAL WORK PERMIT SYSTEM

- ESCORTS does not have a lock out tag out (LOTO) system for electrical isolation. It is recommended to follow LOTO
- ESCORTS should have a standard procedure for temporary connections like arranging temporary power supply, flood lighting etc.
- LOTO register is should be started and maintained and maintained**.**
- Further it is recommended to add a new type of work permit – Energized line work permit which should include necessary PPEs like Gloves, Arc Flash suit , helmet , insulated tools etc.. This should be authorized by a senior level management member to stress its importance.

PERSONS

Plant does not have even a single electrical technician/engineer with the supervisory license issued by Secretary, Licensing Board & Chief electrical Inspector to Government.

Escorts should initiate the process of obtaining electrical supervisory license for its employees.

The display should include the following details

1.Name of the license holder

2. Educational qualifications

3.Type of license

4. Validity of license period (valid up to)

The list should be authorized by a qualified person whose name should not be in the list. (self-authorization should not be done)

Employment of any electrical contractor should be done only after verifying his license and validity.

Supervisory License is issued by Secretary, Licensing board & Chief electrical Inspector to Government, 85-86/17-D, Chandigarh.

MAINTENCECONTRCTOR/OUTSOURCED MAINTENACE ACTIVITIES MANAGEMENT

Certain minimum criteria like having a valid license from State Electrical Inspectorate licensing boards should be made applicable to all the vendors. They should submit a copy of their license with their commercial offer before getting the order

Even for the outsourced activities a schedule may be maintained like when the transformer oil filtration should be done, when relay testing /earth pits testing is required. Vendor reports should carry the calibration certificates along with traceability certificates. Vendor equipment should not be allowed inside without any calibration certificates, before commencing work.

Contractor safety rating / performance may be monitored and to be used as one of the criteria for extension of the contract.

Contractor payment may be paid on the basis of a checklist which lists out all the legal requirements and true copies.

Contractors should be allowed to use only quality tools and meters with IS / CE markings. Their meters should be regularly calibrated.

During Audit HT test equipment like HT Megger were not available.

Whenever transformer oil filtration is carried out, meggering should be done after filtration before charging the transformer**.** As these meters were not available, it is assumed that it is done without meggering which is a great risk.

ELECTRICAL FIRE EMERGENCY PLAN

It is recommended the following potential fire emergency plans may be formulated for

- Fire in the DG rooms
- Transformer fires
- Fire in cable cellar

Similar to fire action plan for main plant

In the fire emergency plan , the following aspects need to be defined clearly with

Respect to handling electrical related emergencies.

- Power isolation to the affected area
- Access
- Fire extinguishing agent quantity & availability
- Fire fighting
- Responsibilities of electrical personnel during emergency situation
- Identification of panels / feeders to be isolated.

ELECTRICAL CHANGE CONTROL PROCEDURE

It should be ensured that an ECCP procedure is developed incorporating the following aspect

- Provision of interlocks (if multiple power sources exist)
- Review of hazardous area – if applicable
- Location of equipment (outdoor/ indoor/flammable area / dust prone)
- Overloading (review the present connected load, cable capacity)
- Protection – rating (relays , MCB, MCCB, RCCB, HRC fuses)
- nearby structures / equipments/ other obstructions (e.g., existence of a water source near generator/ motor)
- Ventilation / heat dissipation (e.g., battery rooms)
- Multiple power sources/dedicated batter power for critical loads /panels (fire alarm, fire water pumps, emergency lights)
- Illumination levels
- Access (for new electrical room)
- Effect of pollution (noise, heat etc.,)
- Approach for easy maintenance

- Requirement of smoke / heat detection

2.9 ELECTRICAL SAFETY TRAINING

Dedicated electrical safety trainings in functional areas like

1. Safety in handling batteries
2. Interlocks in machineries
3. Electrical maintenance in paint booths

Should be imparted to the team. New joiners should be allowed to work only after receiving training at site.

For effective training, ESCORTS may consider using electrical safety films in the training program.

ACCIDENT REPORTING AND INVESTIGATION

It is recommended that all accidents / near misses however small should be reported and investigated to identify the root cause and eliminate it. The first aid cases should also be recorded so that respective accidents are avoided.

Standardized accident investigation report format can be used i.e. why, when technique , fish bone diagram analysis etc.,

LIGHTNING PROTECTION

Lightning protection is provided partly in Paint shop. However it should be extended.

Hence it is recommended to immediately initiate a comprehensive lightning protection study and implement its recommendation.

THERMOGRAPHY

Escorts EHS has carried out thermography paint shop and power house. Nature of hotspots indicates that, preventive maintenance should be carried out with more care & supervision.

Based on hotspot rectification experience preventive maintenance schedule should be modified.

It is recommended to carry out thermography for critical installations once in six months.

EARTHING SYSTEM

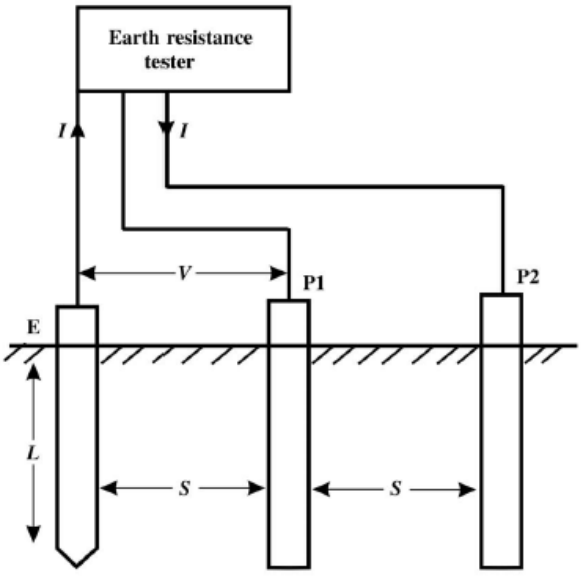
The Earthing testing records of the facility Earthing system were not available for audit. It was found that only the combined grid is tested here .i.e. earth pits are tested without disconnecting the interconnecting earth pits. This was also evidenced by the condition of interconnecting hardware (bolts & nuts). The values will also be very low since, the values read will reflect the combined resistance of earth pits in parallel.

To further verify the methodology of carrying out earth pit resistance testing, the outsourced agency that is carrying out earth pits measurement was asked to do a sample earth pit measurement. As recommended by IS 3043 and following are the observations of audit team

1. Analog meter is used. Only digital meter is recommended as an example values like 0.32 ohms are difficult to measure with analog meter
2. The earth Megger is not calibrated.
3. Only combined resistance is made and individual earth pit value is not measured

Since the system is not very complex here, we recommend 3 point method of testing the earth resistance. **IS 3043 can give further guidelines.**

Below diagram illustrates the connection method prescribed by IS 3043 /IEEE 81-1983



Connection method

recommended- 3 point method

TEST RECORDS/ REPROTS	

Records and reports maintained at ESCORTS were reviewed and the following were the observations and recommendations by the EHS team. A color ranking is given to segregate the records into 1) available, 2) partially available 3) not available .ESCORTS may initiate suitable action.

NO	RECORDS/REPORTS/ DRAWINGS	CURRENT STATUS	RECOMMENDATIONS
1.	Main single line Diagram	Approved drawing is not available.	SLD is displayed in SS. Relevant portions to be displayed in the individual MCC rooms, along with feeder details. This is to be implemented SLD should be made with standard symbols approved by IS/IEC standards
2	Electrical preventive Maintenance schedule ▪ Schedules ▪ Test & measurement records ▪ History cards ▪ Breakdown records ▪ Implementation status	Schedules available Checklists are available	Check lists and readings book to be prepared in alignment with suggested IS standards. Check lists to be more equipment specific & should include more safety measures like Using of HT meggers for

			HT equipments should be done.
3	Relay calibration records	Available.	EHS team recommends carrying out testing of relays every year.
4	Earth pit register	Available at site. Only combined value is tested.	Is recommended to carry out testing of earth pits preferably in the summer season when the conditions are dry. Earth pit readings should have individual & combined resistance values to accurately assess 1.Earth pit condition 2. combined grid condition A register may be maintained with entry of past readings
5	Electrical accident records (shock, fire, panel flashes & near miss accidents)	One major fire incident in DG panel and heavy losses.	
6	Calibration records for Electrical instruments	Not done	Instruments to be identified and Calibrated periodically.

7	Electrical Personal Protective equipments-used.	HT gloves available.	FRP Discharge rod, Arc flash helmet to be purchased. Arc flash study may be initiated and PPE program may be designed based on that.
8	Electrical log books	Available.	
9	Lightning protection drawings	Not available since no study was made.	Lighting protection study to be done for the whole plant and implemented.
10	Electrical safety training	Electrical safety training is given as a general without any special theme.	Equipment specific training like batteries hazards etc needs to be given.
11	Safety meetings	---	Meetings are conducted and safety issues were discussed.
12	Emergency plan	Not included specific scenarios related to transformer /cable fires	To be included in discussion with electrical dept

Observations and Recommendations Specifically in Power house:

Table 4: Observations and Recommendations made to the Power House

Plant II receives power at a voltage level of 11 kv from electricity board. Demand is 6500 kVA. The plant consumes approximately 74000 units/day in summer and 60-65,000 units/day in winter.	
I.TRANSFORMER YARD (Power House)	
1. Transformer yard has 8 numbers outdoor transformers (4*1000 kVA +4*1500 kVA) installed inside in open space.  Fig 4.1 Transformer Yard	For catering to the plant need, transformers have been added as and when required. Instead of having large numbers of 1 mva & 1.5 mva transformers ESCORTS should have gone for 2/2.5 MVA transformers which could have increased the reliability, reduced maintenance requirements and increased floor space for other activities. **(Good Engineering Practice)**

2. Tr-4 incoming & outgoing cable sizes are not marked on the transformer terminal boxes. Transformer end boxes are not sealed and large gaps exist.  Fig 4.2 unsealed cables in boxes	Incoming and outgoing cables sizes to be marked with paint on the end boxes. **(IE Rule 1956 Section 29)** End boxes should be sealed tight so that, moisture/vermin cannot enter inside. Cable gland should be used, so that, cables are supported properly and the cable weight stress is not transferred to the transformer terminal. In the event of any fault, fault current will also flow through the cable armour when the cable is glanded properly. This is a common observation in many of the transformers here. **(IE Rule 1956 Section 29)**
3. Silica gel breather used here is enclosed metal type. Silica gel is pink in color.	It is recommended to go for transparent type breather, so that change in color of silica gel can be observed clearly. **(IS 10028,Part 3)**
4. Oil temperature set point is 80deg C for alarm and 90 deg C for trip.	It is recommended to arrive at a common settings for all the transformers and in no case, trip set should not exceed 90 deg C. **(Standard Engineering Practice)**
5. In TR-1 silica gel breather, oil cup is missing.	Oil cup is provided so that, oil acts as a filter medium for the air breathed by the transformer. Otherwise, dust laden air will enter inside the transformer internals and cause failure of transformers. **(IE Rule 1956 Section 65(7))**

 Fig 4.3 Missing oil cup in silica breather	
6. The transformers are installed in ground level.	Any water logging due to heavy rain, will affect the transformers operation. Hence it is recommended to construct a bund wall around transformer yard with water pumping arrangements. **(Standard Engineering Practice)**
8. For Neutral earthing, PVC insulated cable is used. For some transformers, ALUMINIUM bus bars are used.  Fig 4.4 PVC insulated cables for Neutral Earthing	It is suggested to use, only bus bars as they can withstand heavy short circuit currents in transformers secondary level. Cables cannot withstand the short circuit current. **(Standard Engineering Practice)**
9. The total oil quantity exceeds 8000 litres in the transformer yard and oil soak pit is not available.	When the oil quantity exceeds 2000 litres, oil soak pit is necessary. Escorts to construct oil soak pit and interlink it with all the transformers so that, in the event of fire in any one of the

	transformers, the valves can be opened and oil can be drained. **(IE Rule 1956 Section 65(7))**
10. There is no fire separation wall for the transformers installed.	Clearance between the transformers ranges from 1.67 mtrs to 3.24 mtrs. Hence it is a mandatory requirement to construct fire separation wall of brick /concrete with a height of atleast 600mm taller than the tallest point of the transformer. When the oil quantity exceeds 2000 ltrs, fire separation wall is a must. **(IS 10028,Part 1&2)**
11. Transformer oil is stored in barrels in open near transformer yard.  Fig 4.5 Storage of Transformer oil near transformer Yard	Transformer oil should never be stored in open as there is every possibility of moisture entering the transformer oil **(Standard Practice)**

12. Transformer marshalling boxes are not maintained in dustproof & waterproof condition.  Fig 4.6 No dustproof and water proof condition	This will result in entry of vermin, which may cause short circuit of wires and unnecessary tripping of transformers. **(IE Rule 1956 65(7))**
13. Neutral Bus bars are not Insulated	Neutral bus bars should be insulated to provide a safe working environment to the operating persons **(IE Rule 1956 65(7))**

Risk Matrix:

1. SCORING

PARAMETERS OF ELECT SAFETY	SCORE
ELECTRIC SHOCK PROTECTION	4
ELE SAFETY AWARENESS/TRAINING	7
ELE STATUTORY COMPLIANCE	4
LIGHTNING PROTECTION	3
ELE PREVENTIVE MAINTENANCE	5
Total score/50	**23**
Final score/100	**46 %**

ELECTRICAL SHOCK PROTECTION	**SCORE**	**MAX**
USE OF ELCB	2	**4**
USE OF CORRECT MILLI AMPS ELCB	2	**2**
REGULAR MAINT OF ELCB	0	**2**
TESTING KIT FOR ELCB	0	**2**
Rating	**4**	**10**

ELECT SAFETY AWARENESS/TRG	SCORE	**MAX**
REGULAR INTERNAL TRG	2	**2**
EXTERNAL TRAINING	0	**1**
CONTRACTOR TRG	2	**2**
SCREENING SAFETY FILMS	1	**1**
CELEBRATING ELECT SAFETY	1	**1**

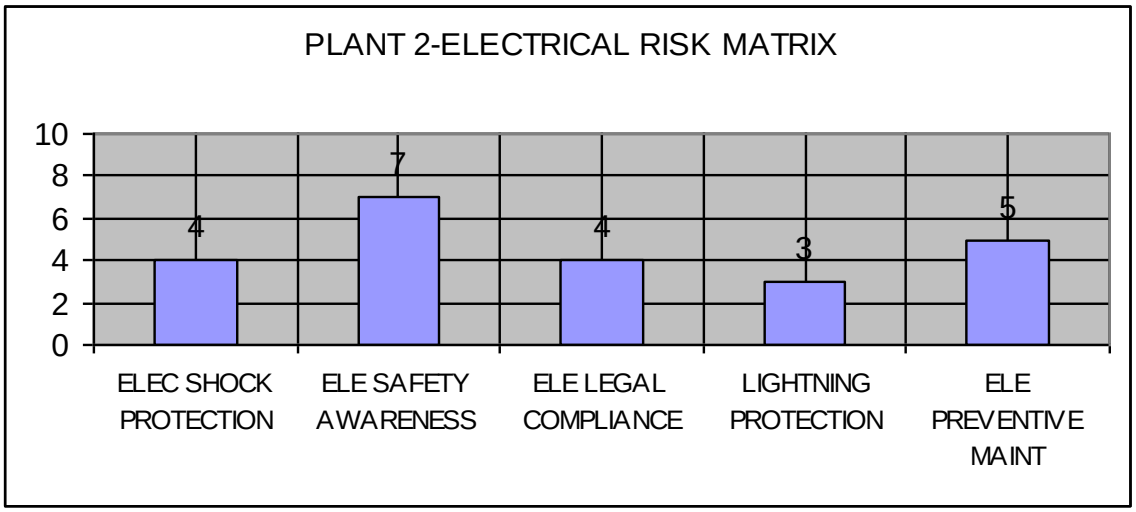
DAY/WEEK		
PAST ELECT SAFETY AUDIT	1	**1**
LOTO PROCEDURE IN FULL	0	**2**
Rating	**7**	**10**

ELETRICAL STATUTORY COMPLIANCE	**SCORE**	**MAX**
APPROVED SLD WITH LATEST LOADS	0	1
RULE 3 PERSON AVAILABLE	0	2
RULE 46 INSPECTION DONE RECENTLY	1	1
COMPLIANCE WITH IE RULE 1956	3	5
ELECT CONTRACTOR VALID LICENSE	0	1
Rating	**4**	**10**

LIGHTNING PROTECTION	**SCORE**	**MAX**
LIGHTNING PROTECTION PROVIDED	2	4
LIGHTININGPROTECTION AVAILABLE	0	2
EARTH PITS MAINTAINED AS PER IS 3043	0	2
AWARENESS OF LIGHTNING	1	2
Rating	**3**	**10**

ELECTRICAL PREVENTIVE MAINT	SCORE	MAX
REGULAR EARTH PIT MAINT	0	1
REGUALAR T MAINT	0.5	1
GOOD OIL FILTERATION PROGRAMME	1	1
HT SWITCHYARD/HT PANELS MAINT	1	1
RELAYS CALIBRATION	0.5	1
LT/HT MOTORS MAINT	0.5	1
HISTORY CARD MAINTENANCE	0	1
FLAME PROOF EQUPMENTS MAINT	1	1
ALL METERS AVAILABLE (HT/LT)	0.5	1
FULLY INSULATED TOOL/ NONSPARKING TOOLS	0	1
Rating	**5**	**10**

Risk Matrix from the above scores:



Chapter 5
Summary and Conclusion

Salient observations were discussed with Plant II Management at the end of the study:

1. Approved Master Single Line Diagram is not available. Single line diagram to be developed by using IS approved symbols and to incorporate cable runs & sizes. Relevant single line drawings are displayed in panel rooms

2. Lock out Tag out (LOTO) is not practiced. LOTO register is recommended for implementation

3. A Sound Electrical preventive maintenance system for maintenance of Transformers may be established based on IS 10028 (Part III) -2003

4. ESCORTS may start a Certification program for the contractor electrical powered equipment program with a fixed validity period.

5. Hazardous Area Classification Study (HAC) needs to be done for paint shop block

6. It is recommended to construct an oil soak pit immediately for the power transformers.

7. Meters like HT Megger, micro ohm meter needs to be purchased.

8. Earth pits need to be checked for their individual values and reconstructed wherever required.

9. Fire segregation walls and isolation of Transformers from each other should be carried out immediately.

10. Oil filtration program needs to include production block isolation transformers and servo stabilizers

Conclusion:

During my tenure of project work I was briefed about the various electrical hazards and risk in the plant (mainly in power house). Accordingly an audit was conducted by EHS department in the Power House to identify the risk and hazard associated so that accidents or further breakdown can be minimized. A risk matrix was accordingly prepared. After conducting the Audit we can conclude that the company is aware of all the standards (IS, OSHAS, IE Rules 1956), but they are unable to interpret the standards specifically while implementing them in many fields. Although they are implementing they are unable to stick to the specific standards that should be actually followed. Otherwise it is committed to the preservation of Environment and Ecology, Sustainable Development, Enrichment of the quality of life of Employees, Customers and the Community around its operational Area. After completing my project here, I can conclude that my intention of doing the project on electrical safety in Escorts Agri Machinery has been successfully accomplished.

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