- Compliance to guidelines during its fitment.
- Condition and calibration of tools and equipments used.
- Failure history of components from same manufacturer.
- Failure history of similar components from different manufacturer.
- Performance on different maintenance units.
- Its location and working in the system.
- Environmental conditions.
- External factors such as non standard or contaminated lubricants, coolants etc.
- Actual operating conditions.
- Failure mode or degraded performance.
- Metallurgical investigation or other Non Destructive Testing reports if necessary.
- Statement from working crew or maintenance staff from the site of failure.

Implementing the outcome from failure investigation

- ***At the component manufacturer***. Identifying problems with raw materials, handling, manufacturing processes, testing, etc., that can be improved, increasing the production yield and the product quality.
- ***At maintenance unit/sheds level***. Knowing the problem origin, and being able to provide solutions to prevent recurrence-applying the correct risk management techniques for each application / need. Sometimes the problem is directly related to the component, and depending on the failure mechanism, corrective actions can be implemented as follows:
  - To change the supplier.
  - To replace the type by a more adequate one.
  - To replace the lot.
  - To suggest any design modification.
  - To introduce any additional checks during assembly.
  - To check failures by introducing drives for implementing changes.

3.6 Quality Management

The maintenance activities are done by humans, which means mistakes will be made regardless of how rigorous the procedures are and how well they are trained. The errors by maintenance crew can have severe consequences, starting from small functional failures to catastrophes like derailment. So quality management in maintenance unit is essential so that the intended function of maintenance activity is satisfied and component can complete its designed lifespan.

Quality management also ensures that quality processes are embedded to maintenance practices so that proactive measures are taken to ensure that no failures occur rather than reactive measures which are taken after failures. Essentially, it involves:

- Establishing zero-defect conditions during maintenance activity by including quality practices.
- Preventing defects after maintenance activity by strictly keeping the test parameters within a standard range of values, and controlling operating parameters within standards.

- Predicting the possibility of defects by monitoring trends in the measured values, and taking preventive action.
- In case of failure, pinpointing the origin of failure and controlling the root cause so that its reoccurrence can be eliminated.
- Discouraging all the activities which do not comply with quality process and make them quality complaint.

3.7 Warranty Liability

Most parts or components in LHB coaches come under warranty for time period specified. It is provided by manufacturing unit of the railways or by original equipment manufacturer. But warranty are bound to terms and situations in which repairs or exchanges will be made in the event that the part or component does not function as originally described or intended.

Some common points to observe causing warranty to void are:

- Damage due to improper use, storage or handling of parts/components.
- Unauthorized alterations in mechanical/electrical system, engine, under truck or structure.
- Spare used in the assembly which does not meet the specification.
- Expired component used in assembly such as rubber components.
- Maintenance/repair/assembly carried out by untrained person.
- Improper operating conditions such as overloading, inappropriate sequence of operations etc.
- Improper repair and maintenance techniques such as electronic cards not removed during welding repair in the vehicle.

4 Safety, Health and Environment

Occupational Safety and Health

It is important to have all aspects of health and safety and to have strong focus on primary prevention of hazards that may sometimes cause grievous injuries to the maintenance staff. It is necessary to have factors affecting health and safety of maintenance staff evaluated from time to time. The terminology used related to safety and health in general terms are **Risk** - It is a combination of the probability that a particular outcome will occur.
Hazard - A hazard is something that can cause harm if not controlled.
Outcome - The outcome is the harm that results from an uncontrolled hazard.

Hazard identification

Hazard identification or assessment is an important step in the overall risk assessment and risk management process. It is where individual work hazards are identified, assessed and controlled/eliminated as close to source (location of the hazard) as reasonably as possible. A hazard-based program should be developed that may not be able to eliminate all risks, but also it should not accept satisfactory /risky outcomes.

Risk Assessment

The assessment should include practical recommendations to control the risk. Generally speaking, control measure should lower risk at an acceptable level. It should be kept in mind that risk management requires risk to be managed to a level

which is as low as is reasonably practical. Its main function is

- Identify the hazards.
- Identify all person affected by the hazard and how they are affected.
- Evaluate the risk.
- Identify and prioritize suitable & feasible control measures

Below are some common hazards related to safety and health commonly observed during day to day maintenance activities are:

- Hearing loss due to hazardous noise levels especially observed on people working for prolonged hours on engine testing, machining process and pneumatic horns.
- Injuries and fatalities due to fall from height.
- Injuries due to machines as they have moving parts, sharp edges, hot surfaces.
- Injuries, burns and impaired vision due to welding.
- Skin allergies due to contact of various petroleum based products and chemicals.
- Respiratory diseases due to inhalation of smoke, dust and fumes.
- Psychosocial problems which include risks to the mental and emotional well-being of workers, such as feelings of job insecurity, long work hours, and poor work-life balance.

4.1 Workplace Safety

To ensure a safe work environment, where assurance of occupational health and safety is the norm rather than an afterthought, a positive, strong safe work place environment is needed. Few points mentioned below broadly covers the factors and will help in improving workplace safety.

- Safety posters needed to be displayed throughout the maintenance units
- Properly stocked and maintained first aid kit should be available.
- All work areas are free from obstructions.
- All work areas should be properly illuminated.
- All work area should have proper ventilation.
- Fire extinguishers marked and maintained should be available at work area.
- Fork lift and overhead cranes to be operated by authorized person under supervision.
- Do not stay or work below suspended loads.
- All tools and equipments responsible for lifting loads, applying torque should be regularly tested for cracks and defects.
- When replacing individual parts and large sub-assemblies attach and secure the latter at the lifting tackle to avoid danger. Use suitable and technically proper lifting tackle only with a sufficient load-bearing capacity.
- Welding/brazing and cutting work in the maintenance area should be done under proper supervision.
- Prior to do welding, cutting, and grinding work, clean the repair area and its surroundings from combustible matter and ensure sufficient ventilation for danger of explosion.
- Stairs and walkways should be properly marked.

- Guard rails should be present in elevated areas.
- Anti slip surfaces should be ensured on stairs and slides.
- All tools and equipments have rotating/moving parts should have safety guards.
- Emergency mock drills to be carried out on timely to familiarize the maintenance staff in case of emergency
- Common gathering areas (in case of emergency) should be properly marked.
- All machinery and plant to be maintained and inspected regularly.
- Only authorized person to use specialized tools.
- All maintenance staff to wear personal protective equipments (PPE) at all times during working in the maintenance area.
- Safety audit to be carried out at regular intervals.

4.2 Working with Tools

Hand tools

All tools are manufactured with safety standards but accident often occurs before steps are taken to search out and avoid or eliminate tool-related hazards. In the process of removing or avoiding the hazards, workers must learn to recognize the hazards associated with the different types of tools and the safety precautions necessary to prevent those hazards.

- Impact tools such as chisels or wedges are unsafe if they have blunt heads. The heads might shatter on impact.
- Around flammable substances, sparks produced by iron and steel hand tools can be a dangerous ignition source.
- Tools such as spanner , pipe wrenched sockets etc. should not have worn out surfaces , it might slip during working and might cause injury
- Tools if not properly calibrated can cause the component / part to fail prematurely.
- Each tool should be tested regularly to check for cracks and other defects.
- Safety requires that floors and work surface to be kept as clean and dry as possible to prevent accidental slips with or around dangerous hand tools.
- Every tool has its defined working function and capability, except that that it should not be used for any other purpose. For example screw driver should not be used as chisel, spanner, torque wrenches should not used as lever to shift load.

Power tools

Power tools can be hazardous when improperly used. There are several types of power tools, based on the power source they use: electric, pneumatic, liquid fuel, hydraulic and powder-actuated. The following general precautions should be observed by power tool users:

- Never carry a tool by the cord.
- Never pull the cord to disconnect it from the switchboard.
- Keep cords away from heat, oil and sharp edges.
- Disconnect tools when not in use, before servicing, and when changing accessories such as blades, bits and cutters.

- All observers should be kept at a safe distance away from the work area.
- Secure work with clamps or a vise, freeing both hands to operate the tool.
- Avoid accidental starting. The worker should not hold a finger on the switch button while carrying a plugged-in tool.
- Tools should be maintained with care. They should be kept sharp and clean for the best performance. Follow instructions in the user's manual for lubricating and changing accessories.
- Be sure to keep good footing and maintain good balance.
- The proper apparel should be worn. Loose clothing, ties or jewelry can become caught in moving parts.
- All tools that are damaged shall be removed from use and tagged.

Guards

Hazardous moving parts of a power tool need to be safeguarded. For example, belts, gears, shafts, pulleys, sprockets, spindles, drums, fly wheels, chains, or other reciprocating, rotating or moving parts of equipment must be guarded if such parts are exposed to contact by maintenance staff.

Safety Switches

The following hand-held powered tools are equipped with a momentary contact on-off control switch: drills, tappers, fastener drivers, horizontal, vertical and angle grinders, other similar tools. These tools also may be equipped with a lock-on control provided that turnoff can be accomplished by a single motion of the same finger or fingers that turn it on.

Electric Tools

Among the chief hazards of electric-powered tools are burns and slight shocks which can lead to injuries. Under certain conditions amount of current can result in grievous injury. A shock also can cause the user to fall off a ladder or other elevated work surface. These general practices should be followed when using electric tools:

- Electric tools should be operated within their design limitations.
- Gloves and safety footwear are recommended during use of electric tools.
- When not in use, tools should be stored in a dry place.
- Electric tools should not be used in damp or wet locations.
- Work areas should be well lighted.

Powered Abrasive Wheel Tools

Powered abrasive grinding, cutting, polishing, and wire buffing wheels create special safety problems because they may throw off flying fragments. Before an abrasive wheel is mounted, it should be inspected closely and sound- or ring-tested to be sure that it is free from cracks or defects. To test, wheels should be tapped gently with a light non-metallic instrument. If they sound cracked or dead, they could fly apart in operation and so must not be used. A sound and undamaged wheel will give a clear metallic tone or "ring."

To prevent the wheel from cracking, the user should be sure it fits freely on the spindle. The spindle nut must be tightened enough to hold the wheel in place, without distorting the flange. Follow the manufacturer's recommendations. Care must be

taken to assure that the spindle wheel will not exceed the abrasive wheel specifications.

Due to the possibility of a wheel disintegrating (exploding) during start-up, the employee should never stand directly in front of the wheel as it accelerates to full operating speed. Portable grinding tools need to be equipped with safety guards to protect workers not only from the moving wheel surface, but also from flying fragments in case of breakage.

Pneumatic Tools

Pneumatic tools are powered by compressed air and include drills, hammers etc. Eye protection is required and face protection is recommended for employees working with pneumatic tools. Noise is another hazard. Working with noisy tools such as jackhammers requires proper, effective use of hearing protection. When using pneumatic tools, maintenance staff must check to see that they are fastened securely to the hose to prevent them from becoming disconnected.

Hydraulic Power Tools

Fluid used in hydraulic power tools must be as per specification and must retain its operating characteristics at the most extreme temperatures to which it will be exposed. Always check for overheating and allow cooling for specified time before continuous use.

The manufacturer's recommended safe operating pressure for hoses, valves, pipes, filters and other fittings must not be exceeded. Personal protective equipments must be used at all times as burst pressure lines can cause eye or skin injury.

Jacks

Jack whether lever and ratchet jacks, screw jacks and hydraulic jacks, make certain of the following points:

- Base rests on a firm level surface,
- Jack is correctly centered,
- Jack head bears against a level surface, and
- Lift force is applied evenly.

Proper maintenance of jacks is essential for safety. All jacks must be inspected before each use and lubricated regularly. If a jack is subjected to an abnormal load or shock, it should be thoroughly examined to make sure it has not been damaged.

- Both wires of an electric circuit;
- One wire of an energized circuit and the ground;
- A metal part that accidentally becomes energized due, for example, to a break in its insulation; or
- Another "conductor" that is carrying a current.

When a person receives a shock, electricity flows between parts of the body or through the body to a ground or the earth.

An electric shock can result in anything from a slight tingling sensation to immediate cardiac arrest. The severity depends on the following:

- The amount of current flowing through the body.
- The current's path through the body.
- The length of time the body remains in the circuit.
- The current’s frequency.

Most electrical accidents result from one of the following three factors:

- Unsafe equipment or installation.
- Unsafe environment.
- Unsafe work practices.

Some ways to prevent these accidents are through the use of insulation, guarding, grounding, electrical protective devices, and safe work practices.

Insulators

Insulators such as glass, mica, rubber, or plastic used to coat metals and other conductors help stop or reduce the flow of electrical current. This helps prevent shock, fires, and short circuits. To be effective, the insulation must be suitable for the voltage used and conditions such as temperature and other environmental factors like moisture, oil, gasoline, corrosive fumes, or other substances that could cause the insulator to fail.

Guarding

Guarding involves locating or enclosing electric equipment to make sure people don't accidentally come into contact with its live parts. Effective guarding requires equipment with exposed parts to be placed where it is accessible only to authorized people qualified to work with it. Recommended locations are a room, vault, or similar enclosure; a balcony, gallery, or elevated platform. Sturdy, permanent screens also can serve as effective guards.

Conspicuous signs must be posted at the entrances to electrical rooms and similarly guarded locations to alert people to the electrical hazard and to forbid entry to unauthorized people. Signs may contain the word "Danger," "Warning," or "Caution," and beneath that, appropriate concise wording that alerts people to the hazard or gives an instruction, such as "Danger/High Voltage/Keep Out."

Circuit protection

Circuit protection devices limit or stop the flow of current automatically in the event of a ground fault, overload, or short circuit in the wiring system. Well-known examples of these devices are fuses, circuit breakers, ground-fault circuit interrupters, and arc-fault circuit interrupters.

Fuses and circuit breakers open or break the circuit automatically when too much

current flows through them. When that happens, fuses melt and circuit breakers trip the circuit open. Fuses and circuit breakers are designed to protect conductors and equipment. They prevent wires and other components from overheating and open the circuit when there is a risk of a ground fault.

Safe Work Practices

Electrical accidents are largely preventable through safe work practices. Examples of these practices include the following:

- De-energizing electric equipment before inspection or repair.
- Keeping electric tools properly maintained.
- Exercising caution when working near energized lines.
- Using appropriate protective equipment.

4.5 Health Hazards

Health according to World Health Organization is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.

Work provides many economic and other benefits, but along with it comes workplace hazards which present risks to the health of maintenance staff at work. These mainly include chemicals, physical factors, adverse ergonomic conditions, psycho-social factors. It is important to safeguard health of maintenance staff caused by their working conditions and factors adverse to health, and help the adaptation of maintenance staff to his job. Some commonly faced health hazards are mentioned below

Chemical Factors

- Skin irritation or allergies due to skin contact of fuel, lubricants and chemical used in maintenance facilities.
- Respiratory allergies and diseases due to chemical inhalation such as Dye penetrant from spray during Non Destructive Testing , cleaning agents, welding fumes, smoke and dust.

Physical Factors

- Hearing impairment due to prolonged working in hazardous noise level such as engine testing, maintenance plant compressor room etc.
- Stiffness of muscles and backbone pain due to lifting of heavy loads.
- Vision impairment due to welding work without suitable control measures.

Psycho-Social Factors

- Inability to work or frustration due to poor ergonomic work conditions in the maintenance unit.
- Fear due to job insecurity or performance anxiety.
- Incompatibility among co-workers due to difference in language, beliefs and customs.
- Tiredness and frustration due to long working hours without proper rest periods.

4.6 Personal Protective Equipments

Personal protective equipment, commonly referred to as "PPE", is equipment worn to minimize exposure to hazards that cause serious workplace injuries and illnesses. These injuries and illnesses may result from contact with chemical, physical, electrical, mechanical, or other workplace hazards. Personal protective equipment may include items such as gloves, safety glasses and shoes, earplugs or muffs, hard hats, safety harness, vests and full body suits.

All personal protective equipment should be safely designed and constructed, and should be maintained in a clean and reliable fashion. It should fit comfortably, encouraging worker use. If the personal protective equipment does not fit properly, it can make the difference between being safely covered or dangerously exposed. Following points are necessary when using PPE.

- When it is necessary
- What kind is necessary
- How to properly put it on, adjust, wear and take it off
- The limitations of the equipment
- Proper care, maintenance, useful life, and disposal of the equipment.

All PPE used by maintenance personnel should have proper fit. PPE's having loose or improper fit are as good as nothing they might cause injury.

4.7 Precautions for Diesel Engines

Diesel Engine maintenance is dealt with either as a system comprising small items or individual larger items. In the latter case, especially, the choices are often considerable. Knowledge of machinery and equipment operation provides the basis for effective maintenance.

Prior to commencing a maintenance task on any piece diesel engine, other than routine tasks normally undertaken while the machinery is in motion, the responsible person is to ensure that the machine has been isolated from its power supply and cannot be inadvertently restarted. Appropriate cautionary notices are to be attached to the isolating device. The responsible person must also ensure that temperatures and pressures in the machine and associated pipe work have been reduced to safe levels prior to commencement of work.

It is particularly important to ensure that machinery capable of being remotely or automatically started has been positively isolated prior to commencement of maintenance.

This is of particular importance with regard to main and auxiliary engines starting, turning gear arrangements, hatch cover and machinery maintenance etc where inadvertent operation of controls whilst under maintenance may cause an accident.

Notices are to be placed at the appropriate stop buttons, local actuators and circuit breakers. A senior official must ensure that other staff are appropriately and adequately fore-warned about the works. Adequate supervision must be arranged according to the criticality.

No safety system is to be isolated without the permission of the concerned authority. When machinery guards or other safety devices are removed during overhaul, they are to be refitted immediately on completion of the work and before the machinery or equipment is tested. Before any machinery or equipment is opened for maintenance it is to be immobilized (locked out / tagged out) to prevent inadvertent starting, particularly when working with automatic or remote control equipment.

The concerned in charge must give careful consideration to any hazards involved before allowing maintenance or repairs to, or immediately adjacent to, moving machinery.

Fuel oil leaks from tanks and pipelines or other parts of the fuel oil system present a serious fire hazard and as such these leaks must be rectified immediately. Frequent inspections of fuel oil systems are essential to ensure that any leaks, which do occur, are quickly traced and rectified. If lagging on pipelines, covers/guards etc, becomes saturated with fuel oil, the affected material is to be removed immediately. It should be replaced with new material after repairing the leak.

The machinery spaces are to be maintained in as clean a condition as possible. In achieving a high standard of cleanliness and housekeeping the following will be essential: -

- Keep engine and its mounting bracket, covers/guards clean and free from oil and fuel deposits.
- Trace and stop any leakage of oil or water.
- Prevent overflow while refilling.
- Keep tank tops, floor plates, ladders, handrails etc, clean and free from oil.
- Tools and movable equipment must be stowed away properly when not in use.

4.8 Environment

Pollution is one of the primary causes of many of the other environmental concerns. Every maintenance unit needs to consider environmental concerns. It helps reduce the unit's impact on the environment while improving operating efficiency. While deciding maintenance strategy environmental concern should also be taken into account.

Some of the common environmental concerns in a maintenance unit are.

- Land pollution due to incompliance of plastic and solid waste management.
- Land and water pollution due to spillage and improper handling of fuel, lubrication oil and chemicals used in maintenance activities.
- Air pollution in and around maintenance unit due to activities such as engine testing, blowout activities and burning of plastic and solid waste.
- Noise pollution in and around maintenance unit due to engine testing, pneumatic horns testing, leakage in compressed air lines, machining operations etc.
- Land and water pollution due to improper disposal and mis-management of waste and water from cleaning.

4.9 Energy Management

The overall objective of the Energy Conservation Guidelines for maintenance & production units is to guide the management to manage energy consumption by standardizing the energy performance values of various energy consuming equipment and systems deployed for the production or maintenance process.

Energy Management Systems for a management shall have standing instructions for the following actions to study the efficient use of energy.

Standard Component	
A	The dedicated certified floor supervisor/manager will be responsible for monitoring and controlling energy use pattern within the industry.
B	The supervisor/manager shall ensure periodic monitoring activities for all major energy consuming equipment or system. The schedule may be yearly, seasonal, monthly, weekly, daily, or hourly, based on the type of requirements of the system or equipment. The performance results of the systems shall be improved, if the performance is lower than the desired value
C	The management shall review maintenance conditions and compare operating characteristics, performance deterioration, etc., to take remedial actions and improve the energy efficiency

Target Component	
A	The management shall undertake appropriate actions to achieve the energy efficiency in individual equipment as well as in the industry as a whole.
B	The management shall implement integrated and centralized automatic controls for various facilities (e.g. combustion, heat-using, WHR, cogeneration, electricity-using, air conditioning, ventilating, and lighting facilities) to improve the energy performance.