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सत्यमेव जयते

भारत सरकार GOVERNMENT OF INDIA

रेल मंत्रालय MINISTRY OF RAILWAYS

VANDE BHARAT EXPRESS TRAINSET (V2.0) MAINTENANCE MANUAL

Volume 1 - Maintenance Management

IRCAMTECH/GWL/2022-23/T-18/MM/2.0
SEPTEMBER, 2022

अग्रम संRDS
रेल अग्रदूत Transforming Railways

An ISO 9001-2015 Certified Organisation
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EXCELLENCE IN MAINTENANCE

Indian Railways
Centre for Advanced Maintenance Technology

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FOREWORD

This is the second revision of the Maintenance Manual for Vande Bharat Express (Train-set) brought out by CAMTECH. The first comprehensive and detailed Maintenance Manual was published by CAMTECH in August 2020.

Subsequently, 44 rakes as per revised specifications are planned to be manufactured at ICF, MCF, and RCF. The prototype rake of this batch has already been turned out by ICF in August'2022.

This Maintenance Manual for the second batch of 44 Vande Bharat rakes has been prepared to incorporate design changes incorporated by ICF. CAMTECH deserves all praise for bringing out such a well-documented and comprehensive guide for the use of our engineers.

Some of the new features like Kavach (Train Collision Avoidance System), Centralized Coach Monitoring System (CCMS) for monitoring air conditioning, communication and feedback to control center/ maintenance staff through a wireless network, Fire Safety Hazard Level HL2 as per EN 45545-1 and 2, Emergency operable windows, etc. has been added in the third rake.

The structure of the maintenance manual has been made in three volumes to facilitate easy understanding for the users. The third volume contains OEM documentation which will be helpful in a greater understanding of the specially designed systems and subassemblies used in the train set. Future revisions and changes will also be easier to issue and understand.

The need for periodic inspection and preventive maintenance of coaches to provide safety and comfort to traveling passengers cannot be over-emphasized. Recommended maintenance practices must be followed in the field, to provide trouble-free and comfortable service to passengers.

Those of us involved in maintenance must appreciate the importance of the right maintenance at the right time so that failures and unscheduled repairs of coaches are minimized. This will also minimize maintenance time and overall maintenance costs.

I express my gratitude towards, Shri Manoj Kumar (Director /Mechanical), Shri Himanshu Maheshwari (Joint Director /Electrical), Shri Siddharth Rakshit (SSE/Mechanical), Shri Kumar Chandra Shekhar (SSE/Mechanical), Shri B.C. Aggrawal (SSE/Electrical) & Shri Arvind Chaturvedi (SSE/Electrical) for finalizing this revised manual.

Future addition/deletions/modifications to this Manual shall be processed by CAMTECH/Gwalior with the approval of the Railway Board.

Date: September 2022

Jitendra Singh
Principal Executive Director
IRCAMTECH

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PREFACE

Indian Railways is one of the world's largest rail networks carrying around 2.3 million passengers daily. Indian Railways has been striving to modernize its rolling stock and infrastructure to increase speeds and also enhance safety for the passengers

Trainset is 16 car train with 4 basic units i.e. two end basic units (DTC MC-TC-MC2) and Two number of middle basic units (NDTC-MC-TC-MC2). These new rakes have reduced the number of coach variants from 8 to 6.

These rakes have 'world-class' passenger amenities such as on-board Wi-Fi and infotainment system, a larger pantry car, 32 Inches LCD Display Common for PIS and Infotainment, a GPS-based passenger information system, Kavach (Train Collision Avoidance System), CCMS, and plush interiors with diffused LED lighting.

To meet passengers' expectations and for making the journey more comfortable, Indian Railways introduced numerous technical innovations and intelligent solutions for various passenger amenities. Bio Vacuum Toilet system, Fire Detection and Suppression System for better fire safety, Automatic plug doors with sliding footsteps, Sealed Gangways, and Passenger Information System are a few mentionable features introduced.

This Maintenance Manual for the second batch of 44 Vande Bharat rakes version 2022 has been prepared with the inputs from ICF, RDSO, OEMs, and Railway Board instructions. Further suggestions from field units have been incorporated to make it more effective and practical.

This maintenance manual has been revised and compiled into three Volumes. The salient features of the revised maintenance manual are as under:-

i) The revised Maintenance Manual is divided into three Volumes.
ii) All the latest instructions and modifications issued by RDSO/ICF/OEMs have been included.
iii) Important dimensions, drawings, layouts, and references to RDSO technical instructions are enclosed.

Technological up-gradation, systems improvement, and learning are continuous processes. Please feel free to write us for any addition/modifications to this document.

Date: September 2022

Manoj Kumar
Director Mechanical
IRCAMTECH

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Contents

Quality Policy

"***We at IRCAMTECH Gwalior are committed to maintain and update transparent standards of services to develop safe, modern and cost effective railway technology complying with statutory and regulatory requirements, through excellence in research, designs and standards by setting quality objectives, commitment to satisfy applicable requirements and continual improvements of the quality management system to cater to growing needs, demand and expectations of passenger and freight traffic on the railways through periodic review of quality management systems to achieve continual improvement and customer appreciation. It is communicated and applied within the organization and making it available to all the relevant interested parties".***

Our Objective

To upgrade maintenance technologies and methodologies and achieve improvement in productivity and performance of all Railway assets and manpower which inter-alia would cover reliability, availability, utilization and efficiency.

CAMTECH is continuing its efforts in the documentation and up gradation of information on maintenance practices of railway assets. Over the years a large number of publications on railway assets have been prepared in the form of handbooks, pocket books, pamphlets & video films, etc. These publications have been uploaded on the internet as well as on the railnet.

For downloading these publications please do the following:

1. On the internet visit: www.rdso.indianrailways.gov.in Go to Directorates ➔ CAMTECH ➔ Publications for download➔Mechanical Engineering
2. On Railnet visit the RDSO website at 10.100.2.19 Go to Directorates ➔ CAMTECH ➔ Publications for download ➔Mechanical Engineering

For any further information regarding publications please contact:

Director /Mechanical

Landline - 0751 - 2470890

CUG - 9752447040

E-mail - dirmech@gmail.com

Fax- 0751- 2470841

Write us at:
Director (Mechanical)
Indian Railways Centre for Advanced Maintenance Technology
In front of Hotel Adityaz, Airport Road
Maharajpur, Gwalior (M.P), Pin code –474 005

Amendment and Revisions

The correction slips to be issued in the future for this report will be numbered as follows:

IRCAMTECH/GWL/2022-23/T-18/MM/2.0# XX date .....

Where “XX” is the serial number of the concerned correction slip (starting from 01 onwards).

Version	Date	Corrections	Remarks
1.0	AUGUST 2020	First Release	For the first and second rake of the VBE trainset manufactured by ICF.
2.0	SEPTEMBER 2022	Second Release	For 44 rakes of VBE trainset (third rake onwards).

1. Structure of Documentation

This Maintenance Manual provides maintenance instruction with procedures and guidelines for maintaining different systems and components. It focuses on various systems, components, procedures, and other related information to carry out maintenance activities. This manual should be used as a base document to frame maintenance guidelines for the maintenance activities of the vehicle.

For ease of readability and to explain the complex maintenance-related information to the end user effectively, the documentation has been divided into three volumes:

Volume -1: Maintenance Management
Volume -2: System Documentation
Volume -3: Original Equipment Manufacturer Documentation

1.1 Volume -1: Maintenance Management

Volume -1 is the introductory part of Maintenance documentation; here the concept of Maintenance and Maintenance Management has been explained. How emphasis on reliability will reduce avoidable failures and ultimately increase operational efficiency and its effect on the maintenance budget has been briefly explained. Occupational health with emphasis on safety and environmental factor has been included in this volume.

This volume also contains brief information about the structure of documentation and chapters in other volumes. It is expected from end users to go through **Volume - 1** before referring to **Volume - 2** and **Volume - 3**.

The topics covered in this volume are for introductory purpose and contain only brief description. In general all maintenance units to follow the general legal and other binding regulations related to quality, Occupational safety and health, environment, energy conservation etc.

1.2 Volume -2: System Documentation

This volume contains the technical details related to various systems, components, and structures in the vehicle. This part of the documentation also includes the details of other related systems/component-wise topics such as maintenance schedule, technical description, troubleshooting, etc.

1.3 Volume -3: Original Equipment Manufacturer Documentation.

This volume of the maintenance manual contains maintenance/ operational/installation-related documents from various OEMs associated with different systems and components of the vehicle.

All technical information & manual provided by OEM's are latest at the time of publishing and are subjected to change due to technology updates and requirements.

2 Documentation Management

2.1 Basic

The document is available in hard copy as well as in electronic format. To allow printing and reading of the manual on electronic devices across different platforms, all files of the documentation have been stored in PDF format.

Document e-file is available at IR-CAMTECH website publication page for download. Before referring the manual please ensure you have the latest issue available.

What is PDF?

Portable Document Format (PDF) is a file format used to present and exchange documents reliably, independent of software, hardware, or operating system. PDF is now an open standard maintained by the International Organization for Standardization (ISO). PDFs can contain links and buttons, form fields, audio, video, and business logic. They can also be signed electronically and are easily viewed using free Acrobat Reader DC software.

2.2 System Requirement for Adobe Reader DC software

Windows

- 1.5GHz or faster processor
- Windows Server 2008 R2 (64 bit), 2012 (64 bit), 2012 R2 (64 bit), 2016 (64 bit), or 2019 (64 bit); Windows 7 SP1 (32 bit and 64 bit), Windows 8, 8.1 (32 bit and 64 bit), or Windows 10 (32 bit and 64 bit)
- 1GB of RAM
- 450MB of available hard-disk space
- 1024x768 screen resolution
- Internet Explorer11

Macintosh

- Intel processor
- macOS v10.12, macOS v10.13, macOS v10.14, or macOSv10.15
- 1GB of RAM
- 380MB of available hard-disk space
- 1024x768 screen resolution
- Safari 10.0, or 11.0 (browser plug-in for Safari supported on 64-bit Intel processor only)

2.3 Installing Software

Follow these steps to install Acrobat Reader DC using Internet Explorer.

- Close all versions of Reader. Close any browser that is displaying a PDF.
- Go to the Adobe Acrobat Reader download page and click Install now.
- When the file download message appears at the bottom of the browser window, click Run.
- When you see the confirmation message that the installation is complete, click Finish.

2.4 Mobile Platforms

PDF files can be viewed on smartphones and portable devices. Following are the commonly used portable devices platforms where PDF files can be read.

- Android
- iOS
- Windows Phone.

Some portable devices and mobile phones have an inbuilt PDF reader with their operating system, so you will be not required to install reader software to view PDF files.

3 Maintenance & Reliability

Maintenance involves functional checks, servicing, repairing, or replacing necessary devices, equipment, machinery, and supporting utilities. Maintenance here can be broadly defined into two categories

- **Planned Maintenance** is where activities can be planned as per the requirement so that failures can be avoided and components and equipment achieve their service lifespan.

- **Unplanned maintenance** cannot be planned but all the activities have to be completed.

The modern concept to deal with maintenance activities is planning the schedule for maintenance of components and sub-assemblies and other utilities, which forms the balance between maintenance activities that can be planned to those which cannot be planned but are necessary. Thus the components can be used in a cost-saving way up to the limits of their expected service life.

3.1 Planned Maintenance

Planned maintenance is a type of maintenance that is done at a regular intervals while the equipment is still functioning with the objective of preventing failure or reducing the likelihood of failure.
Planned maintenance can be time-based i.e. every week, every month, etc., Or usage-based for example every 150 cycles, every 10,000hrs, etc. Or distance traveled based for example every 10,000km.
Planned maintenance objectives are

- To avoid premature failures.
- To reduce functional failures
- To ensure the availability as per requirement.

Planned maintenance activities include safety checks, trip inspections, preventive maintenance, and overhaul and custom modifications.

Safety checks

Safety checks shall be carried out to detect damage to components if any which resulted from external influences during operation which might be the consequence of various factors. From a technical point of view, safety checks are not required in any case, however, are recommended as preventive measures. Visible damage to sub-assemblies and components will thus be recognized early which might under certain circumstances result in serious consequential damage to the equipment and life. The relevant precautions thus limit unplanned failures and casualties and thus reduce overall costs. Safety Inspection is carried out by the driver before the

beginning of the travel or by the maintenance staff during the incoming or at the release of the vehicle after completion of the maintenance schedule.

Trip Inspections

The trip inspections as part of the planned maintenance work are carried out primarily to assess the condition of coaches and their components. Primarily, the trip inspection is related to functioning, safety, and maintenance. The results of the incoming/outgoing inspections in the trip schedule are documented and evaluated as a requirement. Corrections are made immediately, if necessary. Comprehensive measures are planned and carried out as soon as possible.

Preventive Maintenance

Preventive maintenance includes the checking of functions, measuring and comparing with specified reference values, adjustment and optimization, proper cleaning and lubricating of the mechanical units, and replacement of scheduled components and assemblies. Repair work and replacement of wearing parts are carried out during the maintenance activities.

Planned repair work is done primarily according to the results of incoming/outgoing inspections or analysis. Parts will be subject to preventive repair and are replaced if functional troubles are expected before the next maintenance interval.

All faults reported by the operating crew / Loco Inspectors or recorded by the vehicle's recorder must be attended by the maintenance staff. A decision should be made here between faults which affect the operation or represent a reduction in the operating characteristics and must thus be eliminated immediately or those which can be eliminated more conveniently during the next maintenance schedule of the vehicle concerned and which are can planned accordingly. Comprehensive system knowledge both in the electrical/electronic/mechanical sector and operating is required to eliminate failures.

Custom Modifications

Custom modifications in various systems/assemblies and components may be required to meet operational requirements, reduce failures, or improve efficiency. As per requirement custom modification can be deferred or can be completed on a priority basis.

Overhaul

Overhauling is required depending on various factors to get the desired performance. Factors that decide the overhauling period are

- Age.
- Hours of operation.
- Specification by the manufacturer.

3.2 Unplanned Maintenance

As discussed in planned maintenance visible defects due to wear are eliminated by replacing or renewing components. Even if these preventive measures are carried out with utmost care it is not possible to prevent all failures of components due to wear, aging or loading, or other external factors. The functional and operating failures which occur due to these influences require work and repairs which are called unplanned maintenance repair works. This type of maintenance requires repairs to

be attended to immediately but in some cases, it can be deferred as per operational requirements.

3.3 Recording the Maintenance

Recording the maintenance and servicing work carried out is vital. This helps in:

- Processing of guarantee claims and keeping a record of that.
- Conclusions can be drawn about the provision of spare and wearing parts.
- Analysis of failure trends in a particular component or a system.
- Performance evaluation of components.
- For future research and development.

The following data must be recorded during the maintenance and servicing measure:

- Date of Incoming, Outgoing, and activities
- Time
- Maintenance or repair details carried out by Maintenance personnel, approving authority
- Serial number/Component number
- Hours of operation/kilometer coverage
- Measures initiated: Description of activity and fault elimination
- In case of fault: Type of damage/place of installation/cause of the damage(if known)
- In case of failure: Complete detail of failure including the statement of the operating crew.
- The material used: Material description, Identification number (PIL) of the new component installed
- Time expenditure
- Dead time (if necessary)

Or any other information necessary for efficient maintenance may be included.

3.4 Reliability

Reliability is the ability to consistently perform its intended function without degradation or failure. The maintenance strategy is designed keeping in mind the reliability factor, otherwise, the principal risk factors that arise due to failure are:

- Safety
- Operational Effectiveness
- Maintenance budget

Successfully implementing a maintenance strategy that is based on reliability improvement will lead to an increase in cost-effectiveness, reduced maintenance, and a greater understanding of the level of risk that the maintenance unit is managing due to the sudden failure of equipment or component.

The reliability-based maintenance for effective functioning should address the below-mentioned seven questions.

1	**What is the part/component supposed to do and its associated performance standards?**

2	**In what ways can it fail to provide the required functions?**
3	**What are the events that cause each failure?**
4	**What happens when each failure occurs?**
5	**In what way does each failure matter?**
6	**What systematic task can be performed proactively to prevent, or to diminish to a satisfactory degree, the consequences of the failure?**
7	**What must be done if a suitable preventive task cannot be found?**

3.5 Failure Investigation

As discussed in the topic - 3.4 principal risk factors which arise due to failure are safety, operational effectiveness, and maintenance budget. Safety is the most important factor among them, failures of critical items and components in rolling stock may possess the danger of severe consequences such as derailment. In the second part failure of a component or part may fail the system as a consequence which results in delay or blockage which affects operational effectiveness. Finally, every maintenance schedule is designed to cater to the technical and operational needs to run the VEHICLE for a specified time duration, due to failure maintenance needs to be done before the schedule which affects the maintenance budget.

Failure investigation is the process of analyzing the component data or the component itself to determine the reasons for degraded performance or catastrophic failure of a component and to take corrective actions or fix liability. To determine the root cause of a failure, advanced analysis techniques may be employed not just to verify compliance of the part to the defined assembly but to determine the origin of the observed failure mechanism. It is important to know as much detailed information as possible. They may include

- Technical Specification of the component.
- Storage condition before fitment.
- Handling before fitment.
- Compliance with guidelines during its fitment.
- Condition and calibration of tools and equipment used.
- Failure history of components from the same manufacturer.
- Failure history of similar components from a 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 the 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's 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 with 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 the maintenance crew can have severe consequences, starting from small functional failures to catastrophes like derailment. So quality management in the maintenance unit is essential so that the intended function of maintenance activity is satisfied and a component can complete its designed lifespan.

Quality management also ensures that quality processes are embedded in 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 the quality process and making them a quality complaint.

3.7 Warranty Liability

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

Some common points to observe causing the 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.
- The expired component used in an assembly such as rubber components.
- Maintenance/repair/assembly is carried out by an untrained person.
- Improper operating conditions such as overloading, inappropriate sequence of operations, etc.
- Improper repair and maintenance techniques such as electronic cards not being 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 a strong focus on the primary prevention of hazards that may sometimes cause grievous injuries to the maintenance staff. It is necessary to have factors affecting the health and safety of maintenance staff evaluated from time to time. The terminology used related to safety and health in general terms is

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 the 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 measures should lower risk at an acceptable level. It should be kept in mind that risk management requires risk to be managed to a level that is as low as reasonably practical. Its main function is

- Identify the hazards.
- Identify all people 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 is especially observed in 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, and hot surfaces.
- Injuries, burns, and impaired vision due to welding.
- Skin allergies due to contact with 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 workplace environment is needed. A few points mentioned below broadly cover the factors that will help in improving workplace safety.

- Safety posters needed to be displayed throughout the maintenance units
- A 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 areas should have proper ventilation.
- Fire extinguishers marked and maintained should be available in the work area.
- Forklifts and overhead cranes are to be operated by an authorized person under supervision.
- Do not stay or work below suspended loads.
- All tools and equipment responsible for lifting loads, and 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.
- Before doing welding, cutting, and grinding work, clean the repair area and its surroundings from combustible matter and ensure sufficient ventilation for the 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 equipment that have rotating/moving parts should have safety guards.
- Emergency mock drills are to be carried out in a 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 are to be maintained and inspected regularly.
- Only authorized persons use specialized tools.
- All maintenance staff is to wear personal protective equipment (PPE) at all times during working in the maintenance area.
- Safety audits are 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 spanners, pipe-wrenched sockets, etc. should not have worn-out surfaces, they 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 surfaces 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 it should not be used for any other purpose. For example, a screwdriver should not be used as a chisel, and a spanner and torque wrenches should not be used as a 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 a 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, and 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 the use of electric tools.
- When not in use, tools should be stored in a dry place.
- Electric tools should not be used in 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

The 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 a 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 equipment 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:

- The base rests on a firm-level surface,
- Jack is correctly centered,
- Jack's 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.

4.3 Fire Safety

Fire is a chemical reaction that requires three elements to be present for the reaction to take place and continue. The three elements are:

- Heat, or an ignition source
- Fuel
- Oxygen

These three elements typically are referred to as the "***fire triangle***".

Ignition sources can include any material, equipment, or operation that emits a spark or flame—including items, such as torches, as well as less obvious items, such as static electricity and grinding operation. Fuel sources include combustible materials, such as wood, paper, trash, and clothing; flammable liquids or solvents, and flammable gases.

Fire Protection and Prevention

- Awareness posters should be posted in all regulated areas.
- All work areas will be kept free of debris and other combustible materials.
- In the maintenance area and on office premises fire extinguishers should be placed in designated areas.
- No employee will be permitted to use an extinguisher without having been fully trained.

Only trained personnel are allowed to operate fire extinguishers. Wrong operation of fire extinguishers might result in the personal injury.

Flammable and Combustible Liquid Storage

- Flammable liquids or gases will be kept away from heat and ignition sources including welding work or any other operation involving flames or sparks.
- Buildings or structures containing flammable liquids or gases must be constructed of fire-resistant material.
- All containers will be labeled per standard.
- Electrical installations in fuel storage areas - special precautions to be taken.

Handling Flammable and Combustible Liquids

- During refueling operations, proper precautions are to be taken.
- Open flames or other ignition sources must be kept away from flammable or combustible liquids.
- Smoking is strictly prohibited during the fueling handling process.
- When flammable liquids and gases are being transported, all rules will be followed.

Fire Extinguishers

- In buildings, all fire extinguishers will be mounted on a wall and properly marked.
- All vehicles will carry designated fire extinguishers.
- When at a maintenance site, all employees will know the location of each fire extinguisher.
- Before using an extinguisher, all employees will be trained and familiar with the PASS method of firefighting.
- Each fire extinguisher will be inspected at a specified interval to make sure it is in its designated location and has not been tampered with or actuated.
- Each fire extinguisher will be visible with nothing obstructing it from view.

4.4 Controlling Electrical Hazards

Electricity has long been recognized as a serious workplace hazard, exposing employees to electric shock, electrocution, burns, fires, and explosions. Electricity flows more easily through some materials than others. Some substances such as metals generally offer very little resistance to the flow of electric current and are called “conductors." A common but perhaps overlooked conductor is the surface or subsurface of the earth. Glass, plastic, porcelain, clay, pottery, dry wood, and similar substances generally slow or stop the flow of electricity. They are called “insulators."

Electricity travels in closed circuits, normally through a conductor. But sometimes a person's body -- an efficient conductor of electricity -- mistakenly becomes part of the electric circuit. This can cause an electrical shock. Shocks occur when a person's body completes the current path with:

- 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 the 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 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 electrical hazards 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 that present risks to the health of maintenance staff at work. These mainly include chemicals, physical factors, adverse ergonomic conditions, and psycho-social factors. It is important to safeguard the health of maintenance staff caused of their working conditions and factors adverse to health help the adaptation of maintenance staff to their job. Some commonly faced health hazards are mentioned below

Chemical Factors

- Skin irritation or allergies due to skin contact with fuel, lubricants, and chemicals 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 levels such as engine testing, maintenance plant compressor room, etc.
- Stiffness of muscles and backbone pain due to the 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 the difference in language, beliefs, and customs.
- Tiredness and frustration due to long working hours without proper rest periods.

4.6 Personal Protective Equipment

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 harnesses, vests, and full-body suits.

All personal protective equipment should be safely designed and constructed and should be maintained cleanly and reliably. 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. The 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 Environment

Pollution is one of the primary causes of many 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 on maintenance strategy environmental concerns should also be taken into account. Some of the common environmental concerns in a maintenance unit are.

- Land pollution due to the 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 the maintenance unit due to activities such as engine testing, blowout activities, and burning of plastic and solid waste.
- Noise pollution in and around the 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 mismanagement of waste and water from cleaning.

4.8 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 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 patterns 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 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 energy performance.

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