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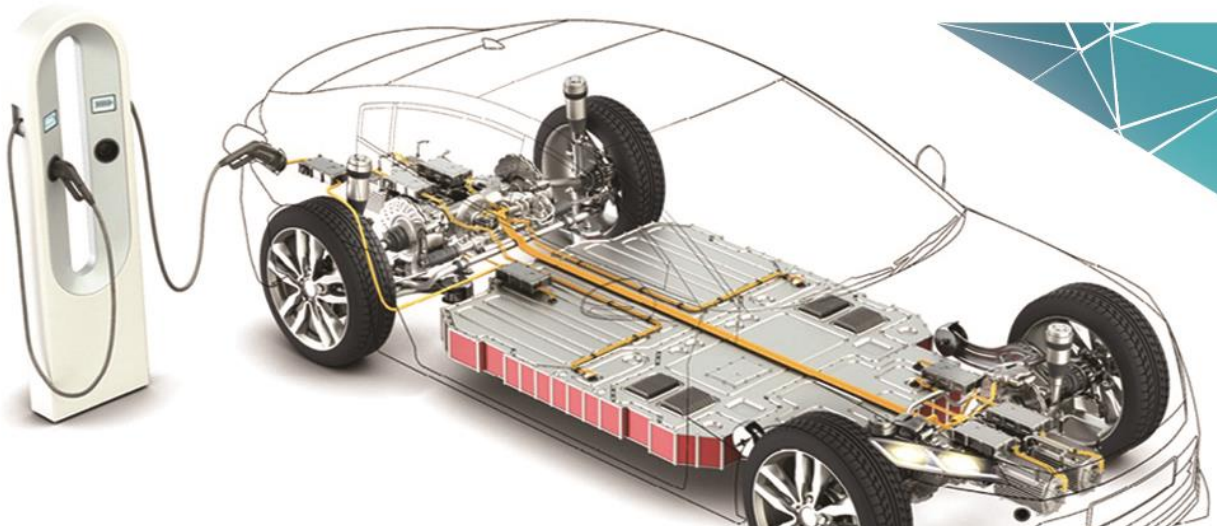
Power Sector Skill Council

EV CHARGING STATION TECHNICIAN

Technical HANDBOOK



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Acknowledgements

USAID is grateful to the leadership of Mr. Vishal Kapoor, CEO, EESL (former Joint Secretary (Distribution), Ministry of Power (MoP), Government of India); and guidance in identifying the training requirement for the electric vehicle charging station technicians.

USAID is thankful to Late Mr. Ravi P. Singh, CEO, Power Sector Skill Council (PSSC) and Mr. Prafulla Pathak, Secretary, Power Sector Skill Council (PSSC) for his guidance and support in producing this training guide.

I would like to thank the SAREP team, comprising Mr. Rakesh Goyal, Mr. Sumedh Agarwal, Mr. Vinod Bihari, Ms. Chandana Sasidharan and Ms. Anindya Upadhyay, for their support in developing this 'Training Guide for Electric Vehicle Charging Stations for Technicians' and also in training the trainers who will eventually impart training to the technicians.

I wish to acknowledge the contributions of International Copper Association and experts, including Satish Kumar Singh, Jay Ojha and S Gautham from Fichtner Consulting Engineers India for their time and effort in preparing this training guide.

I sincerely hope this document supports and contributes to the Government of India's goals to promote electric mobility through the development of a skilled workforce for the deployment of charging stations in the country.

Apurva Chaturvedi

Senior Clean Energy Specialist at USAID/India

Foreword

South Asian region has in the recent years, witnessed considerable growth in usage of electric vehicles (EVs) as a means of public and private transportation. In the context of India, EV assumes strategic significance for the reason that it enables reducing dependence on imported crude oil and thus improves its balance of trade position. Another compelling reason for its growing usage remains thereby ensuring a pollution free environment and help in meeting India's global commitments towards reducing carbon emissions.

The Government of India has been taking several policy initiatives such as National Electric Mobility Mission 2020, Faster Adoption and Manufacturing of (Hybrid and) Electric Vehicles (FAME) Phase I in the year 2015 and Phase 2 in 2019 to promote use of electric vehicles. Apart from financial incentives towards purchase and use of EVs, charging stations have been declared as a delicensed activity. Ensuring adequacy of public charging infrastructure is a critical aspect for electrification of transport. With the increase in the number of EVs on the road, public charging stations are likely to witness a phenomenal growth in the years to come offering huge employment potential.

The challenge that emerges thus is to ensure availability of a well skilled cadre of technicians to install, commission and operate the growing number of charging stations. To deliver on this, USAID's South Asia Regional Energy Partnership Program (SAREP) joined hands with Power Sector Skill Council to develop this critically needed Training Content that will be used to build and enhance capacity and create a pool of human resources that are expected to contribute immensely to this task of national importance. I am sure this handbook will prove an important learning resource for them.

I would like to acknowledge the important role played by SAREP program and Power Sector Skill Council towards developing this Training Handbook that would help develop the skill and knowledge in installation and operation of charging stations across the country and would thus help reduce carbon emissions to a significant measure.

John Smith-Sreen

Director, Indo-Pacific Office, USAID/India

Foreword

PSSC promoted by Ministry of Power (Central Electricity Authority), Ministry of Power, Govt. of India, Ministry of New & Renewable Energy (MNRE), Govt. of India and Indian Electrical & Electronics Manufacturers' Association (IEEMA) is mandated to facilitate the cause of skill development across power sector to ensure availability of readily certified workforce for employability across job roles covering areas of Power Generation, Transmission, Distribution, Distribution Downstream, Renewable Energy, Power Equipment Manufacturers etc. PSSC was to ensure availability of readily employable skill-trained and certified workforce, eventually benefitting the power utilities, manufacturers, and other organizations.

In view of the rigor and complexity of job roles, development of content aligned to QP/NOS posed a great challenge. We took upon this task in right earnest and with great deal of efforts, have been able to develop Curriculum and Contents using the internal capability within PSSC and also drawing upon support of external resource persons well versed with the subject. We have recently successfully completed the development of "**Participant Handbook" for "Electric Vehicle Charging Station-Technician**".

We, gratefully acknowledge valuable contribution and support from industry members and associations, power utilities and other stakeholders, who have enabled us to complete the task of developing this document successfully.

Further, we wish to place on record our appreciation for the work put in by the team of USAID and ICA who have extended their valuable support and supervision enabling us to complete the process.

While we trust that the above publication meets the complete requirements of QP/NOS based training delivery of "**Electric Vehicle Charging Station-Technician**" job role, we would indeed welcome suggestions from readers, experts, and other stakeholders for any improvement in future.

Prafulla Pathak

Secretary, PSSC

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INTRODUCTION

1. INTRODUCTION

Key Learning Objectives:

The trainees will be able to understand:

- The evolution of electric vehicles
- The need for charging infrastructure
- Electric vehicle terminology
- How to charge electric vehicles using charging connectors
- The components of electric vehicle charging systems

1.1 EVOLUTION OF ELECTRIC VEHICLE CHARGING SYSTEM

Since the first appearance of electric vehicles (EV) in the mid-19th century, there has been a need for EV charging technology. The first EVs had disposable batteries, wherein charging was done by replacing dead batteries. Invention of rechargeable batteries meant that new EV models had the possibility to use the same batteries without replacement. All the early models of EVs were not mass made so there was no need for commercial charging stations. Until early 20th century, many homes were without electricity, and that meant it was impossible to charge the vehicle at home. Electrification of homes meant that EVs would be more accessible to public. This would mean that more and more people would buy and use EVs.

The EV charging market has always been fragmented. However, the consolidation and evolution of EV charging systems have led to the assumption that the market stands on the threshold of disruption. EV charging systems are still undergoing change, as illustrated in below figure.

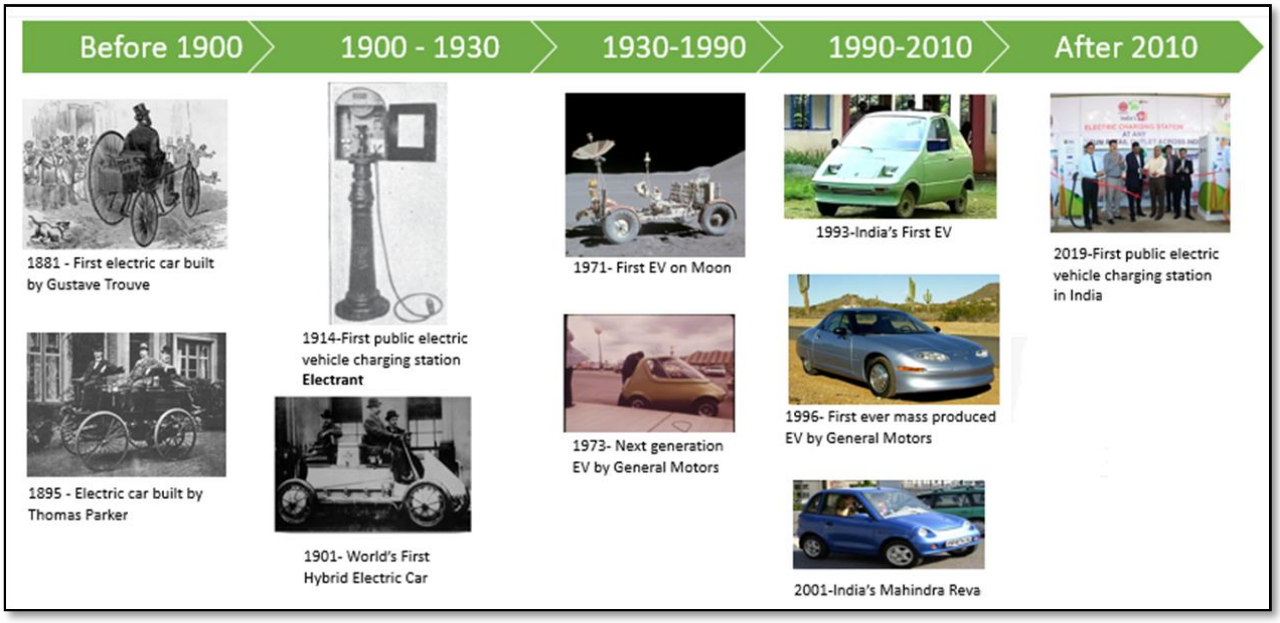


FIGURE 1-1: EVOLUTION OF EV CHARGING SYSTEM

Charge point owners (points of interest), such as shopping centers, restaurants, and gas stations, need to cope with the improved charging performance of new electric vehicles. They need to upgrade their infrastructure to higher charging speeds. This is especially true as drivers of battery electric vehicles (BEVs), with battery capacities of 90kWh and more, demand charging speeds of at least 150kW for public charging incidents.

Charge point operators are currently the most active players along the public EV value chain. As the network of charging points is wide meshed in most markets, growth potential still comes from improved geographical coverage. Besides building up new locations on their own, CPOs may offer customized turnkey solutions to B2B and B2A customers and operate them as full-service providers (at least technically) after deployment. Simultaneously, bigger CPOs are starting to aggregate other CPOs to grow (i.e., in terms of charging network size, customers and revenues) and leverage scale effects. This is a win-win situation for both sides, as operation of additional charging points creates only marginal costs for the aggregating CPO, and the smaller, integrated CPO no longer needs to invest in proprietary costly software solutions.

1.1.1 EMERGING EV CHARGING SYSTEM

- **Vehicle-to-Grid Service (V2G):** The EV battery is used to provide flexibility to the electricity grid, and the EV owner receives a financial contribution for making their EV available. Feasibility and profitability of the technology are related to countries' regulation and incentive mechanisms.
- **Vehicle-to-Home Service (V2H):** The EV battery is used as an energy supplier in case of a blackout, for peak shaving, and as an energy management system that reduces energy costs. V2H technology requires – apart from EVs that manage "reverse flow" – a "smart home" whose main domestic appliances are connected and remotely managed.

Electric vehicle charging alone is not yet a profitable business, but margins will increase as business models sharpen and volumes rise. Today's business model and offerings are very similar and switching between suppliers is easy for customers. To become profitable, most players are heading for scale, consolidations, and acquisitions. This lowers fragmentation and forces all players to evolve beyond their classic roles.

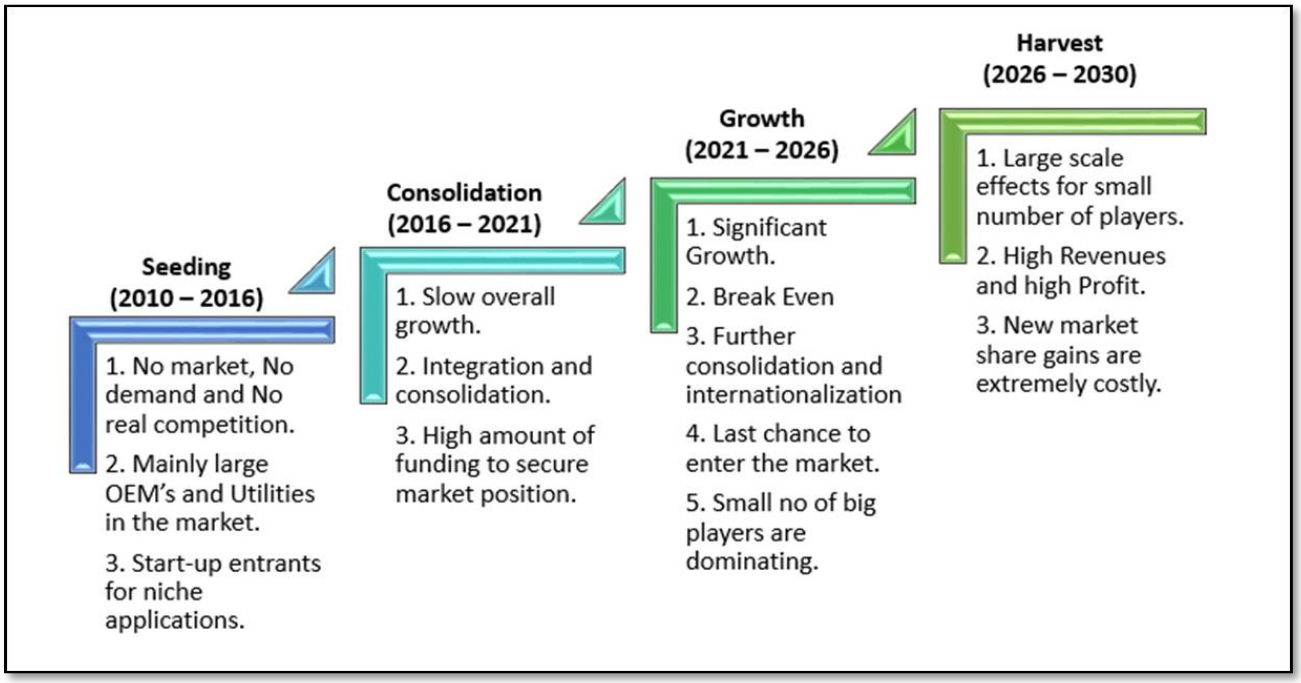


FIGURE 1-2: MARKET STAGES OF PUBLIC EV CHARGING SYSTEM

About Electric Vehicle Charging System

Electric vehicles (EV) can be charged in a variety of ways, depending on location and requirement. Accordingly, charging infrastructure for EVs is of different types and designed for different applications. Specifications and standards for EV chargers, also known as Electric Vehicle Supply Equipment (EVSE), vary from one country to another based on available EV models in the market and the characteristics of the electricity grid. EV charging involves supply of direct current (DC) to the battery pack. As electricity distribution systems supply alternate current (AC) power, a converter is required to provide DC power to the battery. The following abbreviations and definitions related to electric vehicle and charging system will be part of further sections in this handbook:

- EV – Electric Vehicle

  An electric vehicle (EV) is a vehicle that is propelled by an electric motor, powered by one or more sources of electricity such as battery, solar panels, fuel cells, generator, etc.

- BEV – Battery Electric Vehicle

  A battery electric vehicle (BEV) is an EV that is propelled by an electric motor, powered by a battery.

- HEV – Hybrid Electric Vehicle

  A hybrid electric vehicle (HEV) is a vehicle that combines an internal combustion engine with an electric motor, powered by a battery. The electric motor is used as a power boost or to drive the vehicle at low speeds for a short distance. The battery in a HEV is charged by the engine or through regenerative braking.

- PHEV – Plug-in Hybrid Electric Vehicle

  A plug-in hybrid electric vehicle (PHEV) is a HEV with a bigger battery that can be recharged by plugging a charging cable into charging system. A PHEV can be driven by the electric motor at higher speeds and for longer distances.

- EVB – Electric Vehicle Battery

  An electric-vehicle battery (EVB, also known as a traction battery) is a battery used to power the electric motors of an EV, HEV, or PHEV. The EVB consists of multiple cells in parallel and series configurations.

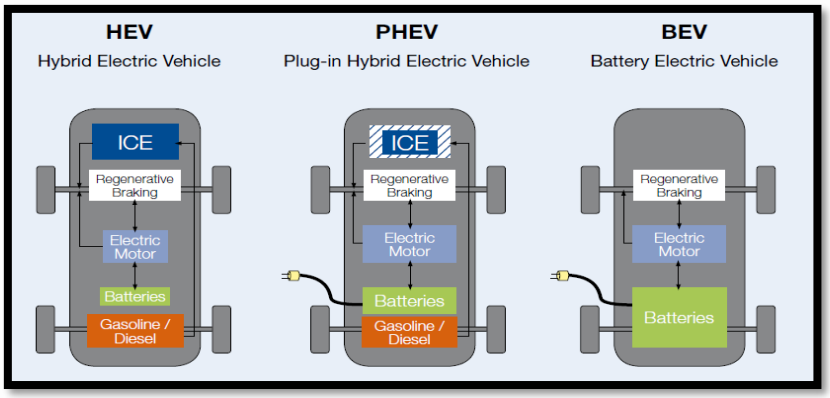


FIGURE 1-3: TYPES OF EV POWERTRAIN

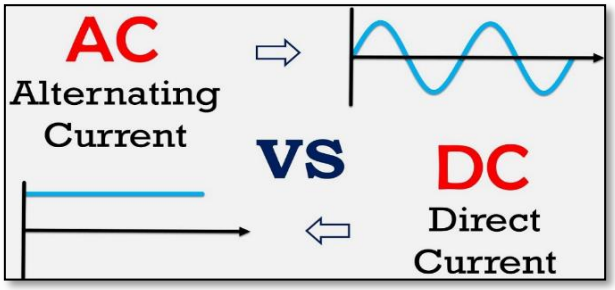
- AC – Alternating Current

  Alternating current (AC) is an electric current that periodically reverses direction and changes its magnitude continuously. All electric power available from the grid is in the form of AC and can be

converted into DC by using a rectifier. Based on the capacity of power to be converted, the number of rectifiers required to convert the AC power to DC power may be decided.

- DC – Direct Current

  Direct current (DC) is one-directional flow of electric charge. Electric power generated from solar, wind, etc. is in the form of DC. Batteries can only take in DC power. DC can be converted into AC by using an inverter.



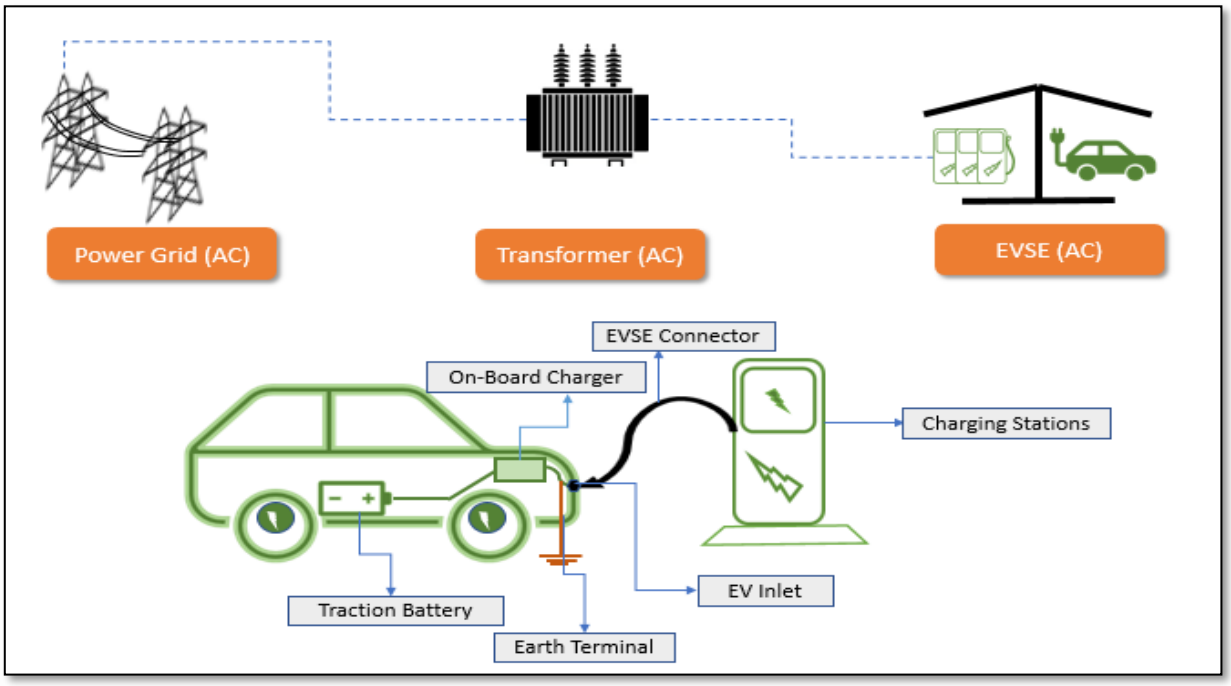


FIGURE 1-4: AC V/S DC SYSTEM

- Regenerative Braking

  Regenerative braking is an energy recovery mechanism that slows down an EV, HEV or PHEV by converting its kinetic energy into electrical energy that can charge the traction battery.

- Portable Charger

  Almost all EVs come with a portable charger that can be plugged into a 15 Amp AC wall socket on one end and into an EV on the other end. Some of the portable chargers, especially for 2-wheelers and 3-wheelers, convert AC to DC before sending power to charge the EV battery. The maximum power for most portable chargers is 3.3 KW.

FIGURE 1-5: PORTABLE EV CHARGER

- Onboard Charger

  The onboard charger is present in the vehicle and converts AC power from the charging station or electrical socket to DC power to charge the EV battery.

FIGURE 1-6: EV ON-BOARD CHARGER

- EVSE Connector

  The EVSE connector is a plug that connects to an EV or PHEV on one end and the EVSE on the other end. The electrical power and communication between the charging station and EV are part of this connector.

FIGURE 1-7: TYPES OF EVSE CONNECTORS

Vehicle-to-Grid Service (V2G)

Vehicle-to-grid technology involves drawing unused power from the car into the smart grid. V2G, which is also known as vehicle-grid integration (VGI), can help the energy grid supply electricity during peak hours.

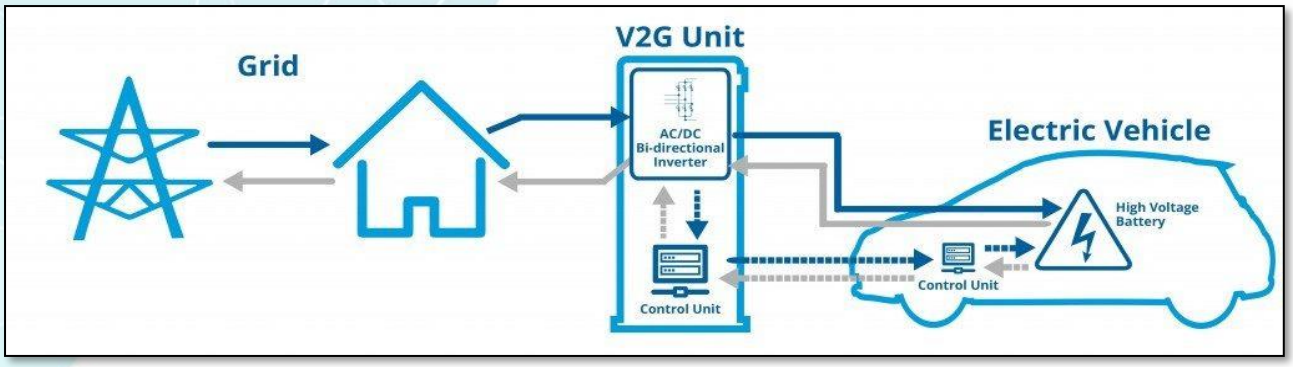


FIGURE 1-8: VEHICLE –TO– GRID (V2G)

- Vehicle-to-Home service (V2H)

  A Vehicle-to-Home (V2H) system enables customers to store home generated renewable energy in their car battery by charging it when energy tariffs are low or even free. Customers can then draw energy out to power their home when it is needed, or tariffs are high.

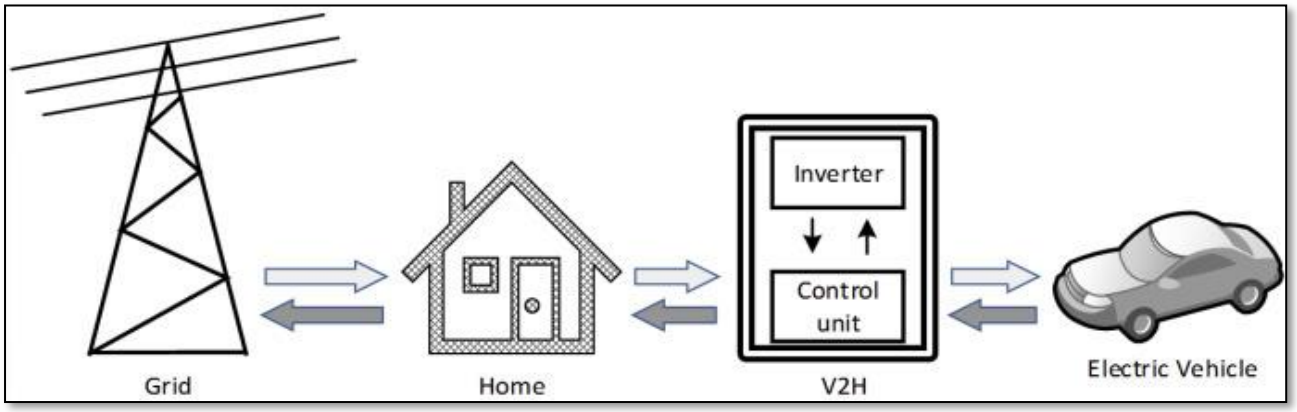


FIGURE 1-9: VEHICLE – TO – HOME (V2H)

- OEM - Original Equipment Manufacturer

  An original equipment manufacturer (OEM) is a company that manufactures parts or equipment.

- EVSE – Electric Vehicle Supply Equipment

  Electric vehicle supply equipment (EVSE) or commonly called an EV charging station, delivers electrical energy to charge an EV or PHEV.

1.1.2 COMPONENTS OF ELECTRIC VEHICLE SUPPLY EQUIPMENT (EVSE)

Electric vehicle supply equipment (EVSE) or commonly called an EV charging station, delivers electrical energy to charge an EV or PHEV. The setup normally consists of:

- Power Input

  Input power supply to the EVSE could be single-phase (240 VAC) or three-phase (415 VAC), based on the type of EVSE.

- EVSE

The EVSE is a singular box which contains one or more of the following:

- ✓ Power supply
- ✓ Energy metering
- ✓ Rectifier (for DC charging stations)
- ✓ Electrical protections (short circuit, ground fault, over current, over / under voltage, etc.)
- ✓ Communication with EV
- ✓ Cloud communication
- ✓ User authentication mechanisms (RFID, QR code, etc.)
- ✓ Contactors / relays

- Power Output

  Power to the vehicle is supplied through sockets, plugs or connectors or a mix of any two or more. Communication between the charging station and EV also happens through this cable. Every EVSE can normally charge one, two or three EVs at a time. Types of EV chargers, AC and DC and their charging modes will be discussed in details in section 5.2.2.

1.1.3 TYPES OF EVCS AND FUTURE TRENDS

The description of each of the various EV charging technologies and future trends are provided as follows:

- ✓ *Conductive Charging*— charging the EVs battery with the use of a power cable or charging cable (direct contact) is classified as conductive EV charging. The charger or cable will be directly in contact with the vehicle charger to charge the battery in a controlled manner. It should be noted that the grid power is Alternating Current (AC) and battery is a Direct Current (DC) Source, and the charger converts the AC to DC power needed for the battery. Conductive charging systems are commonly of two types: AC charging or DC charging based on the location of the charger. In the case of AC charging the charger is on-board the vehicle or part of the connecting cable, and in this case AC power from the grid is supplied to the vehicle at the charging point. In the case of DC charging the charger is part of the EVSE and hence DC power is supplied directly to the vehicle.

- ✓ *Non-Conductive Charging*—Charging the EV battery without any direct contact with the vehicle. The charging takes place wirelessly from the charger or wireless induction pads to the receiving induction pad inside the EVs using high-frequency RF signals (in the range of kHz). EVs collect electric power for their batteries from buried high-frequency power cables under the road or charging station surface through magnetic induction or inductive charging. This type of charging can be done when the vehicle is stopped (static charging) or vehicle is moving (dynamic charging). It should be noted that in this case of charging, only AC power transfer is done wirelessly, and conversion for AC to DC to charge the vehicle needs to be done through on-board charging equipment. The main advantage of this type of charging is no cables, safety, and reduction in battery size of the vehicles. The disadvantage is slow charging, only applicable for AC charging and not for DC charging, costly, and lower efficiencies of wireless charging system.

- ✓ *Solar-Powered Charging*— Distributed solar photovoltaic generation from rooftop panels and microgrids can also charge EVs. In some electric vehicles solar panels are integrated as part of the vehicles itself. The charging process is like conductive charging, but the input source for the on-board charger will be the DC power generated from the solar PV modules connected directly through a cable/ wire. The advantage of solar powered charging is that it can supplement and complement grid powered charging in areas of limited

grid availability or reliability. However, in the case of a standalone solar powered charging station, the electric power available to charge is available during the daytime and varies with the changes in solar radiation or cloud cover.

- ✓ *Battery Energy Storage Systems (BESS)*— The electrical energy is stored in the form of a battery or group of batteries depending on the electricity requirement for charging the battery. It is a type of conductive charging. As this is a battery-to-battery charging, this is DC charging. The BESS can store the energy from renewable energy sources like solar, wind, etc., and supply energy during the night-time or non-solar periods. The advantages of BESS-powered charging is that it is a clean energy source and can deliver power during both day and night times. The disadvantages are high upfront cost and large size. There are many applications globally where battery energy storage is co-located with a charging station. This helps to reduce the grid impact from charging and the charging station can take advantage to store cheap renewable power when it is available. Recently a mobile battery charging has gained popularity, where an EV is charged from a battery pack mounted on another vehicle. Such solutions help avoid stranding of electric vehicles.

- ✓ *Battery Swapping Systems (BSS)*— This is a special case of charging batteries, where the discharged battery is replaced with a fully charged battery usually by automation/robots or manually instead of charging the battery at EVCS. Battery swapping has two parts--the battery charging system and the battery swapping mechanism. The advantages of BSS are fast swapping time, easier process, and longer battery life due to optimized slow charging. The disadvantages are additional battery costs and expensive swapping system. In general, BSS is applied for 2-W and 3-W EVs as the battery weights are less compared to 4-W batteries. In India, in Ahmedabad a robotic battery swapping system is being used for electric buses.

- ✓ *Pantograph Charging*—This is a type of conductive charging, which is used for charging batteries of heavy-duty EVs such as e-buses, e-trucks, etc. in trams and trains. The pantograph can have two arrangements: one which is continuously charging the bus battery through overhead wires like in a tram, or one which charges the bus battery when it is halts at bus stops. The benefits of pantograph charging are FC with a wide range of power levels, less charging time, fully automated and robust design, and the disadvantages are high upfront cost, applicable only for high-power charging, and for heavy-duty EVs.

- ✓ *Smart Charging*—If any of the charging technologies use intelligent software, the internet of things (IOT's), 5G technology, fully automated systems, or use of robots, android/ mobile-based control, etc., then such type of charging can be classified as smart charging.

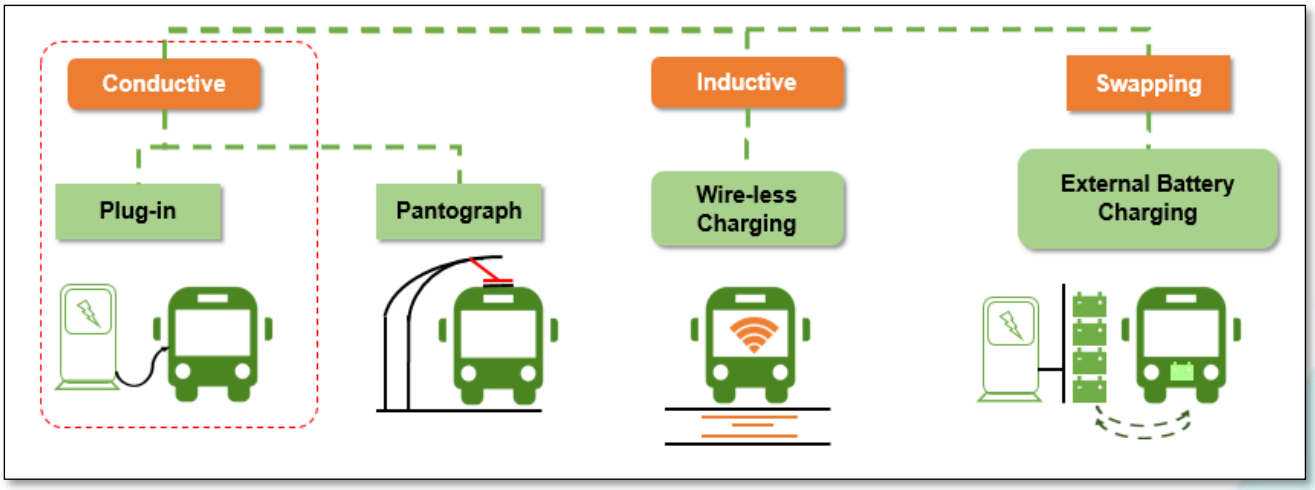


FIGURE 1-10: EVCS CHARGING METHODS

2
Organizational Context

2. ORGANIZATIONAL CONTEXT

Key Learning Objectives:

The trainees will be able to:

- Be familiar with the various agencies that have created the first EV charging standards.
- Understand the stakeholders involved in setting up charging stations.
- Understand the types of locations, at which charging stations are setup.
- Types of charging stations in India.
- Understand the functionality of a charging management system.
- Get an idea on the communication protocols implemented in a CMS.
- Understand the charging station standards published in India.
- Know the certification bodies for charging stations in India.
- Know the regulatory bodies for setting up charging stations in India.
- Understand the responsibilities and expectations of an EV charging station technician.

2.1 STAKEHOLDERS FOR CREATING STANDARDS

2.1.1 ORGANIZATION FOR EVSE STANDARDS

There are two major organizations that have created EV charging standards. These standards cover the general physical, electrical, communication protocol, safety and performance requirements for the EV charging station and the connector. The purpose of these standards is to enable automotive OEMs to create EVs with common charging standards to enable easy set-up and utilization of public charging infrastructure.

- SAE International

  SAE International, previously called the Society of Automotive Engineers (SAE), is a United States-based, automotive professionals association and standards developing organization. Amongst the first standard that is still prevalent today is the J1772 AC charging standard. The J1772 connector, is also known as IEC 62196 Type 1 or J Plug. The J1772 standard was first published in 2001 and California Air Resources Board (CARB) mandated the usage of this standard in the United States beginning with the 2006 model year of EVs.

FIGURE 2-1: J1772 AC CONNECTOR

Subsequently, SAE created a standard for DC charging, also called CCS1 (Combined Charging System Combo 1). This enabled DC fast charging at 200–450 VDC and up to 90 KW.

FIGURE 2-2: CCS1 CONNECTOR

- IEC

The International Electrotechnical Commission (IEC) is an international standards organization that prepares and publishes international standards for all electrical, electronic, and related technologies. IEC was founded in UK in 1906. EV charging station standards in Europe and most parts of the world are based on the IEC standard. The IEC 61851 standard used in Europe and China was derived from J1772 and has similar requirements, adapted for the European and Asian AC voltages. This standard also enabled three-phase AC charging.

The connector in IEC 61851 standard for AC charging is IEC 62196 or Type-2. The first draft for IEC 62196 was published in 2003. The communication standard between the charging stations and the EV is through Pulse Width Modulation (PWM).

FIGURE 2-3: IEC 62196 / TYPE-2 CONNECTOR

The connector in IEC 61851 standard for DC charging is CCS2 and is an extension of the IEC 62196 standard. The Combined Charging System allows AC charging using the Type 1 and Type 2 connector depending on the geographical region. The communication standard between the charging stations and the EV is Power Line Communication (PLC).

FIGURE 2-4: CCS2 CONNECTOR

- CHAdeMO

CHAdeMO is an abbreviation of "CHArge de MOve", equivalent to "move using charge" or "move by charge" or "charge 'n' go", a reference to the fact that it's a fast charger. The name is derived from the Japanese phrase Ocha demo ikagadesu ka, translating to English as "How about a cup of tea?", referring to the time it would take to charge a car.

The CHAdeMO Association was formed by the Tokyo Electric Power Company (TEPCO), Nissan, Mitsubishi and Fuji Heavy Industries. Toyota later joined as a member, followed by Hitachi, Honda and Panasonic. CHAdeMO Research and Development started in 2005 with the goal of developing a public infrastructure of fast chargers that enables people to drive EVs without worrying about the range of their battery. The first commercial CHAdeMO charging infrastructure was commissioned in 2009. As of June 2018, CHAdeMO allows up to 400 kW of charging (400A x 1kV) and aims for 900 kW. An EV that follows the CHAdeMO standard has to have different ports for AC and DC charging. The communication standard between the charging stations and the EV is Controller Area Network (CAN).

FIGURE 2-5: CHADEMO CONNECTOR

2.1.2 ORGANIZATION FOR COMMUNICATION STANDARDS

Public charging stations communicate to a cloud-based system commonly known as a charging management system (CMS) to send availability status, real-time data and other information. The CMS also enables a charging station to be operated through a mobile app or remotely from a control center. There are a few organizations that have standardized the communication between a charging station and a CMS platform, thus enabling easier integration.

- Open Charge Alliance (OCA)

  To enable inter compatibility between charging stations and CMS platforms, an organization named Open Charge Alliance (OCA) was created. OCA is an international organization with more than 220 members from multiple sectors of the industry, including charging equipment manufacturers, software and systems providers, charging network operators, and research organizations. The first protocol, OCPP 1.5, was created in 2009.

- OpenADR Alliance

  The OpenADR Alliance was created to standardize, automate, and simplify Demand Response (DR) and Distributed Energy Resources (DER) to enable utilities and aggregators to cost-effectively manage growing energy demand & decentralized energy production, and customers to control their energy future. OpenADR enables communication between an EV, charging station and the electrical grid, to ensure the electrical grid is not overburdened with the power needed for charging EVs.

- EVRoaming Foundation

  The EVRoaming Foundation was setup with the goal of allowing any EV driver to charge at any charging station. Several large CPOs from the United States and Europe are part of this organization.

2.1.3 GENERAL STAKEHOLDERS

To ensure trouble-free installation and operation of EV charging equipment, approvals and permission may be needed from various stakeholders:

- DISCOM

  A power distribution company is known as a DISCOM. These companies are responsible for the supply and distribution of energy to the consumers (industry, commercial, agriculture, domestic etc.). As EV charging infrastructure needs power, the local DISCOM that supplies electricity in that area is a key stakeholder for setting up of charging stations. Some DISCOMS may provide a separate meter for EV charging, for which the rate of electricity may be lower than for other categories.

- Governmental Agencies

  Local governmental bodies make rules and regulations for setting up and operating charging stations. Some cities may require special permissions to setup and operate EV charging stations. Before setting up charging stations at any location, a thorough understanding of all licenses and permissions needed in the area is required.

- Facility Management

  The facility owner or the building manager of the place at which a charging station is being setup needs to be aware of the installation and the electrical power and wiring requirements. In some cases, the electrical wiring plan must be approved by the facility management.

2.2 ELECTRIC VEHICLE SUPPLY EQUIPMENT (EVSE) IN INDIA

As of August 2021, India has about 2,000 public charging stations. By 2026, an estimated 4 lakh charging stations are required to support 20 lakh EVs. EV charging infrastructure is classified as follows:

- Public Charging Infrastructure

  This type of charging infrastructure is normally accessible by any EV, enabling charging in a public space. This type of infrastructure is normally created in malls, public parking lots, on highways, etc. There may, however, be certain restrictions on the type of vehicle. For example, 3-wheeler EVs may not be allowed to use public charging infrastructure in certain places such as hotels or malls. Charging stations deployed in public charging infrastructure would have most of the features expected from a fully featured charging station including user authentication, energy metering and communication with a CMS platform. Most of these charging stations will be un-manned and the payments are made via e-wallets.

- Semi-Public Charging Infrastructure

  This type of charging infrastructure is focused towards personal EVs or fleets and is setup in places such as apartment complexes, office parks, etc., where vehicle access is restricted. This type of infrastructure is like public charging infrastructure, but the accessibility is limited. In most cases, user authentication and energy metering are required.

- Private / Captive Charging Infrastructure

  This type of charging infrastructure is dedicated for certain vehicles, mainly personal EVs or for EV fleets. This type of infrastructure is normally found in independent homes or in spaces that are owned by an EV fleet. For individual cases, features like user authentication and energy metering may not be required.

2.2.1 UNDERSTANDING CHARGER TYPE AND ITS APPLICATIONS

On a high level, there are two types of EVSE - AC and DC charging stations. There are four levels of EV charging: Level 1, Level 2, Level 3 and Level 4. The higher the level of charging, the faster the charging process, as more power is delivered to the vehicle. It's important to note that different EVs charge at different speeds on each level because each EV can accept different levels of power from the EVSE, industry-speak for electric vehicle supply equipment, the charger. Levels of charging are as follows:

Level 1: Level 1 charging uses a common 120-volt single phase outlet which is common in the US. It should be noted that as 120V is not available in India. The basic power level for India is at 240 V and charging up to 3.3 kW charging is possible from common household power outlets.

Level 2: Level 2 charging is the most used level for daily EV charging. Level 2 charging equipment can be installed at homes, the workplace, as well as in public locations like shopping plazas, train stations and other destinations. Charging from a Level 2 source can be from a single phase or a three phase AC supply based on availability on connection. In the case of three phase power supply 22 kW power can be derived.

Level 3: Unlike Level 1 and Level 2 charging that uses alternating current (AC), Level 3 charging mostly uses direct current (DC). The power is also much higher than Level 1 & 2 charging, which is why we don't see level 3 chargers installed at home. Level 3 chargers are commonly located in public charging stations, and highways.

Level 4: A high power charging level is needed to suit the requirements of heavy-duty electric vehicles such as electric buses and trucks. Popularly known Megawatt Charging systems, these systems of high power can charge large batteries of heavy-duty vehicles.

TABLE 2-1: LEVEL OF EV CHARGING

CHARGER LEVEL & SUPPLY	POWER	VOLTAGE	CURRENT RANGE
Level 1 - 1-Φ AC	<2 kW	120 V AC	6-16 A
Level 2 - 1-Φ AC	3-11 kW	240 V AC	16-50 A
Level 2 - 3-Φ AC	11-22 kW	415 V AC	32 A
Level 3 DC	50-250 kW	300–500 V DC	400 A
Level 4 DC	>250 kW	<1250 V DC	3000

2.2.1.1 AC Charging Connectors

3. Type 1

Type 1 connector is also known as SAE J1772 connector. It is mostly used in the USA, and not used in India.

4. Type 2

Type 2 connector is also known as IEC 62196 connector. It is the most used connector for electric cars.

- ✓ Number of Pins: 7
- ✓ EVSE to Vehicle Communication: Control Pilot (PWM)
- ✓ Typical Power Rating: 3.3 KW, 7 KW and 22 KW (Three-Phase)

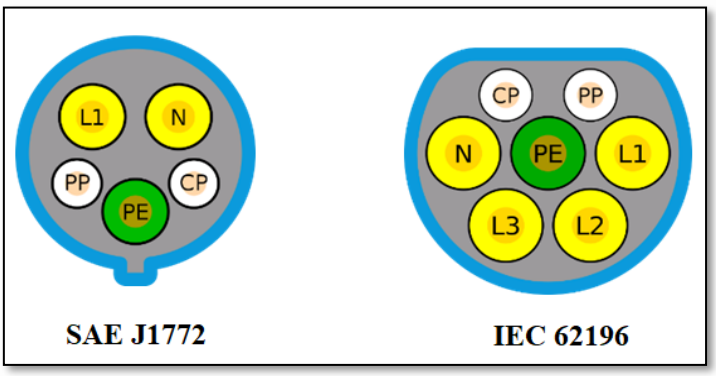


FIGURE 2-6: AC CHARGING CONNECTORS

5. Industrial Connector

A regular industrial connector, IEC 60309, is used by some vehicles. This connector is however not common is associated with Bharat AC-001 Standard.

- ✓ Number of Pins: 3
- ✓ EVSE to Vehicle Communication: None
- ✓ Typical Power Rating: 3.3 KW

2.2.1.2 DC Charging Connectors

3 Combined Charging System (CCS)

The CCS charging standard was created in Europe and is currently the most widely used standard globally.

- ✓ Number of Pins: 5

- ✓ EVSE to Vehicle Communication: Power Line Communication / High Level
- ✓ Typical Power Rating: up to 350 KW

4 CHAdeMO

The CHAdeMO standard was created in Japan. Although several charging stations globally support this standard, there are very few vehicles that follow this standard.

- ✓ Number of Pins: 10
- ✓ EVSE to Vehicle Communication: CAN
- ✓ Typical Power Rating: up 400 KW

5 GB/T

The GB/T standard is a Chinese standard has been adopted by some of the Indian EV manufacturers in the past. This standard is the basis of development of Bharat DC 001 standard. However, this standard may not exist for long.

- ✓ Number of Pins: 9
- ✓ EVSE to Vehicle Communication: CAN
- ✓ Typical Power Rating: up to 180 KW

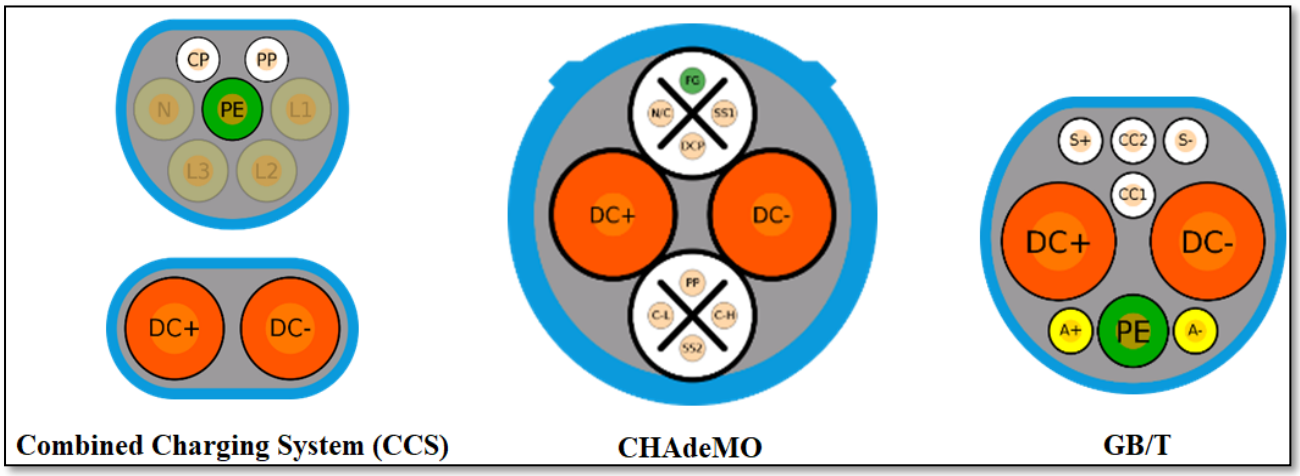


FIGURE 2-7: DC CHARGING CONNECTORS

2.2.1.3 Modes of Charging

The International Electrotechnical Commission (IEC) is an international standards organization that prepares and publishes international standards for all electrical, electronic and related technologies and it defines EV charging in modes (IEC 61851-1):

- ✓ **Mode 1:** Slow charging from a regular electrical socket.
- ✓ **Mode 2:** Slow charging from a regular AC socket but with some electrical protections.
- ✓ **Mode 3:** Slow or fast AC charging using a specific EV connector with communication and protection.
- ✓ **Mode 4:** DC fast charging using a specific charging interface.

Mode		AC / DC	Charger	Charge Control	Communication	
Mode 1	Slow Charging from a regular electrical socket	**AC**	**On-board**	**None**	**None**	
Mode 2	Slow Charging from a regular AC socket but with some electrical protection	**AC**	**On-board**	**Protection device**	**None**	
Mode 3	Slow or fast charging using a specific EV connector with communication and protection	**AC**	**On-board**	**Controller**	**Yes**	
Mode 4	DC fast charging using a specific charging interface	**DC**	**External**	**Controller**	**Yes**	

FIGURE 2-8: DIFFERENT MODES OF CHARGING

2.2.2 TYPES OF EVSE IN INDIA

India currently has EVs with both low voltage traction batteries (< 100 V DC) and high voltage traction batteries (> 300 V DC). EVs with lower voltage use the Bharat EV standard, while the EVs with higher voltage use the CCS standard for charging.

- AC Charging

  There are a few different types of AC charging stations currently being used in India.

  ✓ Smart Socket

  The simplest way of charging for some EVs, especially 2-wheelers, is to plug the portable charger into a 15 A electrical socket. There are a few problems with plugging into any electrical socket:

  - Energy consumption is not accounted, so the user is not billed
  - No electrical protections

To overcome the above issues, there are smart sockets that have user authentication, energy metering, communication with CMS platforms and basic electrical protections such as over voltage, under voltage and over current.

FIGURE 2-9: A SMART SOCKET EV CHARGING STATION

TABLE 2-2: SAMPLE SPECIFICATIONS OF A SMART SOCKET EV CHARGING STATION:

	PARAMETER	VALUE
INPUT	Voltage	230 V AC, single-phase
	Maximum Current	15 A
	Maximum Power	3.3 KW
OUTPUT	Number of Outputs	1
	Output Connector	15 A electrical socket
	Voltage per Output	230 V AC
	Maximum Current per Output	15 A
	Maximum Power per Output	3.3 KW
	Communication with Vehicle	None

✓ Bharat AC-001

Bharat EV Charger AC-001 standard has been published by DHI to enable AC charging for low voltage EVs. This standard enables the charging of 3 EVs parallel.

FIGURE 2-10: AC-001 CHARGING STATION

TABLE 2-3: SPECIFICATIONS OF AC-001 EV CHARGING STATION:

	PARAMETER	VALUE
INPUT	Voltage	415 V AC, three-phase
	Maximum Current	15 A per phase
	Maximum Power	10 KW
OUTPUT	Number of Outputs	3
	Output Connector	IEC 60309 three-pin connector
	Voltage per Output	230 V AC
	Maximum Current per Output	15 A
	Maximum Power per Output	3.3 KW
	Communication with Vehicle	None

✓ IEC 62196 / Type-2

Most of the newer EV 4-wheelers in India follow the IEC standard with an IEC 62196 / Type-2 connector. These charging stations can have 1 or 2 outputs or a 1 three-phase output.

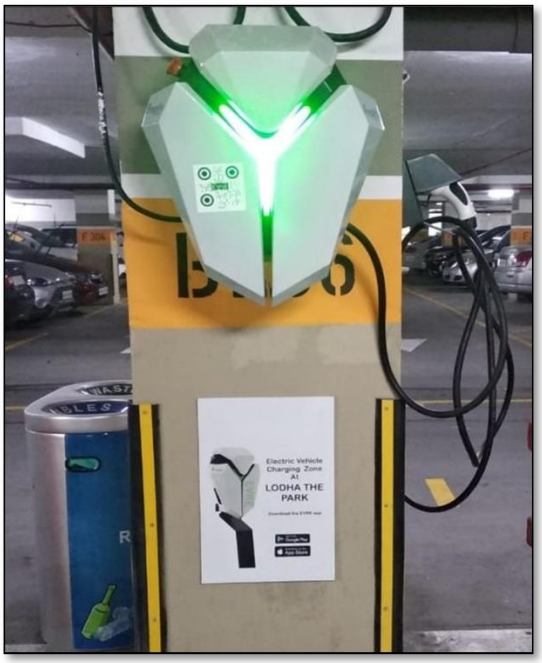


FIGURE 2-11: IEC 62196 / TYPE-2 CHARGING STATION

TABLE 2-4: SAMPLE SPECIFICATIONS OF A TYPE-2 EV CHARGING STATION:

	PARAMETER	VALUE
INPUT		230 V AC, single-phase; 415 V AC, three-phase
	Maximum Current	32 A per phase
	Maximum Power	7 KW for single-phase; 22K KW for three-phase
OUTPUT	Number of Outputs	1 / 2
	Output Connector	IEC 62196
	Voltage per Output	230 V AC, single-phase; 415 V AC three-phase
	Current per Output	15 A / 32 A
	Power per Output	3.3 KW / 7.4 KW / 11 KW / 22 KW
	Communication with Vehicle	PWM / Control Pilot

- DC Charging

There are two major DC charging standards being used in India currently.

✓ Bharat DC-001

Most of these vehicles normally have a nominal battery voltage of 48 V DC or 72 V DC. The power from DC-001 charging station is limited to 15 KW (72 V DC, 200 A). The connector used is from a Chinese standard - GB/T 20234.3.

FIGURE 2-12: DC-001 CHARGING STATION

TABLE 2-5: SPECIFICATIONS OF DC-001 EV CHARGING STATION:

	PARAMETER	VALUE
INPUT	Voltage	415 V AC, three-phase
	Maximum Current	25 A per phase
	Maximum Power	15 KW
OUTPUT	Number of Outputs	1 / 2
	Output Connector	GB/T 20234
	Voltage per Output	48 V DC / 72 V DC
	Maximum Current per Output	200 A
	Maximum Power per Output	15 KW
	Communication with Vehicle	CAN

- CCS2

  Most of the newer EV 4-wheelers in India follow IEC 62196 / CCS2. The high-power DC charging stations installed recently have both CCS2 and CHAdeMo connectors, but there are currently no EVs in India that accept the CHAdeMo connector.

FIGURE 2-13: CCS2 CHARGING STATION WITH 2 OUTPUTS

TABLE 2-6: SAMPLE SPECIFICATIONS OF A CCS2 EV CHARGING STATION:

	PARAMETER	VALUE
INPUT	Voltage	415 V AC, three-phase
	Maximum Current	100 A per phase
	Maximum Power	60 KW
OUTPUT	Number of Outputs	1 / 2
	Output Connector	CCS2 / CHAdeMO
	Voltage per Output	200 -750 V DC
	Current per Output	125 A
	Power per Output	60 KW
	Communication with Vehicle	PLC / CAN

2.3 INTRODUCTION TO CHARGING MANAGEMENT SYSTEM (CMS)

2.3.1 CHARGING MANAGEMENT SYSTEM (CMS)

A charging management system is a cloud-based platform that connects multiple charging stations to a single dashboard. This enables a charging point operator (CPO) to monitor, operate and manage their charging stations. An ideal CMS must support a standardized protocol such as Open Charge Point Protocol (OCPP), but some CMS platforms exist that follow their own communication protocol.

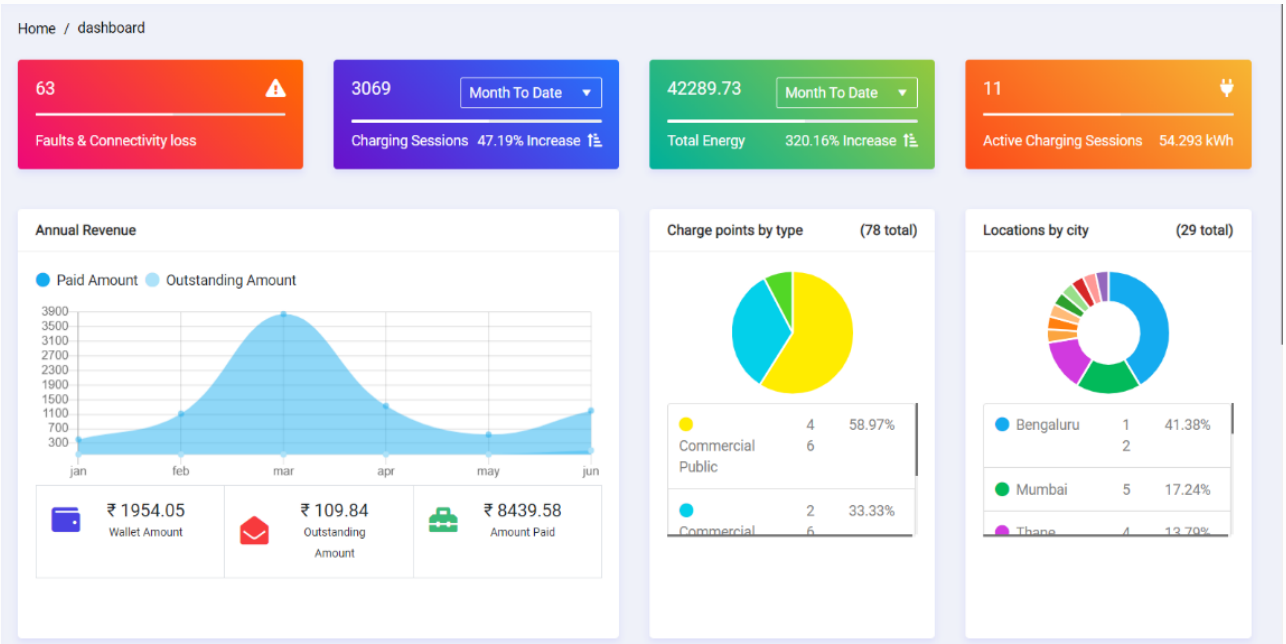


FIGURE 2-14: SAMPLE DASHBOARD OF A CHARGING MANAGEMENT SYSTEM

Some general features of most CMS platforms include:

- Location

The location of every charging station is shown on a map. Charging stations can also be found by location and based on the type.

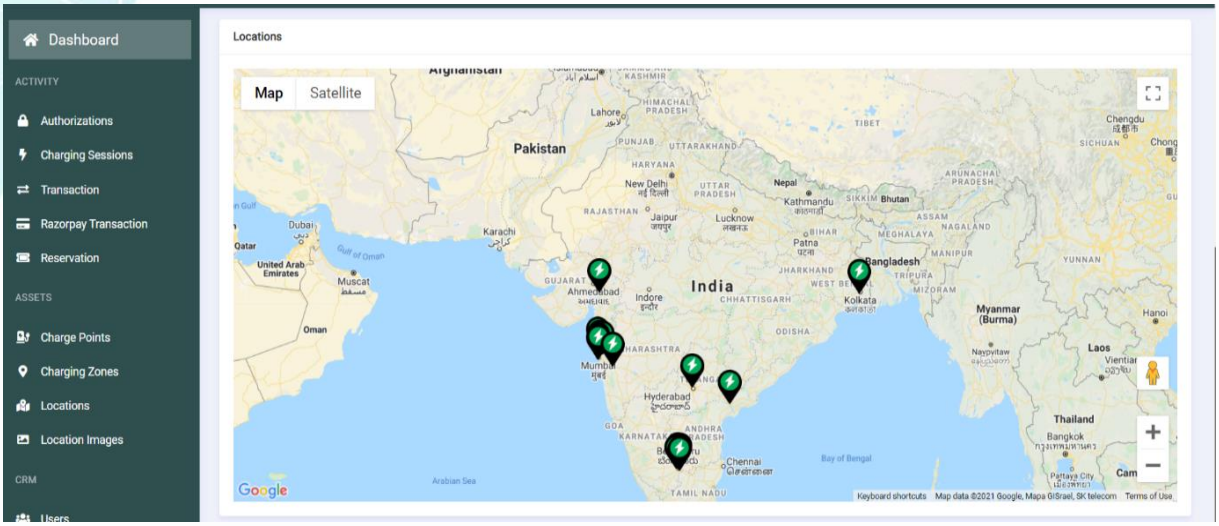


FIGURE 2-15: LOCATION OF CHARGING STATION

- Status

The real-time status of every charging station is shown. This includes information on if the charging station is available to use, in-use or faulted. If a charging station is in-use, real-time power and energy values are received at pre-determined intervals from the charging station.

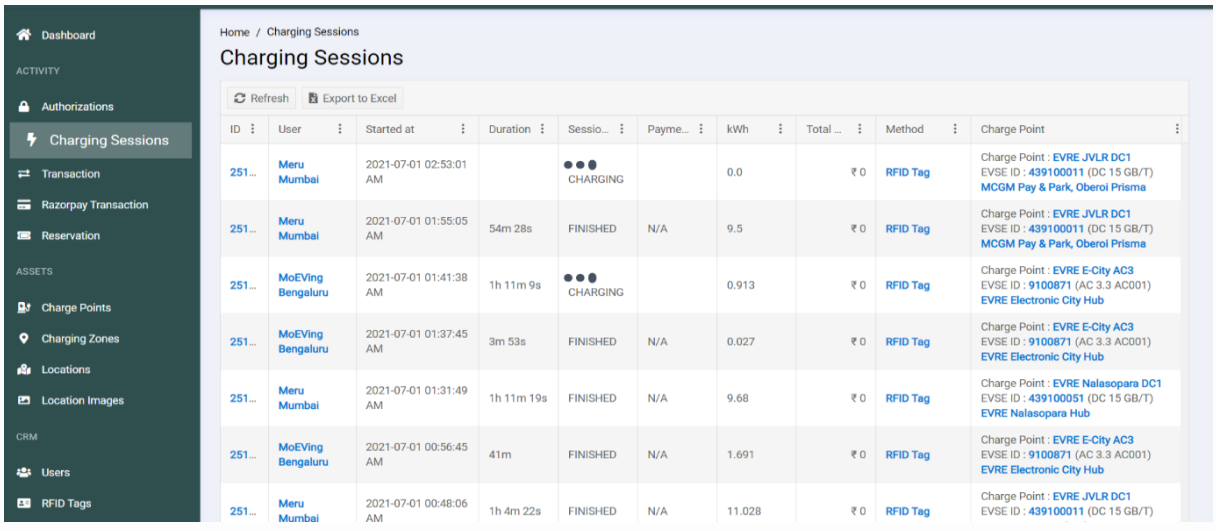


FIGURE 2-16: REAL – TIME STATUS OF CHARGING STATION

- Reservation

The CMS platform enables a user to reserve a charging station for a fixed amount of time.

- Tariff

  The CMS platform enables a CPO to set tariff for every charging station or user, to recover money of the charging station and for the energy consumed.

- Charging Station Management

  CMS enables a CPO to manage every charging station, set its operating hours and restrict access based on the user.

- User Management

  Using the CMS, the CPO would be able to manage users that are able to access the charging stations.

- Reports

  Detailed utilization reports for every charging station can be viewed. These reports may include energy consumed per charging station, revenue generated and utilization hours. Consolidated reports may also be generated for all the charging stations operated by the CPO.

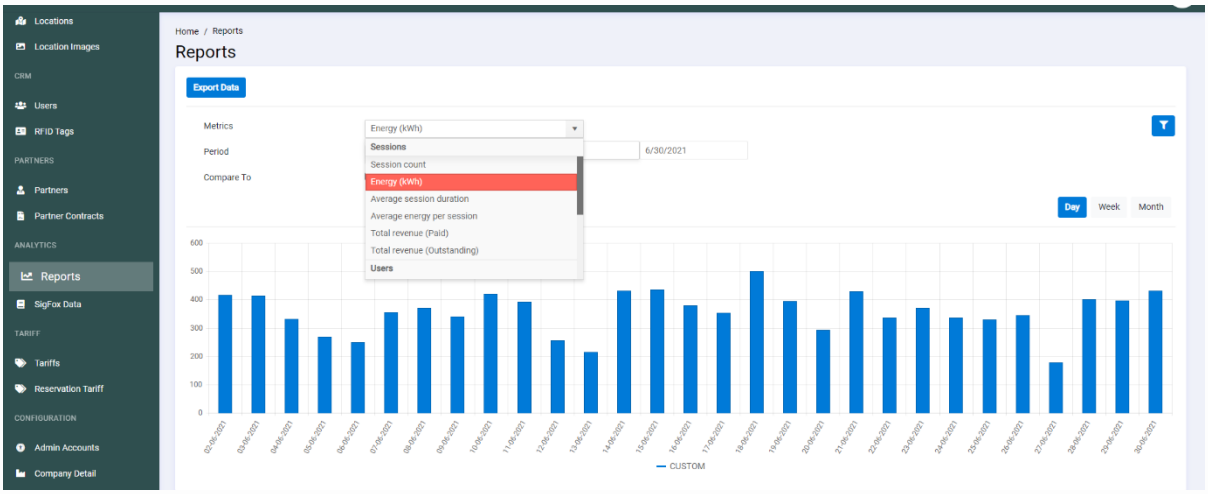


FIGURE 2-17: CHARGING STATION UTILIZATION REPORT

- Mobile App

  The CMS platform can also be integrated to a mobile app that can be used by an EV driver. This app would enable the EV driver to find available charging stations, authenticate themselves for charging by scanning a QR code or through an OTP, see real-time charging status and pay for charging.

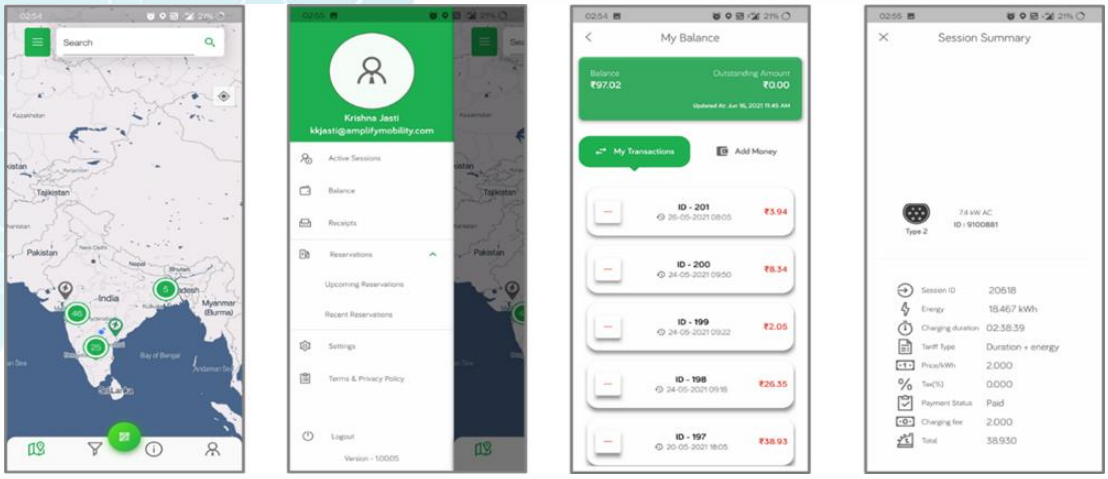


FIGURE 2-18: INTEGRATED CMS PLATFORM WITH MOBILE APP

2.3.2 COMMUNICATION PROTOCOLS

The following communication standards have been created for communication between the charging station, the backend systems, and the grid:

- Open Charge Point Protocol (OCPP)

  Open Charge Point Protocol (OCPP) is the global open communication protocol between charge stations and the back-end systems of CPOs. This protocol enables any OCPP compliant charging station to connect with any OCPP compliant CMS platform, without any modifications or further development. OCPP is managed by OCA. The latest version is OCPP 2.0.1 (as of August 2021), while OCPP 1.6 is the most widely used.

- Open Smart Charging Protocol (OSCP)

  Open Smart Charging Protocol (OSCP) is an open communication protocol between a charge point management system and an energy management system. This protocol was created to enable charging stations to control the charge power to EVs based on the power availability of the electrical grid. This would prevent grid overloading. OSCP is managed by OCA.

- Open Charge Point Interface (OCPI)

  OCPI enables connectivity of a charging station to only a single CMS platform. In most cases, as there are several CPOs in any city, an EV user would have to have multiple CPO apps to find and use public charging stations. To overcome this problem, the Open Charge Point Interface (OCPI) was created. OCPI is an open protocol used for connections between CPOs and service providers. This protocol facilitates automated roaming for EV drivers across several EV charging networks, thus allowing EV drivers to charge on several networks. The protocol provides accurate charging station data such as location, accessibility, and pricing, and it considers real-time billing for energy consumed. OCPI is managed by EVRoaming Foundation.

- ISO 15118

  ISO 15118 is one of the International Electrotechnical Commission's group of standards for electric road vehicles and electric industrial trucks, is an international standard defining vehicle to grid (V2G)

communication interface for bi-directional charging/discharging of electric vehicles. This standard enables power to be drawn from an EV when the electrical grid needs additional power.

- OpenADR

  OpenADR is an open, secure, and two-way information exchange model facilitating automated demand response (DR) actions that help balance grid supply and demand or mitigate high electricity costs. This protocol ensures that dynamic price and reliability signals are uniformly exchanged between utility companies, system operators, and energy management and control systems during DR events. OpenADR is managed by OpenADR Alliance.

The communication protocols for the vehicle communication are given below:

- Vehicle control panel when leaving car
- EV⇔ Telematics (J2847/5) – remote connectivity
- EV⇔ EVSE digital communications (J2831-4)
- HAN / LAN ⇔ EVSE ⇔ EV digital communications
- EV ⇔ EVSE communications (J1772 Control Pilot)
- EV ⇔ Owner (J2847/5) – mobile devices
- Plug-in the car at a particular time to start charging

2.4 CHARGING SYSTEM REGULATIONS AND STANDARDS

2.4.1 CHARGING STATION STANDARDS IN INDIA

Department of Heavy Industries (DHI) has created two charging station standards in 2017 to enable low-cost charging infrastructure. Apart from these, Automotive Research Association of India (ARAI) has also created a standard. These standards define the functional and safety requirements for EV charging stations. The standards that India has created or is following are:

- Bharat EV AC Charger (BEVC-AC001)

  The BEVC-AC001 standard is commonly called AC-001 has been created by DHI. As per the standard, the AC charger is also referred to as a Public metered AC outlet (PMAO), which is to provide AC input an EV's on-board chargers. AC-001 has a three-phase input and three individual outputs. This enables charging of up to three EVs at a time.

Overview of the standard

- ✓ Input: Three-phase input power supply of 415 VAC and 15 A
- ✓ Output: Three outputs of 230 VAC, 15 A each
- ✓ Output Connector: IEC 60309 Industrial blue connectors
- ✓ Energy Metering: Individual metering for all outputs
- ✓ User Interface: Minimum 6-inch touch screen
- ✓ User Authentication: Mobile application or user interface

FIGURE 2-19: SOCKET THAT IS REQUIRED FOR AC-001 CHARGING STATION

- Bharat EV DC Charger (BEVC-DC001)

The BEVC-DC001 standard is commonly called DC-001, has been created by DHI and is a standard for low voltage DC charging stations. DC-001 has a three-phase input and one or two outputs. This enables charging of up to three EVs at a time.

Overview of the standard

- ✓ Input: Three-phase input power supply of 415 VAC and 15 A
- ✓ Output: One / two outputs of 48 / 72 VDC, 200 A, combined
- ✓ Output Connector: GB/T 20234.3
- ✓ Energy Metering: Individual metering for all outputs
- ✓ User Interface: Minimum 6-inch touch screen
- ✓ User Authentication: Mobile application or user interface

FIGURE 2-20: GB/T 20234.3 CONNECTOR FOR DC-001 CHARGING STATION

- AIS-138

  The AIS-138 standard has been drafted by Automotive Research Association of India (ARAI) and covers AC charging stations ranging from 1 KW to 45 KW. This standard closely follows IEC-61851. DHI standards partly refer to AIS-138.

- IS 17017

  IS 17017 is a set of standards for EV charging systems by Bureau of Indian Standards (BIS). The Committee of Electrotechnical Division (ETD) which is set up by the Bureau of Indian Standards (BIS) is mainly responsible for the preparation of Indian standards (IS) for EVCS. These standards apply to EV charging equipment with a rated supply voltage up to 1000 V AC or up to 1500 V DC and a rated output voltage up to 1000 V AC or up to 1500 V DC. The IS 17017 series of standards are derived and adapted (not all are equivalent) from the IEC 61851 series of standards. The local climate considerations and the difference in vehicle types available in the country necessitate new standard compliant with global norms that are specifically applicable to India. IS-17017- Part-1 provides the basic features of all electric vehicle charging systems and all AC EVSE must adhere to this standard. The specific AC connector standard is available the IS-17017-Part-2. Both AC and DC EVSE need to conform to the technical standards IS-17017-Parts 21 & 22. Additional Indian standards for AC EVSEs, IS 17017-22-1 for Light EV AC charging, is 1717-25 for Light EV DC charging, IS 17017023 for Parkbay DC and IS 17017-1 for Parkbay AC chargers have been approved for light electric vehicles and e-cars in the form of low-cost charging points. The Light EV AC charging point standard is for a low-cost universal charger which communicates using Bluetooth technology. The IS-17017-Part-25, which is specifically for providing low DC power of less than 7kW for light EVs. The Parkbay AC and DC chargers are specific charger standards created for parking lots. IS-17017-Part-23 describes the requirements for DC charging stations, with power output of 50kW to 200kW. Beyond this, high power charging standards IS 17017-23-1 and IS 17017-3-1 to cater to buses and other heavy vehicles.

  Activities are underway for development of battery swapping standards for Light EVs and buses. These standard documents will cover the major aspects including the form factor of the battery pack, inter-operable connection systems, communication between the battery management system (BMS) and the EV and charging station, and network management. The removable battery packs can be charged using AC or DC charging systems. A snapshot of the IS 17017 standards which are useful for setting up public charging points are below.

1. *Light EV AC Charge Point*

Power Level 1	Charging Device	EV-EVSE Communication	Charge Point Plug/ Socket	Vehicle Inlet/ Connector
Up to 7 kW	IS-17017-22-1	Bluetooth Low Energy	IS-60309	As per EV manufacturer

2. *Light EV DC Charge Point*

Power Level 1	Charging Device	EV-EVSE Communication	Charge Point Plug/ Socket	Vehicle Inlet/ Connector
Up to 7 kW	IS-17017-25 [CAN]		Combined Socket under development	IS-17017-2-6

3. *Parkbay AC Charge Point*

Power Level-2	Device/ Protocol	EV-EVSE Communications	Infrastructure Socket	Vehicle Connector
Normal Power ~11kW/ 22 kW	IS-17017-1	IS-15118 [PLC] for Smart Charging	IS-17017-2-2	IS-17017-2-2

4. *Parkbay DC Charge Point*

Power Level-2	Device/ Protocol	EV-EVSE Communications	Infrastructure Socket	Vehicle Connector
Normal Power ~11kW/ 22 kW	IS-17017-23	IS-17017-24 [CAN] IS-15118 [PLC]	IS-17017-22-2	IS-17017-2-3

5. *DC Charging Protocol*

Power Level 3	Charging Device	EV-EVSE Communication	Connector
DC 50 kW to 250 kW	IS-17017-23	IS-17017-24 [CAN] IS-15118 [PLC]	IS-17017-2-3

6. *eBus Charging Station (Level-4: 250 to 500 kW)*

Power Level 4 DC High Power (250 kW --> 500 kW)	Charging Device	EV-EVSE Communication	Connector
Dual Gun Charging Station	IS-17017-23-2	IS-15118 [PLC]	IS-17017-2-3
Automated Pantograph Charging Station	IS-17017-3-1		IS-17017-3-2

FIGURE 2-21: SNAPSHOT OF IS 17017 STANDARDS

IEC Technical Standards for Charging Stations

ETD originally adopted the IEC standard respectively for EVCS, that is, the IEC 61851 series of standards summarized below.

i. IEC 61851-1: Part 1: General Requirements
ii. IEC 61851-21: Part 21: Electric Vehicle Requirements for conductive connection to AC/DC supply
iii. IEC 61851-22: Part 22: AC Electric Vehicle Charging Stations

iv. IEC 61851-23: Part 23: DC Electric Vehicle Charging Stations
v. IEC 61851-24: Part 24: Digital connection between a DC EV Charging Station and an Electric Vehicle for control of DC Charging

TABLE 2-7: EVCS REQUIREMENT FOR INDIA RELEASED BY MINISTRY OF POWER, GOVT. OF INDIA

CHARGING TYPE	CHARGER TYPE	EVCS REQUIREMENT	APPLICATION TO EV
FAST Charging	CCS – Type 2 – DC	200 – 750v (DC)	4W
		> 50Kw	
	CHAdeMo – DC	200 – 500v (DC)	4W
		> 50Kw	
	CCS – Type – 2 –AC	380 – 415v (AC)	4W, 3W, 2W.
		> 22kW	
Slow Charging	Bharat DC – 001	48v - Battery	4W, 3W, 2W.
		15kW	
	Bharat DC – 001	72v Battery	4W
		15kW	
	Bharat AC – 001	230v (AC)	4W, 3W, 2W.
		10Kw (3 CGs)	
CCS – Type 2 + [All in single PCS)			

TABLE 2-8: COMPARISON OF CHARGER AND CHARGING METHODOLOGY

SR. NO.	PARTICULARS	CCS	CHADEMO	GB/T	BEVC
1	Country following the methodology	Worldwide adopted	Worldwide adopted	China	India
2	Charging methodology	SAE J1772	IEC 62196-4	GB/T-20234	GB/T-20234
3	Physical layer for EVSE and EV communication	PLCC	CAN	CAN	CAN
4	Digital communication protocol between EVSE and EV	CCS	CHAdeMO	GB/T	BEVC-AC001 for AC, and BEVC-DC001 for DC
5	Type of charging	AC and DC	Only DC	AC and DC	AC and DC
6	Charging limits	1000 V, 350 A, and 350 kW	500 V, 125 A, and 400 kW	750 V, 200 A, and 187.5 kW	72 V, 200 A, and 15 kW (at present). 1000 V, 300 A, and 150 kW (will be released in the year 2022)

[Note: section 5.1.3 – Reference: https://onlinelibrary.wiley.com/doi/full/10.1002/est2.261]

2.4.2 UNDERSTANDING VEHICLE TYPES AND ITS CHARGING REQUIREMENTS

As outlined in the sections above, there are multiple types of EV charging standards with different connectors and electrical outputs. All the EVs in the country currently use any one of the aforementioned standards and it varies from vehicle to vehicle

2.4.2.1 Two-Wheelers

India has always been a huge market for 2 Wheelers due to its accessibility, affordability, and low ownership costs. Electrical 2 Wheelers are no exception to this rule and as the costs of electric 2W are already close to their ICE counterparts, the demand for 2W charging will be substantial. Though the demand for electric 2W

is high, due to the non-availability of a single charging standard, most 2W OEMs use different chargers with different connectors and electrical outputs, some of them proprietary to their vehicles. Due to this, the best way of charging electric 2W today is by using the charger provided by the OEM and plugging the charger in an AC charger with a compatible socket, namely, a Smart Socket charging station or an AC001 charging station which will provide the vehicle's charger with a steady, clean output with necessary protections. Recently the BIS developed standards for Light Electric Vehicles which includes Light EV AC and Light EV DC charging solutions which are suitable for two wheelers.

2.4.2.2 Three-Wheelers

The case with 3W in the country is like that of 2 Wheelers and standardization for charging is very nascent. The solution for this is similar to that of 2W where the best practice today is to charge the electric 3W by using the charger provided by the OEM and plugging it in an AC charger with a compatible socket. A Smart Socket charging station, an AC001 charging station, Light EV AC, Light EV DC, Parkbay AC, and Parkbay DC can be used to provide the vehicle's charger with a steady clean output with necessary protections.

2.4.2.3 Four-Wheelers

Unlike 2 Wheelers and 3 Wheelers, a standard for charging is available for 4 wheelers in India. Apart from a few early model cars, which used DC001 or GB/T standard for DC fast charging, almost all the 4W OEMs have started equipping their EVs with CCS/Type 2 compatible charging hardware for DC fast charging and AC charging respectively. CHAdeMo standard is also allowed by Ministry of Power Guidelines. Recent BIS standards Light EV AC, Light EV DC, Parkbay AC, Parkbay DC, DC charging protocol can be used for charging vehicles in India

2.4.2.4 Heavy Vehicles

Heavy Vehicles such as buses were in most instances the first EVs introduced in the country at a large scale. These vehicles have a much larger battery capacity and will have to be charged with DC or AC fast charging to achieve acceptable charging times. The market is moving towards high power CCS charging, and other high power charging standards such as DC charging protocol, e-bus charging station standard.

TABLE 2-9: VEHICLE TYPE AND CHARGING REQUIREMENT

VEHICLE TYPE	AC CHARGING	DC CHARGING
2 Wheelers	AC001, Smart Socket, Light EV AC	Light EV DC
3 Wheelers	AC001, Smart Socket, Light EV AC, Parkbay AC	Light EV DC, Parkbay DC
4 Wheelers	Type 2, IEC 62196, Light EV AC, Parkbay AC	CCS2, CHAdeMo, DC charging protocol
Heavy Vehicles	Type 2 (High Power/22kW)	CHAdeMO, CCS 2, DC charging protocol, e-bus charging station

2.5 APPROVAL PROCEDURES AND AUTHORITIES IN INDIA

2.5.1 CERTIFICATION BODIES

- Automotive Research Association of India (ARAI)

  Automotive Research Association of India (ARAI) was established in 1966 by the Automotive Industry with the Government of India. ARAI is an autonomous body affiliated to the Ministry of Heavy Industries, Government of India. The Department of Scientific and Industrial Research, Ministry of Science and Technology, Government of India, has recognized ARAI as a Scientific and Industrial Research Organization (SIRO). Apart from research, ARAI is also a Testing and Certification Agency notified by Government of India under Rule 126 of Central Motor Vehicle Rules, 1989. It is also responsible for car mileage figure for every car sold in India. ARAI performs conformity tests for EV charging equipment as per established standards.

- International Centre for Automotive Technology (ICAT)

  The International Centre for Automotive Technology (ICAT), located in Manesar, is an automotive testing, certification, and R&D service provider under NATRiP (National Automotive Testing and R&D Infrastructure Project), Government of India. ICAT performs homologation for various standards for several countries.

- Bureau of Indian Standards (BIS)

  The Bureau of Indian Standards (BIS) is the National Standards Body of India under Department of Consumer affairs, Ministry of Consumer Affairs, Food & Public Distribution, and Government of India. It is established by the Bureau of Indian Standards Act, 2016. One of the major functions of the Bureau is the formulation, recognition and promotion of the Indian Standards. As on 1 January 2019, over 20,000 Standards have been formulated by BIS, are in force. EV charging standards are defined by the Bureau of Indian Standards (BIS).

2.5.2 REGULATORY BODIES

- Ministry of Power (MoP)

  The Ministry of Power (MoP) issued the Charging Infrastructure Guidelines and Standards for public charging infrastructure, which laid out an enabling framework for implementation. In its capacity as a legislative authority, the MoP clarified that the operation of EV charging services did not require licensing under the Electricity Act 2003. The MoP releases guidelines for charging infrastructure for electric vehicles in India, which is updated periodically. The MoP has designated the Bureau of Energy Efficiency (BEE) as

the central nodal agency (CNA) for the rollout of EV public charging infrastructure implementation across the country.

- Central Electricity Authority (CEA)

  The Central Electricity Authority (CEA) is responsible for defining technical standards and regulations for EV charging.

- State Electrical Regulatory Commissions (SERCs)

  The State Electrical Regulatory Commissions (SERCs) set the EV tariff and other regulations concerning electricity supply for EV charging.

- Ministry of Housing and Urban Affairs (MoHUA)

  The Ministry of Housing and Urban Affairs (MoHUA) amended the Model Building Byelaws 2016 and the Urban and Regional Development Plans Formulation and Implementation Guidelines 2014 (URDPFI) to include provisions for EV charging.

- Other Organizations

  At the local level, DISCOMs and urban local bodies (ULBs) are responsible for planning, permissions, approvals, and certifications needed for EV charging infrastructure. ULBs include municipal corporations, municipal councils, and any other statutory governing bodies at the city level. DISCOMs are responsible for providing electricity connections for EV charging, implementing the EV tariff established by SERCs, ensuring that EV charging infrastructure is connected and operating properly, preventing improper use of EV connections, managing the distribution network, and undertaking grid upgrades based on growth in load including from EV charging.

2.6 DUTIES AND RESPONSIBILITIES OF EV CHARGING STATION TECHNICIAN

2.6.1 TECHNICIAN DUTIES AND RESPONSIBILITIES

- Planning and Permissions
  - ✓ Assess space and power requirements for the desired EV charging setup.
  - ✓ Coordinate with nodal agencies and authorities to get the requisite permissions and approvals.
  - ✓ Obtain required permissions from the building management.
- Location Checks
  - ✓ Verify the location is optimal for installation of EV charging stations.
  - ✓ Ensure location is protected from hazards such as flooding and fire.
  - ✓ Ensure the location-related requirements of the CPO are met.

- Civil Infrastructure
    - ✓ Monitor creation of desired civil infrastructure – roofing, foundations, etc.
    - ✓ Ensure the civil structures to hold the charging stations comply with the OEMs requirements.
- Electrical Wiring
    - ✓ Creation of an appropriate SLD by a licensed electrician.
    - ✓ Ensure the wiring diagram complies with the charging station OEM's requirement.
    - ✓ Electrical wiring approval from the building management and DISCOM
    - ✓ Ensure electrical work is executed as per requirement.
- Installation and Commissioning
    - ✓ Ensure the correct equipment is received.
    - ✓ Install the charging stations as per the OEMs and CPOs requirements.
    - ✓ Test for correct electrical wiring.
    - ✓ Connect charging stations to CMS platform.
    - ✓ Ensure charging stations are fully operational.
- Maintenance
    - ✓ Inspect every charging station as per the scheduled maintenance report.
    - ✓ Perform checks on electrical wiring and earthing as defined.

An installation and commissioning certificate may be issued with the following details:

- ✓ Equipment Type
- ✓ Equipment Model and Serial No.
- ✓ Manufacturer name, address, and contact number
- ✓ Charging Station details (name, location, and serial number)
- ✓ Date of commissioning and warranty details
- ✓ Equipment drawing details (as attachment)

3

Erection and Installation of EV Charging Station

3. ERECTION AND INSTALLATION OF EV CHARGING STATION

Key Learning Objectives:

The trainees will be able to,

- Understand the basics of electricity and related terminology.
- Identify the tools needed to measure critical parameters.
- Understand electrical wiring, the prerequisites for building an EVCS (Electric Vehicle Charging Station), permissions needed for the installation of EVCS, safety measures applicable at an EVCS.
- Understand the requirements for installing charging station.
- Gain knowledge about the basic test that need to be performed before commissioning.

3.1 BASICS OF ELECTRICITY AND POWER ELECTRONICS

3.1.1 BASIC OF ELECTRICITY AND BASIC LAWS IN ELECTRICITY

- AC & DC

  The supply of current for electrical devices may come from a direct current (DC) source or an alternating current (AC) source. Alternating current (AC) is an electric current that periodically reverses direction and changes its magnitude continuously. All electric power available from the grid is in the form of AC. AC can be converted into DC by using a rectifier. Direct current (DC) is one-directional flow of electric charge. Electric power generated from solar, wind, etc. is in the form of DC. Batteries can only take in DC power. DC can be converted into AC by using an inverter.

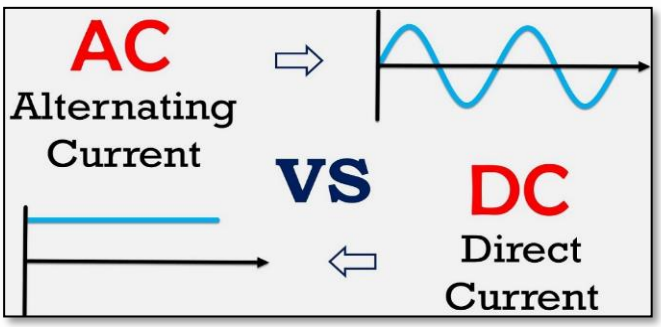


FIGURE 3-1: AC AND DC CURRENT WAVE FORMS

- Electric Circuit

  A simple electric circuit consists of a voltage source (ex: battery or main power), conductors to allow electrons (ex: wire) and the load (ex: bulb). An electric circuit can be either in series or parallel.

  ✓ Series Circuit

The electric current in a series circuit goes through every component in the circuit. Therefore, all the components in a series connection carry the same current. A series circuit has only one path in which its

current can flow. Opening or breaking a series circuit at any point causes the entire circuit to "open" or stop operating.

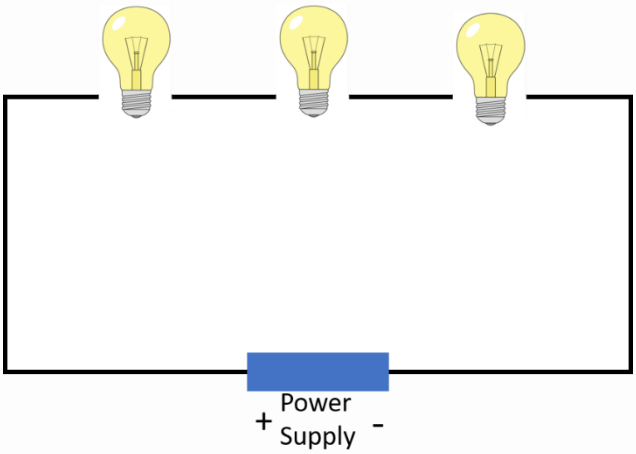


FIGURE 3-2: SERIES CIRCUIT

- ✓ Voltage

In a series circuit, the voltage is the sum of the voltage at individual components.

$V = V1 + V2 + V3$ Equation 3-1

- ✓ Current

In a series circuit, the current is the same for all components in the circuit.

$I = I1 = I2 = I3$ Equation 3-2

- ✓ Resistance

The total resistance of two or more resistors connected in series is equal to the sum of their individual resistances.

$R = R1 + R2 + R3$ Equation 3-3

- Parallel Circuit

The voltage in a parallel circuit is the same across every component in the circuit. The potential differences across the components are the same in magnitude, and they also have identical polarities.

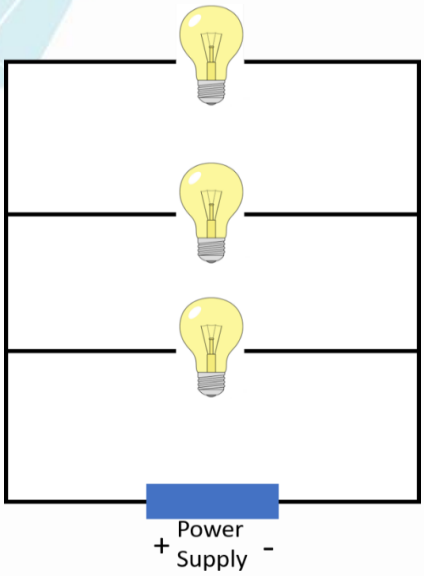


FIGURE 3-3: PARALLEL CIRCUIT

✓ Voltage

In a parallel circuit, the voltage is the same for all components in the circuit.

$V = V1 = V2 = V3$ Equation 3-4

✓ Current

In a parallel circuit, the current is the sum of the current at individual components.

$I = I1 + I2 + I3$ Equation 3-5

✓ Resistance

The total resistance of all components is the reciprocal of the sum of the reciprocals of resistance at each component.

$$\frac{1}{R} = \frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3}$$ Equation 3-6

- Ohm's Law

Ohm's law states that the current through a conductor between two points is directly proportional to the voltage across the two points. Voltage in an electrical circuit is calculated by multiplying the current with the resistance:

$V = I \times R$ Equation 3-7

Thus, as per Ohm's law, if resistance is more, less current will flow through the electric circuit. Ohm's law shows that current varies directly with voltage and inversely with resistance. Ohm's law can be expressed in three ways:

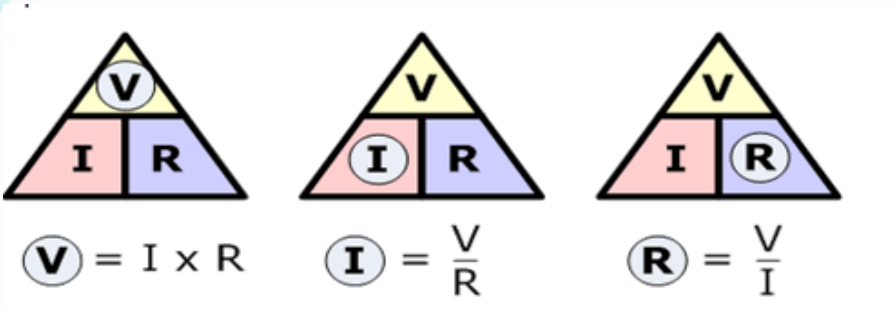


FIGURE 3-4: OHM'S LAW

- Watt's Law

Watt's law defines the relationship between power, amperage, and voltage drop in an electrical circuit.

$P = V \times I$ or $P = I^2 \times R$ Equation 3-8

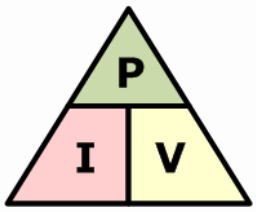


FIGURE 3-5: POWER LAW

- Kirchhoff's Current Law

The total current or charge entering a junction or node is exactly equal to the charge leaving the node as it has no other place to go except to leave, as no charge is lost within the node. In other words, the algebraic sum of all the currents entering and leaving a node must be equal to zero.

Current In = Current Out

✓ Kirchhoff's Voltage Law (KVL)

In any closed loop network, the total voltage around the loop is equal to the sum of all the voltage drops within the same loop, which is also equal to zero. In other words, the algebraic sum of all voltages within the loop must be equal to zero.

✓ Power

Electrical Power is the rate at which electrical energy is transferred by an electric circuit and is denoted by "P". It is related to the voltage and current by the formula:

Power (P) = Voltage (V) × Current (I) Equation 3-9

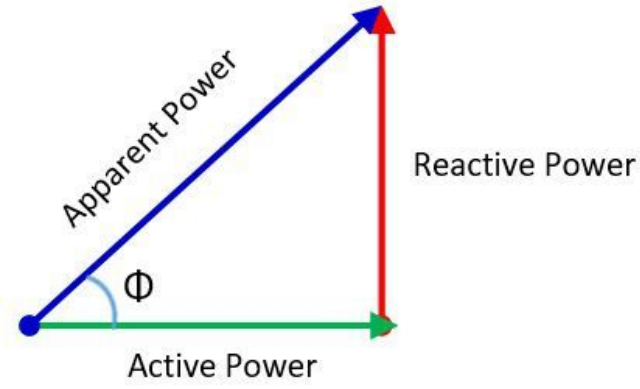
Power is normally measured in watts (W).

1000 W = 1 kW (kilowatt); 1000 kW = 1 MW (megawatt).

The rate at which an EV can charge is dependent on Power output capability of the charging station and power intake capability of the vehicle's battery. In an AC power system, there are two kinds of power - real power that does work, and reactive power that enables transformers to transform, generators to generate, and motors to rotate.

✓ Active Power

Active power is also called actual power, real power, or working power. It is the power that actually powers the equipment and performs useful work. It is measured in kilowatt (kW).



✓ Reactive Power

In electrical grid systems, reactive power is the power that flows back from a destination toward the grid in an alternating current scenario. It is also called, Useless Power or Watt-less Power. Reactive Power is denoted by "Q" and measured in VAR (Volt Ampere Reactive), kVAR or MVARs.

✓ Apparent Power

Apparent power is the combination of reactive and true power measure in kilo volt-amperes (kVA). The kVA value will always be higher than the value for kW.

✓ Power Factor

Power factor (PF) is the ratio of working power, measured in kilowatts (kW), to apparent power, measured in kilovolt amperes (kVA). Ideal power factor is 1. Anything below 0.85 is considered as a bad power factor.

✓ Energy

The power delivered over a period is known as Electrical Energy. It is denoted by "E" and is the product of power and time:

Energy (E) = Power (P) × Time (t) Equation 3-10

The common unit of energy is Kilowatt-hour (KWh). The time needed to fully charge an EV is defined by the energy needed by the EV's battery and is equal to the energy needed divided by the charging power.

3.1.2 MEASUREMENT OF ELECTRICAL QUANTITIES

- Voltage

Voltage is the pressure in an electrical circuit's power source that is responsible for pushing current (electrons) through an electrical circuit, thus powering an electrical load. The value of voltage in a circuit is the difference in electric potential between two points. This potential difference is measured in volts (V) and represented by the symbol 'V' or 'E'. Voltage source can be AC or DC and is represented by VAC or VDC to indicate the type of voltage.

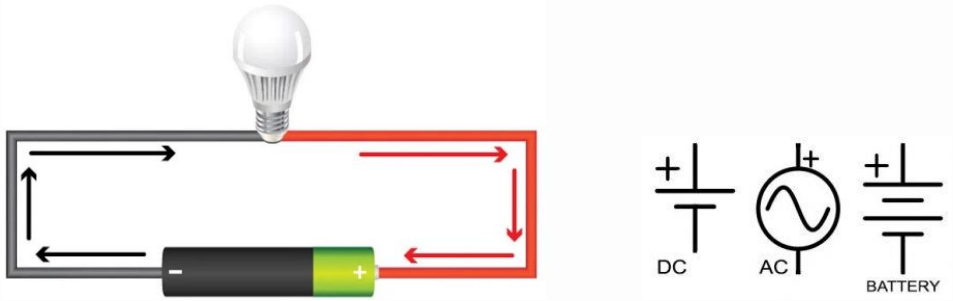


FIGURE 3-6: REPRESENTATION OF POWER FLOW AND SOURCE IN THE CIRCUIT

Voltage is measured by a voltmeter or a multimeter that must be connected in parallel with the component whose voltage is to be measured. Different voltmeters / settings need to be used for measuring AC and DC voltages.

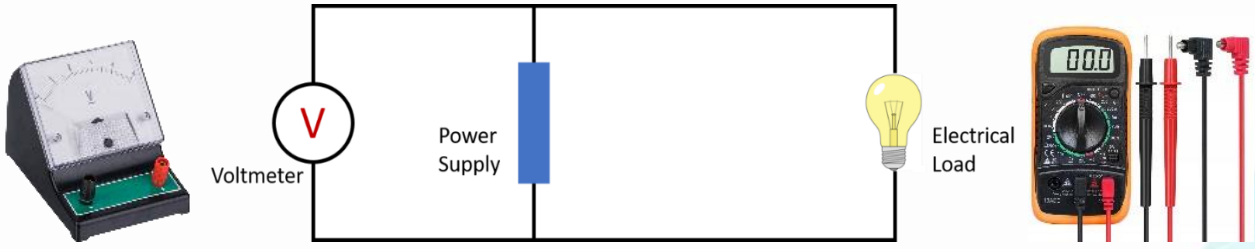
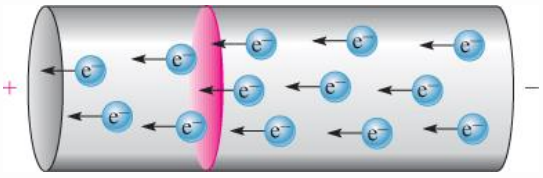
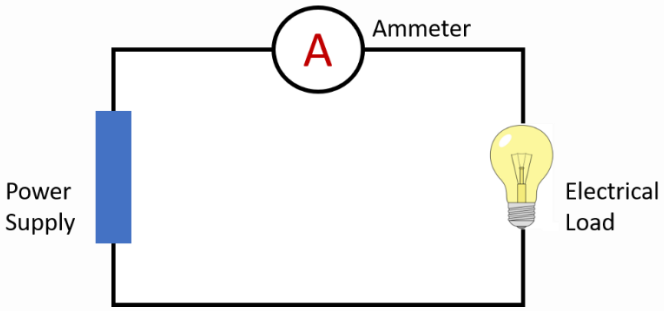


FIGURE 3-7: MEASURING VOLTAGE IN AN ELECTRICAL CIRCUIT

- Current



Current is the flow of electrons. Current flows from negative to positive points and requires a conducting material. Current is measured in amperes (A) and is denoted by the symbol 'I'. One ampere of current is defined as one coulomb of electrical charge moving past a unique point in a second. Current is measured using a device called ammeter. To measure the current flowing through a component in a circuit, the ammeter must be connected in series with it. Current can also be measured using a clamp on ammeter or a multimeter.



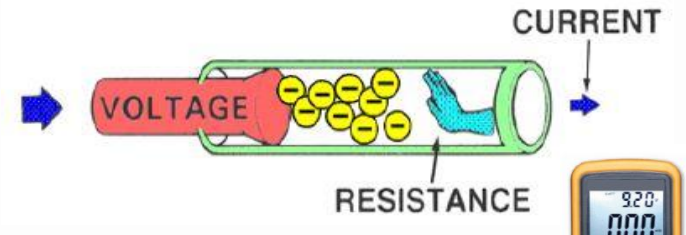
Analog ammeter

Clamp on ammeter

FIGURE 3-8: MEASURING VOLTAGE IN AN ELECTRICAL CIRCUIT

- Resistance

Resistance is the opposition to the flow of electric current in an electrical circuit. Resistance is measured in Ohms (Ω) and is represented by the symbol 'R'. Some materials offer more resistance than others. For example, metals such as silver, copper, aluminum and iron offer less resistance and are known as good conductors of electricity. On the other hand, materials like plastic, glass, mica and rubber offer high resistance and are called bad conductors of electricity, or good insulators.



Ohmmeter

Digital Multimeter

Resistance in a circuit is measured by an instrument called ohmmeter and may be connected to an electrical circuit in parallel or in series. Resistance measurement does not involve measuring the circuit's resistance value itself. Instead, resistance is calculated by measuring the current and voltage applied to the circuit.

- Inductance

Inductance is the property of an electric circuit to oppose a change in the electric current flowing through it. Inductance is represented by the letter "L" and is measured in Henry (H). One henry is the amount of inductance necessary to induce one volt when the current in coil changes at a rate of one ampere per second. An inductor is a passive electrical component that is used to oppose sudden changes in current. It normally is a simple length of wire that is coiled up, creating a magnetic field when current is passed through it. Inductors are also known as coils or chokes. It is commonly measured by using an oscilloscope

Oscilloscope

- Capacitance

Capacitance is the ability of a component or circuit to collect and store energy in the form of an electrical charge. The components that can store energy are known as capacitors. Capacitance is measured in Farads (F) and is represented by the letter "C". Capacitance of a capacitor can be measured using a multimeter.

3.1.3 BASICS OF ELECTRICAL AND ELECTRONIC COMPONENTS

Electronic components are divided into two types based on their functionality:

- Passive Components

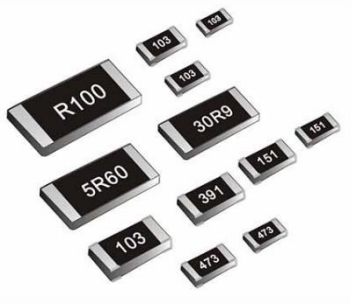
Passive components are electrical components that do not generate power, but can either absorb, store or release. Some of the common passive components are:

✓ Resistors

A resistor is a passive electrical component whose function is to introduce resistance to the flow of electric current in an electrical circuit to limit the current. The magnitude of the opposition to the flow of current is called the resistance of the resistor. Resistors are made from materials like copper or carbon, which make it difficult for the electrical charges to flow through a circuit. Some of the reasons to use a resistor include:

✓ Protecting a circuit from voltage spikes
✓ Providing the proper required voltage by creating a voltage drop
✓ Controlling speed of appliances such as fans
✓ Heating applications such as heaters, toasters, etc.
✓ Reduce current going into sensitive components

In a circuit, a resistor is denoted by the following symbol:



(a) (b)

(c)

FIGURE 3-9: (A) THROUGH – HOLE RESISTOR, (B) RESISTOR SYMBOL, (C) SURFACE MOUNT RESISTOR

Resistors are color coded, to allow anyone to determine their resistance.

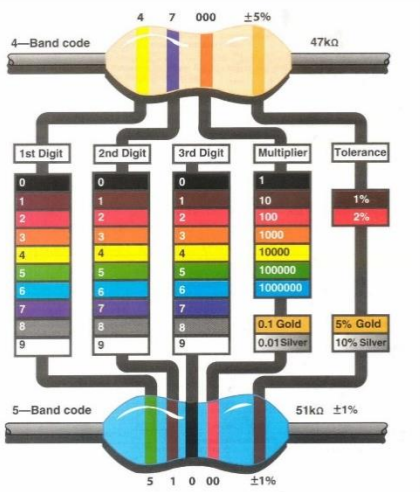


FIGURE 3-10: COLOUR CODING ON RESISTORS

- Capacitor

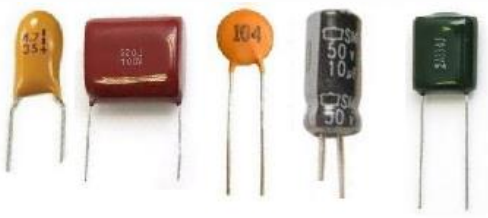


FIGURE 3-11: INDUCTORS

A capacitor is a passive electrical component that stores electrical energy in the form of an electrical charge producing a potential difference across its plates, similar to a small rechargeable battery. A capacitor normally is capable to delivering high power but for a short period of time because the energy density is low. Capacitors can be through hole of surface mount. Some of the reasons to use a resistor include:

- ✓ Charging and discharging electric charges
- ✓ Keeping the voltage at the same level
- ✓ Removing electrical noise

In a circuit, a capacitor is denoted by the following symbol:

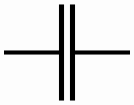


FIGURE 3-12: CAPACITOR SYMBOL

- Inductor

FIGURE 3-13: INDUCTORS

An inductor is a passive electrical component that stores energy in a magnetic field when electric current flows through it. The inductor supplies the stored energy to the circuit to maintain current flow during "off" switching periods, thus enabling topographies where output voltage exceeds input voltage. Inductors play a critical role in power electronics by preventing sudden changes in current. In a circuit, an inductor is denoted by the following symbol:

FIGURE 3-14: INDUCTOR SYMBOL

- Transformer

A transformer is also a passive electronic component that can step-up or step-down voltage. Power and energy remain the same on the primary and secondary side. They widely vary in size and power rating. In a circuit, a transformer is denoted by the following symbol:

FIGURE 3-15: SMALL TRANSFORMER

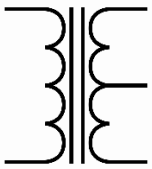


FIGURE 3-16: TRANSFORMER SYMBOL

- Active Components

Active components are electrical components that are capable of providing or delivering power to an electrical circuit. Some of the common active components are:

- Diode

  A diode is an active component that conducts current in one direction only, the "forward" direction, when the voltage at its anode is positive. It blocks voltage in the "reverse" direction. Some of the reasons to use a diode include:

FIGURE 3-17: TYPES OF DIODES

  - ✓ Lighting – LEDs
  - ✓ Power conversion
  - ✓ Over-voltage protection
  - ✓ Protecting circuits from reverse current flow

In a circuit, a diode is denoted by the following symbol:

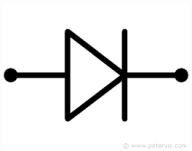


FIGURE 3-18: DIODE SYMBOL

- Transistors

  A transistor is an active component that behaves like a switch, and is used to enable or disable the flow of electronic signals. Some of the reasons to use a transistor include:

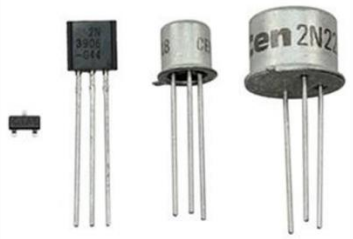


FIGURE 3-19: TRANSISTORS

  - ✓ Amplifying signals
  - ✓ Switching signals
  - ✓ Used as light sensors
  - ✓ Displays

In a circuit, a transistor is denoted by the following symbol:

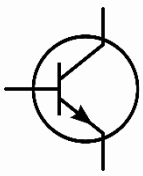


FIGURE 3-20: TRANSISTOR SYMBOL

Voltage Sources

A voltage source is an active component whose voltage at any instant of time is constant and is independent of the current drawn from it. When current leaves from the positive terminal of the voltage source, energy is being supplied to the circuit. Batteries and alternators are examples of voltage sources.

FIGURE 3-21: VOLTAGE SOURCE

In a circuit, a voltage source is denoted by the following symbol:

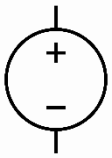


FIGURE 3-22: VOLTAGE SOURCE SYMBOL

- Current Sources

FIGURE 3-23: CURRENT SOURCE

A current source is an active component that supplies an electric current, independent of the voltage developed across its terminals. Photoelectric cells are examples of current sources.
In a circuit, a current source is denoted by the following symbol:

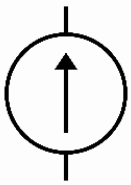


FIGURE 3-24: CURRENT SOURCE SYMBOL

3.1.4 TYPES OF WIRING

- Wire VS Cable

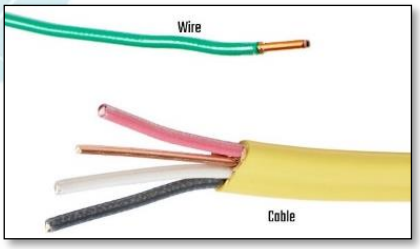


FIGURE 3-25: WIRE V/S CABLE

Although the terms wire and cable are often used interchangeably, a wire is generally a single strand or a group of strands of conductive material, like copper or aluminum, while a cable consists of two or more insulated wires wrapped in a jacket.

- Wires

  There are two types of wires, solid and stranded. A solid wire is a long length of single conductor, while a stranded wire comprises of multiple thin strands of conductor. Solid wires offer low resistance and are ideal to use in higher frequencies. Stranded wires are more flexible and thus, have a longer life.

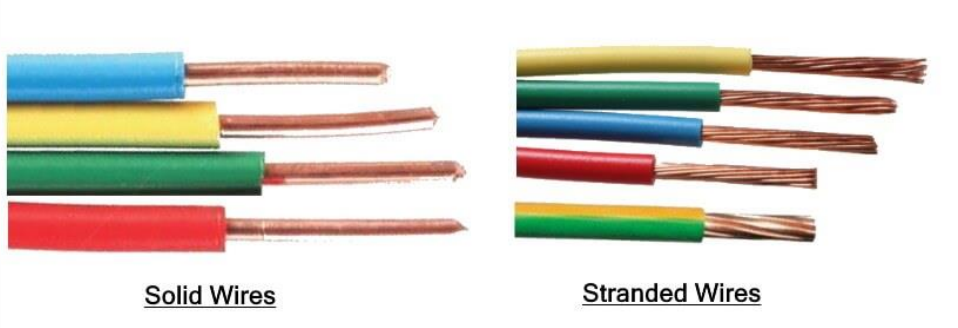


FIGURE 3-26: SOLID AND STRANDED WIRES

A wire is measured by diameter and the wire size that is normally referred to is the cross-sectional area in sq. mm (mm2). The conductor in electric wires is typically aluminum or copper. They are either bare or insulated and typically covered in a thin layer of PVC. If they have a PVC sheath, then the PVC is colored to indicate whether the wire is a neutral, ground or phase wire.

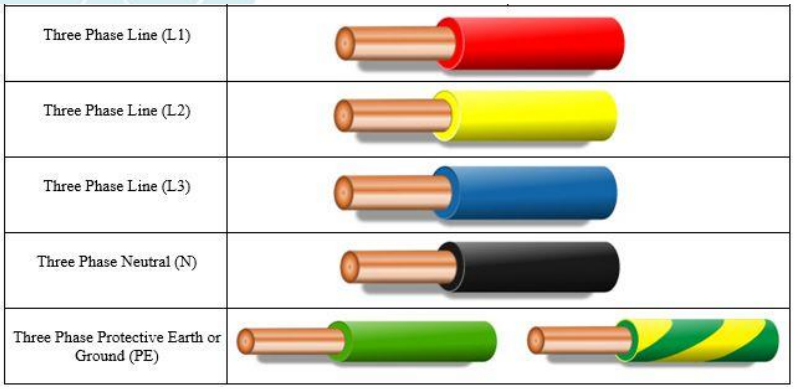


FIGURE 3-27: DIFFERENT THREE PHASE LINES

- Cables

A cable is, generally, two or more wires together. They are mostly insulated to offer better protection than just wires. Cables are largely employed in power transmission, and to carry electrical and telecommunications signals. The wires in a cable are insulated in their own color-coded layer of PVC. The group of wires is then encased in an outer sheath to make up the single cable.

FIGURE 3-28: CABLES

The number of wires in a cable are called cores. Cables can also be armoured, enabling them to be laid without additional casings in the open.

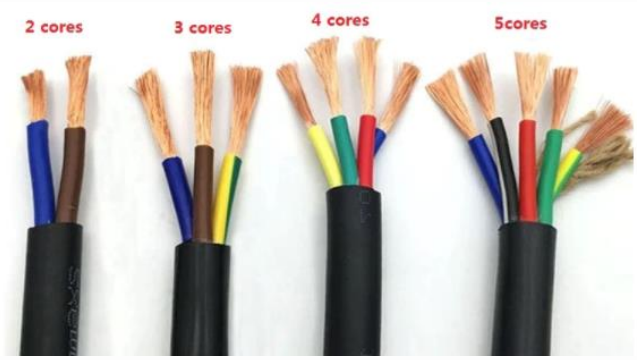


FIGURE 3-29: CORES IN THE WIRE

Key factors that are to be considered for selecting cable length are:

- ✓ Ease of access to the tapping point
- ✓ Space available in the charging station
- ✓ Ease of use
- ✓ Ease of storage
- ✓ Insulation and power rating of cable to maintain optimum weight of cable

The cable length and thickness are based on the current carrying capacity of the charging cable and the size of the charger. Similarly, they also determine the insulation of the cable required. The following formula may be used for the calculation of cable length:

$$l = \frac{V * A}{\rho * Imax}$$

Where,

l = length of cable

V = Voltage

A = Cross sectional Area of the conductor

ρ = resistivity

Imax = Current

The availability of cable length is a key factor is determining the type of vehicles that can be served at that charging station. An example is given below:

TABLE 3-1: CABLE LENGTH REQUIREMENT CALCULATION

CAR SIDE CONNECTOR	TYPE OF CONNECTION	MAX CAR CURRENT RATING	CABLE LENGTH REQUIREMENT
Type 1	Single – phase	16A	5 m
Type 1	Single – phase	32A	10 m
Type 2	Single – phase	32A	5 m
Type 2	Three – phase	32A	7.5 m

3.1.5 IMPORTANCE OF EARTHING & INSULATION

- Earthing

  Any fault in an electrical installation could result in an electric shock if a live metal part is touched. This is because electricity may use a human body as a path from the live part to the earth.

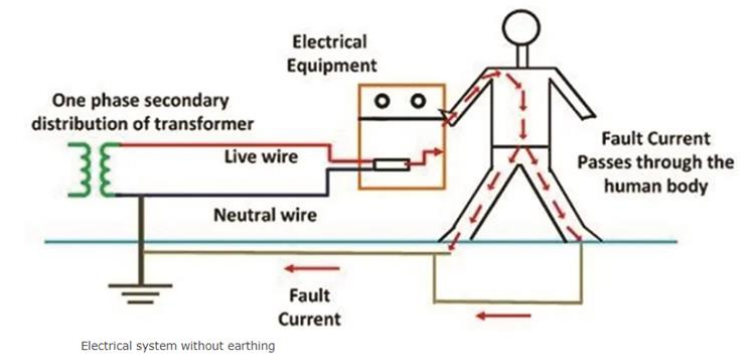


FIGURE 3-30: IMPORTANCE OF EARTHING

Earthing is one of the most important components in an electrical system to protect the humans from getting an electric shock. It is also known as the grounding system. Earthing provides a path for a fault current to flow to the earth.

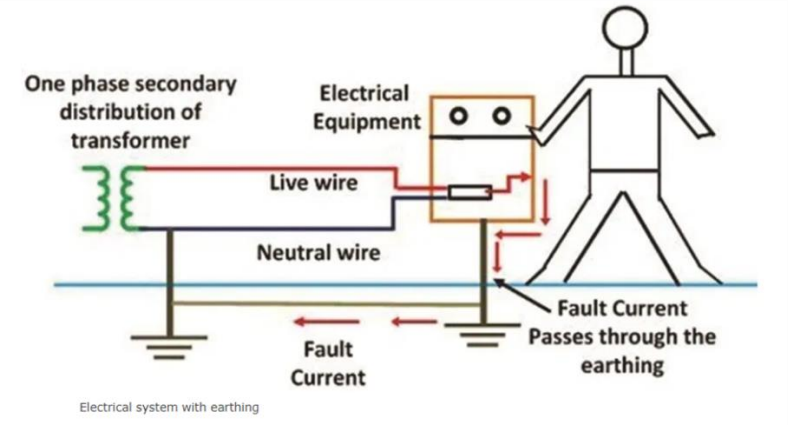


FIGURE 3-31: IMPORTANCE OF EARTHING

Mostly, Galvanized Iron (G.I) strips or Copper Wires are used as earth wires, which are bolted to the plate before burying it in the ground. The wire is made to pass through a GI pipe through which some water is poured in to increase conductivity. Earthing must always be done by an experienced electrician.

FIGURE 3-32: EARTHING

- Insulation

  Electrical insulators are used to hold conductors in position, separating them from one another and from surrounding structures. They form a barrier between energized parts of an electric circuit and confine the flow of current to wires or other conducting paths as desired.

- Insulation Degradation

  While in use, insulation is subject to many effects which can cause it to fail: mechanical damage, vibration, excessive heat or cold, dirt, oil, corrosive vapours, moisture from the air, and general wear and tear. Once started, different degradation processes aid each other. This will then permit excessive current through the insulation, thus resulting in danger to humans and other equipment.

- Monitoring Insulation Resistance

  It is impossible to detect leaking current without special tools. Hence, inability to detect insulation degradation is very dangerous as the consequences can be noticed - often too late. Having a planned maintenance program in place makes it more likely that gradual reductions in insulation resistance will be detected. Defective parts can then be repaired or replaced before full field failure occurs. A sudden drop in insulation resistance is very rare, the most common cause of this is when a device has been subject to complete submersion. Therefore, monitoring gradual drops in resistance as part of a regular insulation resistance testing program is vital to limiting the risk of electric shocks, maintaining the safety of personnel, and reducing repair times due to failure.

FIGURE 3-33: MEGOHMMETER

Insulation resistance can be measured using a special type of ohmmeter called Megohmmeter or an insulation resistance tester. Insulation testers use a high voltage, low current DC charge to measure the resistance within wires to identify current leakage and faulty or damaged insulation. The test voltage can range from up to 1000 V. The voltage is applied through the live-neutral connections and is measured against the earth.

3.2 PREPARATION FOR THE INSTALLATION OF EVCS

3.2.1 BASIC REQUIREMENTS

These are the minimum requirements that have to be met for the installation of an Electric Vehicle Charging Station.

- Space Requirements

  The site where the EVCS has to be installed should meet the minimum space requirements depending on the number of vehicles that are projected to charge simultaneously. It is crucial that adequate space is available at all times for parking, movement of vehicles and fire safety.

FIGURE 3-34: ELECTRIC 3-WHEELERS CHARGING AT A PUBLIC EVCS

Factors to consider for calculating space requirements:

- Dimensions of the vehicle

  This is the most important factor in calculating the space requirements. This will vary depending on the category of vehicles. The following are the average vehicle dimensions for the 3 most used categories of vehicles.

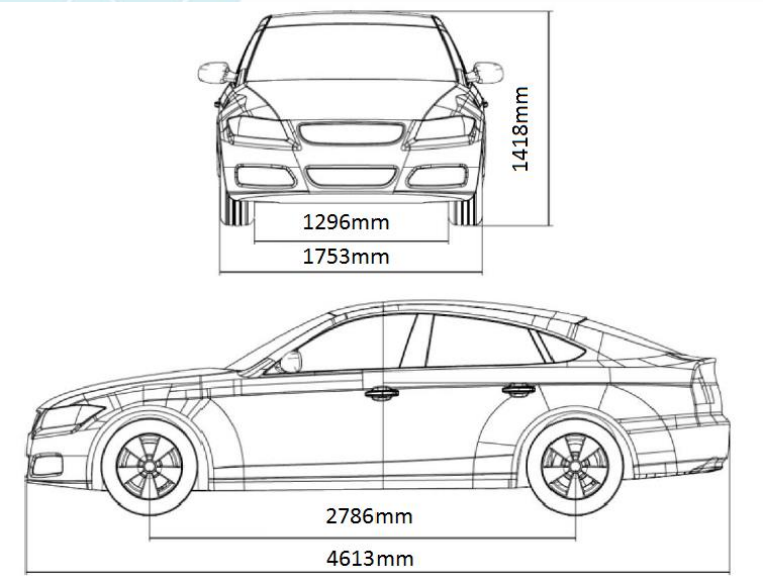


FIGURE 3-35: VEHICLE DIMENSIONS

- Space needed for movement of vehicles
    - ✓ The vehicles should have a reasonable amount of space to traverse around the charging station. It is crucial that this space is not compromised.

FIGURE 3-36: ELECTRIC VEHICLES PARKED FOR CHARGING

- Space between vehicles
    - ✓ Each vehicle should always be at least 2 feet away from each other for preventing damage to vehicles and reducing the risk of fire accidents.

FIGURE 3-37: CHARGING STATION WITH SPACES LEFT BETWEEN VEHICLES

- Space for electrical infrastructure (including distribution transformers, poles, plinths, etc), barriers and signage
    - ✓ Extra space should be considered for the infrastructure related to the installation of an EVCS.

Space for electrical infrastructure might vary at different locations as not every EVCS will have a need for distribution transformers, poles or plinths. Excess space should be considered as directed by the local DISCOMs.

FIGURE 3-38: PLINTH MOUNTED DISTRIBUTION TRANSFORMER

Based on the above considerations, the space needed per vehicle for the three aforementioned categories are as follows:

TABLE 3-2: SPACE REQUIRED AS PER VEHICLE CATEGORY

VEHICLE CATEGORY	SPACE REQUIRED
2 Wheelers	60 Square Feet
3 Wheelers	120 Square Feet
4 Wheelers	170 Square Feet

Example: Based on the aforementioned space values, let's see how to calculate the space needed for an EVCS which needs to have the capability of charging two 2 wheelers, ten 3 wheelers and five 4 wheelers. Consider the extra space needed for other equipment as 100 Square Feet.

Space needed for 2 Wheelers = 60 x 2 = 120 Square Feet Space needed for 3 Wheelers = 120 x 10 = 1200 Square Feet Space needed for 4 Wheelers = 170 x 5 = 850 Square Feet
Total Space Needed = 80+1200+750+100 (Extra Space) = 2270 Square Feet

- Electrical Load Requirements

  Having sufficient electrical power is the most important requirement for installing an EVCS. Depending on the number and type of chargers to be installed, the load requirements vary and has to be calculated thoroughly before proceeding with the installation. To calculate the load requirement, an EVCS Technician should have knowledge of the number, type and rated power of the chargers to be installed. As a practice, 40% to 50% more power should be considered for future installations/expansion and protection from fluctuations and overloads.

Example: Let us calculate the electrical power needed for a charging station which needs to have 2 numbers of 15 KW GB/T, 10 numbers of AC001 and 1 number of 30 KW CCS2 chargers.
From Unit 2, we know that AC001 has a maximum rated power of 10 KW

Power needed for GB/T DC Chargers = 2 x 15 = 30 KW Power needed for AC001 AC Chargers = 10 x 10 = 100 KW Power needed for CCS2 DC Chargers = 1 x 30 = 30 KW
Total Load = (30+100+30) x 150% = 160 + 80 = 240 KW

FIGURE 3-39: MULTIPLE EVSES AT A CHARGING STATION

- Type of Location

  The type of location for EV Charging might vary on the type of vehicle one would want to charge, some vehicles require charging in an indoor location to prevent damage to the vehicle, batteries or chargers. Depending on the requirement, the type of location should also be selected accordingly. Irrespective of whether the location is indoors or outdoors, it should meet the following parameters.

  - ✓ The location should have enough space for the vehicles.
  - ✓ The location should be protected from environmentally harmful elements such as rains & flooding
  - ✓ The route to the location should be easily accessible for the vehicles and the person driving the vehicle
  - ✓ The location should have sufficient height clearance (2 feet above the height of the vehicle) if it is indoors.
  - ✓ The location should be reasonably secure to prevent loss or theft of any equipment.
  - ✓ The location should have good ventilation when it is completely full
  - ✓ The location should have good SIM network connectivity or LAN availability for communication of charging equipment (EVSEs)

FIGURE 3-40: AN OUTDOOR CHARGING STATION

FIGURE 3-41: AN INDOOR CHARGING STATION

- Documentation requirements

  The documentation requirements are based on the type of installation, i.e., residential installation or commercial installation.

  For residential installation, the following documents are required:

  - ✓ Plot Plan
  - ✓ Electrical Load Calculations
  - ✓ Electrical Plans
  - ✓ EVSE Information

  For commercial installations, the following documents are required:

  - ✓ Land Suitability Analysis Report
  - ✓ Land Development Authority or Building Design Guidelines
  - ✓ Existing Use Permits, if any
  - ✓ Electrical Source/Metering
  - ✓ Parking and Signage Requirements
  - ✓ Permit and Inspection Fees, if applicable

This shall ensure compliance with existing law and will result into a smooth process for setting up and operationalizing an EV charging station. For charging stations located in private places for specific type of vehicles or personal use, the vehicle charging timer may prove to be useful. The charger on connecting with the vehicle displays the time left for the vehicle to charge to a desired pre-set level, based on the discharge level of the EV battery. For example, a fleet of buses in a bus depot can be connected to a pre-defined charging limit, which can optimize the use of chargers in the bus depot and prevent overcharging of a vehicle.

3.2.2 PRE-INSTALLATION CHECKS AND ASSESSING EVCS COMPONENTS

Before proceeding with the installation, the technician should make a practice of following a checklist, which should include the following:

- Load Availability
  - ✓ The technician should make sure that enough load is available for supporting the EVCS.
  - ✓ If the available load cannot support the charging station, then the sanctioned load should be extended before proceeding.

- Space Availability
  - ✓ The technician should make sure that the location meets the space requirements. They should also make sure to check other parameters mentioned in 3.2.1(c) of this handbook.

- Permissions
  - ✓ The technician should make sure that all the necessary permissions for the installation have been obtained.

- Wiring
  - ✓ The technician should check whether the electrical wiring work in the premises meet the safety, regulatory and any internal standards before proceeding with the installation

- Electrical Checks
  - ✓ The technician should test the electrical installation before proceeding with the installation of the EVCS. The following tests should be performed, and the technician should only proceed with the installation if the values fall under normal values
  - ✓ Voltage Check - The technician should make sure that the Phase to Phase and Phase to Neutral voltages are in the acceptable range.
  - ✓ Continuity Check - The technician should make sure that the wiring and other connections do not have any break in them.
  - ✓ Earthing Check - The technician should make sure that there is sufficient earthing available at the location to support the EVCS
  - ✓ Switchgear Check - The technician should make sure that all the protective switchgear are connected properly and are working as intended. If any switchgear is found to be not working then it should be replaced immediately

- Type of Connection
  - ✓ The type of connection – i.e., single-phase LT, three phase LT, or high-tension (HT) – is decided based on the required sanctioned load, and directly impacts the cost and time for getting a connection, the electricity tariffs, and the need for ancillary upstream infrastructure like Distribution Transformers (DTs).
  - ✓ An HT connection attracts higher installation and monthly demand charges, involves more time for energization, and requires the set-up of ancillary electrical infrastructure by the applicant. The sanctioned load ceilings for LT and HT connections vary significantly between the States of India.

- Type of Installation

  - ✓ Depending on the type of location and the type of charger, the technician should understand how to install the charging equipment. Currently, there are two types of installation methods
  - ✓ Wall Mounted Chargers - At the location where there is an availability of a wall strong enough to support the weight of the charger and the charger is also capable of being mounted on the wall, the chargers should be mounted on the wall.
  - ✓ Pedestal or Stand Mounted Chargers - In the event when the charger cannot be mounted on the wall, it should be mounted on a pedestal or a stand as per the direction of the OEM. This might involve the construction of a concrete plinth of various sizes.

FIGURE 3-42: A WALL AND PEDESTAL MOUNTED EV CHARGER

- Materials Check

  - ✓ The technician should make sure that all the materials, tools and equipment needed for the installation are available at the site to finish the installation in a timely and smooth manner.

- EVCS Components Check

  - ✓ The technician should make sure that the Electrical Vehicle Charging Equipment (EVSE) for the installation of the EVCS has all its components.
  - ✓ The technician should make a practice of checking and noting down all the presence and the state of the components that are supposed to be with the EVSE, this might include:
  - ✓ The charging unit
  - ✓ The wall mounts or other mounting equipment
  - ✓ The charging connectors
  - ✓ Rectifiers (For DC Chargers)
  - ✓ Bolts, screws, or fasteners
  - ✓ Any other component listed on the EVSE or the work order.

Variance of specifications between the product and equipment to be installed can be prevented by undertaking pre-installation checks to include a final thorough comparison of equipment specifications ordered against the name plate rating or data sheet of equipment being installed on site. On the name plate, the following parameters are generally given:

- ✓ Manufacturer
- ✓ Model
- ✓ Rating
- ✓ Certification marks
- ✓ Warnings
- ✓ Serial Number

On the technical data sheet, the following parameters may be found:

- ✓ Installation side connection Model – 3-phase/1-phase
- ✓ Number of charging units
- ✓ Maximum power per charging point
- ✓ Nominal Power
- ✓ Dimensions
- ✓ Type of charging gun(s)
- ✓ Number/Type of Earth Leakage Circuit Breakers
- ✓ Communication Interface
- ✓ Degree of Protection
- ✓ Impact Strength
- ✓ Load Management

In case variance occurs, escalation matrix should be used to report to relevant authority. A sample escalation matrix is shown below:

TABLE 3-3: ESCALATION MATRIX

Role	Person Responsible	Trigger reason
Senior Level	Name of Person	
Middle Level	Name of Person	
Middle Level	Name of Person	
Junior Level	Name of Person	

The list of concerned departments and emergency contact numbers shall be prominently displayed in the charging station premises, and the escalation matrix may be referred to for responding to issues that requires intervention of multiple authorities. An organogram containing the hierarchy of staff and work personnel may be put up at prominent location in the premises, and awareness be created about the same to approach the right person in the order of as defined by the escalation matrix, on case-to-case basis.

3.2.3 PERMISSIONS AND AUTHORIZATION REQUIREMENTS

It is important to secure all the necessary permissions from the relevant authorities before proceeding with the installation of an EVCS to avoid the following:

- ✓ Problems in securing electrical connections
- ✓ Problems in construction or erection of supporting structures for the EVCS
- ✓ Problems in day to day running of the EVCS post the installation
- ✓ Any distress, nuisance or grievance to individuals and entities around the EVCS
- ✓ Safety-related accidents and issues

A technician should always secure the following permissions/authorizations before proceeding with the installation

- Work Order
  - ✓ A work order is a formal written document stating the allotment and scope of work from one party to another
- Clearance from local DISCOMs
  - ✓ The electrical distribution companies or DISCOMs should be made aware of the installation of the charging station and all matters relating to load availability, tariff category and new electrical connections should be clarified to avoid any problems during the installation or running of an EVCS.
- NOC/Agreement from the landlords/leasing authorities
  - ✓ In the eventuality that the location is under private ownership, a NOC from the landlord or the relevant authority.
- NOC from the local Municipal Corporation or Regulatory authority
  - ✓ Though this is not universally applicable if the location is under the possession of a public/government authority, a NOC from the same should be obtained before proceeding with the installation.
  - ✓ If the installation of the EVCS requires the construction of permanent structures, relevant permissions should be obtained from the concerned authorities.
- Miscellaneous Permissions
  - ✓ The type and number of permissions required for the installation might vary from place to place, depending on the location, the technician should acquire any necessary permissions from the relevant authorities.

3.3 INSTALLATION OF ALL CHARGING STATION COMPONENTS

3.3.1 PRELIMINARY CIVIL ENGINEERING WORKS

- Location

  Ensure the location at which the charging station is installed follows the below criteria:

  - ✓ Location is safe from falling debris
  - ✓ The charging station does not obstruct movement of people or vehicles
  - ✓ The area is well ventilated
  - ✓ There are no combustible gases and corrosive agents
  - ✓ There is no risk of flooding or water accumulation

- Infrastructure

  The civil infrastructure required should be clearly identified and work should be performed by experienced personnel only. The civil work could include:

- Walls

  Walls may be needed to partition certain areas, mount charging stations or to create rooms. If charging stations need to be mounted on a wall, the structural design of the wall should take this into account.

FIGURE 3-43: WALL MOUNT CHARGING STATION

- Metal structures

  Metal structures may be required to cover the charging area. This could include a metal skeleton and metal sheets to cover the sides and the top or a canopy. This structure should be designed by a structural engineer and should consider the geographic conditions of that area.

FIGURE 3-44: METAL STRUCTURE TO COVER CHARGING STATION

- Plinths

  Plinths or foundations may be needed to mount charging stations or their pedestals. This must be done as per standard specified by the charging station manufacturer.

FIGURE 3-45: FOUNDATION TO MOUNT CHARGING STATION

3.3.2 INSTALLATION OF EVCS COMPONENTS

The charging stations must be installed as per the procedures and requirements mentioned by the charging station manufacturer.

The core items of a charging station could include:

- Wall mount / pedestal

  A wall mount is used to mount the charging station on a wall, while a pedestal is used to mount the charging station on the ground.

- Charging station

  The charging station itself would be mounted using a wall mount or a pedestal.

- Connector holder

  For some charging stations, an external connector holder may be provided to hold the connector when it is not plugged-in to an EV.

- Residual current device

  Residual current device, or safety switch, are designed to immediately switch off the supply of electricity when electricity leaking to earth is detected at harmful levels. They offer high levels of personal protection from electric shock.

- Firmware

  The firmware to be used in the charging station depends on the location, type of charging station and the frequency of use of the charging station. It shall happen that the hardware that are currently in use may not be upgraded to newer technologies or comply with newer policies and shall result in becoming a legacy hardware. This results in need for updation of firmware.

The operating systems and firmware of devices shall have standard security measures, such as strong and random passwords (and avoid bypassing), adopt a proper implementation of access control of files and other resources, and they must allow updates from verified sources.

3.3.3 CONNECTION WITH POWER GRID

- Wiring

  Proper cabling has to be done and the correct cable routing mechanisms has to be adopted:

FIGURE 3-46: EXAMPLE PROPER CABLING

  - ✓ The cable should be as per the charging station rating and manufacturer specification
  - ✓ The cable should be routed through cable trays or conduit or in the ground
  - ✓ Armored cable must be used in places where the cable is laying in the ground and for longer distances. Various methods of laying cables are possible:
    - Laying directly into the ground
    - Drawing in ducts
    - Laying on racks in air
    - Laying on rack inside a cable tunnel
    - Laying along building and structure

The power cable to the charging station must be hardwired. With a hardwired EV charging installation, an electrician installs a dedicated line from the main electrical panel to the desired EV charger location.

- Circuit Breaker

  A circuit breaker (MCB / MCCB) must be installed as per the charging station manufacturer's specification.

FIGURE 3-47: CIRCUIT BREAKER

- ✓ Use only the recommended circuit breaker
- ✓ If a replacement is required, use a circuit breaker of the same specification and similar quality
- ✓ Place the circuit breaker in a proper enclosure
- ✓ The charging station must be wired on a dedicated circuit, with no other loads wired on that circuit
- ✓ The circuit breaker must be installed in proximity to the charging station to enable quick shut off in case of an emergency
- ✓ It acts as a safety switch in an electric vehicle and a charging station. The faulty system is disconnected in the charging station, to prevent a complete shutdown of the station.

- Grounding Instructions

  The charging station must be connected to the ground at all times:

  - ✓ Use a copper wire, permanent wiring system to connect to ground
  - ✓ Ensure the earth pit is in good condition
  - ✓ It is recommended to have a dedicated earth pit for EV charging station
  - ✓ Connections to the charging stations should comply with all local and building regulations

3.3.4 PRE-POWER UP TESTS

Test should be performed to ensure the electrical wiring and installation is as per standards.

- Visual Inspection

  The entire wiring should be visually inspected to ensure best practices have been followed. It should be ensured that the charging station is mounted securely. Ensure all required branding and safety labels are present.

- Checks

  The following voltage measurements must be performed using a multimeter:

- Phase to Neutral

  - ✓ Tool Required: Multimeter
  - ✓ Connection: The voltage between phase and neutral must be measured at the input to the circuit breaker. For a 3-phase connection, voltage must be measured between every phase and neutral.
  - ✓ Desired Value: Voltage between any of the phases and neutral should be around 240 V AC.

- Phase to Phase

  - ✓ Tool Required: Multimeter
  - ✓ Connection: For a 3-phase connection, the voltage between every phase must be measured at the input to the circuit breaker.
  - ✓ Desired Value: Voltage between any of the phases and neutral should be around 415 V AC.

- Neutral to Earth
  - ✓ Tool Required: Multimeter
  - ✓ Connection: The voltage between neutral at the input to the circuit breaker and earth must be measured.
  - ✓ Desired Value: Voltage between neutral and earth should be less than 2 V AC.
- Insulation Test
  - ✓ Tool Required: Insulation Tester
  - ✓ Connection: The insulation resistance should be measured with a voltage of 500 V DC applied between all inputs/outputs connected (power source included). The test voltage shall be applied for 1 min.
  - ✓ Desired Value: The insulation resistance between the accessible parts shall be more than 1 MΩ.

INSULATION TEST RESULTS			
MEASUREMENT	RESISTANCE / 500 V DC	MEASUREMENT	RESISTANCE / 500 V DC
R-E		Y-E	
B-E		N-E	
R-N		Y-N	
B-N		R-Y	
Y-B		B-R	

FIGURE 3-48: INSULATION TEST RESULT TABLE

3.3.5 POWERING UP THE EVCS

Ensure the charging station enclosure is securely mounted and all the openable panels are closed. The power ON indication for every charging station is different. The user manual must be carefully read and understood before turning ON the charging station. After ensuring everything is in order, the charging station can be turned ON by switching ON the circuit breaker.

4

Commissioning of Electric Vehicle Charging Station

4. COMMISSIONING OF ELECTRIC VEHICLE CHARGING STATION

Key Learning Objectives:

The trainees will be able to,

- Understand all international regulations and directives needed for EVCS certification
- Understand the significance of external test - earthing test, mechanical test, distribution transformer checks, etc. and internal tests - Input voltage & currents, output voltage & current, continuity etc.
- Identify and rectify the EVCS equipment malfunctioning during the commissioning
- Document the charging station related records which includes site cleaning and waste management

4.1 TESTING OF THE CHARGING STATION FOR VALIDATION OF INSTALLATION

4.1.1 CONFIRMATION OF ALL EVCS CERTIFICATIONS

It should be ensured that the charging station installed matches the specification desired. Some of the key elements to be verified:

- Model

  Ensure the charging station received is of the same Make and Model of the requirement.

- Input Power Rating

  Ensure the input voltage and current of the charging station are in line with the electrical wiring and load availability. In case the wiring or the electrical load is not sufficient for the charging station, ensure the required changes are done before installing and commissioning the charging station.

- Outputs

  Ensure all required outputs are present and the proper output connector mounting mechanism is in place to ensure cable or connector are not on the ground.

- Certifications

  Ensure the charging station is certified as per the desired standard. For testing of the charging station and components, following are the standards IEC 61982, IEC 62133, IEC 62196, IEC 61851, IEC 61851-1, -21, -22, -23, IEC 61850, IEC 60950, SAE J2929, SAE J2464, SAE J2894, SAE J1772 and SAE J2293. The Bharat DC 001 and Bharat AC 001 EV charger is designed by ARAI to charge electric vehicles. CE certification tests involving EV charger (station) or components include the following aspects:

  - ✓ Electrical safety testing
  - ✓ EMC/EMF, FCC/ISED test
  - ✓ Wireless and IoT testing: such as Wi-Fi, Zigbee, Bluetooth, GDPR, IoT product certification, functional safety testing
  - ✓ Durability test (life cycle test)
  - ✓ Data communication/protocol testing (CHAdeMO, CharIN)

- ✓ Climate test: IP test, ultraviolet radiation, corrosion test, etc.
- ✓ Mechanical and material testing: flammability test, glow wire test, etc.

- International regulations and directives, including:
  - ✓ Low Voltage Directive (LVD) 2014/35/EU
  - ✓ Electromagnetic Compatibility Directive (EMC) 2014/30/EU
  - ✓ Radio Equipment Directive (RED) 2014/53/EU Charging System: IEC61851/IEC61752/UL2202
  - ✓ Wireless Charging System: IEC61980
  - ✓ Protection Device/Personal Protection System: IEC60755/UL2231
  - ✓ Plug, Socket, Connector, Socket: IEC62196/UL2251
  - ✓ Cables and Liquid-Cooled Cables: IEC62893 and 2PfGQ2473
  - ✓ Low-Voltage Switchgear and Control Equipment Components for Charging Stations: IEC61439-7
  - ✓ IEC61347-1: 2015 General and safety requirements for lighting control devices
  - ✓ IEC61347-1:2015 Describes the general and safety requirements of light controllers for DC Power Supplies up to 250V and/or AC power supplies up to 1000V at 50Hz or 60Hz
  - ✓ IEC61347-1: 2015 provides IEC61347-1: 2015RLV, which contains the International Standard and its Redline Version, and shows all the changes in the technical content compared with the previous version.
  - ✓ IEC61347-1:2015 specifies the general and safety requirements for lighting control devices, which are suitable for DC power supplies up to 250V and/or AC power supplies up to 1000V at 50Hz or 60Hz. The third edition cancels and replaces the second edition released in 2007, revision 1: 2010 and revision 2: 2012. This version constitutes a technical revision.

4.1.2 EXTERNAL TESTS

Various tests must be conducted at regular intervals as preventive measures also (apart from those situations when there is fault). Availability of requisite instruments and trained manpower is needed for this purpose. The text as reproduced from CEA is given below:

Testing of EVs Charging Stations:

(i) All apparatus of EV charging station shall have the insulation resistance value as stipulated in the relevant IEC 61851-1.

(ii) Any testing as specified in the manufacturer's instructions for the RCD and the EV charging station.

Periodic maintenance and assessment of electric vehicle charging stations:

(i) An electric vehicle charging station operator shall arrange periodic test/ inspection of an EV charging station or EVSE should be carried out by electrical inspector/CESE in every four years.

(ii) The owner/operator shall establish and implement a safety assessment programme for regularly assessing the electrical safety of EVSE, conductors and fittings.

(iii) The owner/operator shall keep records of the results of every periodic assessment and details of any issues found during the assessment; and any actions required to be taken in relation to those issues.

(iv) The owner/operator shall retain a copy of all records, whether in hard copy or electronically, for at least seven years and shall provide a copy of the records to the inspecting officers.

The various external tests are described below:

- Earthing Test

  Earthing test is done by using the help of instrument called Earth resistance tester. Every equipment in the power system is earthed to ensure protection for both the system and personnel. Earthing is the process of establishing electrical connectivity between noncurrent bearing parts of an electrical device and earth through a low resistance path. This protects the person working with the electrical device from leakage current flowing through its body. By maintaining all the equipment of the power system at earth potential, unexpected electrical charges due to lightning or static electricity are dissipated to the earth through earthing, thus protecting the system. it is recommended to maintain an earth resistance of less than 2Ω for EVSE.

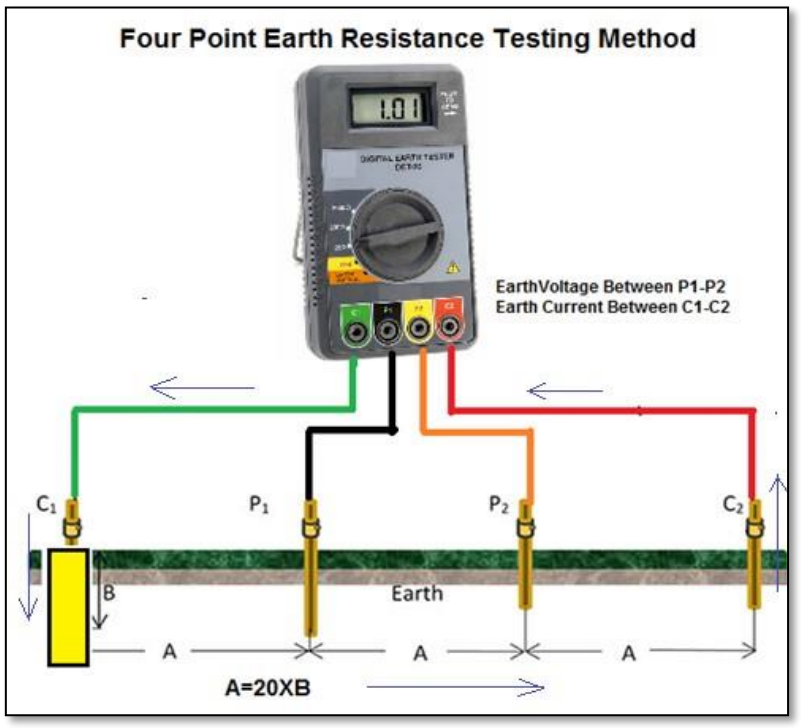


FIGURE 4-1: FOUR POINT EARTH RESISTANCE TESTING METHOD

- Insulation Resistance Test

  An insulation resistance (IR) test measures the total resistance between any two points separated by electrical insulation. The test, therefore, determines how effective the dielectric (insulation) is in resisting the flow of electrical current. Such tests are useful for checking the quality of insulation, not only when a product is first manufactured but also over time as the product is used. The Megger insulation tester is a small, portable instrument that gives you a direct reading of insulation resistance in ohms or megohms. For good insulation, the resistance usually reads in the megohms range.

Insulation resistance measurement is based on Ohm's Law. (R=V/I). By injecting a known DC voltage lower than the voltage for dielectric testing and then measuring the current flowing, it is very simple to determine the value of the resistance. In principle, the value of the insulation resistance is very high but not infinite, so by measuring the low current flowing, the megohmmeter indicates the insulation resistance value, providing a result in mega ohms. This resistance characterizes the quality of the insulation between two conductors and gives a good indication of the risks of leakage currents flowing.

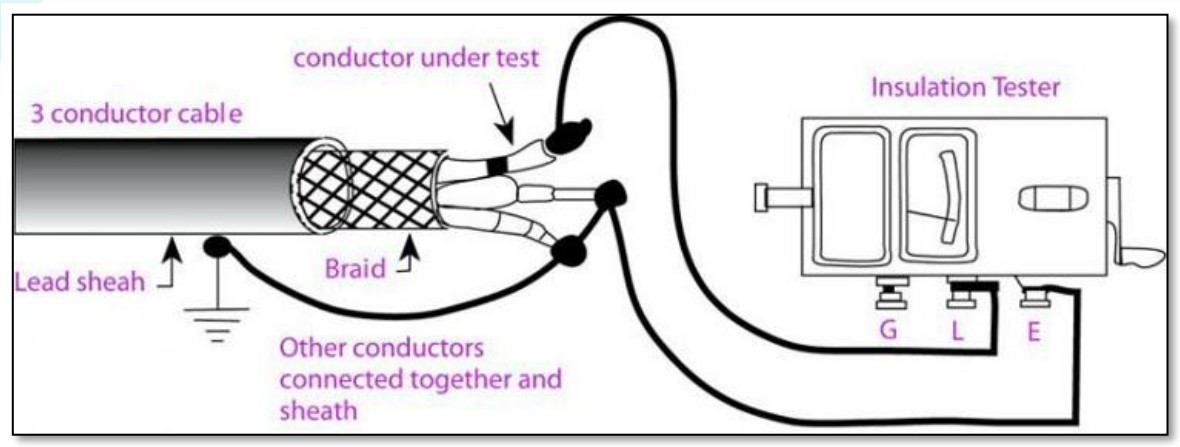


FIGURE 4-2: MEASUREMENT OF INSULATION RESISTANCE

The insulation resistance measured with a 500 V DC voltage applied between all inputs/outputs connected (power source included) and the accessible parts shall be:

- ✓ For a class I EV supply equipment: R > 1 MΩ;
- ✓ For a class II EV supply equipment: R > 7 MΩ.

- Class I EV supply equipment: Charger with basic insulation as provision for basic protection and protective bonding as provision for fault protection.
- Class II EV supply equipment: Charger with
  - ✓ Basic insulation as provision for basic protection, and
  - ✓ Supplementary insulation as provision for fault protection or in which
  - ✓ Basic and fault protection are provided by reinforced insulation
- Glow Wire and Flammability Test

Glow wire requirements for home appliances are specified in IEC 60335-1. However, the actual glow wire test methodology is covered in the IEC 60695-2 series of specifications. Glow wire testing is performed by heating an element to a pre-determined temperature. The heated element is referred to as the glow wire. See figure 3 for an example of the heated element used for glow wire testing. The sample to be tested is fixture in place and tissue paper is positioned directly below the sample. After reaching the pre-determined temperature, the element is then pressed into a sample material under a set force of 1N for 30 seconds. If

ignition occurs, recordings are made to note the duration, flame height, and if drips of the material ignite the tissue paper.

- ✓ GWT stands for Glow Wire Test (IEC 60695-2-11). GWT is used when glow wire testing is performed on an end product. The results of this test will be either PASS or FAIL at a given temperature. Passing the test requires that the sample does not ignite or self-extinguishes within 30 seconds after removal of the heated element. Also, the sample may not ignite the tissue paper if drips occur.
- ✓ GWFI stands for Glow Wire Flammability Index (IEC 60695-2-12). This is a property associated with raw material used in the end product. This property is determined by conducting the glow wire test on a test plate of a raw material of a given thickness. The Glow Wire Flammability Index (GWFI) is the highest temperature at which the material does not ignite or self-extinguishes within 30 seconds after removal of the heated element.
- ✓ GWIT stands for Glow Wire Ignition Temperature (IEC 60695-2-13). This is a property associated with raw material used in the end product. This property is determined by conducting the glow wire test on a test plate of a raw material of a given thickness. The Glow Wire Ignition Temperature (GWIT) is the lowest temperature at which the material ignites and burns for longer than 5 seconds while the heated element is in contact with the test plate. Knowledge of the three terms is essential to understand how glow wire testing is applied under the overall safety standard IEC 60335-1.

IEC 60335-1 is a general specification that governs the safety of household appliances. Within the specification, glow wire testing is used to evaluate flammability of non-metallic materials supporting current carrying connections used within the appliance. The glow wire test severity prescribed in IEC 60335-1 is determined by whether the appliance is attended or unattended during use, and by the amount of current that is carried by the connection. Attended appliances are basically any appliance that is operated by an attending consumer such as vacuum cleaners, irons, and coffee pot.

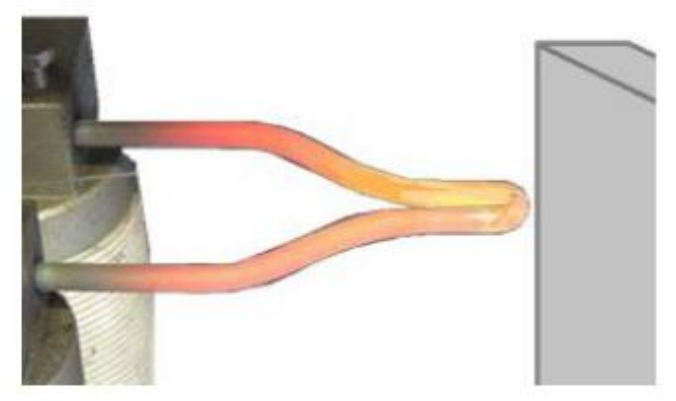


FIGURE 4-3: TYPICAL GLOW WIRE SETUP SHOWING HEATED ELEMENT GLOWING RED/YELLOW IN COLOUR.

(Temperature set to 750 °C) Photo provided by: TE Connectivity.

Unattended appliances are those that are set in place and operated on their own. Such examples include refrigerators, cooking units, dishwashers, washing machines, and dryers. Connectors used in an application that is categorized as unattended with current greater than 0.2A are subject to the most severe evaluation. To comply with this specification, three levels of flammability evaluation may be required:

- ✓ In order to pass the first level of evaluation, the material must have a minimum GWFI 850 °C OR the end product must pass the glow wire test at 850 °C. It is important to note that for the end product to pass, the sample must self-extinguish within 30 seconds as identified in the above passage. The test is subject to the procedure 60695-2-11.
- ✓ In order to pass the second level of evaluation, the material must have a minimum of GWIT 775 °C OR the end product must pass the glow wire test at 750 °C. It is important to note that if the end product is tested, any ignition must self-extinguish within 2 seconds, or the surrounding components must pass a third level of evaluation.
- ✓ The third level of evaluation (performed only if the connector exhibits a flame for longer than 2 seconds) is not performed directly on the connector, but instead is performed on any components within the appliance falling within a theoretical envelope above the connector. Components within the envelope made from a material that has a minimum flammability designation as UL 94 V1 are not subject to further evaluation. However, components within the envelope that have less than UL 94 V1 are subject to a needle flame test. Refer to the flow diagram located in the figure 4.4 for an illustration of the testing required for materials supporting connections carrying current greater than 0.2 A in unattended appliances. Connectors used in appliances that are categorized as unattended with a current less than 0.2A or categorized as attended appliances are subjected to less severe testing methods. It is important for the appliance manufacturer to understand the appropriate categorization of their finished product, to apply the correct level of testing per IEC 60335-1 to the components.

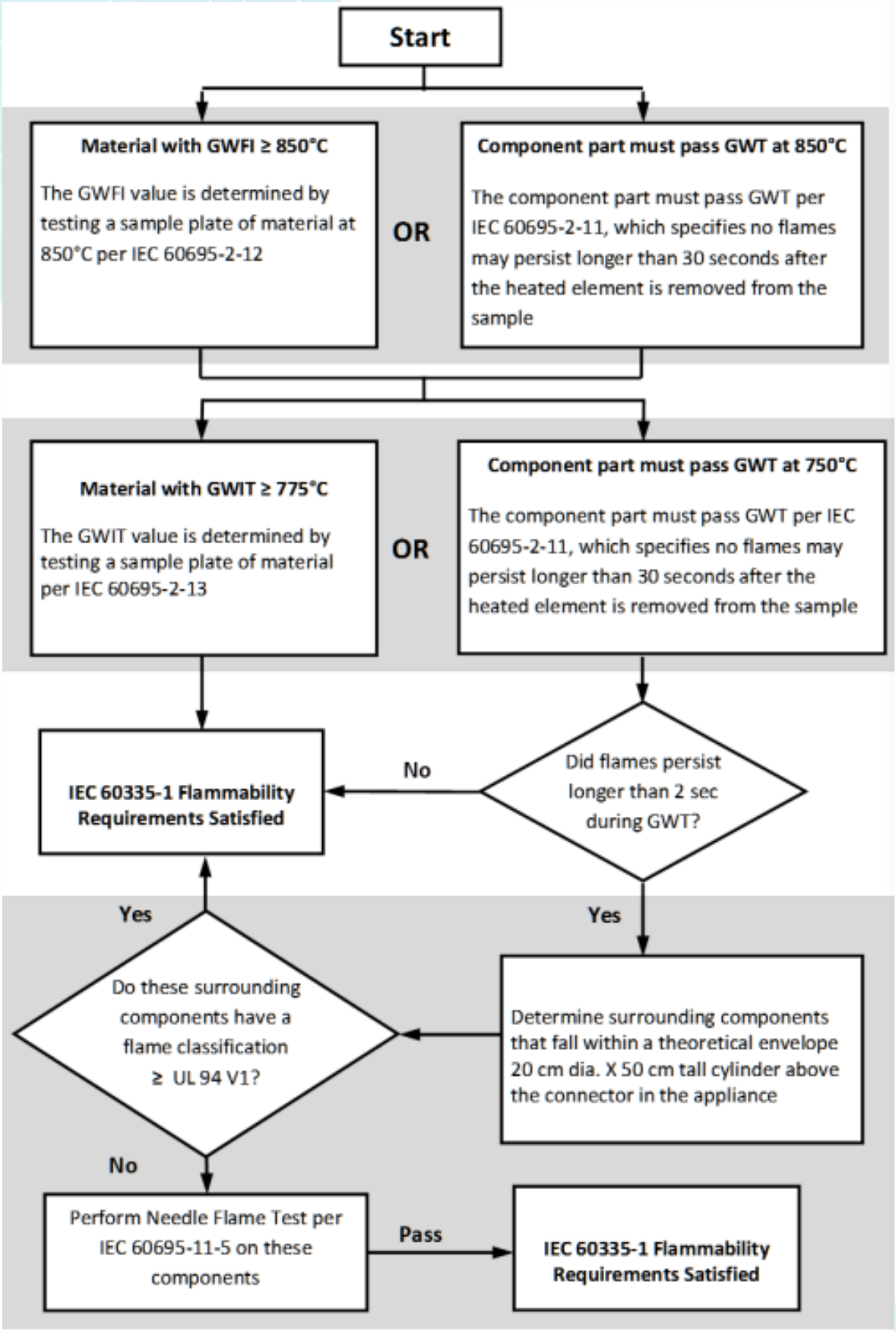


FIGURE 4-4: FLOW DIAGRAM OF GLOW WIRE / FLAMMABILITY TEST

- Ingress Test

  Electric and electronic equipment deteriorate or malfunction when water or dust enters the device. The IEC has developed the ingress protection (IP) ratings, which grade the resistance of an enclosure against the intrusion of dust or liquids. The ratings are widely used throughout industry.

  IEC 60529 has been developed to rate and grade the resistance of enclosures of electric and electronic devices against the intrusion of dust and liquids. It also rates how easy it is for individuals to access the potentially hazardous parts within the enclosure.

  The IP code is composed of two numerals:

  The first numeral refers to the protection against solid objects and is rated on a scale from 0 (no protection) to 6 (no ingress of dust).

  The second numeral rates the enclosure's protection against liquids and uses a scale from 0 (no protection) to 9 (high-pressure hot water from different angles).

  The testing shall be carried out in accordance with IS/IEC 60529.

- Environmental Tests:

  Standards and the contents are mentioned briefly in the table below:

TABLE 4-1: DETAILS OF IS STANDARDS FOR ENVIRONMENTAL TESTS

IS Standard	Contents of the standard in brief
IEC 60068-2-30:2005	Environmental testing – Part 2-30: Tests – Test Db: Damp heat, cyclic (12 + 12 h cycle).
IS 9000(Part 7/Sec 7):2006/ IEC 60068- 2-75:1997	Basic environmental testing procedures for electronic and electrical items: Part 7: Test Impact, Sec 7 Test Eh: Hammer tests
IS 9000 (Part 4): 2008/ IEC 60068-2- 78:2001	Basic environmental testing procedures for electronic and electrical items: Part 4 Damp Heat (Steady State).

4.1.3 INTERNAL TESTS - INPUT VOLTAGE & CURRENTS, OUTPUT VOLTAGE & CURRENT, CONTINUITY

All wiring systems shall be tested for continuity of circuits, short circuits and earthing after wiring is completed and before energizing. A Multimeter is one of the most useful tools for any electrical purpose, such as for testing the voltage-current resistance, continuity measurements.

- Voltage Test:
  - ✓ Switch on your multimeter and set the dial to DC voltage mode (indicated by a V with a straight line, or the symbol ⎓). Virtually all consumer electronic devices run on DC voltage. AC voltage—the kind

that runs through the lines to your house—is considerably more dangerous, and beyond the scope of this guide.

- ✓ Place the red probe on the positive terminal, and the black probe on the negative terminal.
- ✓ If your range was set too high, you may not get a very accurate reading. Here the multimeter reads 9 volts. That's fine, but we can turn the dial to a lower range to get a better reading.
- ✓ If you set the range too low, the multimeter simply reads 1 or OL, indicating that it is overloaded or out of range. This won't hurt the multimeter, but we need to set the dial to a higher range.
- ✓ With the range set correctly, we get a reading of 9.42 volts.

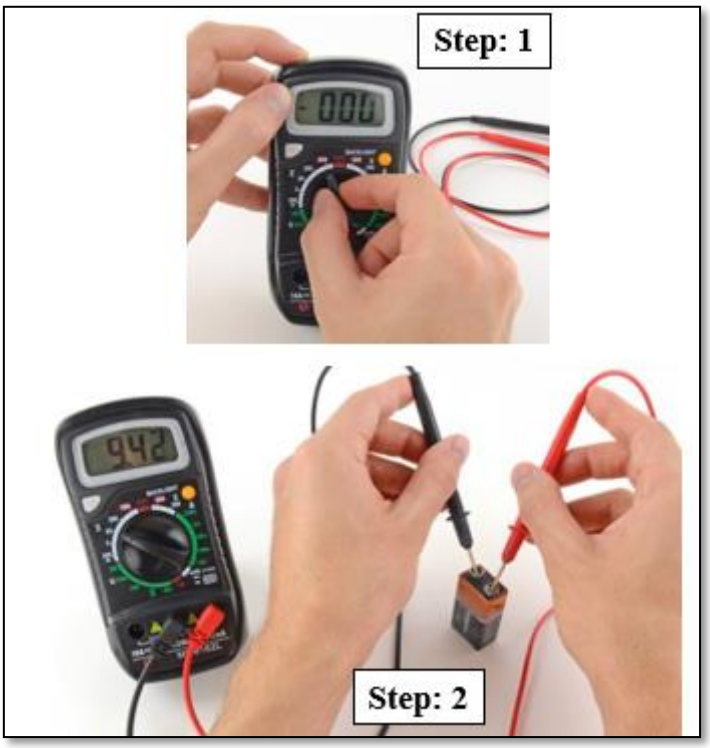


FIGURE 4-5: VOLTAGE TESTING USING MULTIMETER

- Resistance Test:
  - ✓ Switch on your multimeter and set the dial to resistance mode. Resistance is measured in ohms, indicated by the Ω symbol.
  - ✓ Place one probe at each end of the circuit or component you want to test. It doesn't matter which probe goes where; resistance is non-directional.
  - ✓ If your multimeter reads close to zero, the range is set too high for a good measurement. Turn the dial to a lower setting.
  - ✓ With the multimeter set to a usable range, we get a reading of 1.04k ohms.

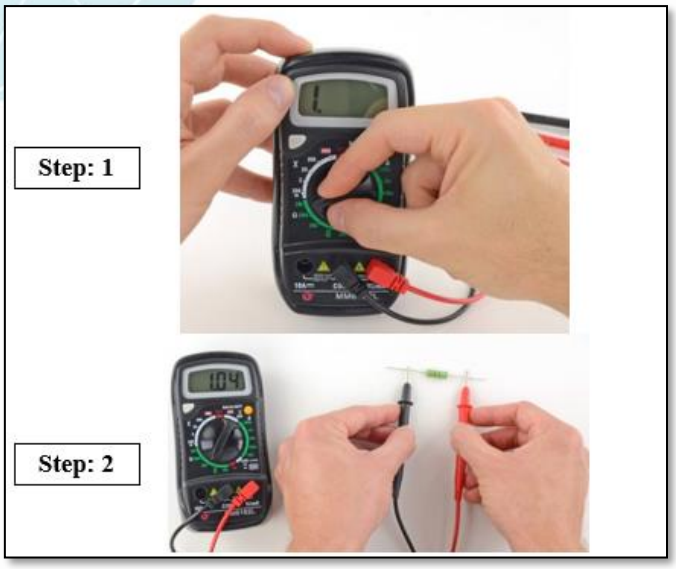


FIGURE 4-6: RESISTANCE TESTING USING MULTIMETER

- Continuity Test:
  - ✓ Switch on your multimeter and set the dial to continuity mode (indicated by an icon that looks like a sound wave).
  - ✓ To complete your continuity test, place one probe at each end of the circuit or component you want to test.
  - ✓ As before, if your circuit is continuous, the screen displays a value of zero (or near zero), and the multimeter beeps.
  - ✓ If the screen displays 1 or OL (open loop), there's no continuity—that is, there's no path for electric current to flow from one probe to the other.

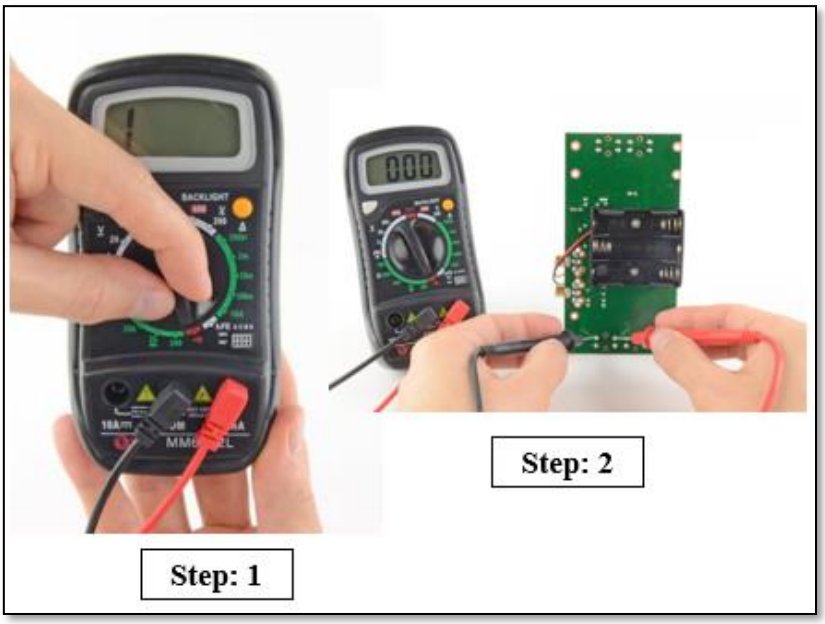


FIGURE 4-7: CONTINUITY TESTING USING MULTIMETER

4.1.4 CHARGING CAPABILITIES TESTS - CHARGER-VEHICLE ELECTRIC & DATA CONNECTIVITY TESTS

End to end testing and certification services for all types of electric vehicle supply equipment (EVSE) including home & industrial charging solutions (including for e-buses and e-trucks), fast-chargers, vehicle-to-grid chargers and inductive charging systems is must.

Electromagnetic compatibility (EMC) testing ensures that the electronics within EVSE do not emit interference and that they will continue to function in the presence of various electromagnetic phenomena such as power supply surges or radiated electric fields. The certification of EMC standard IEC 61851-21-2, is also important for EVSE technology ranging from AC to DC and up to 360 kW.

Another relevant communication protocol in this area is Open Charge Point Protocol (OCPP) testing, developed by the Open Charge Alliance. The OCPP protocol is used worldwide to correctly exchange information between the EV charging station and the charging station management system operated by the CPOs. The advancement of vehicle-to-grid (V2G) and smart charging applications is making communication protocols even more crucial, as the EV is increasingly becoming an active element in the grid.

- EV Charging Station Technology and Infrastructure Testing:
  - ✓ Safety and functional testing (IEC 61851, SAE J1772, UL 2202, UL 2594)
  - ✓ EMC testing (IEC 61851-21-2)
  - ✓ Interoperability & conformance testing (CHAdeMO, CharIN-CCS, OCPP, ISO 15118, DIN 70121, GB/T 27930)
  - ✓ Electrical safety (IEC 61851, IEC 62752, UL 2231)
  - ✓ Functional safety (IEC 61508
  - ✓ Performance testing (IEC 62116)
  - ✓ Wireless testing (IECEE 802.11p/Wi-Fi, 3G/4G/5G)
  - ✓ Development testing
  - ✓ Validation testing
  - ✓ Environmental testing
  - ✓ EV charging cables (IEC 62893, IEC 62752)
  - ✓ Grid (IEC 60364-7-722, IEC 62909-1/2)
  - ✓ Connectors/ inlets/ plugs (IEC 62196)

The documentation process can contain the details of the values and test conditions considered for each of the above tests undertaken as shown in table below:

TABLE 4-2: SAMPLE DOCUMENTATION FOR TESTS

Date	Test Type	Test No.	Parameter	Reading	Compliance status
…… …… ……..		…… …… ……	…… …… …	…… ……	……

4.2 COMMISSIONING OF THE CHARGING STATION

4.2.1 EQUIPMENT MALFUNCTION

The electrical and mechanical components may malfunction, resulting in temporary or permanent damage to the equipment. While the priority should be to isolate the equipment from the circuit to prevent the normal operation of the remaining system, the damage to the equipment also should be limited to as minimum as possible. However, there may arise situations wherein the equipment malfunction result in permanent damage to it. In such a scenario, the equipment must be replaced. Minor faults can be repaired after isolating the equipment from the system and then reconnecting it. Regular inspection of all equipment, especially the joints and insulation of cables must be conducted to take preventive action, when possible.

Charging station may malfunction for multiple reasons:

- ✓ Wrong input wiring
- ✓ Wrong input voltage
- ✓ Problem with internal components

Any fault with the charging station is indicated on the display on the charging station if available, through the status LED of the charging station or through the app integrated with the charging station. If a fault is determined, the reason for the fault should be identified and the problem should be rectified, through the electrical contractor for electrical faults and through the charging station manufacturer for charging station faults. The training of the staff shall include imparting knowledge of the common faults or problems that may occur, and the corrective action to be taken, in any of the charging equipment. It is key to map the daily customer demand (which can be tracked through the employee work done report), for analysing the possibility of undertaking a maintenance schedule during low peak hours. The charging station can be shut down during the low peak hours, and the scheduled maintenance of the various components be undertaken.

In case of faults/damage to equipment, it is best to isolate the equipment from the system to minimize the impact of interruption during unscheduled outages.

4.2.2 ADAPTATION TECHNIQUES OF EXISTING SYSTEMS AND OTHER ELECTRICAL DEVICES

With the extent of the electrification in the country, most of the places where a charging station needs to installed need to have an electrical connection with other appliances, equipment or machinery possibly connected to it. It is the responsibility of the EVSE Technician to make sure that there is enough electrical power available for the charging station and for the other equipment connected to the same electrical connection and that it is not being overloaded than its sanctioned load.

- Independent/Dedicated Electrical Connection

  If a charging station(s) is to be installed on its dedicated electrical connection, then a new electrical connection from the local DISCOM has to be acquired based on the type, power and number of chargers (based on the calculations discussed in Unit 3.2).

  As this electrical connection is specifically dedicated to the charging station, as long as the maximum load isn't more than the sanctioned load of the electrical connection, the technician need not account for any other systems.

  A dedicated electrical connection is widely used and needed for the installation of high-powered DC chargers.

FIGURE 4-8: A DC CHARGER ON ITS DEDICATED CONNECTION

- Shared Electrical Connection

  Many a times, especially with Level 1 AC chargers which consumes lesser power, the charging station(s) might have to be installed on an existing electrical connection. In this case, the technician needs to factor in the electrical power being consumed by other appliances, equipment and systems connected to the same connection to make sure that the connection is not being overloaded.

  Before the installation of the charging station, the technician should get the following information about the electrical connection, preferably from the electricity bills of the previous months.

FIGURE 4-9: A 10 KW AC CHARGER ON A SHARED CONNECTION, CONNECTED THROUGH A SUBMETER

- **Sanctioned Load/Contracted Demand (SL)** - The maximum power that can be supplied by the electrical connection.
- **Maximum Demand (MD)** - This information will be visible on the electricity bill and will show you maximum power is actually being used on a monthly basis. The MD is usually lesser than Sanctioned Load.

FIGURE 4-10: ELECTRICITY BILL SHOWING SANCTIONED/CONTRACTED LOAD AND MAXIMUM DEMAND

- **Power Consumed by Existing Systems** - If available, the technician should get the information about all the systems connected to the electrical connection and the maximum power drawn by them.

  Based on the aforementioned details, the available/spare load can be calculated for the installation of an EV charger. The availability of spare load can be found out in the following ways.

- Sanctioned Load Method

  If the total sanctioned load is found to be less than the power needed for the charger, then the technician should not install the charging station on that connection as it'll exceed the maximum sanctioned load. Instead, the load should be extended by filing an application with the local DISCOM.

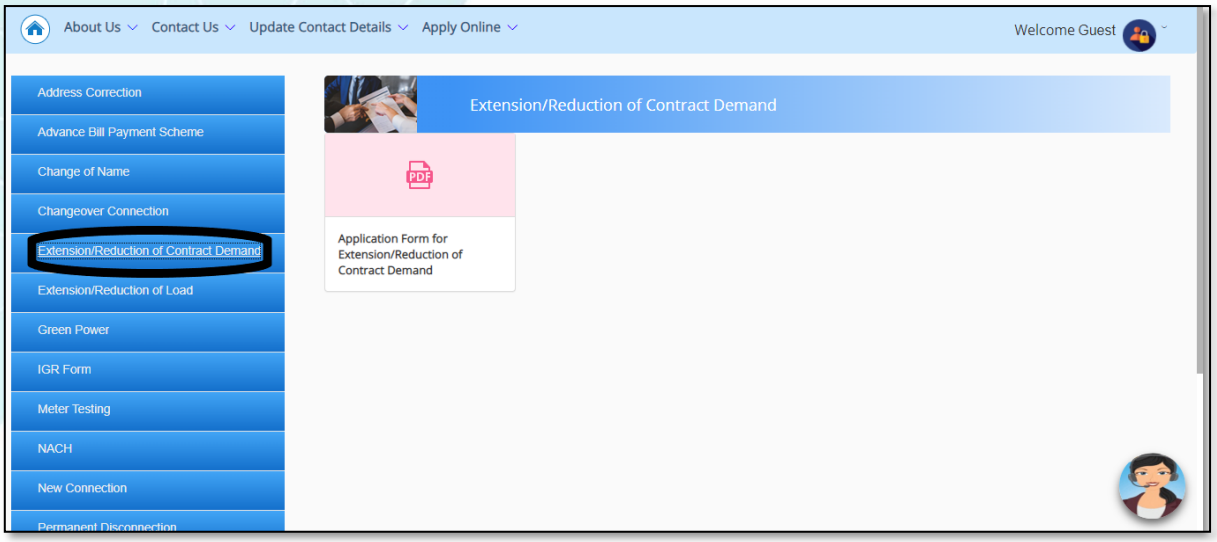


FIGURE 4-11: LOAD EXTENSION OPTION ON TATA POWER'S CUSTOMER PORTAL/WEBSITE

This is a very common problem with domestic electrical connections. Most of the domestic connections in India range between 0.5 kW to 3.5 kW on Single-Phase Connections and 3.5 kW to 5 kW on Three-Phase Power. In most cases, this is not enough for the installation of any type of EV Charging Station and the load has to be extended to accommodate for the charging station.

- Maximum Demand Method

  In cases where the total sanctioned/contracted load is more than the power needed by the EV Charging Station, we look at the average Maximum Demand of the electrical connection on which charger has to be installed. This information can be obtained from the previous electricity bills of the said connection (preferably for the last year).

  If the MD is consistently found to be significantly lesser than the sanctioned load and if the difference is large enough to power the charging station, then the technician can go ahead with the installation. This method is only applicable to low powered chargers from 3.3 kW to 20 kW.

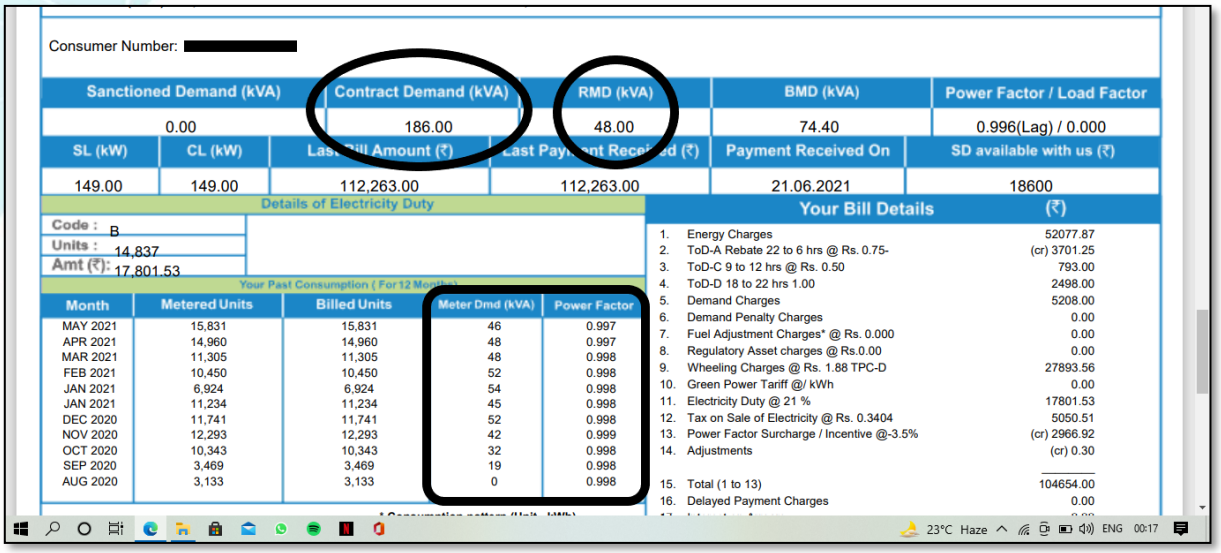
TABLE 4-3: THE CAPACITY OF THE CHARGING STATION BASED ON THE DIFFERENCE BETWEEN MD AND SL

SR. NO	EV CHARGING STATION	SL - MD (SANCTION LOAD - MAX DEMAND)
	Up to 3.3 kW	10 kW to 20 kW
	Up to 7.4 kW	20 kW to 40 kW
	Up to 15 kW	40 kW to 80 kW
	Up to 30 kW	80 kW+

This method works as users rarely consume the entire load sanctioned to them consistently and there is always an overhead available.

Example

Let us consider an example of the bill shown below to calculate the difference between SL and MD and to understand the maximum capacity of the charging station that can be installed.



Consumer Number: [redacted]

Sanctioned Demand (kVA)	Contract Demand (kVA)	RMD (kVA)	BMD (kVA)	Power Factor / Load Factor
0.00	186.00	48.00	74.40	0.996(Lag) / 0.000

SL (kW)	CL (kW)	Last Bill Amount (₹)	Last Payment Received (₹)	Payment Received On	SD available with us (₹)
149.00	149.00	112,263.00	112,263.00	21.06.2021	18600

Details of Electricity Duty

Code : B
Units : 14,837
Amt (₹): 17,801.53

Your Past Consumption (For 12 Months)

Month	Metered Units	Billed Units	Meter Dmd (kVA)	Power Factor
MAY 2021	15,831	15,831	46	0.997
APR 2021	14,960	14,960	48	0.997
MAR 2021	11,305	11,305	48	0.998
FEB 2021	10,450	10,450	52	0.998
JAN 2021	6,924	6,924	54	0.998
JAN 2021	11,234	11,234	45	0.998
DEC 2020	11,741	11,741	52	0.998
NOV 2020	12,293	12,293	42	0.999
OCT 2020	10,343	10,343	32	0.998
SEP 2020	3,469	3,469	19	0.998
AUG 2020	3,133	3,133	0	0.998

Your Bill Details (₹)

1.	Energy Charges	52077.87
2.	ToD-A Rebate 22 to 6 hrs @ Rs. 0.75-	(cr) 3701.25
3.	ToD-C 9 to 12 hrs @ Rs. 0.50	793.00
4.	ToD-D 18 to 22 hrs 1.00	2498.00
5.	Demand Charges	5208.00
6.	Demand Penalty Charges	0.00
7.	Fuel Adjustment Charges* @ Rs. 0.000	0.00
8.	Regulatory Asset charges @ Rs.0.00	0.00
9.	Wheeling Charges @ Rs. 1.88 TPC-D	27893.56
10.	Green Power Tariff @/ kWh	0.00
11.	Electricity Duty @ 21 %	17801.53
12.	Tax on Sale of Electricity @ Rs. 0.3404	5050.51
13.	Power Factor Surcharge / Incentive @-3.5%	(cr) 2966.92
14.	Adjustments	(cr) 0.30
15.	Total (1 to 13)	104654.00
16.	Delayed Payment Charges	0.00

FIGURE 4-12: ELECTRICITY BILL SHOWING THE MAXIMUM DEMAND (MD) OF THE PAST 12 MONTHS

As the sanctioned load is always constant, we can arrive at the following conclusion

- ✓ Sanctioned Load = 186 kVA
- ✓ Average Maximum Demand = 48 kVA

Difference between Sanctioned Load and Maximum Demand (SL-MD) = 186-48 = 138 kVA.

To convert kVA to kW, you have to multiply the kVA units with 0.8

i.e, 138 kVA = 138 x 0.8 = 110 kW

As the difference between SL and MD is 110 KW, one can easily install EV chargers with a total power capacity of up to 30 KW.

Note: The owner of the electricity connection has to regularly inspect the MD after the installation of the EV charging station to make sure that the sanctioned load is not being exceeded.

- Total Load Method

  This method is similar to the Maximum Demand Method but instead of measuring the difference between the Sanctioned Load and the Maximum Demand, we calculate the sum of the power needed for all the devices and systems connected to the electrical connection. After the total load connected to the electrical connection is known, the difference has to be calculated between 80% of the sanctioned load and the total load. The remaining 20% of the sanctioned load is always considered as an overhead for safety reasons.

Example

Let us consider an example where the sanctioned load is 20 kW and the actual total load connected is 12 kW.
80% of Sanctioned Load = 16 kW
Difference = 80% of SL - Total Load = 16 - 12 = 4 kW
i.e., an EV charging station with a maximum power draw of 4 kW can be installed on the electrical connection. The demand assessment and load curve of a charging station shall be important in forecasting the future load and hence the need for augmentation of the available supply. Regular monitoring of demand and audit of logbooks can ensure in demand forecasting. The existing systems can be upgraded/modified to cater to the increased load. This shall also help in effectively managing the capital expenditure of the charging station.

4.2.3 FINAL DOCUMENTATION AND SITE CLEANING

A good practice after any installation is to document the entire installation and to make sure that the location is properly cleaned to provide a clean and aesthetically pleasing environment for the user to use the charging station, this also includes the dressing and covering of any electrical wires, switchgear and panels.

- Documentation

  The technician needs to make sure that the following elements are documented during the installation process and make sure that an installation report is created for the same.

  1. Name of the technician and the organization
  2. Address and type of location of the installation
  3. Type, make and power of the Charging Station installed
  4. Electrical load available at the site before and after installation
  5. The gauge of cables used for wiring and installation
  6. Connectivity in all the cables
  7. Insulation between cables of different phases, neutral and earth
  8. Earthing resistance
  9. All connections to the charging station, i.e. Phase(s), Neutral and Earth
  10. Phase to Phase, Phase to Neutral, Phase to Earth and Neutral to Earth Voltages
  11. All the tests that are done during the installation and commissioning of the charging station
  12. Charging Stations connection to the internet and the destination server
  13. Date & Time the charger was made fully operational

An installation report has to be created, this installation report has to be submitted and vetted by the person or entity responsible for the charging station. A photocopy of the vetted report should be submitted to the technician's organization or has to be kept by the technician on file for record-keeping.

A checklist in the required template may be prepared for this purpose with respect to Section 3 of Ministry of Power's (MoP) Revised Consolidated Guidelines & Standards for EV Charging Infrastructure - "Public

Charging Infrastructure Requirements" (No. 12/2/2018-EV (Comp No. 244347 dated 14th Jan 2022) as updated from time to time as shown:

TABLE 4-4: CHECKLIST FOR TRANSFORMERS:

Sl. No.	Requirement	Status (Yes/No)	Remarks
1	An exclusive transformer with related substation & safety equipment (Only if required & approved by Appropriate Regulatory Commission)		
2	Appropriate Civil works		
3	Appropriate cabling & electrical works ensuring safety		
4	Adequate space for charging & entry/exit of vehicles		
5	Fire protection equipment and facilities		
6	Any combination of charges as prescribed by Annexure II and Annexure III of the guideline		
7	2W & 3W are free to install any charger provided compliance to CEA Technical & Safety Standards		
8	Tie-up with Network Service Provider to enable online/remote booking		
9	Charging station data sharing with State Nodal Agency while adhering to protocols prescribed by Central Nodal Agency (BEE)		
10	Compliance with CEA Technical Standards for Connectivity of Distributed Generation Resources Regulations 2019		
11	Compliance with CEA Measures relating to Safety and Electric Supply Regulations 2019		

- Site Cleaning

  To provide an aesthetically pleasing and clean environment for EV users to charge their vehicles, the site has to be cleaned of all garbage and the electrical work has to be dressed and covered.

- Disposing of Garbage

  After every installation varying amount of garbage is produced, this might include the debris from the civil works, packaging of the materials used for installation, waste generated by the personnel working, etc. This garbage has to be segregated and needs to be disposed of in a proper manner in their respective bins or methods.

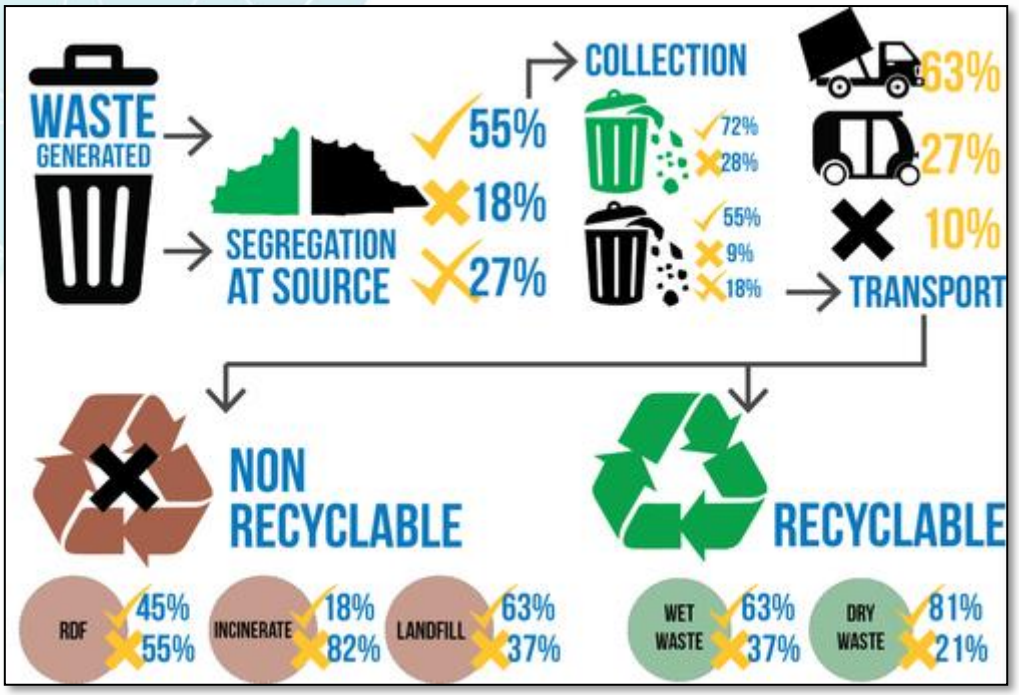


FIGURE 4-13: WASTE MANAGEMENT

- Electrical Work Dressing

  For the purpose of easy identification of all the connections during servicing and for aesthetics, all the electrical work done for the installation of the charger has to be dressed and marked properly. This is particularly important if there are multiple charging stations installed at the same place.

FIGURE 4-14: IMPROPERLY DRESSED ELECTRICAL WIRING

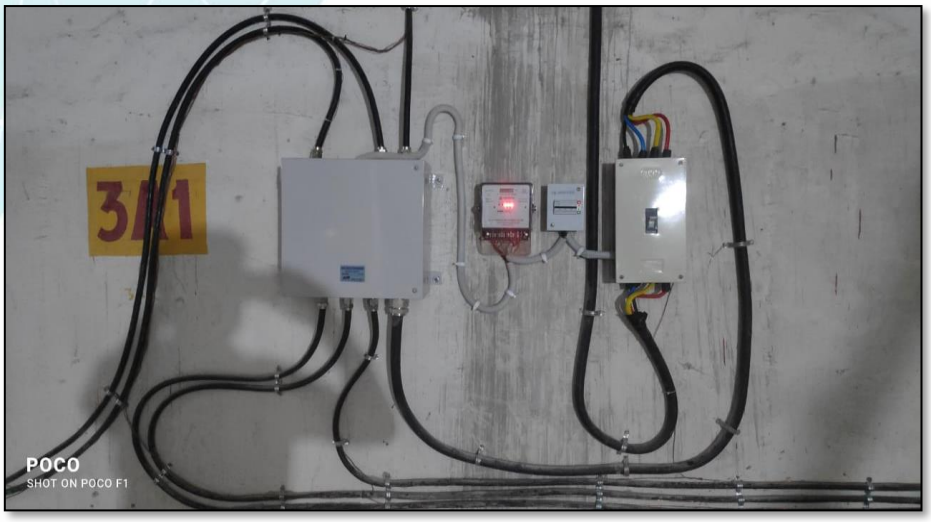


FIGURE 4-15: DRESSED (SADDLED) ELECTRICAL WIRING

This is usually done by the electrician, or the electrical contractor commissioned for the electrical works but it's the responsibility of the EV Charging Station technician to supervise and make sure that the marking is correct, and the dressing is up to the mark.

5

Operation of Various Types of EV Charging Stations

5. OPERATION OF VARIOUS TYPES OF EV CHARGING STATIONS

Key Learning Objectives:

The trainees will be able to,

- Understand recommended setting, functional, communication protocol and safety related checks required for effective operation of charging station systems.
- Differentiate the capability of different charging standards and chargers.
- Understand the importance of standard operating procedures for effective operation of charging station systems that too in emergency like situation.
- Understand charging station requirements, types of chargers and its application for the vehicle charging.
- Understand the effectiveness of documentation related to EVCS in monitoring the charging process.
- Understand the importance of safety signage at charging station premises for the stakeholders.
- Understand the importance of customer feedback on delivered services and their query resolution.

5.4 PRE-OPERATION CHECKS OF CHARGING STATION SYSTEMS

5.4.3 RECOMMENDED SETTINGS AND FUNCTIONAL CHECKS

Before using a charging station, it should be ensured that:

- ✓ No faults are present in the charging station. This is normally indicated in the display of the charging station or through the status LED
- ✓ No physical damage to the charging station enclosure is present
- ✓ Connector and its cable are in acceptable condition

If at any time you don't feel comfortable with the state of the charging station, do not use the charging station and immediately report the issue to the charging point operator or the charging station technician.

5.4.4 COMMUNICATION PROTOCOL CHECKS AND MESSAGE INTERPRETATION

For most charging stations, it is also possible to ensure the charging station is connected to the server. This is normally indicated in the display of the charging station or through the status LED. Most charging stations may not work if this connectivity is not available because user authentication happens on the server end. Any communication faults are represented in the display (if available) or for some charging stations through a commissioning app. Some of the common problems for communication failure include:

- ✓ Loss of internet connectivity (GSM / Wi-Fi / Ethernet)
- ✓ Problem with the server
- ✓ Incorrect OCPP configuration

To develop a software-based tracking of various parameters, apart from logging manually (in the logbook), the use of modem is essential in charging station. The correct placement of modem in a charging station shall help

in achieving uninterrupted communication access in the charging station. The charging station data should be shared with appropriate DISCOM to maintain appropriate protocols as prescribed by such DISCOM (if any) for this purpose. CEA may also get access to this database for future needs.

5.4.5 EVALUATION OF CHARGING CAPABILITIES: COMPARISON WITH STANDARDS

For evaluating charging capabilities, the reference document is the Ministry of Power's guidelines for public charging infrastructure in India, and the details of charging standards are available in section 2.4 .

5.4.6 PREPARATION OF STANDARD OPERATING PROCEDURES (SOP) AND SAFETY CHECKLISTS

Charging station manager will take action to manage their facilities, plant, work environment and tasks as to eliminate the risks associated with battery use and charging, and if that is not possible, charging station manager will minimise the risks so far as is reasonably practicable. The charging of batteries can be hazardous. However, this hazard may be overlooked by workers seeing as battery use is a common activity in many workplaces. The two primary risks are from a) the hydrogen gas that is formed when the battery is being charged; and b) the sulphuric acid contained in the battery fluid. To manage the risks associated with the storage, charging and use of batteries at their worksites, charging station manager will:

- ✓ Identify and assess the risk for all locations and tasks that could cause injury or damage due to battery use.
- ✓ Supply and maintain suitable plant and equipment for workers to reduce the likelihood of a battery-related incident.
- ✓ Provide training to workers in the safe use of equipment and plant relevant to their tasks.
- ✓ Educate workers in the risks and controls required for managing batteries; and
- ✓ Develop and test emergency response, rescue and first aid plans.

Battery storage, charging and use will vary at each charging station workplace or controlled site. Charging station manager will determine battery-related requirements (i.e. equipment, facilities and personnel) through a risk management approach. This will involve:

- ✓ Identifying hazards that could result in work-related injury, illness or damage.
- ✓ Assessing the type, severity and likelihood of injuries and illnesses.
- ✓ Providing appropriate equipment, facilities, first aid and training; and
- ✓ Reviewing battery storage, charging and use requirements on a regular basis or as circumstances change.

To have safe working practices, the general safety precautions defined and needs in section 7.1.3 on fire and explosion, spills management, manual handling, first aid, battery storage, battery charging, disposal of sealed batteries / battery-related waste, training, competency and supervision.

A guidebook can be prepared detailing the available features in the charging station. The following indicative parameters may be included:

- ✓ Site area and coordinates, other geographical features
- ✓ Nearby electrical, gas installations which may affect or get affected due to the operation of the charging station and associated risks
- ✓ Detail the various safety procedures to be followed in case of natural and man-made hazards.
- ✓ Develop protocols for adhering to various safety measures based on the electrical and other equipment in use at the charging station.
- ✓ Emergency contact numbers of senior officials in-charge of the charging station and other government departments.

Whenever the operation of charging station is re-started after shutting down due to any reason, a trial run must be conducted on all the equipment under use, before being opened for public use. During the trial run, various initial values and initial factors should be set for optimum performance of the equipment. All data obtained during the trial run should be recorded.

5.4.7 STANDARD OPERATION PROCEDURE FOR FLOODING

It is extremely important to ensure that the charging station is not soaked in water. Normally, wall mounted charging stations are mounted at a height of at least 4 feet from the ground and are less prone to water, but floor mounted charging stations, especially DC charging stations are normally within 1.5 feet from the ground and most of them have vents to enable air cooling. Because of these vents, there is a very high chance that water will go into the charging station and may pose serious hazards to equipment and people.

FIGURE 5-1: FLOOR MOUNTED CHARGING STATION

One of the most important parameters to be considered while identifying a location for charging stations is that the location is safe from flooding and water logging. But in the event of flooding or water logging near a charging station, the incoming supply to the charging station (MCB / MCCB) should be turned off before the water reaches the charging station level. Best practice is to be proactive and shut down the supply before water starts to accumulate. After the water recedes, ensure a technician from the charging station manufacturer inspects the charging station before it is powered ON. Failure to do this may result in serious injuries to users and permanent damage to charging station equipment.

5.5 OPERATION OF CHARGING STATION

5.5.8 DAILY SAFETY CHECKS

It is a good practice to visually inspect every charging station every day to make note of any damage or vandalism and make the necessary corrections. However, this may not be practically possible. As a practice, an EV charging station technician should conduct a series of safety checks on a regular basis to ensure that the charging station and the accompanying equipment and infrastructure. These safety checks should be carried out at a shorter frequency than the scheduled maintenance of the charging station. Depending on the number and capacity of the charging station(s), these tests should be carried out between once every month to once a week to make sure that everything is in working order. The higher the capacity of the charging station(s) the shorter the frequency of checks.

- Visual Inspection

  The charging station and its accompanying equipment should be checked regularly for any visible damage or concerns. In this check, the following are to be checked

- ✓ Electrical Wiring - Check if there is any damage to the wires and cables
- ✓ Connections & Terminations - Check if all the connections and cable terminations are firm and there are no loose or undesirable connections. This should also be checked for any bus bars or distribution panels installed.
- ✓ Burns or Shorts - Check if there are any burns or indications of short circuits in the entire circuit.
- ✓ Charging Station - Operate the charging station and check if it is operating as desired.

Due to the very brief nature of this inspection, it can be carried out at any time and very often. A visual inspection will provide the technician with much-needed information about the health of the charging station.

FIGURE 5-2: BUSBAR WITH SHORT CIRCUIT AND BURNT WIRES

FIGURE 5-3: PROPERLY WIRED BUSBAR

Note - The technician can also have the premises and charging station cleaned while doing the visual inspection.

- Electrical Inspection

  The electrical inspection is a detailed inspection of the charging station and its adjoining infrastructure. These are the series of same tests that the technician would perform as a part of pre-installation tests for the installation of charging stations (Unit 3.2.2). The tests are as follows:

  - ✓ Voltage Check - The technician should make sure that the Phase to Phase and Phase to Neutral voltages are in the acceptable range.
  - ✓ Continuity Check - The technician should make sure that the wiring and other connections do not have any break in them.
  - ✓ Earthing Check - The technician should make sure that there is sufficient earthing available at the location to support the EVCS.
  - ✓ Switchgear Check - The technician should make sure that all the protective switchgear are connected properly and are working as intended. If any switchgear is found to be not working, then it should be replaced immediately.

FIGURE 5-4: USING A MULTIMETER TO CHECK THE PHASE TO NEUTRAL VOLTAGE

Additionally, depending on the type of charger the technician should also check the output voltages from the charging station if it allows for that. Charging stations should at least be monitored on the web dashboard every day to ensure they are operational and have no faults. If any fault is seen through the web dashboard or if a charging station has gone offline, a technician should be sent to the location to diagnose and rectify the issue. It is also a good practice to display a customer care number near or on the charging station, to enable anyone to report safety or functionality issues.

- Maintaining a logbook

  Various documentation materials such as timesheet of employees, and of electric chargers (both first use and standby chargers) shall be used to assess and analyse the pattern of various electrical parameters, and

also the vehicle details which had been re-charged at the station. This helps in keeping a record and assessing whether the parameters operate within the safety limits.

5.5.9 CHARGING STATION INDICATOR LIGHTS

The various types of most common indicator lights in the process of EV charging includes:

- Switch on/off
- Stand-by/charging
- Availability Status (Operational/non-operational)
- Source of power (renewable/conventional)
- Safety light for fault detection (due to overheating, line faults, etc.)
- Charging completion indicator

There can be different modes of the use of indicator lights, for example, use of pulsating lights (for charging), pulsating light with beep sound (in case of fault occurrence). A datasheet to this effect can be prepared and referred to for every parameter.

A micro-controller-based timer may be displayed to estimate the time left in charging the vehicle.

The operators, supervisors and other personnel at the charging station must be trained to interpret and deduce the meaning of the indicator lights and digital displays displayed on the screens of the various instruments and other equipment. A training manual of various test cases on the operation of each machine may be created for this purpose, the copy of which may be stored in the physical form and digital form. A display board and a handbook can be maintained.

5.5.10 STARTING AND MONITORING A CHARGING SESSION

Most of the charging stations have some form of backend communication with the server of the Charge Point Operator (CPO) and this will enable the chargers to be used by a mobile app, RFID or any type of remote authentication method. Almost all private vehicles users will use their mobile to start charging at a charging station and the same can be monitored on the CPOs mobile app. The process of starting a charging session is usually very simple to create a good user experience and will follow these steps:

- Step 1 - Connect the EV to the charging station
- Step 2 - Enter the units (kWh) or amount of charge needed
- Step 3 - Pay for the charging
- Step 4 - Start charging
- Step 5 - Stop charging from the mobile app or from the vehicle

The most important step here would be to understand how much charge the vehicle needs, this varies depending on the vehicle type, battery capacity and the charge available in the battery (usually indicated in percentage). Let us consider an example,

An EV has a battery pack of 40 kWh and has a 20% charge left on the battery; then how many units of power would be needed to charge the battery to a 100%.

- ✓ Total Battery Capacity - 40 kWh
- ✓ Charge available in battery = 20% = 20% of 40 kWh = 8 kWh
- ✓ Charge needed for full battery = 40 - 8 kWh = 32 kWh

i.e. to charge the battery fully the user will have to charge 32 kWh (or units) of power and the same should be entered on the mobile app of the CPO.

FIGURE 5-5: ENTERING THE AMOUNT OF CHARGE ON THE CHARGING STATION'S MOBILE APP

Occasionally, the mobile app of the CPO might also have the option of entering the value of charge the user wants in rupees. In that case, the user should calculate the value based on the number of units they want to charge and multiply it with the cost per unit given by the CPO.

Example: If the cost per unit is Rs. 15/- and the user wants to charge 32 kWh (units) of power then the total cost of the charge is = 15x32 = Rs. 480/-

Once the charging session has begun, it can be monitored on the CPO's mobile app by the user or the EVs mobile app (if it has one), additionally, the technician can also monitor the charging session to make sure that everything is working properly on the Charge Point Operator's (CPO's) CPMS system.

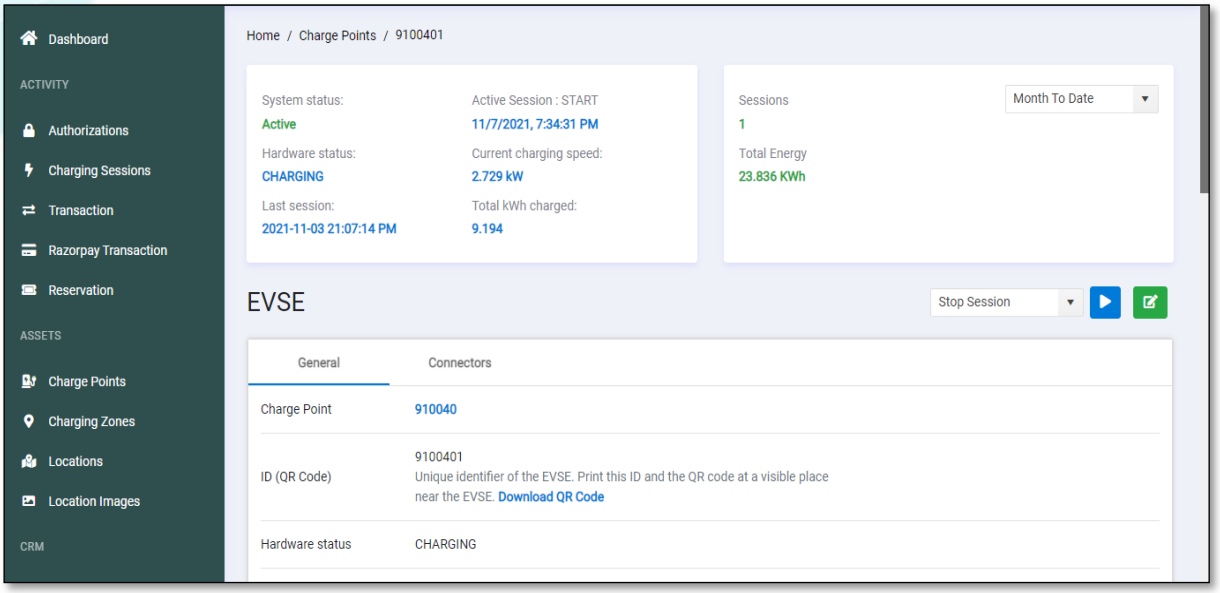


FIGURE 5-6: CONSUMPTION AND CHARGING DATA ON CPOS CPMS SYSTEM

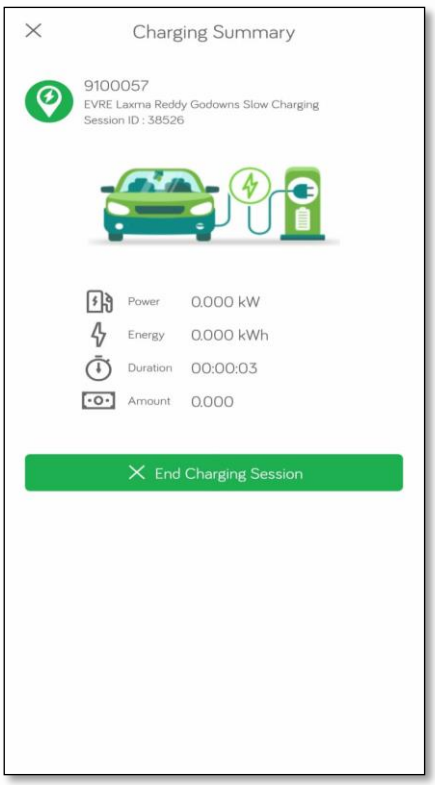


FIGURE 5-7: REAL-TIME CHARGING DATA BEING SHOWN ON THE CHARGING STATION'S MOBILE APP

The initial settings (or base settings) at which a charging station operates is key to ensure smooth operability of the charging station. This can help in the prediction of minimum load and the maximum load at which the charging station can operate. EVs could alter demand peak and minimum, impacting demand forecasting. Hence the need for smart charging arises. Smart charging refers to charging units that can shift the charging time following either internal or external signals, thereby adopting the approach of demand side management and smoothening of the load curve.

5.5.11 DOCUMENTING THE USAGE AND ISSUES WITH THE CHARGING STATION

During the life of a charging station, its usage (on monthly basis) and any issues should be recorded and kept on file. The usage data might be useful for invoicing, knowing the monthly consumption of the charging station, calculating profit/loss and the issues and servicing data will be useful for understanding the costs associated with the servicing, repair and maintenance of the charging station and also for improving the parts or components which fail frequently. This will improve the overall efficiency of operating a charging station and also will help the OEM develop a better product with the help of the feedback provided.

- Usage

The usage data of the charging station can be acquired from the CPMS system of the charging station or from an energy meter installed for the charging station. The consumption data can also be seen on the mobile app of the user for their respective accounts.

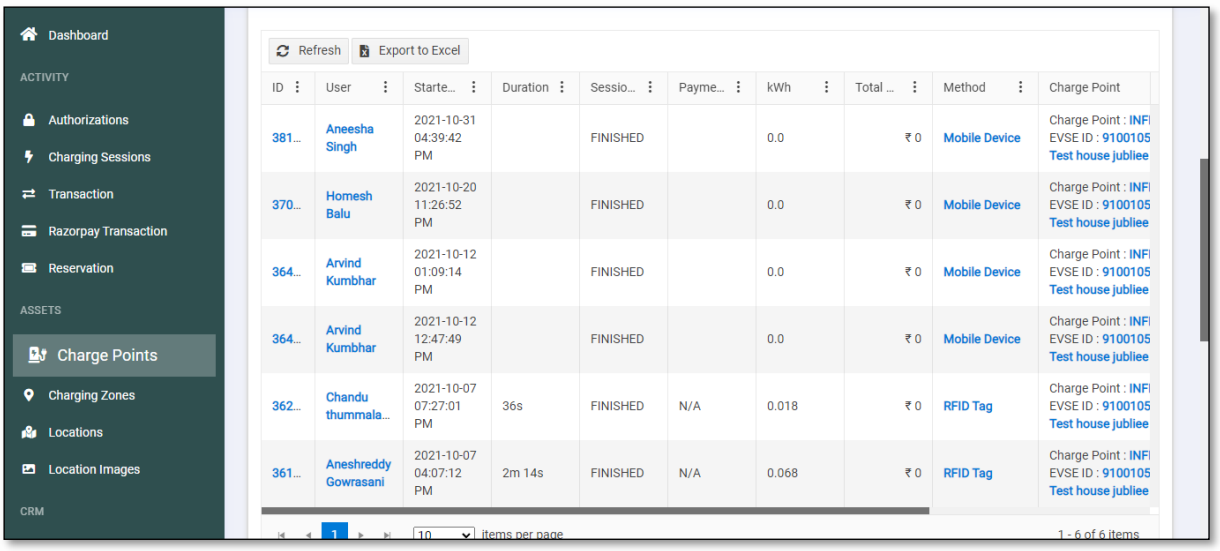


FIGURE 5-8: CONSUMPTION DATA FROM A CPMS SYSTEM

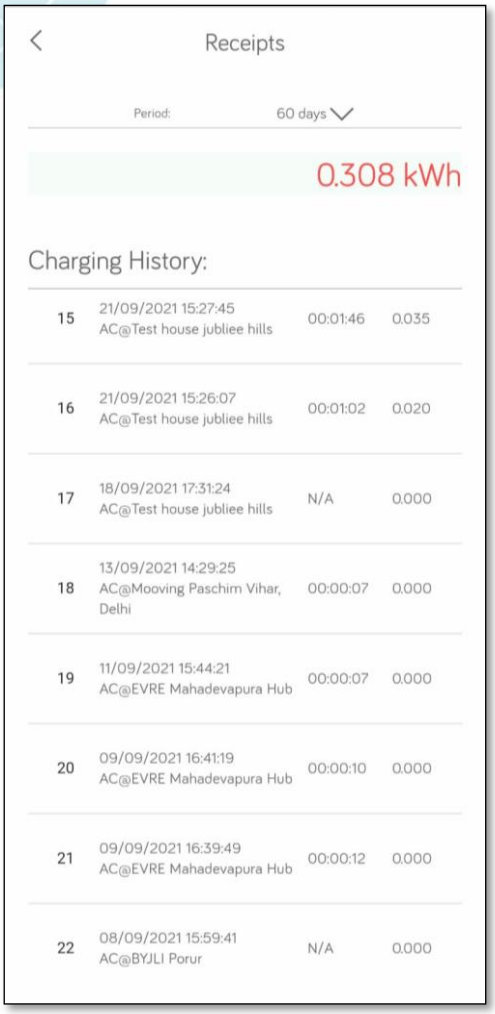


FIGURE 5-9: CONSUMPTION DATA ON THE MOBILE APP OF THE CHARGING STATION

- Issues

All the issues and services that happen on a charging station should be recorded in a register, either physical or digital. Apart from the issues, all the logs about scheduled maintenance and repair work should also be recorded for future reference.

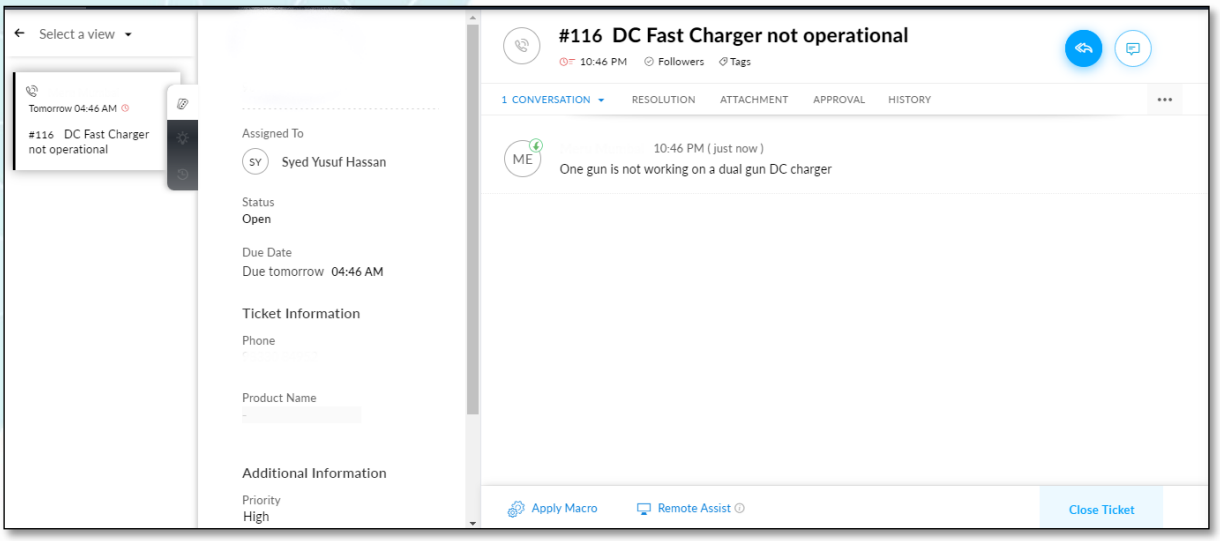


FIGURE 5-10: A COMPLAINT TICKET RAISED AND RECORDED ON A TICKETING SYSTEM

5.6 CUSTOMER SUPPORT SYSTEMS AND PROCESSES

5.6.12 SAFETY AND TRAFFIC GUIDELINES FOR CUSTOMERS

EVSE Signage While many EV users will find charging locations through their smart phones or on-board navigation systems, there is still a need for clear roadside signage for EVSE. Many users will be visitors to charging station area, and signage will help alleviate anxiety about finding a charging location. Signage required for EV users include General Service signs (at interstate exits), "trailblazing" signs to lead the driver from an interstate or major highway to the EVSE, and regulatory signage and pavement marking that will indicate that the parking is restricted to EVs while charging. With so few EVSE state-wide, signage is an important component of EV infrastructure, and guidance is needed to direct patrons to EVSE locations. Policies and guidance for signage should strike a balance between the needs of those who may rely on the signs, and the potential difficult of finding appropriate places to install signs and funds to maintain them. The Manual on Uniform Traffic Control Devices (MUTCD) has adopted a standard sign symbol for EV charging stations, shown in Figure 5-15.

FIGURE 5-11: RECOMMENDED EVSE SYMBOL

If signs are desired for locations that only provide Level 1 charging, then a supplemental plaque denoting "Level 1" could be added beneath so drivers are aware of the limitations. The final type of signage that is required is

a regulatory sign to restrict use of the parking spaces to charging EVs only. The recommended practice is to use language restricting parking "Except for Electric Vehicle Charging" to prevent instances of EV owners taking up charging spaces without plugging into the equipment. Enforcing this requirement may require updates to municipal ordinances governing parking requirements.

FIGURE 5-12: RECOMMENDED SIGNAGE FOR EV CHARGING

It may be noted that the location of the charging station holds the key to the visibility and use of the charging station. However, the need for availability of charging (slow, fast, rapid) charging station depends on the location of the charging station. For example, at a location where the customer is likely to spend more time, it may have slow chargers, (like malls, offices, and film theatres) while at locations such as highways, the fast chargers are required, as the customer servicing time is less.

At urban locations, the charging stations will serve a mix of customers including personal vehicle owners who cannot charge at home or work, personal vehicles that need a top-up to make it to their normal charging means. A mix of fast chargers and slow chargers may be deployed to cater the demand. For top-up purposes, the slow chargers may be deployed, while fast chargers may be used for recharging the battery.

The FAME – I and FAME – II requirements may be considered for choosing the location and setting up of charging stations.

5.6.13 SCHEMES/OFFER SHARING AND TAKING SERVICE FEEDBACK

Growing demand in electrification of vehicles and so it's charging market will create a significant opportunity for automotive organisations committed to delivering the most outstanding customer experience. Charging points offer a host of new customer touchpoints and those that align their customer service strategy early will undoubtedly build stronger relationships with customers making the switch from traditional internal combustion engine (ICE) vehicles.

When it comes to charging infrastructure, there are two key considerations for manufacturers in implementing the most effective customer service strategy.

- Proactively ease customer concerns

  - ✓ Talk to any driver about EVs and they will have questions about charging the vehicles. As battery technology evolves, concerns about vehicle range are being replaced by charge anxiety, which spans from installation and maintenance of home charging points to the availability and compatibility of public ones.
  - ✓ Allaying these concerns through clear and proactive communication will offer a simple way to build customer loyalty in the EV era. Not only will regular updates ensure you are front of mind but being able to solve customer queries proactively and confidently will drive brand preference as drivers make the transition from their ICE vehicle.
  - ✓ A key component of this will be equipping customers with the tools and contacts they will need in the event of any problems with their battery or charging equipment. The vast majority of drivers won't be familiar with frequent problems that can arise – from a battery not retaining its charge to a broken charging point – and the steps they will need to take to solve them. Utilizing available data to identify the issue and proactively support the resolution will reduce customer effort and impact.
  - ✓ Ensuring that they have the information to hand before driving their vehicle away for the first time will be critical. For example, to build trust and loyalty, manufacturers should take the opportunity to educate their customers on how to get the best from their battery, by providing advice on different types of public chargers, typical charge times and how to maximize battery life.

- Take ownership of the customer relationship

  - ✓ The ecosystem around a charging point is complex and involves many different parties, from the charging point installer and maintenance provider to the electricity supplier.
  - ✓ Navigating this can be daunting and confusing for drivers. They will expect that the first person they speak to will be able to provide the advice they need to solve their query quickly and concisely. Not having the tools or processes to facilitate this is not only frustrating, but can potentially be damaging for the brands involved, including the vehicle manufacturer.
  - ✓ Simplifying the customer journey by reducing effort on their behalf is key to providing an outstanding experience and manufacturers have a big opportunity to place themselves at the heart of this process.
  - ✓ By building relationships with both energy and charging point providers, manufacturers can provide customers with access to a broad network of charging options while acting as the central contact for managing any issues they experience.

- ✓ This demonstrates that collaboration between different providers across the EV ecosystem will be critical to getting customer experience right. Helping customers to solve queries and issues as easily as possible will be vital in building longer-term loyalty and advocacy among drivers using their EVs.

The charger positioning plays a critical role in improving the service quality. Vehicles using fast chargers would be parked at the charging station for smaller durations while vehicles using slow chargers are likely to be parked for longer. It is important to enable easy and swift entry and exit for all vehicles. Depending on the charging speed and density of target vehicles in the area, positioning can be optimized for improved service experience.

5.6.14 CUSTOMER QUERY RESOLUTION

- Central to delivering outstanding customer service in any business is ensuring that those dealing with customers are well informed and knowledgeable. But in the largely unchartered territory of EVs, drivers will lean on manufacturers for advice and support, meaning it's crucial to reassure them.
- In the EV era, customer experience will extend beyond the vehicle itself. Drivers will be contacting agents for assistance in troubleshooting problems with charging infrastructure and not just their cars or vans.
- In this environment, the relationship between human agents and technology has never been more important. While customers will expect human contact to help overcome issues, such as encountering faulty charging points, data will be the key to finding the right solution quickly and effectively.
- Having systems in place that automatically collate data from both vehicles and the charging infrastructure means that agents can run diagnostics and provide bespoke advice to customers to help them get back on the move.
- Training will also be vital. While brand immersion and knowledge has grown in prominence with the standardisation of vehicle features, it must become the norm as connected car functionality and EV adoption increases, to ensure that agents have also experienced the expanding range of technologies involved in the pre- and post-purchasing journey. This will not only support with the effective resolution of issues being encountered but will also help with the promotion of features and benefits to drive loyalty with the brand.
- Charging infrastructure offers new chances to build relationships with drivers and automotive companies must be ready to make the most of the opportunities that the expanded range of touchpoints will bring. Those that act now and set the benchmark for best practice customer service as EV adoption grows, are likely be the ones that thrive when the Government ban on petrol, diesel and hybrid vehicles is implemented.

- The precautionary measures to be taken before charging the electric vehicle must be conveyed through various means of mass communication. Signages, pamphlets can be used for spreading important information, while a notice board can be used for detailing the precautionary measures and the details of charging points available at that charging station.
- The customer may be engaged in activities like filling of feedback form or get incentivize through various means each time the customer may recharge at a particular station. This shall boost customer retention and keep the charging station in the good books of the customers. Valid suggestions from the customers based on their experiences at other charging stations may be used to upgrade the facilities at the concerned charging station.

All the issues and services that happen on a charging station should be recorded in a register, either physical or digital. Apart from the issues, all the logs about scheduled maintenance and repair work should also be recorded for future reference.

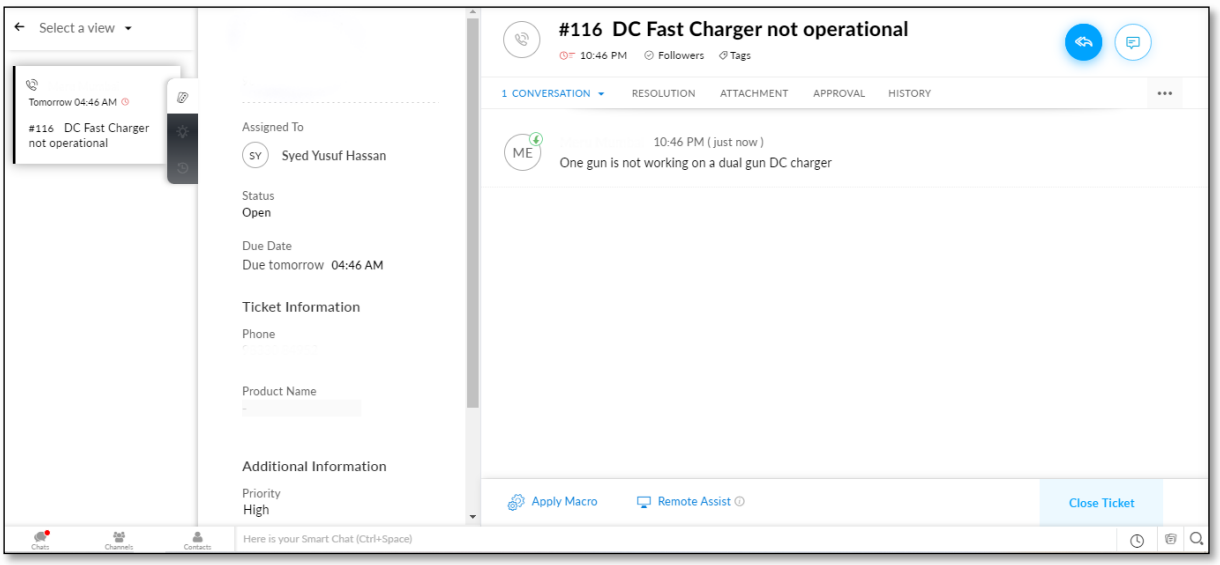


FIGURE 5-13: A COMPLAINT TICKET RAISED AND RECORDED ON A TICKETING SYSTEM

5.6.15 PAYMENT COLLECTION PROCESS

EVs and CPOs are already adopting the ISO 15118 standard, but there are still limitations in the payment process that will only intensify as the market matures. Every CPO must have bilateral agreements with other providers. And future CPOs could be almost any organization—an electric power generation company, a grocery store, a hotel chain, or even the owner of an apartment building. To resolve this challenge today, every charging station is required to have a payment terminal. This approach ignores the potential represented by the software and data processing capabilities built into an EV. EVs can use electricity not only for propulsion but also to power electronic equipment. By combining current EV charging interface and payment industry standards, built-in "direct payment" can be added to the ISO 15118 PnC use case. The method this paper

proposes is a hybrid solution that combines contract based PnC and its alternative, external payment, but with one significant difference: a payment terminal may not be required when routing a payment credential supplied directly by the EV.

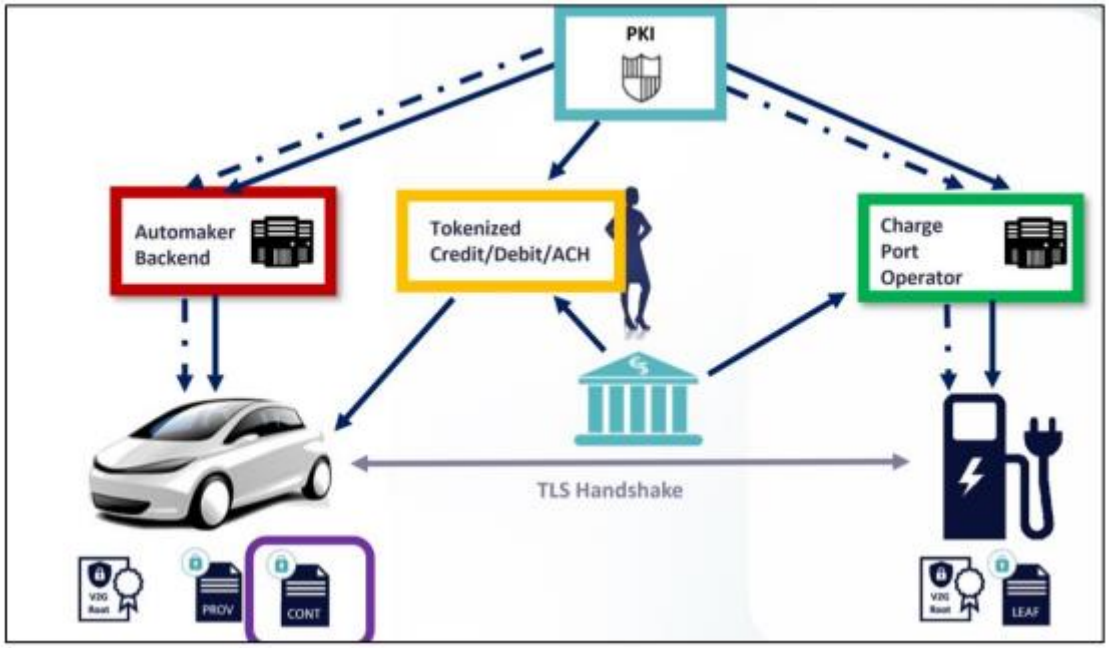


FIGURE 5-14: HOW DIRECT PAYMENT FITS IN THE ISO 15118 DATA FLOW

5.3.4.1 PnC Direct Payment Credential Options

This section describes two options for paying directly at a charging station:

- ✓ Using a tokenized EMV payment credential
- ✓ Using an e-Commerce payment credential

- PnC Direct Payment: Tokenized EMV Payment Credential

  EMV technology defines a protocol for payment data exchange using the ISO 7816 standard, which was originally designed for chip cards but is now widely used in other form factors. The proposed approach uses EMV ISO 7816 messages with the built-in EV software, similar to how mobile payments are implemented today. There is no need to change the format of the messages. ISO 15118 can wrap EMV messages, as has been previously done (for example) for contactless payments using the ISO 14443 standard. The payment credential is tokenized: no PAN is stored in the EV. The payment credential and cryptogram are communicated directly to the charging station, using ISO 15118 communication protocols, either automatically or at the request of the consumer. The charging station processes the payment through the payment network as if it were any payment made using a chip card or phone app. The vehicle becomes an extension of a chip card.

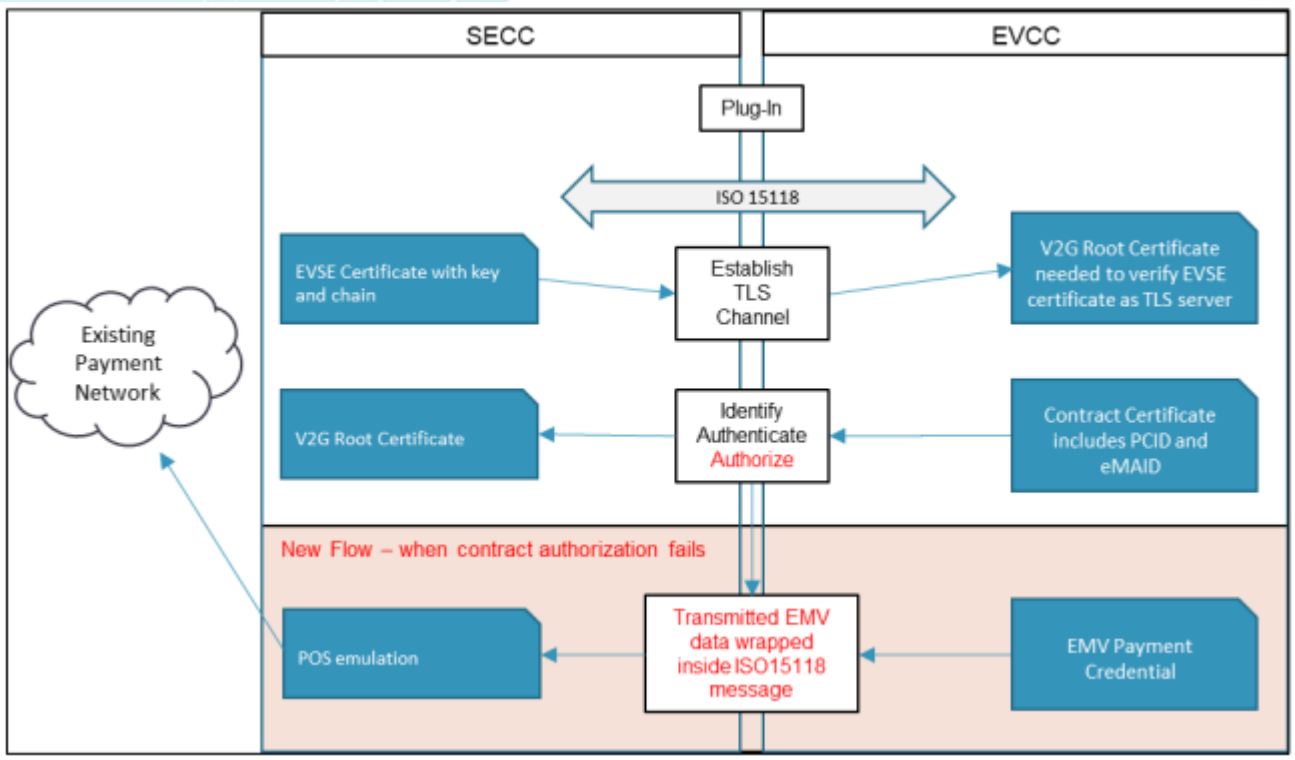


FIGURE 5-15: DIRECT PAYMENT USING TOKENIZED EMV PAYMENT CREDENTIALS

One advantage of this option is that it is highly scalable, because it does not affect the payment networks. While charging stations would still require a POS device, it would be a much simpler one, needing no external interface to accept a payment card or produce a display. The EV can communicate with the driver either on the dash display or a mobile app, tracking the payment process and allowing the driver to accept payment rates and initiate or halt a charging session. The challenge presented by this solution is how to store the credential in an EV. Three methods are available:

- ✓ Use software-based solution in vehicle. The EV's hardware security module protects the credential. Host Card Emulation (HCE) is one implementation.
- ✓ Use hardware-based solution in vehicle. Store the payment application and payment credential in the EV's embedded secure element.

- PnC Direct Payment: e-Commerce Payment Credential

  Many tokenization providers and merchants use e-Commerce tokens. This payment token was designed to replace a card on file for merchants who process multiple payments using the same payment credential. Payments using e-Commerce tokens, however, do not follow the same payment flow as payments made using a card or a mobile payment. To adopt this option, the charging station must support e-Commerce tokens via its backend processing and acquiring relationships. Most EV CPO's may already support the use of e-Commerce tokens, as they have accounts on file for their own customer base. To implement this

payment option, they would simply need to be able to receive these tokens on the fly rather than storing them. For the EV, implementation of direct payment using an e-commerce token affects only the ISO 15118 software implementation. Since an e-commerce token is typically static, it can be passed on as part of the ISO 15118 authentication.

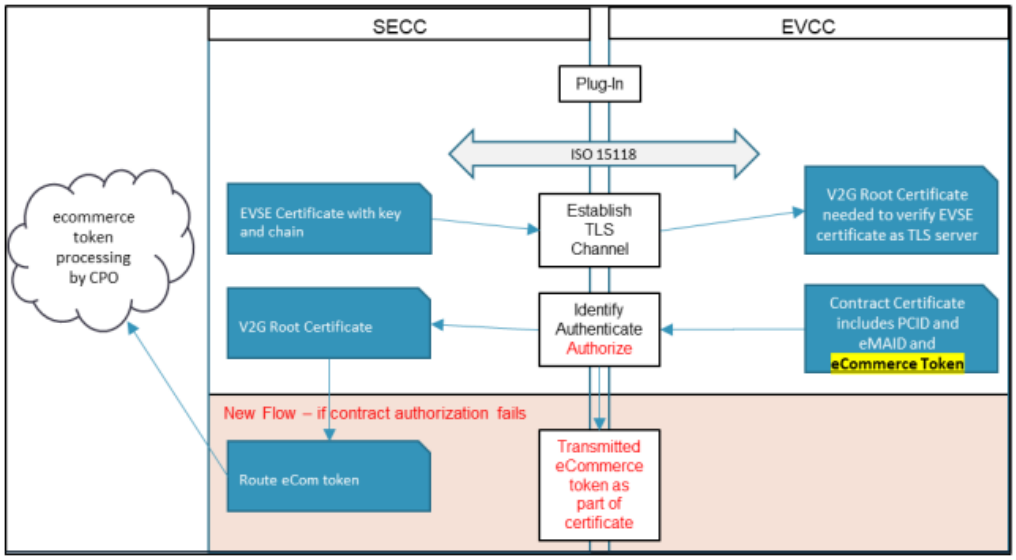


FIGURE 5-16: DIRECT PAYMENT USING E-COMMERCE PAYMENT CREDENTIALS

[Note: Section 5.3 – Reference: Secure Technology Alliance.]

6

Maintenance of Various Types of Electric Vehicle Charging Stations

6. MAINTENANCE OF VARIOUS TYPES OF ELECTRIC VEHICLE CHARGING STATIONS

Key Learning Objectives:

The trainees will be able to,

- Understand the processes related to periodic inspection and preventive maintenance.
- Understand the standard operating procedures for repair and maintenance.
- Understand how to record and report the spare requirement to be sourced for the repair activities.
- Perform the periodic check of distribution transformer.

6.1 CHARGING SYSTEM EQUIPMENT MAINTENANCE

EVSE equipment maintenance involves the fault diagnosis, routine servicing, and repair or replace of electrical components of a machine. An Electrical Maintenance Engineer is responsible for planning the maintenance to ensure the smooth running of the EVSE. The purpose of this System Equipment Maintenance is to reduce hazard to life and property that can result from failure or malfunction of EVSE. Various building and equipment protection devices shall be installed at appropriate places and of appropriate ratings to ensure safety of the premises. Lightning arrestors, circuit breakers, fuses, isolators, switches, additional earthing rods for grounding, etc. can be used as for equipment protection.

6.1.1 PERIODIC INSPECTION AND PREVENTIVE MAINTENANCE PROCESS

Electrical Preventive Maintenance (EPM) is the practice of conducting routine inspections, tests, and the servicing of electrical equipment so that impending troubles can be detected and reduced or eliminated. Periodic maintenance must be established to obtain the best service from the EVSE charger. A monthly check of the switchgear devices and all connections should be the minimum requirement for EVSE. Equipment subject to highly repetitive operation may require more frequent maintenance.

EVSE deterioration is normal, but equipment failure is not inevitable. As soon as new equipment is installed, a process of normal deterioration begins. Unchecked, the deterioration process can cause malfunction or an electrical failure. Deterioration can be accelerated by factors such as a hostile environment, overload, or severe duty cycle. An effective EPM program identifies and recognizes these factors and provides measures for coping with them.

In addition to normal deterioration, there are other potential causes of equipment failure that may be detected and corrected through EPM. Among these are load changes or additions, circuit alterations, improperly set or improperly selected protected devices, and changing voltage conditions. Without an EPM program, management assumes a much greater risk of a serious electrical failure and its consequences. Benefits of an effective EPM program fall in two general categories. Direct, measurable, economic benefits are derived by

reduced cost of repairs and reduced equipment downtime. Less measurable but very real benefits result from improved safety. To understand fully how personnel and equipment safety are served by an EPM program, the mechanics of the program inspection, testing and repair procedures should be understood. Such an understanding explains other intangible benefits such as improved employee morale, better workmanship and increased productivity, less absenteeism, reduced interruption of production, and improved insurance considerations. Improved morale will come with employee awareness of a conscious management effort to promote safety by reducing likelihood of electrical injuries or fatalities, electrical explosions, and fires. Reduced personal injuries and property loss claims can keep insurance premiums at favourable rates.

- Main Parts of an EPM Program

  Essential ingredients of an EPM program are:

  - ✓ Responsible and qualified personnel.
  - ✓ Survey and analysis of EVSE and systems to determine maintenance requirements and priorities.
  - ✓ Programmed routine inspections and suitable tests.
  - ✓ Accurate analysis of inspection and test reports so that proper corrective measures can be prescribed.
  - ✓ Performance of necessary work.
  - ✓ Complete, but concise records.

- Tools and Instruments

  Proper tools and instruments are an important part of an EPM program, and safety protective gear is an essential part of the necessary equipment. Proper tools, instruments, and other equipment will ensure maximum safety and productivity from the maintenance crew.

6.1.2 STANDARD OPERATING PROCEDURES FOR REPAIR AND MAINTENANCE

Standard operating procedures can improve the quality control, facilitate training, ensure compliance, and keep EVSE running efficiently. Before inspection or any maintenance work is done, be sure that all electrical power is disconnected. Make sure that the main breaker of the EVSE is turned off, as well as the upstream breaker in the distribution panel.

- ✓ Why standard operating procedures are required?
- ✓ To protect the health and safety of the employees.
- ✓ To help ensure that everyone performs their task to the same degree of precision.
- ✓ To save time when performing a task.
- ✓ To help ensure that standards and regulations are met.
- ✓ To minimize the effects of personnel turnover.
- ✓ To increase equipment reliability.

- ✓ To help document the equipment management procedure.
- ✓ To help protect the environment.
- ✓ To provide a basis for accident investigation.

6.1.2.1 Standard operating procedures for maintaining of EVSE

- ✓ Always make sure to carry all the tools required for maintenance.
- ✓ Ensure that the maintenance team is properly trained.
- ✓ Make sure that the power circuit is not energized.
- ✓ Check for the power circuit connecting the main upstream breaker to EVSE circuit breaker. Ensure that the power circuit is in good condition without any damages on the cables.
- ✓ Check if the circuit breakers are in good condition.
- ✓ Ensure that all the connections are terminated at the breaker end and are fitted tightly
- ✓ Using the earth resistance device, check if the earthing is done perfectly.
- ✓ Check if the earthing is properly connected and laid across the power circuit.
- ✓ Measure the incoming voltages at the main breaker input end and verify that they are in the specified range.
- ✓ Using the insulation tester, check the insulation of the conductors.
- ✓ Ensure the EVSE enclosure is in good condition.
- ✓ Ensure the enclosure is properly fitted to wall or pedestal.
- ✓ Press the test button to check if the breaker is in working condition.
- ✓ Press the test button to check whether the RCCB is in working condition.
- ✓ If the EVSE is placed outdoors, please open the EVSE enclosure and check for watermarks or water seeping inside.
- ✓ Check if the transformer is in good condition or not.
- ✓ Make sure all the functionalities in the EVSE are functioning perfectly.
- ✓ Fill the maintenance and service report and submit it to the relevant team.

6.1.2.2 Standard operating procedures for repairing of EVSE

- ✓ Always carry the tools that are required for Repairing EVSE.
- ✓ Ensure that the repairing team is properly trained.
- ✓ Always carry one set of switch gears and PCB's.
- ✓ Ensure the power circuit is not energized.
- ✓ Please find the exact problem from the relevant team.

- ✓ If firmware or network related issues arise, try resolving the issue by updating the firmware through OTA without opening the EVSE. If the issue is not solved, take the required help from the Firmware team and troubleshoot the EVSE.
- ✓ If the problem is related to hardware, we must refer to the procedure that is provided by the EVSE manufacturer after opening the EVSE enclosure. Contact the hardware team for further guidance to resolve the issue.
- ✓ Make sure that all the components and switch gears placed in the EVSE are in good condition.
- ✓ Check if all the wires are fitted properly.
- ✓ Check if all the connectors are connected properly.
- ✓ Ensure that all the PCBs are cleaned. In case, they're not, please check for the specific solution used for cleaning the PCB.
- ✓ If replacement is required, replace particular switchgears or the PCBs by taking the guidance of expertise. After replacement, ensure the connections and connectors are placed in the right place and fitted rightly and tightly.
- ✓ Please perform continuity or non- continuity tests as recommended by the manufacturer.
- ✓ After the completion of normal tests, energize the circuit without closing the enclosure and do the functionality test.
- ✓ Close the enclosure after all the functional tests are passed.
- ✓ Do all the tests required on the EVSE after the enclosure is closed and mounted back to the normal position.
- ✓ Lastly, fill in the reports and submit it to the relevant team.

6.1.2.3 Tools required for maintenance and repairing the EVSE

- Multi-meter

Most of the engineers, as well as technicians in the electronics field, know the measurement device namely a multi-meter. Multi-meters are available in different forms in the market based on the characteristics. A multi-meter is an essential measurement instrument. The main function of this device is to measure the electrical properties of tools as well as wiring. At present, multi-meters are used for different purposes based on the requirements like to deal with electricity, laboratories, power sources & circuits.

A Multi-meter is an electronic instrument, every electronic technician and engineer's widely used piece of test equipment. A multi-meter is mainly used to measure the three basic electrical characteristics of voltage, current, and resistance. It can also be used to test continuity between two points in an electrical circuit.

FIGURE 6-1: MULTIMETER

- Clamp Meter

To measure parameters like current and voltage, you'll need a dedicated instrument. Instruments such as analog, multi-meters and digital multi-meters are often used to measure current, but they require that the circuit be cut so that the instrument's test leads can be inserted into the circuit in series. In many cases, it's not possible or practical to do that. Cutting the circuit also poses risks, for example of electric shock.

A clamp meter is a clothespin-shaped instrument that can be clamped around a live wire in order to measure the current it's carrying. As a measurement principle, clamp meters detect the magnetic field emitted by current flowing in a wire in order to measure the current value. Unlike instruments like multi-meters, this design has the advantage of being able to measure current without requiring that the circuit under measurement be cut.

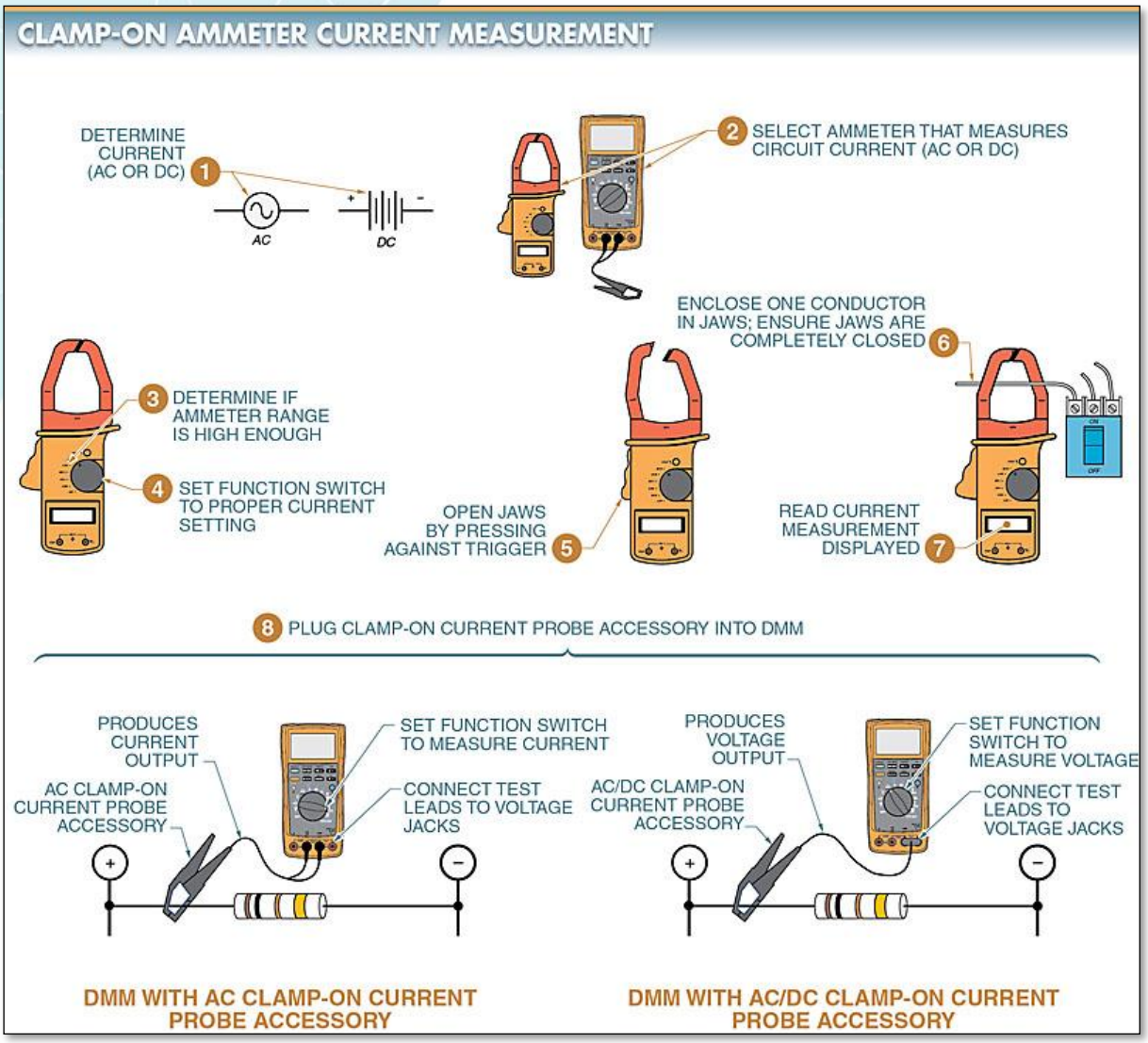


FIGURE 6-2: CLAMP – ON AMMETER CURRENT MEASUREMENT

- Insulation Resistance Tester

An insulation resistance (IR) test measures the total resistance between any two points separated by electrical insulation. The test, therefore, determines how effective the dielectric (insulation) is in resisting the flow of electrical current. Such tests are useful for checking the quality of insulation, not only when a product is first manufactured but also over time as the product is used. The Megger insulation tester is a small, portable instrument that gives you a direct reading of insulation resistance in ohms or megohms. For good insulation, the resistance usually reads in the megohm range.

Insulation resistance measurement is based on Ohm's Law. (R=V/I). By injecting a known DC voltage lower than the voltage for dielectric testing and then measuring the current flowing, it is very simple to determine the value of the resistance. In principle, the value of the insulation resistance is very high but not infinite, so by measuring the low current flowing, the megohmmeter indicates the insulation resistance value,

providing a result in M OHM. This resistance characterizes the quality of the insulation between two conductors and gives a good indication of the risks of leakage currents flowing.

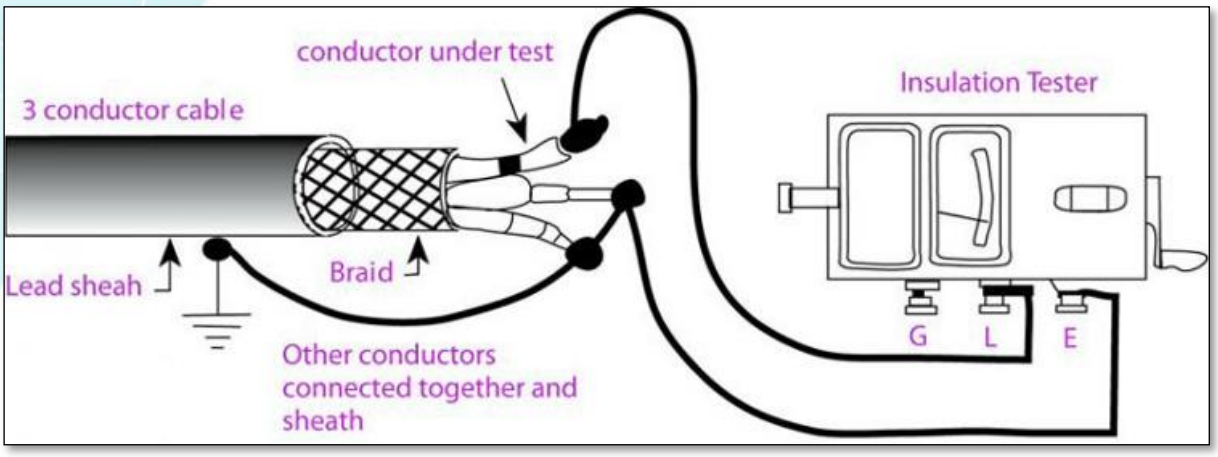


FIGURE 6-3: INSULATION RESISTANCE TESTER

- Earthing Test

Earthing test is done by using the help of instrument called earth resistance tester. Every equipment in the power system is earthed to ensure protection for both the system and personnel. Earthing is the process of establishing electrical connectivity between noncurrent bearing parts of an electrical device and earth throw a low resistance path. This protects the person working with the electrical device from leakage current flowing through its body. By maintaining all the equipment of the power system at earth potential, unexpected electrical charges due to lightning or static electricity are dissipated to the earth through earthing, thus protecting the system.

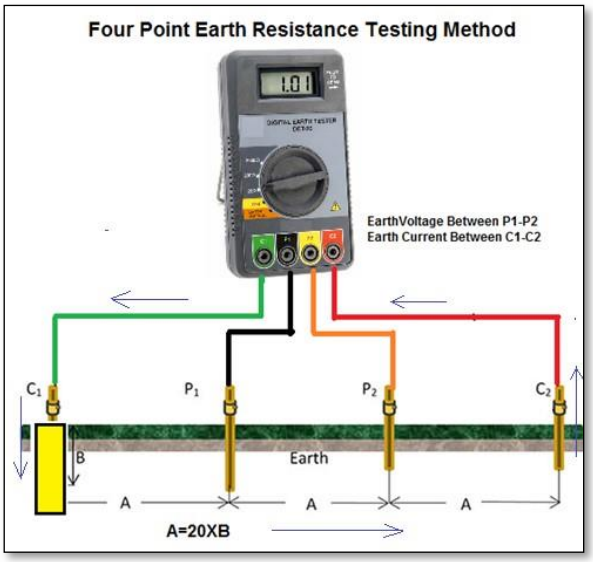


FIGURE 6-4: EARTH RESISTANCE TESTING

6.1.2.4 Basic Electrical Maintenance Tools

- ✓ Pliers
- ✓ Screw drivers
- ✓ Hammer
- ✓ Drilling machine
- ✓ Cutters
- ✓ Electrical tape
- ✓ Drill bits
- ✓ Cable ties
- ✓ Wire lugs
- ✓ Knife
- ✓ Wrench set
- ✓ Wire crimper

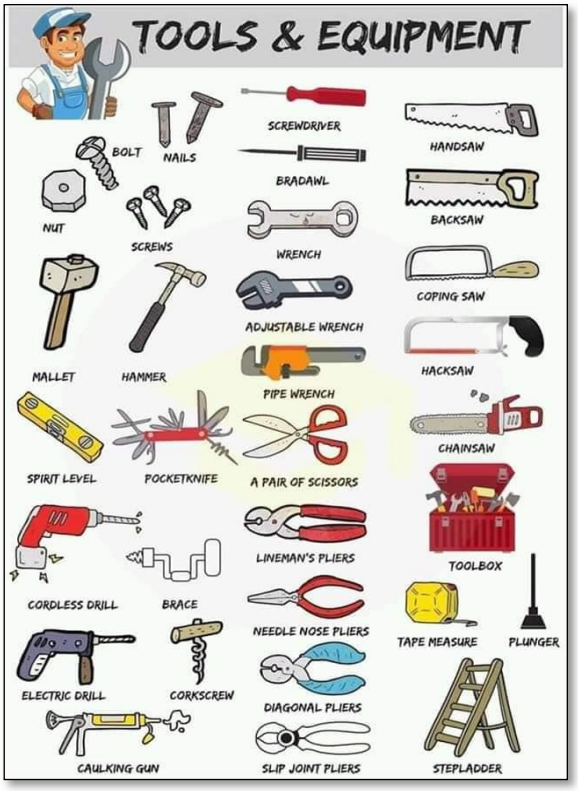


FIGURE 6-5: TYPES OF EQUIPMENT

The maintenance of the charging stations depends on the circuitry that is present. Various common cost factors to be considered for maintenance are:

- Electricity Costs related to maintenance work
- Extended Annual Maintenance Costs and Warranty Costs
- Manpower costs
- Equipment Replacement costs
- Miscellaneous expenses that may not cover the above

Basic steps of troubleshooting for EV charging station maintenance include:

- Check the electricity supply to the charging station
- Check phase wise connection to identify fault, if any
- Check for tripping of circuit breaker or fuse
- Check for equipment damage or fault on load side

6.1.3 RECORDING AND REPORTING SPARE REQUIREMENTS TO BE SOURCED FOR REPAIRING

The word Repair means responding to the breakdown of equipment and undertaking work to correct the problem in order to return the equipment to a working condition. Before EVSE can be repaired, you need to be aware that there is a problem! Therefore, there should be a clearly understood system for reporting faults and breakdowns and EVSE users should be encouraged to report faults and breakdowns as soon as possible. If there is no back-up for EVSE, a breakdown will mean that the service the EVSE was providing will come to a halt. Simple repairs can be done by the relevant team on the site. If the equipment is being repaired on site, it is important that the team is trained to work safely and do not create any hazards harmful for users or the repair team who is handling the EVSE.

Why is it required to record and report spare requirements?

- ✓ Recording and reporting is required to maintain a track of the components. The EVSE needs to be maintained effectively so that it functions efficiently.
- ✓ Maintaining a record also helps in understanding the lifespan of components that can be replaced with specified service timings.
- ✓ Making sure that all the components are labelled correctly with appropriate names.
- ✓ Figuring out the exact problem with the component that is to be rectified.
- ✓ Checking and verifying the components which need to be replaced are critical.
- ✓ The downtime of the equipment must be monitored and managed accordingly.
- ✓ The stock of spare parts for the EVSE are to be maintained by the manufactures to ensure lesser downtime of the equipment.
- ✓ The maintenance department should maintain at least two sets of spare parts at the operational cities for ensuring faster repair or replacement.

- ✓ Maintaining a document specifying the quantities of spare parts available is required.
- ✓ Planning for maintenance of the EVSE and ensure that the necessary accessories as well as enough spare parts to last for at least a year.
- ✓ Protecting the accessories used in EVSE when not in use is needed.
- ✓ Storing the accessories in a dry and clean environment. Ensuring that the PCBs and other electronic items are stored in anti-static area.

TABLE 6-1: RECORDING OF SPARE REQUIREMENT FOR REPAIRING

WHAT SHOULD BE RECORDED	THIS PROVIDES INFORMATION ABOUT
The details of work done on each EVSE (including cause/suspected cause, and who carried out the repair)	• The history of each EVSE • Common problems
The spare parts and material used	• The parts most frequently used • What need to be ordered
The date when the EVSE has broken down, and the date of repair	• What still needs to be repaired (which allows you to prioritise the next week's tasks) • The duration of equipment not in use.
The cause of delays	• What are the most common causes of delay (Skill, labour, spare parts, transport) and what additional resources may be needed to complete work on the time

6.1.4 PERIODIC CHECK OF DISTRIBUTION TRANSFORMER

- What is distribution transformer?

  A distribution transformer or service transformer is a transformer that provides the final voltage transformation in the electric power distribution system, stepping down the voltage used in the distribution lines to the level used by the customer.

- Why is transformer maintenance required?

  The fundamental goal of transformer maintenance is to guarantee that the internal and exterior components of the transformer and accessories are in good condition, "fit for purpose," and can work safely at any time. It is also critical to keep a record of the transformer's condition over time.

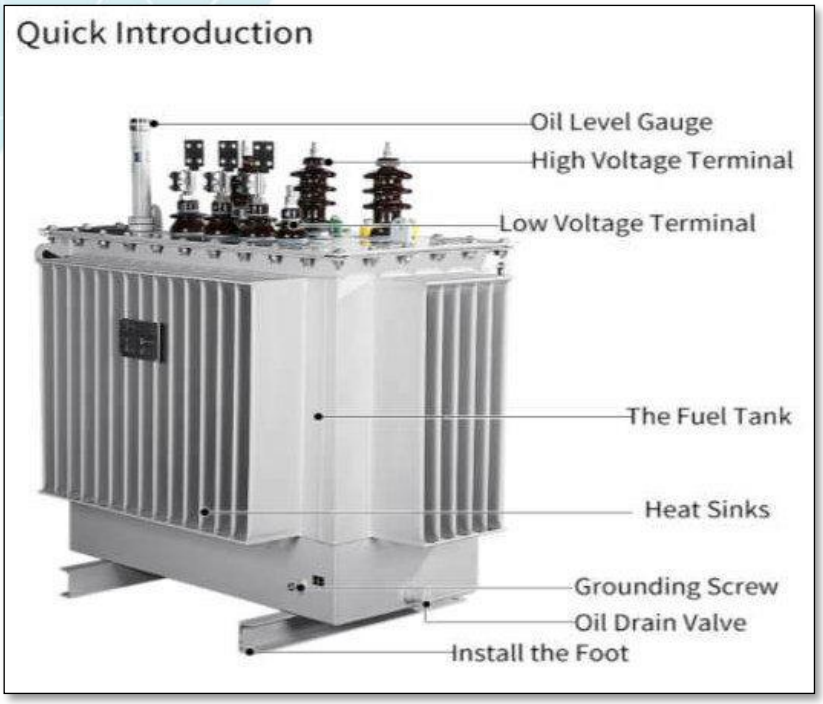


FIGURE 6-6: DISTRIBUTION TRANSFORMER

- Distribution transformer routine maintenance

  The scope of routine and preventive maintenance covers following activities

  - ✓ Routine Inspection and Maintenance.
  - ✓ Preventive Maintenance.
  - ✓ Routine inspection and maintenance can be carried out while the transformer is On-line.

- Pay attention to the following parameters

  - ✓ Abnormal noises, irregular vibrations, external damages, silica gel condition and deterioration of paint.
  - ✓ A record of the readings/recordings, from the meters/gauges provided on the transformer, should be maintained, and compared with the past values. In case of abnormalities, suitable measures should be taken.

TABLE 6-2 DISTRIBUTION TRANSFORMER ROUTINE MAINTENANCE CHECKLIST

Transformer Temperature	Take and record the reading of oil/winding temperature indicator.
Oil Level	Take and record the reading of oil level indicator.
Noise	Check for abnormal sound/noise.
Oil Leakages	Check oil leaks especially on location of valves, indicators, packing and welded parts.
Breather	Pay attention to the color of silica gel. Regenerate or replace if color has changed, (from healthy condition to the exhausted condition, the color change depends on the type of the silica gel being used).
Bushings	Check for excessive bushing contamination.
Indication Signs	Check for danger signs and indication signs.

- Preventive Inspection and Maintenance: -
    - ✓ The period for the inspection is not absolute and is dependent on atmospheric and operating conditions of each transformer.
    - ✓ The recommended period under normal conditions is one year.

Preventive maintenance and inspection should include but not limited to the following (Many of these require the transformer to be shut down).

TABLE 6-3 PREVENTIVE MAINTENANCE AND INSPECTION CHECKLIST

Tank	Check for oil leaks and paint finish.
Radiators	Check for oil leaks, paint finish and contaminations.
Bushing	Check for local heating, damages, and contamination and oil leaks.
Insulating oil	Check for dielectric strength, carbon sludge, offensive odor and discoloration.
Dehydrating breather	Check for discoloration of silica gel breather.
Indicators	Check for proper functioning.
Physical Checks	Visual Inspection of complete transformer, oil level checks, connections of cables, bus bars or overhead conductors to bushings & earthing.

- Recommended Electrical Tests
    - ✓ Measurement of Insulation Resistance of the Windings (Megger Test).
    - ✓ Measurement of Voltage (Turns) Ratio (TTR).
    - ✓ Measurement of Winding Resistance.
    - ✓ Measurement of dielectric strength of oil.

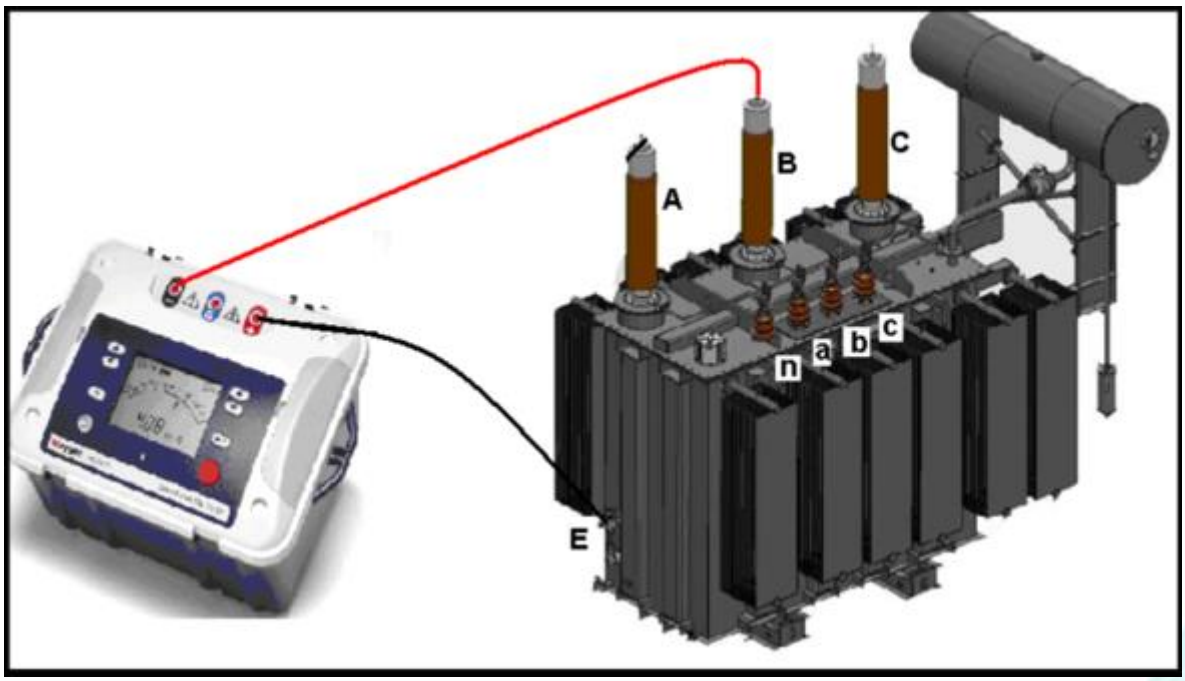


FIGURE 6-7: TESTING OF DISTRIBUTION TRANSFORMER

- Fluid Dielectric Test (Annual)

  As described below. The dielectric strength of the insulating fluid should measure at least 26KV.

Sampling of Insulating Fluid

Transformers are filled with insulating fluid, which provides electrical insulation within the transformer tank and transfers heat generated in the coils to the tank wall and radiators. The fluid is either:

- ✓ Conventional transformer oil (mineral oil),
- ✓ Enviro-temp FR3 fluid, or
- ✓ Silicone fluid.

Periodically check the transformer for proper fluid level by reading the fluid level gauge. Add fluid if necessary. When adding fluid, add only the same type of fluid that is in the transformer. It is also recommended that a fluid sample be drawn annually and tested for dielectric strength. Samples should be drawn from the bottom of the tank. Use proper sampling procedures to prevent erroneous test results. Dielectric strength should measure a minimum of 26kV.

FIGURE 6-8: PERIODIC CHECK OF THE TRANSFORMER

- ✓ Open Circuit Test & Short Circuit Test (If possible, to be performed).
- ✓ Functionality test and physical check of all accessories, parts and components.
- ✓ Complete Chemical Analysis of Transformer Oil (once after every five years).

6.2 SOFTWARE INSTALLATION AND TROUBLE SHOOTING

Installation and troubleshooting of software are essential. While charger manufacturer is better equipped to handle such issues, standard procedure for troubleshooting and reporting must be incorporated.

Troubleshooting related to following software issues should be identified and worked upon. For example, charging protocols mandate that the charging should start only when certain criteria like connection to ground, current filtering, etc. are met. The real challenge here is to program the software to detect the protocol that the EV supports and change the charging modes accordingly. For instance, the CCS (Combined Charging System) supports SAE J1850 for diagnostics and data sharing applications in EVs. Hence, the battery charger system must be equipped with the same protocol.

- The Standard Operating Procedures for the troubleshooting:
- Have a procedure in place for determining what procedures or processes need to be documented
- Understand the compliance regulations well
- Be knowledgeable about the activity
- Be knowledgeable with the internal structure
- Be subject-matter expert who performs the work or uses the process
- Follow a team approach, especially for multi-tasked processes where the experiences of several individuals are critical
- Review and validate the SOPs by one or more individuals with appropriate training and experience with the process
- Test draft SOPs by individuals other than the original writer before finalizing
- Have the SOPs approved as per the Organization's Quality management plan
- Review SOPs on a periodic basis
- When there is a process change, update and re-approve SOPs
- Maintain a master list of SOPs indicating the SOP number, version number, date of issuance, title, author, status, organizational division, branch, section, and any historical information regarding past versions

7

Health and Safety Practices at the Workplace

7. HEALTH AND SAFETY PRACTICES AT THE WORKPLACE

Key Learning Objectives:

The trainees will be able to,

- Understand the roles and responsibilities, importance of Personal Protective Equipment and First Aid kit in standardizing safe working practices.
- Identify the abnormalities in the equipment and communicating it effectively with the higher Authorities.
- Prevent accident at workplace, understand various safe / standard practices while handling the materials and machines.
- Understand the importance of periodic checks of Emission and Pollution levels of Diesel generators and Safety systems of distribution transformer.
- Familiar with the importance of audits of safety systems and processes for flooding and water intrusion
- Understand the various types of fire.
- Demonstrate various types of fire extinguisher along with "How to operate fire extinguisher".
- Understand fire rescue and fire prevention technique.
- Understand implementation of Safe Evacuation Procedure for Customers and Staff.
- Understand the various check list in detail – Fire prevention practices, Personal emergency evacuation plan and Risk assessment.
- Understand the functionality of a charging management system.
- Understand the communication protocols implemented in a CMS.

7.1 CHARGING STATION - HEALTH AND SAFETY PRACTICES

The overall purpose of health and safety practices to be followed at charging station is to ensure that risks associated with battery storage, charging and use are adequately managed in order to minimise the risk of injury or harm to workers. The practices or procedures defined here provides practical guidance on how to manage these health and safety risks. This SOP only applies to battery storage, charging and related activities associated with charging station and equipment use. This procedure applies to all charging station staff, including contractors and other persons on charging station-controlled worksites where battery storage, charging and related activities occur. Outlined below are responsibilities specific to battery storage, charging and use at all charging station workplaces and controlled sites.

- Charging station Executive

Charging station Executive and Senior Management (CEO, General Managers – Officer and Non-Officer Appointed) are responsible for overseeing and ensuring the implementation of the requirements of SOP and related procedures within their respective functional areas. This includes ensuring all sites are suitably risk assessed and have appropriate facilities, filling personal emergency evacuation plan (PEEP) filled from every employee, services and resources to ensure that risks Associated with battery storage, charging and use are adequately managed to minimise the risk of injury or harm to workers.

- Managers

  Managers in all operational areas and charging station worksites are responsible for ensuring the review and Management of risks associated with battery storage, charging and use. This includes:

  - Provision of appropriate resources so that design and operation requirements for Battery charging and storage areas are appropriate.
  - Provision of appropriate resources to deliver training to workers who handling and charge batteries in:
    - ✓ Related chemical hazards;
    - ✓ The risks associated with recharging (i.e., fire and explosion);
    - ✓ Manual handling risks associated with removing, installing and handling large batteries.
    - ✓ Personal Protective Equipment (PPE) requirements.
    - ✓ Filling and updating "Fire Prevention practices checklist" for the charging station premises. This cycle needs to repeat after every 6 months.
  - Supervisors

    Supervisors and Team Leaders in all operational areas and charging station worksites are responsible for ensuring that risks associated with batteries and its charging are managed including:

    - ✓ Completing a risk assessment in relation to battery storage, charging and use.
    - ✓ Operating and maintaining storage areas as per charging station guidelines and manufacturer's specifications.
    - ✓ Providing areas / space suitable for rechargeable batteries or battery charging station.
    - ✓ Keeping battery charging and storage areas free of ignition sources.
    - ✓ Mandating that workers who handle batteries (e.g. changing and charging batteries etc.) do not wear metallic jewellery and accoutrements.
    - ✓ Ensuring workers who handle batteries or undertake battery charging activities are appropriately trained and use required PPE; and
    - ✓ Informing all workers and contractors of requirements of this SOP and ensuring their compliance with this SOP.

- ✓ Filling and updating "Risk Assessment checklist" from every employee working within charging station premises. This cycle needs to repeat after every 6 months.

- Workers

  All workers shall ensure that they:

  - ✓ Follow the guidelines of this Battery Storage and Charging SOP and related procedures and comply with manufacturers' recommended procedures for charging and handling rechargeable lead-acid batteries.
  - ✓ Workers wear appropriate PPE; and
  - ✓ Report any incidents to their supervisor and follow the injury management procedure; and
  - ✓ Complete a charging station "Incident and near misses Report Form" in accordance with charging station Incident Reporting Procedures.

A timesheet and a work done report in a specified format may be maintained to analyse the tasks of all personnel at the charging station. A detailed job-description may also be provided, for understanding the nature of job assigned to any person in case of a new role being assigned.

Daily work done report sample format:

1. Name of Employee:
2. Employee Code:
3. Shift Timing:
4. Total vehicles serviced:
5. Total amount collected – digital payment
6. Total amount collected – cash payment
7. Initial reading and final reading data of each recharge point:

- Contractor

  At all times when performing work on a charging station site or for/on behalf of charging station, contractors must comply with charging station's battery management requirements detailed in this and related procedures and must report any incidents to the relevant charging station Manager and to their employing / contracting agency in accordance with charging station Incident Reporting Procedures.

[References: PRO425 Battery Storage and Charging Standard Operating Procedure.]

7.1.1 PROTECTIVE CLOTHING AND GEARS

Charging station Executive and Senior Management to ensure all tasks are assessed to identify the required PPE; and ensuring appropriate management practices are implemented to make sure that PPE is a) available, used and maintained and b) regularly monitored and reviewed to ensure effectiveness. This also includes:

- ✓ Facilitating adequate resourcing to ensure the provision of PPE is sufficient.
- ✓ Ensuring personnel are trained in the selection, use and maintenance of PPE for all work environments.
- ✓ Ensuring sufficient PPE is available for all work environments and is correctly used and maintained.
- ✓ Documenting and retaining records of inspections; and providing appropriate training, instruction and supervision for workers.
- ✓ Ensure that workers do not interfere or alter any PPE; Wear PPE in the manner instructed.
- ✓ Report any PPE defects/damage immediately to their supervisor; and complete Incident Report in accordance with charging station incident reporting procedures.

As more electrical workers go out into the field to meet the growing demand of electric power sources, it is critical they have the right PPE to help keep them safe.

- Hand Gloves:

FIGURE 7-1: CLASS 0 ELECTRICIANS INSULATED GLOVES AND LEATHER OVER PROTECTOR GLOVES

Insulating rubber gloves are among the most important articles of protection for electrical workers against electrical shock hazards. Electrical insulating equipment is made of materials that block the transmission of electric charges so that no electricity up to a certain voltage can go through the material and rubber is the most used insulator. Insulating rubber gloves comes in different lengths and hand sizes depending on the individual user's needs and vary based on the level of voltage protection they provide. When picking gloves for a specific task, workers should know the voltage they expect to encounter and choose the right glove accordingly. Insulating rubber gloves must be rated for the voltage to which a worker will be exposed and marked to indicate their rating,

- ✓ class 00 – Resistance up to 500 V alternating current (AC)/proof tested to 2,500 V AC and 10,000 V direct current (DC).
- ✓ class 4 – Resistance up to 36,000 V AC/proof tested to 40,000 V AC and 70,000 V DC.

- Arc shield [IS 8521:1977 Part 1]:

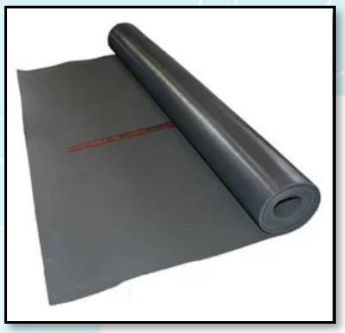
Arc flash events are serious safety hazards that take the form of electrical explosions. These quick, explosive blasts can cause severe damage, including potential blindness or deafness and other hidden fatal injuries such as internal bleeding. When an arc flash event occurs, it is caused by a short circuit where electricity travels outside of its planned path. Arc flash PPE requires head-to-toe solutions. When workers don their PPE ahead of entering an environment with the potential for an arc flash, they need to be wearing protective garments like coats, bib overalls and coveralls made with arc flash resistant materials rated for the work and environment. Head, face and neck protection is critical too. Arc flash hoods are designed to cover the head, face and neck to protect against extreme temperatures and should always be worn in combination with the proper hard hat and face shield. When considering the right face shield to use, workers should opt for selections that ensure reliable visibility even in poorly lit rooms and anti-fog and anti-scratch coatings to guarantee lens longevity. Eye protection should be worn when testing for high voltage, which is considered by many experts to be over 60 volts. Eye protection should include the following features:

1. Plastic frames (avoid metal frames as these are conductive and could cause a shock hazard).
2. Side shields
3. Meet the relevant safety standard

Most hybrid electric systems use voltages higher than this threshold. If the system has not been powered down or has not had the high voltage system disabled, a shock hazard is always possible. Even when the high voltage system has been disconnected, there is still high voltage in the HV battery box.

- 1000v Insulated Mat [IS 15652: 2006] and Dielectric Footwear [ASTM F1117 - 03(2019)]:

  Insulated mat prevents direct contact with the ground to reduce current flow, furthermore, it grounds and insulates any static charge you may be carrying.



Just as it is important to protect workers' hands and arms from electrical hazards, protective footwear should also be used to protect workers' feet. A considerable safety hazard that many electrical workers face is called step potential. Step potential is the way in which workers could experience an injury or electrocution by stepping near an energized, grounded object without actually touching the exposed power source on the ground. To prevent against step potential, electrical workers should be equipped with dielectric footwear to provide high voltage protection and prevent charges from passing through workers' bodies from the ground. Depending on the electrical job being performed, workers can choose from dielectric boots, intended for users who rely on a single boot for step potential protection, or over boots and overshoes, which are designed to be worn over daily industrial work boots.

- 45Kv 1.65m Fiberglass Rescue Pole:

  A large, insulated fiberglass pole should be available outside the safety zone to be used to pull a technician away from the vehicle in the unfortunate event of an accident where the technician is shocked or electrocuted. Your hands must remain below the rubber shield to increase the resistance between your hand and the current source.

FIGURE 7-2: PERSONNEL PROTECTIVE EQUIPMENT: HAND GLOVES, SAFETY SHOES, INSULATED MAT, RESCUE POLE ETC.

7.1.2 IDENTIFICATION AND RISK MAPPING OF JOB SITE HAZARDS

A hazard map is a map that highlights areas that are affected by or are vulnerable to a particular hazard. Hazard mapping helps to or instructions to build hazard map is as follows:

- ✓ Identify location(s) for high risk of injury;
- ✓ Pinpoint systems and services that need to be strengthened.

- ✓ Develop a corrective action plan
- ✓ Incorporate safety and injury prevention into ongoing-monitoring activities at charging station premises.

For details guidelines on hazard map and risk assessment matrix at charging station, refer section 7.3.1.

7.1.3 STANDARD SAFE WORKING PRACTICES

Charging station manager will take action to manage their facilities, plant, work environment and tasks as to eliminate the risks associated with battery use and charging, and if that is not possible, charging station manager will minimise the risks so far as is reasonably practicable. The charging of batteries can be hazardous. However, this hazard may be overlooked by workers seeing as battery use is a common activity in many workplaces. The two primary risks are from a) the hydrogen gas that is formed when the battery is being charged; and b) the sulphuric acid contained in the battery fluid. To manage the risks associated with the storage, charging and use of batteries at their worksites, charging station manager will:

- ✓ Identify and assess the risk for all locations and tasks that could cause injury or damage due to battery use.
- ✓ Supply and maintain suitable plant and equipment for workers to reduce the likelihood of a battery-related incident.
- ✓ Provide training to workers in the safe use of equipment and plant relevant to their tasks.
- ✓ Educate workers in the risks and controls required for managing batteries; and
- ✓ Develop and test emergency response, rescue and first aid plans.

Battery storage, charging and use will vary at each charging station workplace or controlled site. Charging station manager will determine battery-related requirements (i.e. equipment, facilities and personnel) through a risk management approach. This will involve:

- ✓ Identifying hazards that could result in work-related injury, illness or damage.
- ✓ Assessing the type, severity, and likelihood of injuries and illnesses.
- ✓ Providing appropriate equipment, facilities, first aid and training; and
- ✓ Reviewing battery storage, charging and use requirements on a regular basis or as circumstances change.

To have a safe working practice, following are the general safety precautions defined and needs to be followed.

- Fire and explosion
  - ✓ Hot works are not permitted in areas where batteries are stored, handled, or recharged, unless appropriate controls have been implemented through a risk assessment process.

- ✓ Battery charging and storage areas must be designated and separated from work areas;
- ✓ All battery charging and storage areas must be bundled, undercover and well ventilated.
- ✓ Ignition sources must be removed from battery charging areas.
- ✓ All battery training must be conducted by a suitably trade qualified worker; and
- ✓ Warning signage must be displayed at charging areas.

- Spills management

In the event of a spill:

- ✓ Shower or wash exposed areas of skin as appropriate to size of spill and exposure.
- ✓ Stop leak if safe to do so.
- ✓ Contain the spill using spill kit materials. Do not allow to enter drains/waterways or natural environment;
- ✓ Clean up using soda ash/spill material when containment completed or remove contaminated soils as directed by the Environmental Team;
- ✓ Store waste in approved container;
- ✓ Complete an incident report and investigate causes; and
- ✓ Dispose of waste material.

- Manual handling
  - ✓ Batteries must not be carried manually where more than one battery lift is required or where battery is large and/or awkward in size.
  - ✓ Appropriate mechanical handling aides (e.g. cradles, trolleys etc.) must be used and secured for the transportation of batteries;
  - ✓ All batteries must be stored at heights below 1.2 metres: and
  - ✓ Battery electrolyte acid must be transported in or decanted from approved containers only.

- First Aid

  All designated battery storage and charging facilities must provide:

  - ✓ Access to emergency wash facilities to allow rapid and continuous flushing with water.
  - ✓ Emergency showers must have green, fluorescent lighting.
  - ✓ Access to saline eye wash for minor splashes to the eyes; and
  - ✓ First aid kits, stocked with appropriate electrolyte acid exposure countermeasures (e.g. neutralising agent); and
  - ✓ Access to first aid in the event of acid burn to the skin.

- Battery storage

  Batteries must be stored:

- ✓ In a bounded, cool, well-ventilated area;
- ✓ Away from ignition sources (e.g. welding, smoking, etc.);
- ✓ Used batteries are to be stored in well ventilated cupboard area; and
- ✓ New batteries are to be stored on wooden shelving or on other non-corrosive material.

- Batteries storage areas must:
  - ✓ Be designated and indicated by appropriate signage; and
  - ✓ Have appropriate emergency response equipment such as fire extinguisher, eye wash facilities and spill kits located nearby.
  - ✓ Battery terminals are to be insulated to prevent the risk of contact by metal tools/objects.
- Battery charging

  To minimise the risk of danger and injury, the following precautions are to be applied when charging batteries:
  - ✓ Manufacturer's instructions on battery handling and charging must be followed.
  - ✓ Relevant Safety Data Sheets (SDS) must be located within charging area.
  - ✓ All electrical sources must be disconnected from the battery prior to any work.
  - ✓ Battery must be removed from vehicle or plant for charging (where appropriate).
  - ✓ Charging must be conducted in designated area.
  - ✓ Charger must be located as far from battery as cabling will permit.
  - ✓ Fluid level in each cell must be checked prior to charging.
  - ✓ Oversharing batteries must be avoided.
  - ✓ Charging area must be well-ventilated.
  - ✓ Contact with battery acid must be avoided.
  - ✓ Required/correct PPE must be worn.
  - ✓ Appropriate emergency response equipment (such as fire extinguisher, eye wash facilities and Spill Kits) must be located nearby.
  - ✓ Spill Kits and/or soda ash must be available for spills; and
  - ✓ If battery acid contacts with the skin, affected area must be washed immediately.

- Disposal of sealed batteries / battery-related waste

  Battery material is hazardous waste and must not be disposed of in normal waste systems. Charging station manager work areas that store, use or recharge batteries that are not considered to be general waste material must collect the material (battery components, cells and electrolyte liquids) in approved containers for disposal. All waste batteries and related battery waste material must only be disposed of in approved waste receptacles through charging station manager approved hazardous/ industrial waste contractors.

- Training, competency, and supervision

  Charging station manager will provide instruction to workers on:

  - ✓ Chemical hazards associated with batteries.
  - ✓ Emergency procedures related to batteries; and
  - ✓ Manufacturer's requirements for charging and changing batteries.

7.1.4 IDENTIFICATION OF ABNORMALITIES IN EQUIPMENT

To take care of abnormalities in equipment well in advance, introducing total productive maintenance concept (TPM) which emphasizes proactive and preventative maintenance to maximize the operational efficiency of equipment. It blurs the distinction between the roles of production and maintenance by placing a strong emphasis on empowering operators to help maintain their equipment. The implementation of a TPM program creates a shared responsibility for equipment that encourages greater involvement by charging station workers. In the right environment this can be very effective in improving productivity.

The traditional TPM model consists of a 5S foundation (Sort, Set in Order, Shine, Standardize, and Sustain) and eight supporting pillars. The goal of 5S is to create a work environment that is clean and well-organized. It consists of five elements:

- ✓ Sort: eliminate anything that is not truly needed in the work area
- ✓ Straighten: organize the remaining items
- ✓ Shine: clean and inspect the work area
- ✓ Standardize: create standards for performing the above three activities
- ✓ Sustain: ensure the standards are regularly applied

It should be reasonably intuitive how 5S creates a foundation for well-running equipment. For example, in a clean and well-organized work environment, tools and parts are much easier to find, and it is much easier to spot emerging issues such as fluid leaks, material spills, arcing etc.

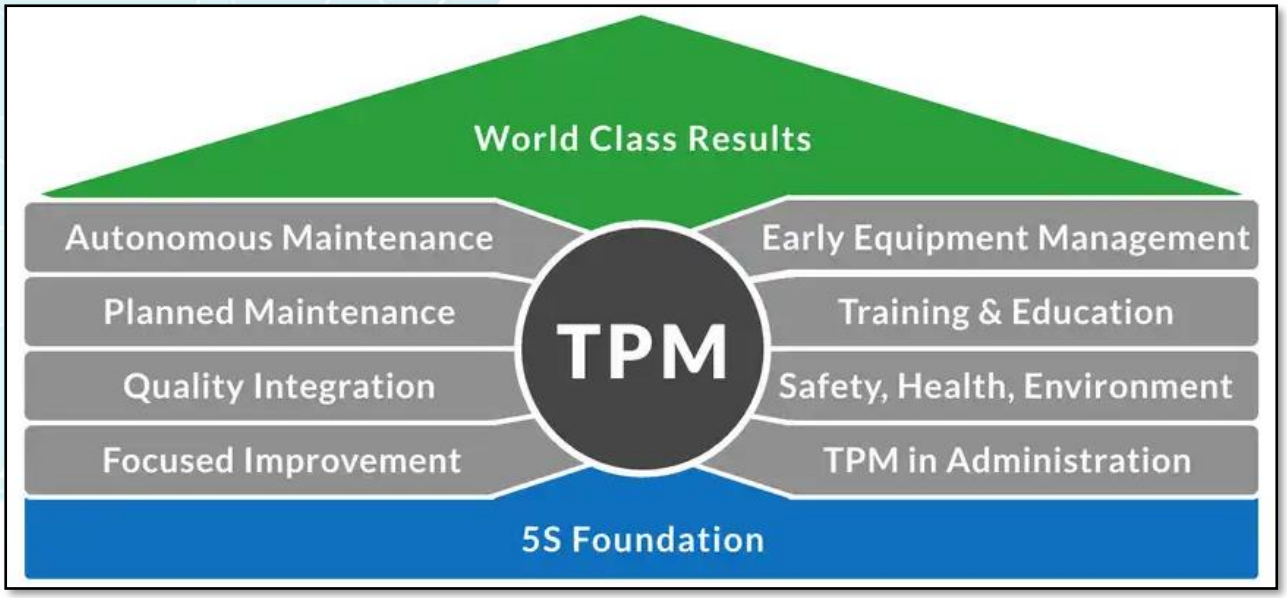


FIGURE 7-3: TOTAL PRODUCTIVE MAINTENANCE

- The Eight TPM Pillars:

  The eight pillars of TPM are mostly focused on proactive and preventative techniques for improving equipment reliability.

TABLE 7-1: EIGHT PILLARS OF TPM

PILLAR	WHAT IS IT?	HOW DOES IT HELP?
Autonomous Maintenance	Places responsibility for routine maintenance, such as cleaning and inspection, in the hands of operators.	• Gives operators greater "ownership" of their equipment. • Increases operators' knowledge of their equipment. • Ensures equipment is well-cleaned and lubricated. • Identifies emergent issues before they become failures. • Frees maintenance personnel for higher-level tasks.
Planned Maintenance	Schedules maintenance tasks based on predicted and/or measured failure rates.	• Significantly reduces instances of unplanned stop time. • Enables most maintenance to be planned for times when there is no more battery charging happening. • Reduces inventory through better control of wear-prone and failure-prone parts.
Quality Maintenance	Design error detection and prevention into production processes. Apply Root Cause Analysis to eliminate recurring sources of quality defects.	• Specifically targets quality issues with improvement projects focused on removing root sources of defects. • Reduces number of defects. • Reduces cost by catching defects early (it is expensive and unreliable to find defects through inspection).

PILLAR	WHAT IS IT?	HOW DOES IT HELP?
Focused Improvement	Have small groups of employees work together proactively to achieve regular, incremental improvements in equipment operation.	• Recurring problems are identified and resolved by cross-functional teams. • Combines the collective talents of a company to create an engine for continuous improvement.
Early Equipment Management	Directs practical knowledge and understanding of charging equipment / point gained through TPM towards improving the design of new charging equipment / point.	• New charging point / equipment reaches planned performance levels much faster due to fewer start-up issues. • Maintenance is simpler and more robust due to practical review and employee involvement prior to installation.
Training and Education	Fill in knowledge gaps necessary to achieve TPM goals. Applies to operators, maintenance personnel and managers.	• Operators develop skills to routinely maintain equipment and identify emerging problems. • Maintenance personnel learn techniques for proactive and preventative maintenance. • Managers are trained on TPM principles as well as on employee coaching and development.
Safety, Health, Environment	Maintain a safe and healthy working environment.	• Eliminates potential health and safety risks, resulting in a safer workplace. • Specifically targets the goal of an accident-free workplace.
TPM in Administration	Apply TPM techniques to administrative functions.	• Extends TPM benefits beyond the plant floor by addressing waste in administrative functions. • Supports production through improved administrative operations (e.g., order processing, procurement, and scheduling).

TPM cycle, if implemented effectively, identification of abnormalities in the equipment will be easier and accordingly maintenance activity across the charging station can be schedule well in advance.

7.1.5 DIFFERENT ACCIDENT PREVENTION METHODS

Accidents are unplanned occurrences that result in injuries, illness, death, and loss of property and/or production. While there is no way to eliminate accidents, there are certain plans, preparations, and actions that can be taken to reduce them.

- Know the Hazards
  - ✓ Be aware of surroundings. Look around and identify workplace hazards that could cause harm.
  - ✓ Look for ways to reduce or eliminate hazards and implement them.
  - ✓ Report unsafe areas or practices.
  - ✓ Dress for the weather.

- ✓ Use the hazard map tools (Refer section 7.3.1) to identify hazards associated with job types.

- Create a Safe Work Area
  - ✓ Keep an orderly workplace. Poor housekeeping can cause serious health and safety hazards. The layout of the workplace should have adequate egress routes and be free of debris.
  - ✓ Continually cultivate a safety standard.
  - ✓ Take breaks and move around regularly throughout the day. Small breaks (standing up and moving around) can make a big difference in combating the dangers of staying in a static position all day long.
  - ✓ Pay attention to workstation ergonomics.
  - ✓ Refer to the fire prevention practices checklist and update it every 6 months.

- Use Safe Lifting Techniques

  Follow the following safe lifting practices:

  - ✓ Lift from a position of power
  - ✓ Keep the load close
  - ✓ Use a staggered stance
  - ✓ Don't twist while lifting
  - ✓ Training in body mechanics can reduce strain injuries and keep employees safe during lifting and moving.

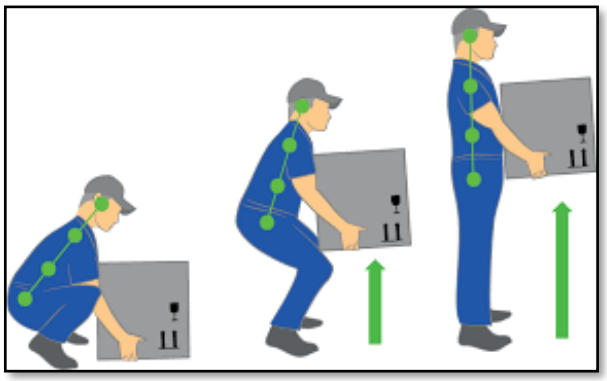


FIGURE 7-4: SAFE LIFTING PRACTICES

- Personal Protective Equipment

  The proper use of Personal Protective Equipment (PPE) can dramatically reduce the risk of injury. Examples of PPE include gear such as earplugs, hard hats, safety goggles, gloves, air-purifying respirators, and safety shoes.

- Regular Communication
  - ✓ Notify supervisors about safety hazards by filling up "Incident and near misses report".

- ✓ Speak up and be involved in safety planning.
- ✓ Continually cultivate a safety standard.
- ✓ Paste the list of emergency contact number details near every charging point and at required places in the charging station premises.

- Education and Training
  - ✓ Ensure everyone has the proper safety training relating to the hazards of the job.
  - ✓ Plan Environmental Health and Safety programs.
  - ✓ During the training, explain the templates of personal emergency evacuation plan, risk assessment checklist, fire prevention checklist and incident and near-misses report etc.
  - ✓ Schedule Mock safety drills and safety training on PPE kits.
  - ✓ Training on awareness about "Fire audit checklist" will help proactively be ready for the audit cycles. For fire audit checklist, refer section 7.3.4.

It is each employee's responsibility to take an active role in maintaining safety.

7.1.6 SAFE HANDLING OF MATERIALS AND MACHINERIES

While automation is swiftly taking over material handling solutions, the issue of workplace safety remains a primary concern for most organizations. These material handling injuries often lead to expensive medical treatments and worker's compensations, and low employee morale, and result in a substantial loss of productivity. With increasing globalization, even the smallest downtime can cost your business a fortune. You need to have proper safety measurements in place to ensure your business continues to function smoothly. Here are safety tips you may find extremely useful when it comes to material handling. Safety First:

- Always warm-up your back and legs before performing any lifting task! We are all athletes in life, so we need to warm-up our body to improve performance and to reduce risk of injury. It's important to prepare your body for work.
- Low Back Rotation Stretch - Stand with hands on hips. Stabilizing the hips and legs, gently roll your upper body forward, right, backward, and left to stretch your lower back. Perform 5 slow circles gradually expanding the circle each time. Repeat in the opposite direction.
- Hamstring & Achilles Stretch - Position your body with one leg forward and the toes of that foot raised up. Keep your back straight while you bend forward at the waist. You should feel a stretch in the back of your thigh and knee. Then shift your weight onto your forward leg and bend knee, keep the back leg straight and heel on floor. Hold each stretch for 20 seconds. Perform each stretch 2 times for each leg.

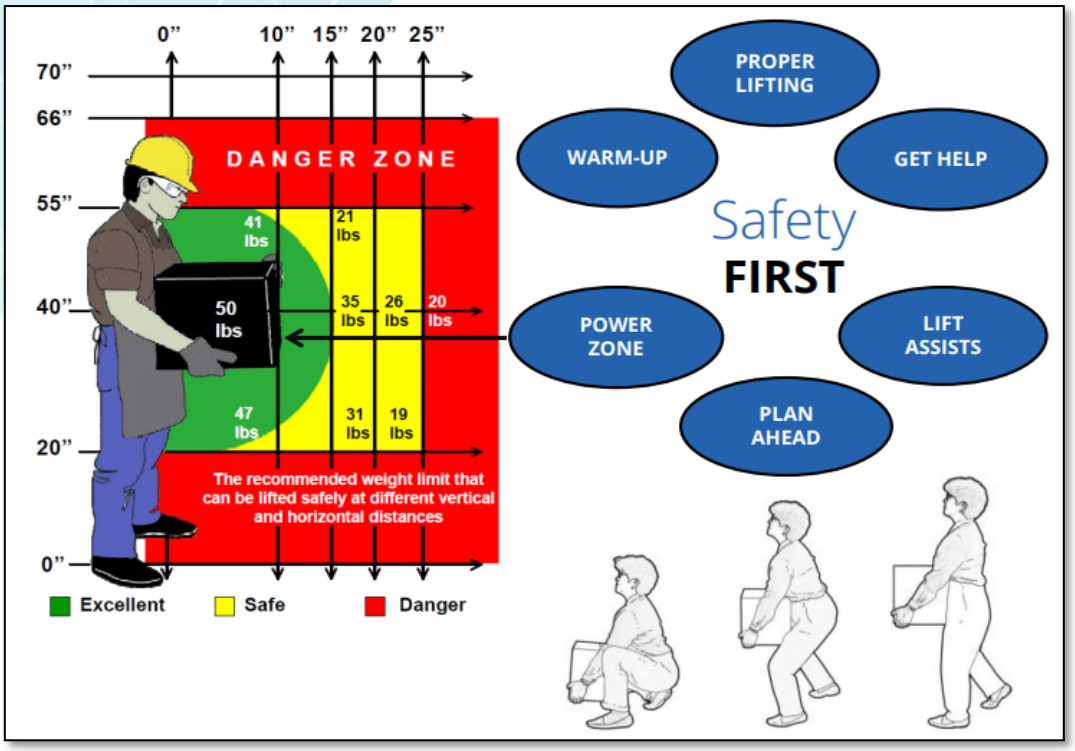


FIGURE 7-5: GUIDELINES ON SAFE LIFTING TECHNIQUES

Follow the Lifting Do's and Don't:

DO…

1. Know or test the object weight.
2. Use ergonomic lift assists when possible.
3. Plan the lift and clear your path.
4. Get help for heavy or awkward loads.
5. Keep the object in the power zone.
6. Use a wide stance for balance.
7. Use your legs to lift.
8. Pivot your feet to avoid twisting.

DON'T…

1. Don't hold your breath.
2. Don't bend or twist at the waist.
3. Don't use a partial grip (1-2 fingers).
4. Don't obstruct your vision when carrying.
5. Don't jerk or lift quickly.
6. Don't pinch you fingers or toes.
7. Don't pull a load if you can push it.
8. Don't forget to wear proper PPE.

FIGURE 7-6: MATERIAL HANDLING EQUIPMENT: FORKLIFT, SAFETY BELT AND PPE.

7.1.7 EMISSION AND POLLUTION CHECKS (BACK UP DG SETS?)

A typical diesel generator converts the chemical energy contained in diesel fuel to mechanical energy which then rotates the generator's crank to generate electricity. A diesel genset achieves the highest thermal efficiency as compared to any other combustion engine, which is quite close to the Carnot efficiency. That is why diesel generators are quite popular among users and mostly used at charging stations for the back-up power supply. However, when diesel is burnt in a generator, it emits Oxides of Nitrogen, Carbon Monoxide and particulate matter. These emissions are directly released into the atmosphere, and they are detrimental to the environment as well as the inhabitants. When released, these tend to substantially reduce the quality of air. The emissions from diesel generators make it difficult for people living around to breathe and even affect their quality of life. That is why these emissions should be kept in control or need to check periodically. So, the Central Pollution Control Board (CPCB) of India in collaboration with the Ministry of Environment and Forests has laid down emission regulations for diesel gensets. Emissions standards for new gensets with up to 800 kW generator engine are as follows:

TABLE 7-2: EMISSIONS STANDARDS FOR NEW GENSETS WITH UP TO 800 KW GENERATOR ENGINE.

POWER CATEGORY	EMISSION LIMITS (G/KW-HR)			SMOKE LIMIT (LIGHT ABSORPTION COEFFICIENT, M-1)
	NOX +HC	CO	PM	
Up to 19 KW	≤ 7.5	≤ 3.5	≤ 0.3	≤ 0.7
More than 19 KW up to 75 KW	≤ 4.7	≤ 3.5	≤ 0.3	≤ 0.7
More than 75 KW up to 800 KW	≤ 4.0	≤ 3.5	≤ 0.2	≤ 0.7

7.1.8 COMMUNICATION WITH HIGHER AUTHORITIES WITH RESPECT TO ABNORMAL EQUIPMENT BEHAVIOUR

In continuation to Total productive maintenance to identify abnormal behaviour of equipment and to ensure high overall equipment effectiveness (OEE) and equipment availability for operation activities, charging stations may adopt a predictive maintenance (PDM) approach as a communication tool for higher authorities, especially for their critical assets. PDM consists of a set of modern technologies that effectively monitor equipment performance and schedule necessary maintenance interventions in a timely manner. In contrast to reactive and preventive maintenance, PDM offers a predictive, condition-based approach that detects potential failures well in advance and plans appropriate actions accordingly. This approach eliminates the need to shut down equipment, resulting in increased equipment uptime. Condition monitoring, a major component of PDM, is a methodology of monitoring equipment conditions and identifying potential faults in advance of failures. With condition monitoring, experienced maintenance users play a crucial role in interpreting data and determining what is contributing to potential failures. It should also be noted that because prediction is the foundation of PDM, it is critical that the correct methods are employed to obtain future probabilities of failures. So further evolution of it is prescriptive maintenance as shown in Figure 7.6 shows the evolution of maintenance—from reactive maintenance to prescriptive maintenance. Building on predictive maintenance, prescriptive maintenance provides the capability to advice on cause-and-effect relationships and prescribes timely maintenance actions. So this advice with timely maintenance actions will come from higher authorities of the charging stations and so can arrest probability of failure of abnormal equipment.

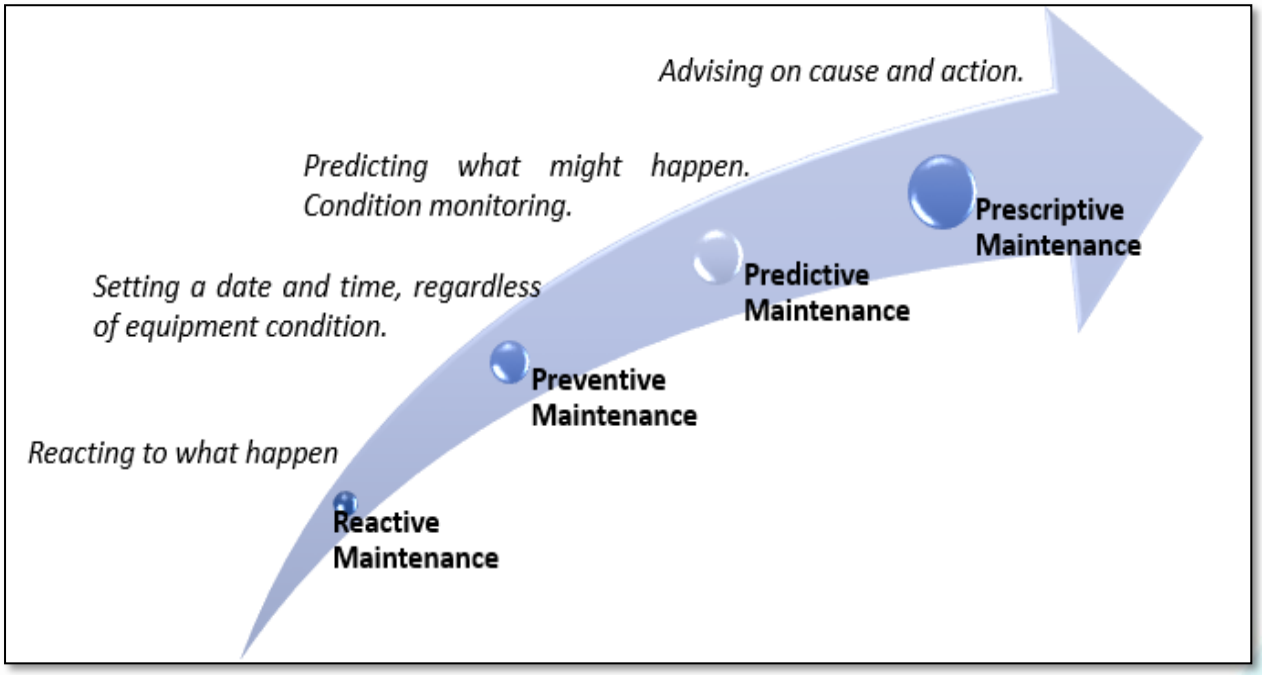


FIGURE 7-7: EVOLUTION OF MAINTENANCE

[Courtesy of "http://creativecommons.org/licenses/by/4.0/"]

7.1.9 PERIODIC CHECKS OF DISTRIBUTION TRANSFORMER SAFETY SYSTEMS

The principal object of transformer maintenance is to maintain the insulation in good condition. Moisture, dust and excessive heat are the main reasons of insulation deterioration and avoidance of these will keep insulation in good condition. The transformer is a most important equipment installed in a substation which is static in nature. This fact may lead to an impression that it needs no maintenance, but this is not true. In many cases faults takes place due to lack of proper maintenance. Maintenance includes regular inspections testing and rectification of defects. Up-keepment of records of each inspection is essential. If any replacement is carried out or adjustment of certain setting is done then these must be entered in a logbook. A rigid system of maintenance will ensure long-life, trouble-free service of transformer and reduction in unnecessary interruption. All work on transformer must be carried out under permit to work system. The "permit to work" is to be issued through permit card only by an authorized person. As the name suggests it authorizes the maintenance supervisor and his team to carry out the work. Furthermore, this card will indicate unambiguously the points at which it is safe to work, the time interval when it is to be done, steps to be taken to ensure safety such as earthing, display of danger notices etc. at the nearest live point. It should have the signature of the authorized person. After the work is completed, the permit card should be cancelled, and it should be taken back. Danger notices should be put up or removed by the responsible supervisor who will take the charge of keys of equipment, rooms, etc.

TABLE 7-3: RECOMMENDED PERIODIC CHECK FOR TRANSFORMER OF CAPACITIES OF 1000 KVA & ABOVE.

[Reference: MAINTENANCE OF DISTRIBUTION & POWER TRANSFORMER, CAMTECH/2004/E/X-mer/1.0].

INSPECTION	ITEMS TO BE INSPECTED	INSPECTION NOTES	ACTION REQUIRED IF INSPECTION SHOWS UNSATISFACTORY CONDITION
Hourly	1. Ambient 2. Temperature 3. Winding Temperature 4. Oil Temperature 5. Load (amps.) 6. Voltage	• Check that temperature rise is within limit • It should be reasonable • Check against rated figures. • Check & record	• Shut down the transformer and investigate if it is persistently higher than normal • An improper condition can cause excessive core loss. • Switch off, if excessively high
Daily	1. Oil level in transformer 2. Explosion vent 3. Dehydrating breather	• Check oil level • Check for any crack or damage • Check that air passages are free • Check color of active agent	• If low, top up oil, examine transformer for leak • Replace if cracked or broken • If silica gel is pink, change it. • The gel may be reactivated for use
Quarterly	1. Bushing 2. Transformer oil 3. Dehydrating breather	• Examine for cracks & dirt deposits • Check for dielectric strength & water content	• Clean or replace • Take suitable action to restore quality of oil • Make up oil if required

INSPECTION	ITEMS TO BE INSPECTED	INSPECTION NOTES	ACTION REQUIRED IF INSPECTION SHOWS UNSATISFACTORY CONDITION
		• Check oil level in oil cup and ensure air passages are free	
Yearly	1. Transformer oil 2. Insulation resistance 3. Oil filled 4. Bushings 5. Gasket joints	• Check for acidity & sludge • Compare with value at the time of commissioning • Test oil • Check for leakage or cracks	• Filter or replace if not in order • Process if required • Filter or replace • Tighten the bolts evenly to avoid uneven pressure
	6. Cable boxes	• Check for sealing arrangements. Examine compound for cracks	• Replace gaskets if leaking
	7. Arcing horns	• Examine for dirt deposits	• Clean
	8. Surge diverter and gaps	• Examine for cracks & dirt deposits	• Clean or replace
	9. Relays, alarm, their circuits etc.	• Examine relay alarm contacts their operation, fuses etc. • Check relay accuracy etc.	• Clean components • Replace contacts and fuses, if necessary • Change setting if necessary
	10. Temperature indicator	• Pockets holding thermometers should be checked	• Oil to be replenished if required
Inspection	**Items to be inspected**	**Inspection notes**	**Action required if inspection shows unsatisfactory condition**
a) 5 yearly (POH)	1000 to 3000 KVA Capacity Transformer	• Overall inspection including lifting of core & coils	• Wash with clean oil
b) 7-10 yearly (POH)	Above 3000 KVA Capacity Transformer	• Overall inspection including lifting of core & coils	• Wash with clean oil

Note:

- The silica gel may be reactivated by heating to 150- 200°C.
- Every time the oil is changed, oil seal should also be changed
- No work should be done on any transformer unless it is disconnected from all external circuits and the tank, and all windings have been solidly earthed
- In case of anything abnormal occurring during service, maker's advice should be obtained giving him complete particulars regarding the nature and extent of occurrence, together with the nameplate particulars

7.1.10 AUDITS OF SAFETY SYSTEMS AND PROCESSES FOR FLOODING AND WATER INTRUSION

Water intrusion into structures can occur via several failure modes including piping rupture due to overpressure or freezing, valve failure, accidental actuation of automatic fire sprinklers, appliance overflow or failure, acute or longer-term building envelope failure and many other sources of intrusion. The property damages and business disruption created from these failures can be significant. Factors that can influence the size and magnitude of such a loss include the use of the structure, existence of early notification systems, and the extent of mitigation plans. Additionally, the extent of knowledgeable staff on premises which are familiar with critical water control valve locations and operation and have been trained in mitigation and restoration best practices can have a dramatic impact on the overall magnitude of the event and disruption. This checklist is designed to address potential sources of water intrusion, inspection procedures to implement and Liquid Damage Prevention Plans to mitigate risk of damage and business disruption during a water intrusion event occurrence, and recommended restoration and recovery procedures.

- Pre-Event Actions to Implement

  Unless otherwise noted below, items that are listed as an action step or procedure should be conducted on at least an annual basis. When any alteration, renovation or modification is made to the building or structure, the inspection items listed below should be conducted.

7.1.10.1 Pre-Event Survey – Internal Piping Systems

- ✓ Survey structure and identify potential internal and external entry sources of water intrusion (semi-annually).
- ✓ Create diagram or map for each liquid source system (domestic, waste, fire protection, process water, etc.) showing zonal, floor and main water control (shutoff) valves.
- ✓ Diagram should clearly identify the areas associated with identified water control valves – display what area is controlled by which valve using colour coding of the floor areas.
- ✓ Assure each water control valve is equipped with securely affixed label with identifying code/number and indicating area controlled.
- ✓ For piping entering any basement or ground floor levels from below grade, assure that any shut-off valves have been identified outside of the structure. This will also allow quicker access to shutoff valves if the area is being flooded.
- ✓ Assure all water control valves are in good and operable condition, open and close freely and that any tamper or monitoring equipment is functioning.
- ✓ Assure a master list of water control valves is readily accessible by building engineering and maintenance personnel.
- ✓ Survey all floor or other internal drain openings to assure each is free and clear of obstructions, refuse, dirt, etc. (quarterly).

- ✓ Inspect the condition and tightness of any floor curbs and any seals provided at floor openings to lower floors (quarterly).
- ✓ Inspect and where possible, test drains to assure each terminate freely to a repository on the external of the structure or to internal drain piping that is secured and free/open of blockage (semi-annually)
- ✓ Inspect and test, where possible, any sewer backup preventers or devices to assure they are in good working order and operable (quarterly).
- ✓ Assure that all rooms or enclosures housing water piping networks, fittings, tanks, and control valves, especially those with exterior-facing walls, are provided with heat from reliable systems that can maintain a minimum temperature of 50°F (10° C) (seasonal).

7.1.10.2 Pre-Event Survey – External Building Envelope

- ✓ Survey potential external entry points of water intrusion due to inclement weather including windows, doors, vents, wall air conditioners, wall penetrations, etc. (semi-annually).
- ✓ Inspect to assure weather-stripping and seals are in good condition and not crimped, torn or damaged (semi-annually).
- ✓ Assure that all openable windows and doors close tightly, and self-closing door appurtenances are functioning correctly (semi-annually).
- ✓ Assure those exterior entries to basement and lower-level areas are provided with drainage or curbing to keep surface water out of the building (semi-annually).
- ✓ Where safe and accessible, have trained maintenance and building engineers inspect roof drains, scuppers, gutters and downspouts on a regular basis to assure they are in good condition and not obstructed with debris, leaves, limbs, etc. (quarterly).
- ✓ Where safe and accessible, have trained maintenance and building engineers inspect roof systems to assure no missing shingles, damaged or loose ridge vents, missing or damaged water and ice shields, water ponding, other physical damage exists to roofing systems (semi-annually).
- ✓ Where safe and accessible, have trained maintenance and building engineers inspect exterior cladding of structure including siding, clapboard, EIFS, etc. to assure no visible damage, missing or unsecured components (semi-annually).
- ✓ Where safe and accessible, have trained maintenance and building engineers inspect to assure there are no unprotected openings into the wall system(s), unsealed openings around penetrations such as vents, electrical conduit, HVAC wall units, etc. (semi-annually).

7.1.10.3 Pre-Planning

- ✓ Develop a written Liquid Damage Prevention Plan (LDPP) for the structure which identifies high risk areas of potential damage as identified in the facility surveys.
- ✓ Develop contractual relationships with water and liquid damage remediation, heating and restoration vendors and include key contact information within the LDPP. If appropriate, provide differing contacts for differing types of leaks, spills or water damages, recovery, and restoration.
- ✓ Configure the LDPP to address and respond to both clean and contaminated water incidents. Where other liquid exposures exist, they should be addressed in a specific section of the LDPP.
- ✓ The LDPP should include or reference a diagram of all domestic and fire protection systems showing location of zonal, floor and main water control (shutoff) valves and tanks.
- ✓ The LDPP should contain a log of reportable water intrusion events to assist in identifying leaking or intrusion trends and should comprise date, location, source of intrusion, extent of damage, duration of response and restoration activities, etc.
- ✓ The LDPP should identify responsibilities for personnel designated to respond to a water intrusion event, including off peak times and when the facility is closed from operations including a stop flow (shut valve) authority procedure designating LDDP members that have the authority to shut down valves when a water intrusion event occurs.
- ✓ The LDPP should include clear instructions and procedures on response protocol and identify location of LDPP reference diagram and valve closure instructions.
- ✓ Provide training on the existence and use of the LDPP to all building maintenance and engineering personnel as well as supervisors and managers (semi-annually).
- ✓ Inspect to assure that the facility contains a Water Intrusion Response kit on premises containing flashlights and emergency lanterns, electrical extension cords, ground-fault circuit interrupters (CFCI) with multiple taps, plastic buckets (5 gallon), wet/dry vacuum, rubber boots, hoses equipped with required adaptors, squeegees, pipe wrenches and fire sprinkler shut-off devices (semi-annually).
- ✓ Acquire and stage spill and leak clean-up supplies at critical locations within the structure to enable rapid response and mitigation.
- ✓ Assure that heat is always maintained during frigid and freezing weather within rooms or enclosures that comprise piping or equipment susceptible to freezing (seasonal).
- ✓ In warm climate regions where exterior or equipment is susceptible to freezing (HVAC, sprinkler risers, etc.), provide in the LDPP procedures for freezing weather conditions not common to your area. Contact your equipment vendors for solutions on temporary

drainage of the system or continuous flow of the systems that will maintain water temperature above freezing.

- ✓ Inspect and validate required spill and leak mitigation supplies and replenish as required (semi-annually).
- ✓ Update the LDPP piping and control valve diagram when new liquid piping systems and components are added to the structure. Review and revise the LDPP accordingly (semi-annually).
- ✓ Consider the installation of an approved, water intrusion detection system at critical source areas of water entry or release with monitoring at a constantly attended location such as a security office or main control room.
- ✓ Update the LDPP on a regular basis or as required to comprise system and piping changes, personnel changes and assigned responsibilities (semi-annually).
- ✓ Conduct re-inspections of the facility components at the frequency indicated above **(semi-annually)**
- ✓ Conduct component, system and notification testing of any installed water intrusion sensor detection systems within the structure **(quarterly).**

7.1.10.4 Actions to Implement When a Water Intrusion Event Occurs:

- Response
  - ✓ Activate the LDPP (Liquid Damage Prevention Plan) and provide immediate notification to all appropriate parties (including building engineer and maintenance personnel) as listed in the plan based upon the type and location of the event.
  - ✓ Appropriate response members should assemble at the site of the intrusion to evaluate the extent of the leakage or intrusion and activate the LDPP accordingly.
  - ✓ Designated response members should move to staging areas identified in the LDPP to initiate viable mitigation procedures including liquid shutoff of zonal, floor or area control valves.
  - ✓ Immediate notification to other Team members as outlined in the LDPP should occur to implement protective mitigation actions of vulnerable materials, stock, goods, equipment, or other assets including removal of exposed items or application of protective coverings, spill control, water damming set-up, temporary drain measures, etc.
  - ✓ Notification to external authorities, as warranted and recommended by the LDPP, should be initiated where assistance will be required (local utility service shutoffs), where personnel safety is at jeopardy or where nearby facilities may be exposed.
  - ✓ Depending upon the magnitude of the event and were warranted and required within the LDPP, notification of pre- arranged restoration and recovery mitigation firms should be commenced.

- ✓ Activate the LDPP to investigate potential leaks in piping, fittings, and valves where the interior of the structure experiences freezing conditions. Note that systems incurring freezing of content should be shut down and drained while piping thaws and verification of system integrity is conducted by an HVAC, plumbing or commercial fire sprinkler contractor.

- Restoration and Recovery
  - ✓ Assure that the LDPP (Liquid Damage Prevention Plan) includes a section that addresses responsibilities and procedures to follow for restoration once the water intrusion event has ended or mitigated.
  - ✓ Assure that any approved recovery and restoration vendors are listed within the LDPP with their appropriate contact information, e-mail addresses, phone numbers, etc.
  - ✓ Activate the restoration and recovery component of the LDPP as soon as the event has ended or been mitigated, including contacting approved vendors to support clean-up and restoration.
  - ✓ Assure adequate spill, clean-up supplies and necessary equipment are stored in a pre-positioned protected place and that adequate supplies are available on site. This might include spill control material, water vacuums, fans, tarps, plastic sheeting, utility tape, and other materials used to support restoration, cleaning and recovery.
  - ✓ Assure that a member of the LDPP Team is assigned and equipped to take photographs or video of the areas damaged and evidence of mitigation and restoration to support insurance claim submission.

[References: AIG Insight Water Intrusion COM-CG-12-0020]

7.2 CHARGING STATION FIRE SAFETY PRACTICES

The increasing use of electric vehicles has necessitated the provision of charging facilities that – if not managed appropriately – can introduce potential ignition hazards into the workplace, or public areas, such as motorway service areas and car parks. This chapter aims to provide practical guidance on fire hazards and appropriate control measures associated with the charging of electric vehicles, and similar devices in public places; on commercial and industrial premises; and within or in the vicinity of residential premises such as blocks of flats, care homes and sheltered accommodation.

7.2.1 SOURCES OF FIRE IN A CHARGING STATION

There always occurs a possibility of fire hazards in the charging stations, given the wide use of electricity in the system, and the presence of flammable materials in the charging station.

The possible sources of fire in the charging station could be:

- Battery leakage
- Faulty Electrical Equipment
- Loose Connections during charging
- Overheating of equipment due to overheating or hot weather conditions

7.2.2 TYPES OF FIRES AND FIRE EXTINGUISHERS

- Types of fires

  Fire is the rapid oxidation of any combustible material. It is a chemical reaction involving fuel, heat, and oxygen. These three elements, commonly referred to as the fire triangle, in the right proportions, will always produce a fire. Remove any one side of the triangle and the fire will be extinguished.

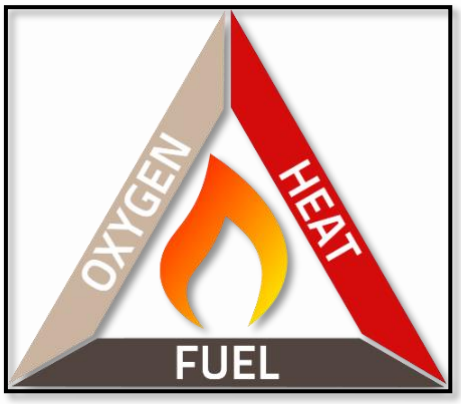


FIGURE 7-8: FIRE TRIANGLE

Not all fires are the same. Fires are classified by the types of materials that are burning. Extinguishers are labelled to correspond to the classes of fires they are designed to fight. If you use the wrong type of fire extinguisher on a fire, you can, in fact, make matters worse. Understanding the four different fire classifications is therefore very important.

CLASS "A" - These fires are fuelled by ordinary combustible materials, such as wood, cloth, paper, and many plastics. This type of fire burns with an ember, leaves an ash, and is best extinguished by removing the heat side of the triangle. Extinguishers suitable for Class "A" fires should be identified by a triangle containing the letter "A"; if color-coded, the triangle will be green.

FIGURE 7-9: DIFFERENT FIRE CLASSIFICATIONS

CLASS "B" - These fires are fuelled by flammable liquids, combustible liquids, petroleum greases, tars, oils, oil-based paints, solvents, lacquers, alcohols, and flammable gases. This type of fire burns on the surface of the fuels and is best extinguished by a blanketing or smothering action. A fire of this type is fast-spreading and capable of engulfing a large area in a very short time. Extinguishers suitable for Class "B" fires should be identified by a square containing the letter "B". If color-coded, the square is red.

CLASS "C" - These fires occur in energized electrical equipment, where the electrical nonconductivity of the extinguishing media is of importance. Blanketing or smothering this type of fire with a non-conducting extinguishing agent is of prime importance. Water, or solutions containing water, is never to be used on a Class "C" fire. Extinguishers suitable for Class "C" fires should be identified by a circle containing the letter "C"; if color-coded, the circle is blue.

NOTE: If possible, shut off the source of electricity as soon as possible. Extinguishers suitable for more than one of the three classes of fire defined above may be identified by multiple symbols (ABC). Generally, the extinguishing agent is referred to as DRY CHEMICAL.

CLASS "D" – These fires involve combustible metals, such as magnesium, titanium, zirconium, sodium, lithium and potassium. Generally, the extinguishing agent is referred to as DRY POWDER. These extinguishers should be identified by a star containing the letter "D", if colour coded, the star is yellow.

CLASS "K" – These are fires in cooking appliances that involve combustible cooking media such as vegetable or animal oils and fats. The extinguishing agent is referred to as WET CHEMICAL. These extinguishers should be identified by the letter "K."

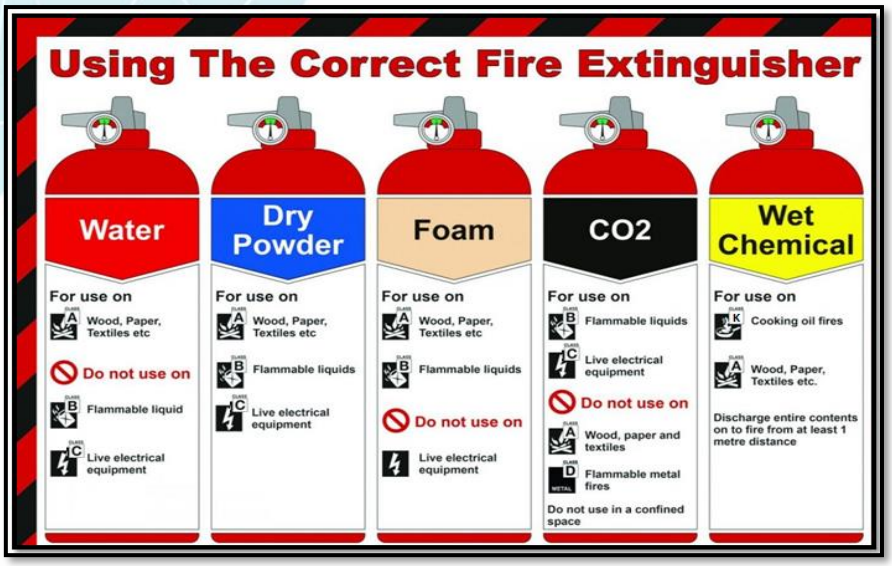
- Types of fire Extinguishers

Fire extinguishers are clearly marked with the classes of fires they will extinguish safely. All extinguishers will have one or more of the following classes' symbols, to indicate which they are suitable for. Each type of fire extinguisher contains different materials that make them suitable for fighting certain types of fires and is designed to discharge its contents safely and effectively. The correct one must be used for the right class of fire, otherwise they may prove ineffective or in fact worsen the situation. For example, using a water extinguisher on an electrical fire or a carbon dioxide one on a burning oil fire is extremely dangerous. Put fire extinguishers close to where they might be needed. Class A extinguishers should be in areas where paper, wood, and other ordinary combustibles are used. Class B extinguishers should be located where flammable liquids are present. Class C extinguishers should be placed where they would be easily accessible for electrical fires. Fire extinguishers should be in clean, dry areas that are easy to access. They should be hung so the top is between 31/2 and 5 feet above the floor and must be quick and easy to remove. Their locations should be clearly marked, and everyone familiarized with their locations and use. There are five main types of fire extinguishers:

1. Water.
2. Powder.
3. Foam.
4. Carbon Dioxide (CO2).
5. Wet Chemical.

FIGURE 7-10: TYPES OF FIRE EXTINGUISHER

Each type is easily identifiable by their names, colours, and sometimes their hoses. Depending on their size, some may not come with a flexible hose, such as smaller foam or aqua water spray extinguishers.



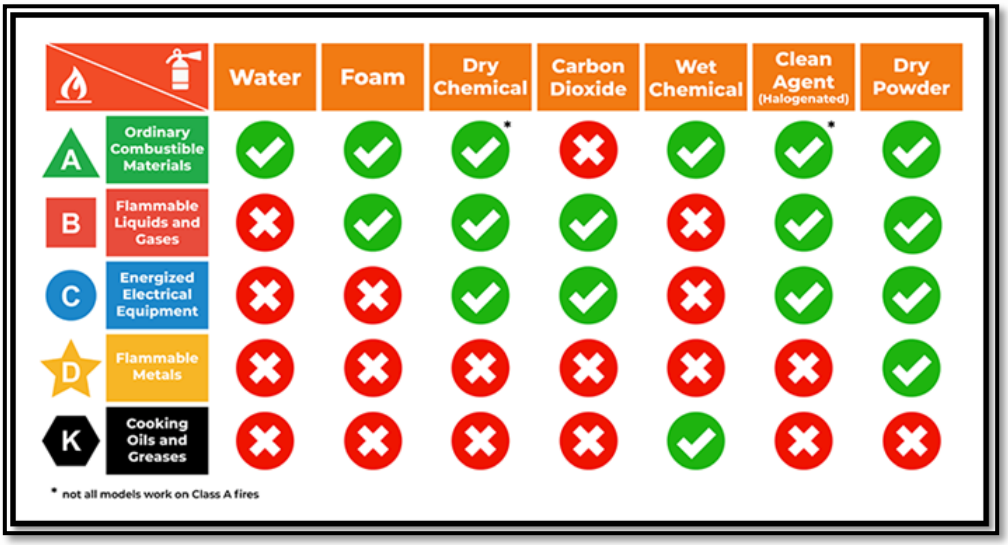


FIGURE 7-11: APPLICABILITY OF FIRE EXTINGUISHER FOR VARIOUS FIRE TYPES.
[REFERENCE: BIS STANDARD IS 15683:2018 FOR ALL PORTABLE FIRE EXTINGUISHER]

- How to Use Fire Extinguisher

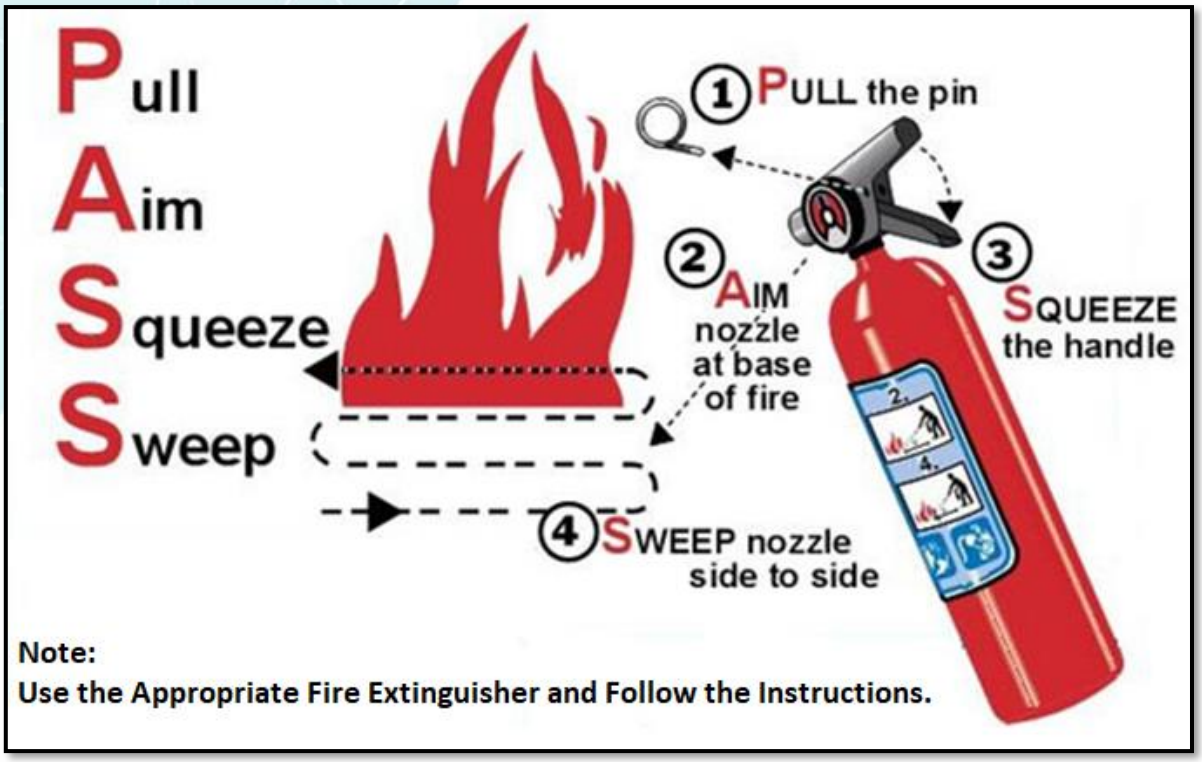


FIGURE 7-12: HOW TO USE FIRE EXTINGUISHER

7.2.3 FIRE RESCUE TECHNIQUES

With the large influx of electric vehicles on the roads, it means work need to be done to strengthen electric grid to support electric vehicle charging stations across the country. It also means that more auto mechanics will need to learn the safety precautions of servicing engines in close proximity to electric vehicle batteries. So, as electrical workers upgrade the grid, install more charging stations and repair more electric vehicles and chargers during regular maintenance schedules, risk for encountering electrical hazards will increase, as well. Powered electrical lines have high voltages which can cause major burns, electric shock and even life-threatening electrocution to workers, making electrical safety in work environments crucial.

A fire involving an EV or HEV should generally be approached in the same manner as a conventional motor vehicle, although several additional factors should be considered. One approach indicating the basic steps that should be considered for extinguishing a fire involving any motor vehicle (including an EV or HEV) are illustrated in Figure 7.11 Example of Approach to Vehicle Fire Extinguishment.

Offensive Attack: Recommended where exposures are present, or the high voltage battery is not involved.

Defensive Attack: Recommended if the high voltage battery is involved and no exposures are present. Due to the difficulty in reaching the burning cells inside the battery or fire area at charging stations with the extinguishing agent, the Incident Commander may choose to allow it to burn itself out. Any individuals without PPE should remain upwind of the fire an avoid inhalation, due to toxic compounds in the smoke.

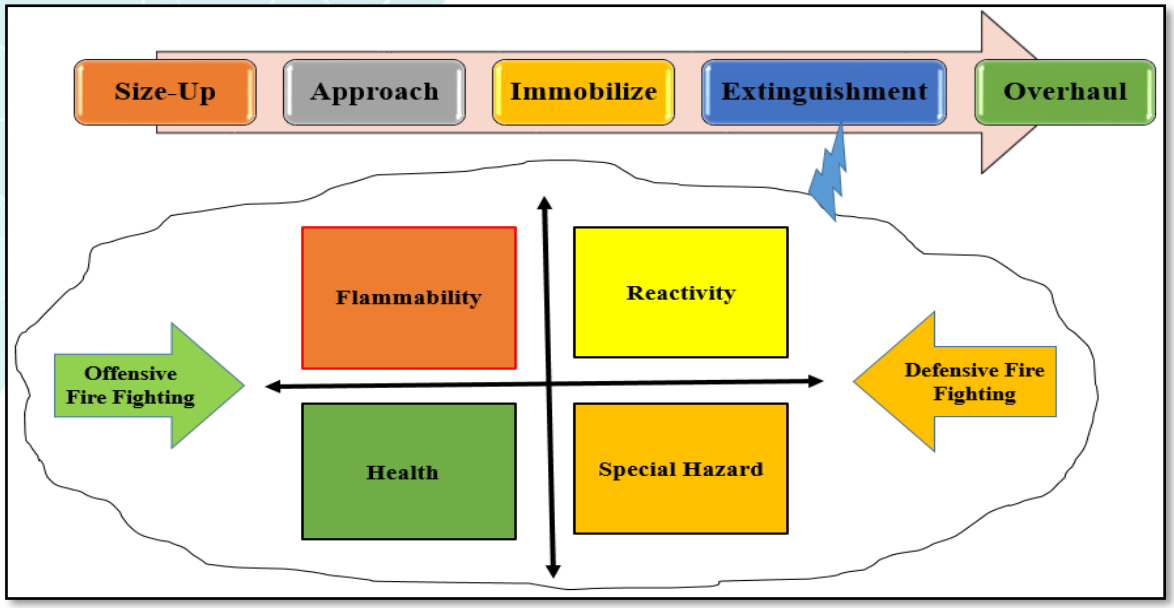


FIGURE 7-13: EXAMPLE OF APPROACH TO VEHICLE FIRE EXTINGUISHMENT

Use water to fight a high voltage battery fire. If the battery catches fire, is exposed to high heat, or is generating heat or gases, use large amounts of water to cool the battery. It can take approximately 3,000 gallons of water (applied directly to the battery); establish sufficient water supply. Extinguish small fires not involving the battery using typical vehicle firefighting procedures. Always use insulated tools for overhaul. Heat and flames can compromise some components, resulting in an unexpected explosion. Perform an adequate knock down before entering a hot zone. There must not be fire, smoke, or heating present in the battery for at least one hour (consider using a thermal imaging camera to measure the temperature) and the battery must be completely cooled before the vehicle can be released to second responders. Always advise second responders that there is a risk of battery re-ignition.

Warnings:

- For small lithium-ion battery fires (i.e., vehicles) fire extinguishment can be attempted using dry chemical, CO2, water spray, or regular foam. For large fires, it is recommended that extinguishing method is water spray, fog, or regular foam, and it also suggests moving containers/components away from the fire area if it can be done without risk.

Some guidelines for firefighter safety, for working on vehicles with lithium-ion batteries are as follows,

- ✓ All personnel should wear and utilize full PPE.
- ✓ Identify the type of vehicle involved — standard vehicle, EV, HEV etc.
- ✓ Use a thermal imaging camera to help with the 360 size-up
- ✓ Establish an appropriate incident command structure.
- ✓ Establish tactical priorities (fire, extrication, victim care)
- ✓ Stabilize the vehicle and power down, if possible.

- ✓ If an HV battery catches fire, it will require a large, sustained volume of water supply — one or more fire hydrants or multiple water tenders.
- ✓ Use a large volume of water such as master stream, 2½-inch or multiple 1¾-inch fire lines to suppress and cool the fire and the battery. Using only a small amount could allow dangerous toxic gases to be released.
- ✓ If a Lithium Ion (Li-Ion) HV battery is involved in a fire, there is a possibility that it could reignite after extinguishment. If available, use thermal imaging to monitor the battery. Do not store a vehicle containing a damaged or burned Li-Ion HV battery in or within 50 feet of a structure or other vehicle until the battery can be discharged.
- ✓ Because high voltage batteries are in protective cases, it is very difficult to get any extinguishing agent directly onto the burning cells. The application of large volumes of water may cool the high voltage battery sufficiently to prevent the propagation of fire to adjacent cells.
- ✓ Have sufficient fire personnel and apparatus on scene for an extended operation to monitor the battery's heat or possible re-ignition.

Fires Involving Charging Stations:

- ✓ Locate the power source for the charging station and shut it down.
- ✓ Until power to the charging station is cut, treat the fire as you would an energized electrical fire.
- ✓ If a vehicle is plugged in to the charging station, it should be unplugged as soon as it is safe to do so. If possible, shut down the charging station first.

7.2.4 FIRE PREVENTION PRACTICES

The fire prevention practices provide practical guidance on fire hazards and appropriate control measures associated with the provision, management, and use of charging points for various forms of electrically powered transport in public areas, commercial and industrial premises. Advice is provided concerning the charging provisions, the areas where this process should be undertaken and appropriate fire protection measures that should be considered. Furthermore, the checklist have prepared as an audit tool for the on-site inspection considering following verticals,

- ✓ Compliance with fire safety legislation
- ✓ Business continuity
- ✓ Fire safety management
- ✓ General considerations
- ✓ Electrical provisions
- ✓ Compartmentation and segregation
- ✓ Mobility scooters
- ✓ Fire protection

Note:

- This checklist is based on the guidance and certain recommendations made in RC59: ***Recommendations for fire safety when charging electric vehicles*** and designed for use by premises operators – and members of the maintenance or facilities team – as an audit tool for use on site. It is recommended an audit using this checklist be undertaken at least every six months.
- ***Appendix – I*** Fire Prevention practices – Checklist.

7.2.5 SAFE EVACUATION PROCEDURE FOR CUSTOMERS AND STAFF

In the fire like situation at charging stations, Plan to get everybody, including customers and staff, to safety point / safe assembly point if there is an emergency. Following things need to review and improve on regular basis:

- ✓ Emergency procedures
- ✓ Emergency equipment
- ✓ Visual and auditory alarms
- ✓ Safety zones
- ✓ Signage

- Emergency procedures

  Regularly review evacuation procedures and safety statement. Make fire procedure instructions available to all staff and visitors. Make sure that those instruction are in formats and a language that each person can understand. Those instructions should include:

  - ✓ Fire escape signs
  - ✓ Location of signs
  - ✓ Fire point identification
  - ✓ Statutory fire and first aid signs
  - ✓ Signs indicating escape routes for people.

Make sure you have an emergency evacuation plan recorded in your Safety Statement.

- Personal Emergency Evacuation Plans

  Provide Personal Emergency Evacuation Plans (PEEP) for staff and regular visitors as necessary. Use the PEEP template and Review the PEEPs every 6 months and whenever there is a relevant change in the building, service, or evacuation plan at charging stations. **Appendix – II** for PEEP Template.

- Drills

  Carry out evacuation drills at least twice a year and include everybody in the drills. Identify any potential problems, prioritise them, and plan to solve them. Make sure that all ground floor exit routes are accessible and that the area outside the exit is accessible too.

- Equipment

  Provide both visual and auditory alarms in the charging station premises. Provide and maintain emergency equipment as necessary. Place emergency equipment no more than 1200mm above floor level. This includes:

  ✓ Fire blankets
  ✓ Break-glass alarm points
  ✓ Communication equipment
  ✓ Fire extinguishers (heavier types should have their base no more than 650 mm above the floor).

  Inspect all emergency equipment regularly. Make sure that all fire signs are maintained and comply with international standards

- Fires Involving Charging Stations:
  ✓ Locate the power source for the charging station and shut it down.
  ✓ Until power to the charging station is cut, treat the fire as you would an energized electrical fire.
  ✓ If a vehicle is plugged in to the charging station, it should be unplugged as soon as it is safe to do so. If possible, shut down the charging station first.

- Training

  Train:

  ✓ Relevant staff on how to safely transport people with mobility difficulties.
  ✓ The Health and Safety officer, as appropriate.
  ✓ A number of staff in Occupational First Aid.

Note:

1. **Appendix – III** Risk Assessment check list - **Safe Evacuation Procedure for Customers and Staff** need to maintain, review and update every 6 months.

7.2.6 RESPONSE TO A FIRE HAZARD

The development and implementation of an identification system providing critical information for emergency responders is the first step in dealing with a fire hazard. There may be a need for special firefighting procedures to be considered depending on the technology and materials used for these charging stations. A key strategy in such fires is to isolate the power supply and de-energize the charging equipment. Importantly, this may become difficult to implement if a vehicle is on fire and is plugged into the charging station, since the vehicle batteries themselves will be the power source back into the electrical connection of the charging station. An ability to control the back-feeding of electrical energy from the vehicle back to the charging station (and the building's electrical system) is a technical issue to be actively addressed.

7.3 CHARGING STATION EMERGENCIES, RESCUE AND FIRST-AID PROCEDURES

There should be standard operating procedure, checklist, or the tools to ensure that risks associated with battery charging and charging stations are adequately managed to minimise the risk of injury or harm to workers / staff. Some part of fire rescue, fire prevention and emergency evacuation plan at charging station already been discussed in section 7.2.2, 7.2.3 and 7.2.4. Hot works are not permitted in areas where batteries are stored, handled or recharged, unless appropriate controls have been implemented through a risk assessment process.

7.3.1 IDENTIFICATION OF INJURY HAZARD AND RISK MAPPING

A hazard map is a map that highlights areas that are affected by or are vulnerable to a particular hazard. Hazard mapping helps to or instructions to build hazard map is as follows:

- Identify location(s) for high risk of injury.
  - ✓ Create a map of the charging station, Head Start the entry gate. Label the various places and/or equipment in the location(s) that is being mapped. Make the map as accurate as possible.
  - ✓ Have staff, administrators, or anyone who observed the incident place a "dot" or "marker" on the map to indicate where the specific incident and/or injury occurred.
  - ✓ Depending on the size of the program and number of injuries reported, use data from injury/incident reports for the past three to six months. Add more "dots" or "markers" to identify additional locations where injuries occurred.
  - ✓ Analyse and chart the findings. To do this, count the number of incidents in each location.
  - ✓ Count how many of the incidents resulted in an injury and the level of severity of each injury. Use incident and/or injury reports to collect this additional data.
  - ✓ Determine where most incidents occur and where to focus initial efforts for a corrective action plan.
- Pinpoint systems and services that need to be strengthened.
  - ✓ To identify and understand patterns of injuries at locations throughout the program, review additional information from injury and/or incident reports.
  - ✓ Who was involved in each injury? (Child/children; staff, volunteers, visitors, Vehicle owners, Driver)
  - ✓ Where did the injury occur?
  - ✓ What happened? (What was the cause?)
  - ✓ What was the severity of each injury?
  - ✓ When did each injury occur?
  - ✓ Who – e.g., what staff were present and where were they at the time of each injury?
  - ✓ How could each injury have been prevented?
  - ✓ Using your/the program plan, determine areas where systems and services affect these findings.
  - ✓ Translate these findings into recommendations that strengthen systems and services.

- Develop a corrective action plan
  - ✓ Review all the findings and recommendations regarding injuries and incidents.
  - ✓ Prioritize and select specific activities/strategies to resolve problem areas. These should focus on the everyday service delivery level and the higher systemic level.
  - ✓ Develop an action plan to correct the problem areas you identified. Include each of the activities/strategies selected in this corrective action plan. Identify the steps, the individuals responsible, and the dates for completion.
  - ✓ Create a plan for sharing the corrective action plan with management, staff, and visitors to get buy in for injury and/or incident responses.
- Incorporate safety and injury prevention into ongoing-monitoring activities.
  - ✓ Based on an analysis of these data, determine what action(s) needs to be taken to avoid future injuries in the location(s) identified. Determine if any additional questions should be added to injury/incident report forms to obtain this missing information.
  - ✓ When developing corrective action plans, consider prioritizing more serious injuries, even if they have occurred less often.
  - ✓ A reduction in injuries and/or incidents happens over time if the correct set of interventions is selected based on analysis of the data about patterns of injuries.
  - ✓ Continuously review incident and/or injury data to make sure that interventions are reducing the number of incidents and the severity of injuries. They may include:
- Educational opportunities about safety and injury prevention for staff
- Environmental modifications
- Procedures to monitor compliance with program policies, and/or
- Other necessary corrective actions

To prepare the Hazard Map, students can refer following hazard code keys and hazard levels [*Reference: Hazard Mapping, Injury and Illness Prevention Programs - NJ Work Environment Council. Guidelines produced from the Occupational Safety and Health Administration, U.S. Department of Labor*],

TABLE 7-4 GUIDELINE FOR HAZARD MAP: HAZARD CODE KEY

HAZARD CODE KEY		
	Blue	Electrical Hazards
	Green	Chemical Hazards
	Orange	Physical Hazards (heat, noise, air quality, slippery floors, poor lighting, poorly designed workstations, etc.)
	Brown	Flammable/Explosive Hazards
	Black	Other Hazards (specify)

TABLE 7-5: GUIDELINE FOR HAZARD MAP: HAZARD LEVELS

HAZARD LEVELS / CLASS	
1	Low Hazard
2	Medium Hazard
3	High Hazard
4	Very High Hazard
Example	
	A number "2" inside a Blue Circle indicates "Class 2, Medium Hazard, and Electrical.

- Group Activity for the Students:

  Visit the charging station and prepare layout of charging station. Follow the hazard code key and hazard class for Hazard Mapping and how it can be used to help you identify the areas in your facility where the risks of accidents and injuries are greatest. Then, collect the injury / accident data from the charging station manager. Use the factsheets to help you label and describe the specific hazard areas.

  ✓ Step 1: Make a drawing on the sheet of paper that shows the basic layout of charging station
  ✓ Step 2: Identify the hazards in each area of the facility using a color-coded circle on the map
  ✓ Step 3: Rate each hazard on a scale of 1 to 4
  ✓ Step 4: Label each hazard with a name or brief description

- ✓ Step 5: Based on your map, make a list of the hazards that concern you the most and be ready to tell us why these hazards are a concern for your group

- Sample Hazard Map is as follows,

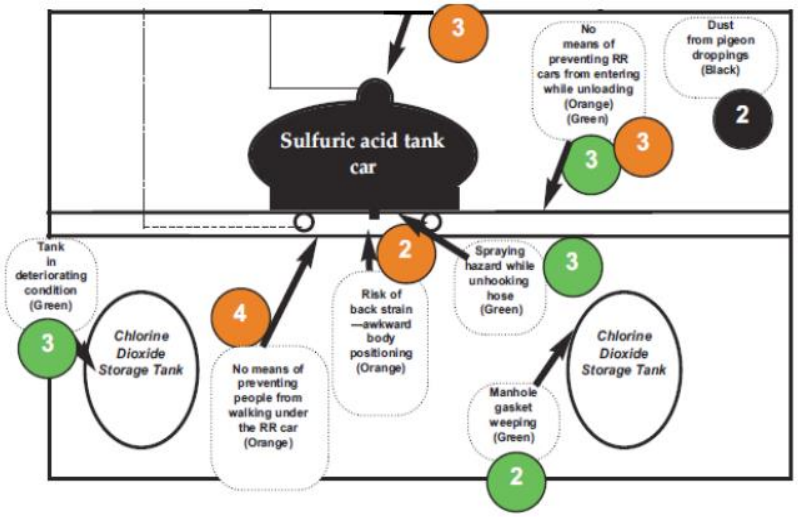


FIGURE 7-14: SAMPLE HAZARD MAP

- Risk Mapping

A risk map, also known as a risk heat map, is a data visualization tool for communicating specific risks an organization faces, here it is EV's charging station. A risk map is built by plotting the frequency of a risk on the x-axis of the chart and the severity on the y-axis. Frequency is how likely the risk is or how often you think it will occur; severity is how much of an impact it would have if it did happen. The higher a risk ranks for these qualities, the more threatening it is to your organization. A hazard is defined as the potential for harm and includes all aspects of technology and activity that produce risk. A risk is the likelihood that a hazard will cause harm. In response to the identified hazardous situations for the EV's charging station and the corresponding safety considerations, consider the following points to analyse the risk of EVCSs, prepare risk matrix for the charging station and take a promising risk control action.

- ✓ Risk of Injury or Health Damages
- ✓ Risk to Power System Operation

Risk Matrix						
		Probability				
Severity		Remote	Unlikely	Possible	Likely	Certain
		1	2	3	4	5
Fatal Injuries Death	Catastrophic 5	5	10	15	20	25
Extensive Injuries	High 4	4	8	12	16	20
Medical Assistance Required	Medium 3	3	6	9	12	15
First Aid Procedures	Low 2	2	4	6	8	10
Small Cuts	Negligible 1	1	2	3	4	5

FIGURE 7-15: RISK MATRIX GUIDELINES

To tackle with various risks at EV's charging station, refer the following risk management model *[Reference: Electrical Safety Considerations in Large-Scale Electric Vehicle Charging Stations, August 2019IEEE Transactions on Industry Applications PP (99):1-1. DOI:10.1109/TIA.2019.2936474].*

It includes three layers:

- ✓ Safety considerations of EV's charging station,
- ✓ Risk assessment, and
- ✓ Risk control.

The safety considerations in different layers of EV's charging station are explored, risk assessment analytics are suggested, and finally the integrated analysis and comparisons are done in the design and planning procedures to meet the requirements of the hierarchy of risk control measures.

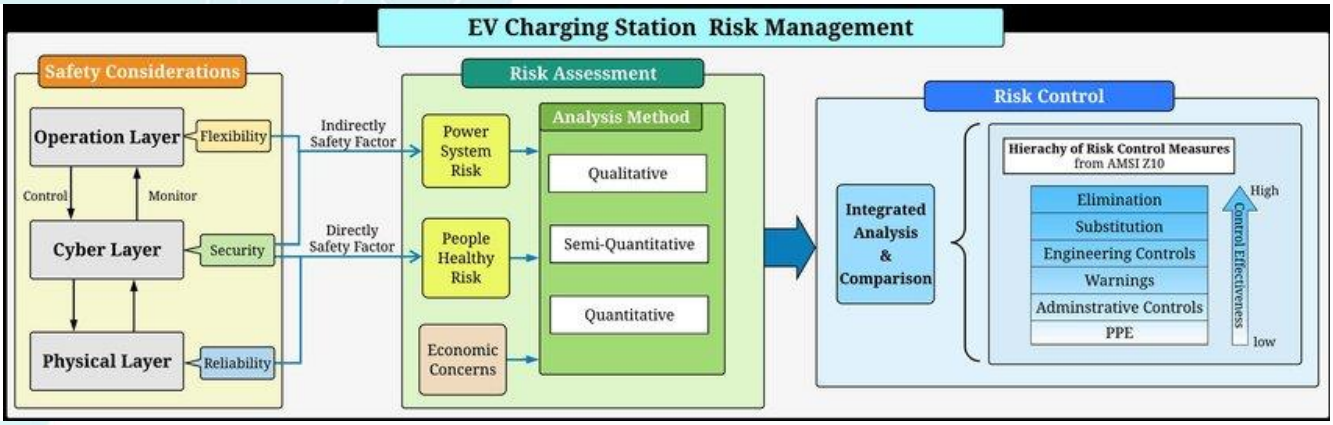


FIGURE 7-16: THE RISK MANAGEMENT FRAMEWORK FOR THE EVCSS

7.3.2 HANDLING OF EMERGENCY SITUATIONS AND FIRST AID TECHNIQUES

Emergency situations vary greatly but there are four main steps that always apply:

- ✓ Make the area safe.
- ✓ Evaluate the injured person's condition.
- ✓ Seek help.
- ✓ Give first aid

- **STEP 1: MAKE THE AREA SAFE**

Your own safety should always come first. As a first aider, you should:

- ✓ Try to find out what has just happened.
- ✓ Check for any danger is there a threat from traffic, fire, electricity cables, etc.;
- ✓ Never approach the scene of an accident if you are putting yourself in danger.
- ✓ Do your best to protect both the injured person(s) and other people on the scene.
- ✓ Be aware that the property of the injured person is at risk. Theft can occur. So mind your safety, and
- ✓ Seek police or emergency help if an accident scene is unsafe and you cannot offer help without putting yourself in danger.

Note:

- An important part of safety also includes washing your hands and wearing gloves or a protection when coming in contact with the injured or sick person's blood or body fluids.
- As a general rule, the injured person should not be moved from the scene of an accident. Any movement may make the injury worse if there has been a head, neck, back, and leg or arm injury.

Only move injured people if:

- ✓ The injured person is in more danger if he is left there,
- ✓ The situation cannot be made safe,

- ✓ Medical help will not arrive soon, and
- ✓ You can do so without putting yourself in danger.

- **STEP 2: EVALUATE THE CONDITION OF THE SICK OR INJURED PERSON**

If it is safe, you can evaluate the sick or injured person's condition. Always check that he is conscious and breathing normally. Situations in which consciousness or breathing are impaired are often life threatening. Bleeding can also happen inside the body and can be life-threatening although the loss of blood is not seen. Techniques of resuscitation (CPR), the recovery position, etc. are explained in this manual.

- **STEP 3: SEEK HELP**

Once you have evaluated the sick or injured person's condition you can decide if help is needed urgently. If help is needed, ask a bystander to call for help. Ask him to come back and confirm that help is underway. If you call for help, be prepared to have the following information available:

The location where the help is required (address, street, specific reference points, location; if in a building: floor, room);

- ✓ The telephone or mobile number you are calling from
- ✓ The nature of the problem
- ✓ What happened (car accident, fall, sudden illness, explosion)
- ✓ How many injured
- ✓ Nature of the injuries (if you know)
- ✓ What type of help is needed
- ✓ Ambulance
- ✓ Police
- ✓ Fire brigade, or
- ✓ Other services and any other information that might help

You might be asked to give your name. Always stay calm and answer their questions calmly. The call takers are professionals and will give you further guidance. If an ambulance can be obtained in a short time, it is best to call for one and use it to transport the injured or sick person to the healthcare facility. An ambulance is the best way to transport ill or injured persons, but they are not always and everywhere quickly available. You can always ask the police for help. If no help is available, you will have to arrange transport yourself (in a van, a truck, a car, an auto-rickshaw, a motorbike, a scooter, a bike-rickshaw, a bike...). Always move the sick or injured person with great care.

- **STEP 4: PROVIDE FIRST AID**

  Give first aid in accordance with the instructions given in the following chapters in this manual. When providing first aid, try to protect an ill or injured person from cold and heat. Do not give anything to eat or drink to a person who is:

  - ✓ Severely injured
  - ✓ Feeling nausea
  - ✓ Becoming sleepy, or
  - ✓ Falling unconscious.

Note:

In fact, as a general principle, the rule is not to give a casualty anything to drink or eat. Important exceptions include hypothermia (low body temperature), hypoglycaemic shock (low blood sugar in a diabetes patient), diarrhoea and fever leading to dehydration and in case of heat exhaustion or heatstroke. The details can be reviewed in the specific chapters on these conditions. Be aware that experiencing an emergency is a very stressful experience for the injured or sick person. To support him through the ordeal, follow these simple tips:

- ✓ Tell the sick or injured person your name, explain how you are going to help him and reassure him; this will help to relax him
- ✓ Listen to the person and show concern and kindness
- ✓ Make him as comfortable as possible
- ✓ If he is worried, tell him that it is normal to be scared
- ✓ If it is safe to do so, encourage family and loved ones to stay with him; and
- ✓ Explain to the sick or injured person what has happened and what is going to happen.

- **WHEN CAN I STOP PROVIDING FIRST AID?**

The question arises when your first aid 'duty' comes to an end? Within first aid, CPR is a lifesaving activity. But when you can stop giving CPR? There are four reasons allowing you to stop CPR:

- ✓ You see a sign of life, such as breathing;
- ✓ Someone trained in first aid or a medical professional takes over;
- ✓ You are too exhausted to continue; or
- ✓ The scene becomes unsafe for you to continue.

Very Important:

- You should know the Location of First Aid kit and how to use first aid kit items.

- Open the First Aid kit and identify the items / name the items and describe its usage. Refer the image.

FIGURE 7-17: IDENTIFICATION OF ITEMS IN THE FIRST AID KIT

7.3.3 INCIDENTS AND NEAR-MISSES REPORT WRITING AND SUBMISSION TO AUTHORITIES

An incident report is a form to document all workplace illnesses, injuries, near misses and accidents. An incident report should be completed at the time an incident occurs no matter how minor an injury is. Any illness or injury that impacts an employee's ability to work must be noted. The specifics of what is required by law to be included in an incident report will vary depending on the federal or provincial legislation that affects your workplace.

It is important to be prepared for accidents and near misses in your organisation and to make sure your employees know what to do if one unfortunately does take place. There are three key stages that you need to be aware of and plan for.

- Recording accidents and near misses

  We would recommend that you record all accidents and near misses and if you employ more than ten employees, the law requires you to maintain an accident book. Recording accidents and incidents helps you to spot trends. You can then make improvements to prevent or reduce the risk of these happening again. You legally must record an accident when it,

  ✓ Results in an employee not being able to work for three days or more.
  ✓ Is a reportable incident, injury, disease, or dangerous occurrence.

- Investigating accidents and near misses

  All accidents and near misses should be investigated as soon as possible, but only when safe to do so. Investigating allows you to,

  - ✓ Find out what went wrong
  - ✓ Find out why it went wrong
  - ✓ Reduce or prevent the risk of it happening again
  - ✓ Provide information for any legal investigations or insurance claims that are made.

- Who to involve: For an investigation to be worthwhile it is important to involve the relevant employees. This allows you to gather all the facts. The person leading the investigation should have,

  - ✓ The required investigative skills
  - ✓ A good understanding of health and safety best practice and legal requirements.

- Reporting accidents and near misses

  It is important that all staff, contractors and workers know how to report an incident and to whom. The person receiving a report should also know what is expected of them. You may use a form for this, or advertise another route in your workplace, for example an internal phone number to a person who will record the details and pass them on for analysis and investigation.

Note: Kindly Refer to **Appendix – IV** "Accidents and near misses Report".

7.3.4 SAFETY AUDITS FOR EQUIPMENT AND PROCEDURE EFFECTIVENESS

Audits evaluate the effectiveness of safety plans, double-check that processes are still accurate and determine if established procedures are being followed. Because they can be time-consuming, facilities don't tend to perform audits frequently. But like preventative maintenance schedules for equipment, audits can help you catch and prevent injuries and fatalities. Audits are often voluntary. When this is the case, facilities have the liberty to determine the scope of an audit as well as the frequency. Audits may also be required by regulations and standards or as part of an enforcement action from the Occupational Safety and Health Administration. No matter what the reason is for conducting an audit, facilities that perform audits are better able to identify emerging safety issues before they become problems. An audit can also help serve as a catalyst for necessary changes to improve employee safety. Refer the following Audit check list when working with charging station like organization. Kindly refer to the **Appendix - V** Safety Audit Checklist

8

Work Effectively with Others

8. WORK EFFECTIVELY WITH OTHERS

Key Learning Objectives:

The trainees will be able to,

- How effectively can understand and follow instructions from supervisors and fellow workers
- Understand importance of timely information sharing with concern persons and do's and don'ts while sharing the information.
- Understand the various aspects of effective communication at workplace along with 7 C's of communication.
- Understand the importance of
  - Gender diversity and its impact on organization
  - Respectful verbal and non-verbal communication
  - Workplace etiquettes and resolving conflicts at workplace
  - Communication without any social biases
- Understand how to develop positive attitude and self-confidence and its benefits at workplace.
- Understand the how to take ownership and dealing with charge at workplace and benefits.
- Understand the symptoms of stress caused by poor time management, various time wasters and importance of priority matrix and its importance.

8.1 WORKING IN AN ORGANIZATION

Organisation is the foundation upon which the whole structure of management is built. Organisation is related with developing a framework where the total work is divided into manageable components to facilitate the achievement of objectives or goals.

FIGURE 8-1: AN ORGANIZATION

According to Louis A. Allen, "Organisation is the process of identifying and grouping the work to be performed, defining and delegating responsibility and authority, and establishing relationship for the purpose of enabling people to work most effectively together in accomplishing objectives." The significance or main advantages of organisation are as follows:

- ✓ It Facilitated Administration and management
- ✓ It Help in the Growth of Enterprise
- ✓ It Ensures Optimum Use of Human Resources
- ✓ It Stimulates Creativity
- ✓ A Tool of Achieving Objectives
- ✓ Prevents Corruption
- ✓ Co-ordination in the Enterprises
- ✓ Eliminates Overlapping and Duplication of work

8.1.1 UNDERSTANDING AND FOLLOWING INSTRUCTION FROM SUPERVISORS AND FELLOW WORKERS

If you are going to lead a successful business, you must create an environment with open communication and trust. Open communication allows your employees to be more engaged and understand that what they do matters in the success of the business. Making sure your employees understand the big picture and the part they play in the success of the organization will help them understand why decisions are made and how those decisions impact them specifically and the company as a whole. Effective communication will lead everyone to be on the same page, moving in the same direction toward the same goal and while receiving and taking the instructions.

- While giving directions:

  - ✓ Provide context and be specific: Give all the details. Provide any background to help that person better understand the task at hand. Try your best to be as detailed as you can, especially when you have a set idea about how the task should be done.
  - ✓ Ask politely rather than barking orders: Tone of voice can change everything, especially when telling someone what to do. Speak at a reasonable volume and use kind, respectful words. Try to avoid negative language and don't forget to say "please."
  - ✓ Offer the other person the opportunity to ask questions: Whenever the one receiving the task is unsure, it's important that you allow him time to ask questions. The better he understands what to do, the greater chance for a successful outcome.
  - ✓ Resist any urge to micromanage: If you give directions properly, you should not feel the need to oversee or micromanage. Instil faith in your task-doer by letting him do things without you to the best of his ability. Provide positive feedback and appropriate gratitude: When the task is complete, be sure to affirm the person. This makes your team member feel respected and trusted. And give clear, helpful feedback or constructive criticism if the task was done improperly.

- While taking directions and fulfilling tasks:

  - ✓ **Actively listen**: Try to listen intently, not just hear. When you actively listen, you can better understand what you need to do. Here's a trick that may help: pretend that there is going to be a quiz after the conversation. Visually think about what's being said and maybe even repeat it in your head.
  - ✓ **Take notes**: Instead of trying to remember everything, write it down. There's nothing wrong with keeping notes; it shows that you are prepared, organized and want to do the job correctly.

- ✓ **Ask questions**: If you are even slightly unsure of what you are being asked to do, don't be afraid to question. Make sure the other person allows you the chance to find out all the needed details to move forward.
- ✓ **Respond with a good attitude**: Just as the person giving directions needs to speak respectfully, it's important to respond respectfully. If you go into the conversation with a bad attitude, it's likely that performing the task will be much more challenging.
- ✓ **Before starting the task, make a checklist**: Whenever there is a job that requires multiple steps, try organizing a to-do list. Check things off as you go to make sure you don't miss anything. Then when you're done, be sure to review your work.

Overall, positive communication and listening are essential when giving and taking instructions.

Student Activity: Imagine that you are a grocery store owner. Ask a partner to imagine being a cashier. Role-play giving criticism while your partner receives it. Then switch roles for a different owner-worker situation. Afterward, review the tips above and discuss which ones you used and which ones you wish you had used.

8.1.2 TIMELY INFORMATION SHARING WITH CONCERN PERSONS

Sharing information is an intrinsic part of any employee's job when working with colleagues of his organization. The decisions about how much information to share, with whom and when, can have a profound impact on individuals and on organization's culture also. The most important consideration while sharing information are:

- Relevant

  Only information that is relevant should be shared with those who need it. This allows others to do their job effectively and make informed decisions.

- Adequate

  Information should be adequate for its purpose. Information should be of the right quality to ensure that it can be understood and relied upon.

- Accurate

  Information should be accurate and up to date and should clearly distinguish between fact and opinion. If the information is historical then this should be explained.

- Timely

  Information should be shared in a timely fashion to reduce the risk of missed opportunities to offer support. Timeliness is key in emergency situations, and it may not be appropriate to seek consent for

information sharing if it could cause delays and therefore place an individual or organization at increased risk of harm. Employees should ensure that sufficient information is shared, as well as consider the urgency with which to share it.

- Secure

  Wherever possible, information should be shared in an appropriate, secure way. Employees must always follow their organisation's policy on security for handling personal information.

- Record

  Information sharing decisions should be recorded. If the decision is to share, reasons should be cited including what information has been shared and with whom, in line with organisational procedures. If the decision is not to share, it is good practice to record the reasons for this decision and discuss them with the requester. In line with each organisation's own retention policy, the information should not be kept any longer than is necessary. In some rare circumstances, this may be indefinitely, but if this is the case, there should be a review process scheduled at regular intervals to ensure data is not retained where it is unnecessary to do so. Follow the Flowchart of when and how to share information:

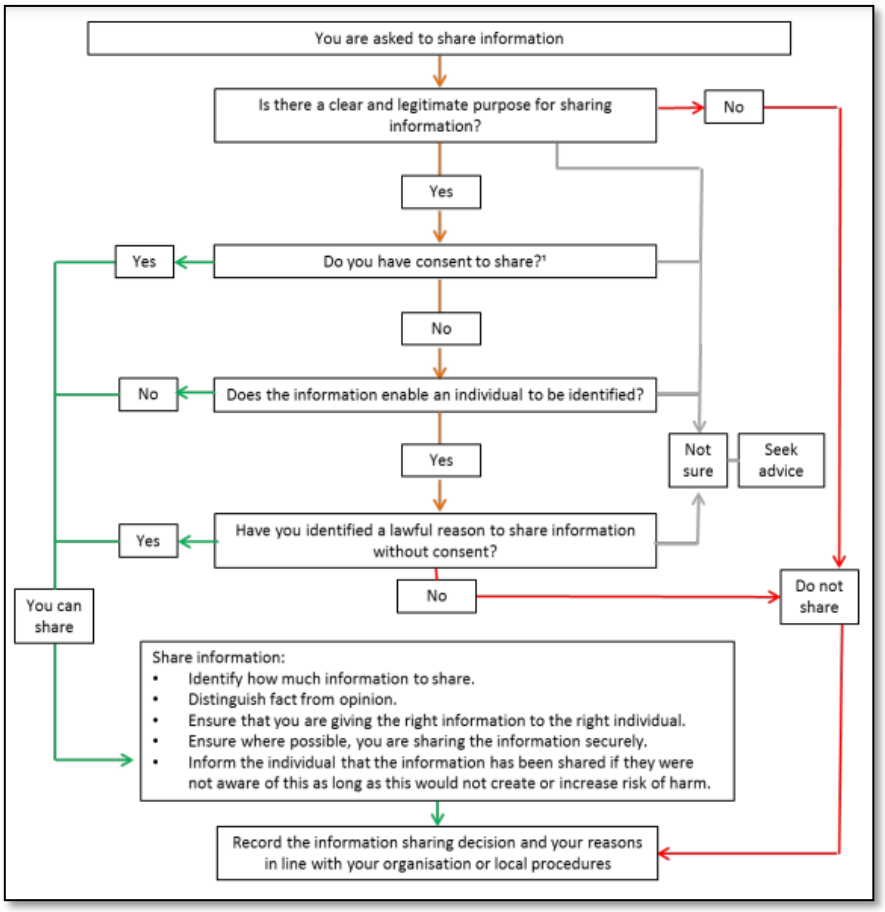


FIGURE 8-2: FLOW CHART ON INFORMATION SHARING

8.2 EFFECTIVE COMMUNICATION AT THE WORKPLACE

The importance of communicating with your workers and reporting managers in a clear and direct manner cannot be underestimated. They need to be informed at all times about your expectations, such as what tasks need to be completed, by when and how. Give them honest feedback about the work they do and listen to what they have to say as well. Make sure your employees feel that they are being heard. How well you listen determines how well they think you can help them find solutions. Instead of ordering them to do something, ask them questions that lead them in the same direction. Good communication with your supervisor is important. There are important aspects to remember when communicating with your supervisor and working in an organization:

- ✓ You must be able to follow instructions.
- ✓ You need to know how to ask questions.
- ✓ You should report any problems and results of your work.
- ✓ You should accurately record and give messages to your supervisor.
- ✓ You need to discuss your job performance.
- ✓ Communicate face-to-face whenever possible
- ✓ Provide clear information
- ✓ Combine verbal and nonverbal communication
- ✓ Don't just hear – listen
- ✓ Ask questions
- ✓ Handle conflicts with diplomacy
- ✓ Refrain from gossip
- ✓ Avoid being personal with your co-workers
- ✓ Avoid discussing controversial topics
- ✓ Offer positive feedback

Providing directions for new assignments and tasks is a normal part of the role of a supervisor or manager. How you provide directions via your tone of voice, word choice, and body language go a long way towards gaining support and promoting a healthy workplace. Effective supervisors and managers work hard to cultivate their skills in providing direction to their team members. There are many methods of communication, but there are some general practices which workers, supervisors and managers should use to ensure team members are receiving clear directions.

- ✓ Always provide context for the task to be completed. People do their best work when they understand the importance of the task to the larger operation. When you take the time to explain the business

importance of the task you are requesting to be completed, you are teaching and showing respect for the individual you asked to complete the work.

- ✓ Be specific when assigning tasks. Outline when the task must be completed and share any quality standards.
- ✓ Ask the team member to complete the tasks. Choose a respectful tone of voice, polite words and deliver the message with the appropriate volume. Contrast these statements: "Go unload that truck," and "John, the shipment on that truck is needed on the production line. Please help unload the truck before noon." There is little doubt the latter approach would be perceived as positive and the former as negative.
- ✓ Give your team a chance to ask questions. Offer the individual(s) being asked to complete the task the opportunity to clarify their questions. This step helps strengthen communication between the employee and supervisor and improves the probability of a successful outcome. The employee has the opportunity to confirm that he or she truly understands what is being asked of them.
- ✓ Trust your employees. Resist the urge to oversee or micro-manage an employee's completion of the requested task. Part of leading effectively is learning to trust that your team can complete tasks without you.
- ✓ Reinforce your employee's confidence. Offer appropriate thanks and positive feedback for jobs completed properly.
- ✓ Ensure you give constructive feedback. Offer clear, behavioural, focused feedback for any tasks that are completed improperly.

- 7 C's of Communication

The 7 C's of Communication is a checklist that helps to improve professional communication skills and increases the chance that the message will be understood in exactly the same way as it was intended. To have effective communication, one should keep the following 7 C's of communication in mind:

- **Clear**: The message should be clear and easily understandable for the recipient. The purpose of the communication should be clear to the sender only then will the receiver be sure about it. The message should emphasize a single goal at a time and shall not cover several ideas in a single sentence.
- **Concise**: The message should be precise and to the point. The sender should avoid lengthy sentences and try to convey the subject matter in the least possible words. Short and brief messages are more comprehensive and help in retaining the receiver's attention.
- **Concrete**: The communication should be concrete, which means the message should be clear and should leave no room for misinterpretation. All the facts and figures should be clearly mentioned in a message so as to substantiate whatever the sender is saying.

- **Correct**: The message should be correct, i.e. the sender must ensure that grammatical and spelling mistakes are avoided. Also, the message should be exact and well-timed. The correct messages have a greater impact on the receiver and at the same time, the morale of the sender increases with the accurate message.
- **Coherent**: The sender must take into consideration the receiver's opinions, knowledge, mindset, background, etc. in order to have an effective communication. In order to communicate, the sender must relate to the target recipient and be involved.
- **Complete**: The message should be complete, i.e. it must include all the relevant information as required by the intended audience. The complete information gives answers to all the questions of the receivers and helps in better decision-making by the recipient.
- **Courteous**: It implies that the sender must take into consideration both the feelings and viewpoints of the receiver such that the message is positive and focused at the audience. The message should not be biased and must include the terms that show respect for the recipient.

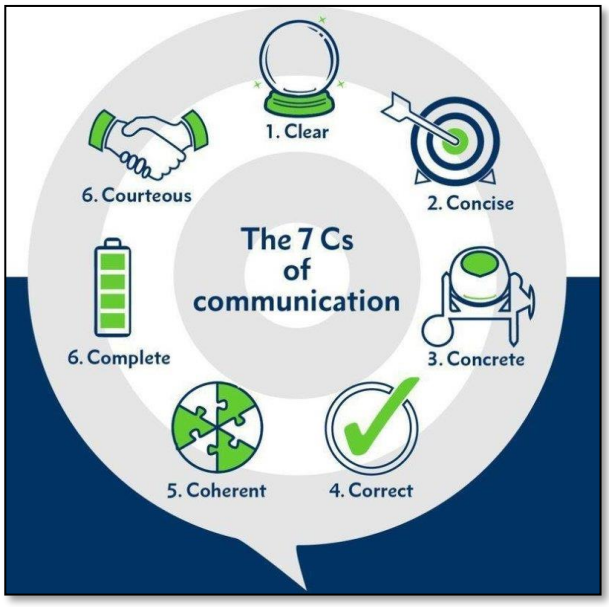


FIGURE 8-3: SEVEN C'S OF COMMUNICATION AT WORKPLACE

8.3 GOOD INTERPERSONAL RELATIONS

A strong bond between two or more people refers to interpersonal relationship. Attraction between individuals brings them close to each other and eventually results in a strong interpersonal relationship. An interpersonal relationship can develop between any of the following:

- Individuals working together in the same organization.
- People working in the same team.
- Relationship between a man and a woman (Love, Marriage).
- Relationship with immediate family members and relatives.

- Relationship of a child with his parents.
- Relationship between friends.

Relationship can also develop in a group (Relationship of students with their teacher, relationship of a religious guru with his disciples and so on). Must haves in an Interpersonal Relationship:

- Individuals in an interpersonal relationship must share common goals and objectives. They should have more or less similar interests and think on the same lines. It is always better if individuals come from similar backgrounds.
- Individuals in an interpersonal relationship must respect each other's views and opinions. A sense of trust is important.
- Individuals must be attached to each other for a healthy interpersonal relationship.
- Transparency plays a pivotal role in interpersonal relationship. It is important for an individual to be honest and transparent.

8.3.1 RESPECT GENDER DIVERSITY

Gender diversity is important. Ensuring equal representation of women in the workplace can have positive effects across your entire organization. Diversity and inclusion are important in the workplace and organizations are missing out if they don't get gender balance right:

Seven reasons why gender diversity is good for business:

- A wider talent pool

  Companies that don't encourage women to join them are missing out on the talents and abilities of half the population. Tapping into these can make a huge difference to your productivity and your bottom line.

- Different perspectives

  Having both women and men in your team means you benefit from different points of view and approaches that come from different life experiences. A multiplicity of perspectives can spark creativity and innovation, and help organizations spot and seize new opportunities. It can also encourage organizations to challenge gender stereotypes.

- Enhanced collaboration

  Having women on teams can help improve team processes and boost group collaboration. Researchers have observed that women have stronger skills reading non-verbal cues. They also conclude that groups

with more women were better at taking turns in conversation, which helps them make the most of the groups combined knowledge and skills.

Improved staff retention

Having an inclusive culture in your workplace boosts morale and opportunity. Inclusive workplaces tend to have lower employee churn rates – which represents big savings in terms of time and money spent on recruitment.

- A better reflection of your customers

  Customers come from all walks of life. The more the make-up of your organization reflects your customers the more likely it is you'll communicate effectively with them. That means making sure your teams have a diversity of genders, as well as backgrounds and ethnicities.

- Improved recruitment and reputation

  Having an inclusive workplace is a powerful recruiting tool. Female millennials look for employers with a strong record on diversity. A reputation as an inclusive employer will also demonstrate your positive company values and that will enhance your reputation in the recruitment marketplace.

- Greater profitability

  Time and again, evidence supports the theory that gender diversity has a positive impact on the bottom line. According to McKinsey, the most gender-diverse companies are 21% more like to experience above-average profitability.

8.3.2 RESPECTFUL VERBAL AND NON-VERBAL COMMUNICATION

It is said that nonverbal communication conveys as much as 93% of our overall communication messages. This is perhaps why it is said that actions speak louder than words. Nonverbal cues are our actions and behaviours, facial expressions and gestures, and vocal cues. They cover considerations of personal space, touch, body movement, and tone of voice, among others. In considerations of courtesy and etiquette, you want to be sure that your nonverbal communication cues are sending the same courteous, respectful, considerate, and honest messages as your words themselves. You also want to pay close attention to the nonverbal cues of those with whom you are interacting, and try as best you can to catch and accurately interpret the signals they are sending you. For facilitators, the most meaningful types of non-verbal communication for making observations are body movement and vocal qualities.

- Body Movement

  This category includes the way we stand, sit, our posture, eye movements and facial expressions. If a learner is sitting back with arms crossed over their chest, this may convey a message such as I am not comfortable or I am paying attention to you – it depends on the context. You will need to pay close attention to the physical cues of your learner group from the beginning, as this will help you interpret their non-verbal communication throughout the session.

- Vocal Qualities

  This refers to how something is said rather than what is said. The qualities of the voice that can affect the meaning of what is said include:

  - Pitch range
  - Pitch control
  - Rhythm control
  - Tempo
  - Articulation control
  - Resonance
  - Vocalisations such as yawning, sighing, whispering, clearing the throat, pauses, humming.
  - Eye Contact

"The fact is that if someone is making more than 60% eye contact with you during a conversation, they are more interested in you than in what you are saying…"

- Workplace Etiquette:

  Respect your . . .

  ✓ Organization or company, understanding its mission, its current goals, and how you can help.
  ✓ Supervisor, following her or his directions.
  ✓ Co-workers, treating them well, communicating clearly, and collaborating effectively.
  ✓ Customers, providing them with the best products and services possible.
  ✓ Self, dressing appropriately and conducting yourself professionally.
  ✓ Job, following the schedule, arriving on time, and working hard.
  ✓ Career, providing your expertise and taking on new challenges.

Student Activity: Think about a job that you currently hold or consider school as your current workplace. Do you routinely show respect in all the ways discussed above? What changes can you make to become more respectful?

- Resolving Conflicts:

  If you develop the gracious, helpful habits outlined above, you will probably face few conflicts with others. Sometimes, though, conflicts do arise. If you have a disagreement with someone, try the following listening exercise:

  - ✓ Position 1 Statement: The first person gets one to two minutes to calmly explain his or her point of view and to list the reasons why his or her suggested course of action would be best.
  - ✓ Restatement of Position 1: The second person then paraphrases the first person's thoughts aloud, starting with "I hear you saying. . ." and ending with "Am I understanding you correctly?"
  - ✓ Clarification of Position 1: If the answer is "no," the first person receives another 30 seconds to a minute to clarify his or her position.
  - ✓ Position 2 Statement, Restatement, and Clarification: Once the first person's position is clear, the second person takes one to two minutes to calmly explain his or her point of view, and the process starts over.
  - ✓ Cooperation and Compromise: Once both sides have been heard, both people should seek ways to cooperate and compromise on the matter.
  - ✓ Mediation: If the conflict still has not been resolved, it's time to get another person involved to mediate.

Student Activity: Think about a conflict that you have had with another employee or with a person at school. How did you resolve the conflict? With a classmate, role play resolving the conflict with the process outlined above.

8.3.3 COMMUNICATION WITHOUT ANY SOCIAL BIASES

- *Communication is said to be the basis of every interpersonal relationship*. In fact effective communication is the key to a healthy and long lasting relationship. If individuals do not communicate with each other effectively, problems are bound to arise.
- *Communication plays a pivotal role in reducing misunderstandings* and eventually strengthens the bond among individuals.
- *A relationship loses its charm if individuals do not express and reciprocate their feelings* through various modes of communication. A healthy interaction is essential for a healthy relationship. It is not always an individual needs to talk to express his /her feelings. Feelings can be expressed through non-verbal modes of communication as well. Your body movements, gestures, facial expressions, hand movements communicate something or the other. Make sure you do not make faces at anyone. You should look happy and contented for the other person to enjoy your presence. Do not always look

sad and irritated. Eye movements also have an important role to play in relationships. One can make out whether you are angry, unhappy or frustrated through your eyes only.

- *Take care of your tone and pitch as well.* Make sure you are not too loud or too soft. Being loud might hurt the other person. Speak softly in a convincing way. The other person must be able to understand what you intend to communicate.
- *Choice of words is important in relationships*. Think twice before you speak. Remember one wrong word can change the meaning of an entire conversation. The other person might misinterpret you and spoil the relationship. Be crisp. Express your feelings clearly. Do not try to confuse the other person. Being straightforward helps you in relationships.
- *An individual must interact with the other person regularly for the relationship* to grow and reach to the next level. Voice and video calls and messaging are ways to stay in touch especially where individuals hardly meet.
- *Be polite*. Never ever shout on your partner even if he has done something wrong. Discuss issues and try to sort out your differences amicably. Abusing, fighting, criticizing spoil the relationship and in adverse cases might end it as well. Being rude is a crime in relationships.
- *Try to understand the other person's point of view as well.* Be a patient listener. Unless you listen carefully, you will never be able to communicate effectively.
- *Individuals can also communicate through emails*. If you do not get the time to call your partner regularly, drop him/her a mail. The other person would feel happy and important. Emails are also an effective mode of communication at workplace. For better relations at workplace, try to communicate through written modes of communication. Be careful about the mail body and make sure they are self-explanatory. Using capital letters in emails is considered to be rude and loud. Do not share any information with any of your fellow workers verbally. Mark him a mail and do keep your Boss in the loop. All the related employees must be marked a cc as well. If discussed orally, the other person might refuse later on, creating problems for you.

8.3.4 REORGANISATION AND REPORTING OF HARASSMENT AND DISCRIMINATION AT WORKPLACE

Knowing the law is one thing, but understanding how it applies to you is another, starting with recognizing the differences between discrimination and harassment. Although the terms are used interchangeably, they are not the same thing. Discrimination is when a member of a protected class receives unfair treatment based on being a member of that group. For instance, denying a woman a promotion just because she is a woman is illegal because gender is a protected class under the law. Harassment is the pattern of conduct or behaviour toward an employee that can result in a discrimination charge. Whether harassment takes the form of verbal, physical, sexual, or others—it is typically one of two types: quid pro quo or hostile environment.

- Types of Discrimination:
  - ✓ Age

    Workers 40 years of age and older are protected from discrimination under the law. For example, it's not okay to mention age in help wanted ads, put age limits on training programs, or force employees into retirement because they reach a certain age. Older employees must also have access to the same benefits as younger employees.

- Race

  Treating an employee differently due to race is against the law. For instance, it is illegal to ask different questions during a job interview to someone of colour than to a white applicant. Also, businesses cannot set policies that have a negative effect on an ethnic minority, such as requiring women to have straightened hair or not allowing dreadlocks.

- Religion

  Employers cannot hire, fire, or set terms of employment that conflict with a person's religious or spiritual beliefs. As long as it doesn't cause undue hardship, the employer must also provide reasonable accommodations such as providing flexible scheduling or allowing the employee to swap shifts. Additionally, dress codes can't be so restrictive as to interfere with an employee's religion.

- Sex

  It's illegal to pay a male employee more than a female employee for doing the same job. Although not spelled out specifically, gender identity and sexual orientation are also protected from workplace discrimination under the interpretation of Title VII. For example, refusing to hire someone because they are gay, lesbian, or transgender is against the law. Eighteen states have separate LGBT anti-discrimination laws.

- Pregnancy

  A woman cannot be fired or demoted for becoming pregnant. It's also illegal to harass or fire a woman for pumping breast milk. Additionally, women cannot be penalized for taking time off after having a baby because it is illegal to restrict medical leave.

- ✓ Mental or Physical Disabilities

Employees with disabilities have a variety of protections including the right to receive reasonable protections when they are requested. For instance, the workplace environment must be accessible for everyone including those who use wheelchairs. Providing an interpreter for an employee who is deaf during the interview process is another example of an accommodation.

- Types of Harassment at work:
  - ✓ Sexual Harassment
  - ✓ Verbal Harassment
  - ✓ Cyber Harassment
  - ✓ Physical Harassment
  - ✓ Retaliatory Harassment
- How Harassment Affects the Workplace:

  Harassment often leads to a lack of morale in the workplace. First, workplace bullying can take a mental and physical toll on the victim which then can impact their job performance. Below are some of the most common results of workplace harassment and bullying according to the Workplace Bullying Institute.

  - ✓ Severe Anxiety
  - ✓ Clinical Depression
  - ✓ Anxiety
  - ✓ Guilt
  - ✓ Shame

  But it's not just the victim who suffers at work. Workplace bullying is disruptive for everyone. Co-workers who witness the harassment may feel guilty for not saying something or worry about becoming victims themselves. In fact, a Canadian study found co-workers who witnessed workplace bullying were more likely to take antidepressants and tranquilizers. Other employees may feel frustrated because co-workers miss work to give statements for litigation, leaving extra tasks and responsibilities to them. It's management's responsibility to create a supportive atmosphere and recognize when to intervene.

- What to Do If You're Experiencing Workplace Harassment or Discrimination:

  According to report 94 % of individuals do not file a formal complaint after experiencing discrimination or harassment. They fear blame, that nothing will be done, or that they will be ostracized. However, reporting workplace harassment or discrimination can be important for a couple of reasons. One, it proves the employer was aware of the problem and therefore responsible for handling it. Secondly, it may be the only way to stop the behaviour. So, what should you do if you are a victim of workplace harassment or discrimination? Here are some suggestions:

✓ Keep a record.

Buy a pocket-sized notebook and keep track any time the offending behaviour takes place. Note details like time and date, and a summary of the incident. Be as specific as possible. Should anything end up escalating through the legal system, this record will be invaluable evidence.

✓ Find witnesses.

Chances are, one or more of your co-workers witnessed the behaviour at some point—so think about who was there. Talk to them about what they saw and include it in your notebook. Also, ask if they are willing to be a witness.

✓ Save evidence.

If there are photos or other objects that can prove your case, keep them safe until you need them. Did you receive harassing emails or phone calls? Then keep email and call histories. The more proof you have, the easier it will be to make a case.

✓ Don't wait.

As soon as something happens, you need to create a plan because there are state and federal time limits to reporting harassment. Check to see how discrimination is handled by your company. Is there a workplace policy? Can you get a physical copy of a workplace handbook? If your company has a website, the grievance procedure should also be located there.

✓ Ask for support.

Harassment can be traumatic. Whether it is a friend or therapist, reaching out to someone you trust and talking about it can be essential for your mental health. They can also help you decide whether you want to file a complaint.

✓ Review your options.

Is there a supervisor you feel comfortable approaching? If not, you may have a Human Resources representative or someone responsible for handling internal complaints. An counsellor can also help you decide how to proceed as well as discuss the possibility of litigation and what it entails.

8.4 DEVELOPING POSITIVE ATTITUDE AND SELF-CONFIDENCE

What actually the self – confidence is and is as follows: "Our self-assurance in trusting our abilities, capacities, and judgments; the belief that we can meet the demands of a task."

- Benefits that come from boosting your self-confidence:
  - ✓ Improved coping and thriving under stress
  - ✓ Better ability to influence and persuade others
  - ✓ More leadership and executive presence
  - ✓ Increased positive attitude
  - ✓ Enhanced sense of feeling valued (by yourself and probably others as well)
  - ✓ Improved performance at work
  - ✓ Being perceived as more attractive
  - ✓ Reduced negative thoughts
  - ✓ More fearlessness and less anxiety
  - ✓ Greater freedom from social anxiety in particular
  - ✓ Increased energy and motivation
  - ✓ Greater levels of happiness

Although self-confidence is vital in leaders, it's also important for the rank-and-file. A healthy sense of self-confidence can result in many benefits relevant to the workplace, including:

- ✓ Greater optimism
- ✓ Ability to run meetings effectively and confidently
- ✓ More effective delegating
- ✓ A greater sense of autonomy
- ✓ More frequent promotions and higher positions
- ✓ Higher pay and more frequent pay raises.

It's easy to spot self-confident people; in addition to signs like the ones above, there are plenty of other signs that indicate a person is confident and self-assured, including:

- ✓ People who are self-confident do what they believe is right, even if they are mocked or criticized for it.
- ✓ They are more willing to take risks and "go the extra mile" to get what they want.
- ✓ They can admit when they've made a mistake and learn from their mistakes.
- ✓ They wait for others to congratulate them on their accomplishments instead of bragging and boasting.
- ✓ They accept compliments with grace and gratitude

8.4.1 BUILDING SELF-CONFIDENT SKILLS:

Following are some guidelines on building your self-confidence and boosting your belief in yourself:

- **Preparing for Your Journey**
  - ✓ Take inventory of what you've already achieved.
  - ✓ Think about your strengths and weaknesses (but especially your strengths).
  - ✓ Think about your goals and values.
  - ✓ Practice stopping negative self-talk in its tracks and replacing it with positive thinking.
  - ✓ Commit to the journey to self-confidence!
- **Setting Out**
  - ✓ Identify and enhance the knowledge and skills you need to succeed.
  - ✓ Focus on the basics—don't get bogged down in details or reaching for perfection.
  - ✓ Set small goals and achieve them to "pile up successes."
  - ✓ Keep working on your positive thinking and self-talk.
- **Accelerating Towards Success**
  - ✓ Celebrate your successes.
  - ✓ Keep yourself grounded.
  - ✓ Assess your current level of self-confidence and identify what strategies you can use to keep building it up.

8.4.2 A POSITIVE ATTITUDE

It is at the heart of optimistic and successful people. Successful and confident people have positive attitudes. Self-confidence is based on a belief that one's efforts and abilities will allow one to reach a goal. Successful and confident people have positive self-images. This image of self—or self-image—is largely developed in early life. Self-image is how you see yourself in relation to the world. Self-image includes:

- ✓ What you think you look like physically—and acceptance of your physical characteristics
- ✓ What kind of person you think you are—your values and beliefs
- ✓ What you think others think of you—how your personality comes across
- ✓ What you believe your strengths and weaknesses are—your ability to have an accurate and objective view of yourself

- ✓ How much you like yourself—and how well you take care of yourself

- How to improve your self- image?
  - ✓ Stop comparing yourself to others.

When you do this, you are likely to compare yourself in a negative way. Besides, each of us is a unique individual with our own strengths and weaknesses. Celebrate your individuality!

✓ Acknowledge your positive qualities.

Make a list of your positive attributes. Include appearance, personality and skills. If you have difficulty with this, ask others to help you. They'll come up with things you might not see in yourself.

✓ Involve yourself in work and life activities that you love.

So many people with low self-esteem fail to fill their lives with meaningful activities. Follow the career path that is most rewarding to you. If you are not fully satisfied with your job but are not in a position to make immediate changes in your career, you can still devote leisure time to hobbies and activities that are enjoyable and fulfilling.

✓ Develop a positive personal support network.

The people with whom you associate influence your own self-image. Negative people can bring you down. On the other hand, when positive and supportive people surround you, you feel better about yourself.

✓ Speak up for yourself.

Learn to be assertive and practice clear communication. Not voicing and acknowledging your needs or setting limits with others means that you are putting up with more stuff than you need to for your own well-being. By learning how to say "no," you are sending the message that you value yourself and that you deserve to be treated with respect. Lighten up! Take yourself less seriously. Learn to laugh at yourself and see the humorous side of life. Smile as much as you can; it's contagious!

✓ Accept all compliments graciously.

Don't dismiss or ignore compliments or praise from others. When you do, it not only sends the message that you are not worthy of praise, but also that you don't value the opinion of the person giving you the compliment.

✓ Take advantage of personal growth programs.

Actively pursue an elevated self-image by reading self-help books; listening to inspirational tapes; attending motivational workshops, lectures and classes; starting an exercise program or using life coaches or personal counsellors for self-improvement.

✓ Develop tolerance for yourself and others.

Remember, nobody's perfect! Stop criticizing yourself and others for every imperfection or shortcoming. Recognize that a mistake is just a mistake so don't dwell on it.

✓ Stop putting yourself down.

You can't develop high self-esteem if you constantly berate and belittle yourself. Don't beat yourself up for making mistakes. Instead, find ways to learn something valuable from them and then move on. Use positive affirmations to reprogram your negative inner conversations.

✓ Help others.

Do something useful for others. Help others feel good about themselves by giving those compliments or acknowledgements for accomplishments. Make a positive contribution to the lives of others through volunteer work or community service.

Note: To test and build the self-confidence and so the positive attitude of the student, fill the following worksheets,

✓ Self - esteem-journal
✓ Self – confidence worksheet
✓ Strengths - exploration

8.5 TAKING OWNERSHIP AND DEALING WITH CHARGE

If you've ever worked with or managed someone who was indecisive and unconcerned about their work, passing off their responsibilities to others, then you know how much of an issue this can cause in the workplace. Taking ownership of your work prevents those issues by showing others that you can be trusted, even when the job is serious. If everyone on your team is doing his or her part, big or small, then everything runs more smoothly. As Marcus likes to say, "Your job as the CEO of the business is to be the coach. Rather than running people under the bus, you've got to get them on the bus with you."

- Why Should I Take Ownership?

  Employees who do the bare minimum are a drain of energy in the office. As a manager, it's your job to inspire them. Make them more thoughtful of their work, give them the initiative, and keep their minds sharp. In essence, you have to teach them about taking ownership. When an employee feels that they are

contributing to your company's overall achievements, they are personally invested in its success. When an employee feels that they are contributing to your company's overall achievements, they are personally invested in its success. You may feel more ownership in your business than your employees by the very nature of your job and title. Still, those benefits extend to you as well. An office full of employees proud of the work they put their names on is a constructive, rewarding place to be for all.

- Is it Really That Important?

  One of the unique things about being an entrepreneur or small business owner is that you are your first employee. You represent your company every day in two ways: the boss and the worker. Ultimately, your standards are the only ones that matter. That's why taking ownership in business is so important. You're taking ownership of your work, your employees' work, and every other aspect of your company. At heart, taking ownership is about taking responsibility and having the initiative to lead. As an entrepreneur, you've already invested in yourself. Anything less than the best from you or your team is unacceptable as an investor. As Marcus has said, "People will work for recognition and opportunity more than they'll work for anything else." So here's how to take ownership of your creation and inspire your team to do it too.

- What Are the Benefits of Taking Ownership?
  - ✓ Feeling Ownership in Business can Expand Your Organization.
  - ✓ Who Doesn't Want Passionate, Loyal Employees?
  - ✓ Taking Ownership of Your Work Every Day Will Engage Your Customers.
  - ✓ When You Take Ownership in Business, You Can Communicate Your Ideas More Clearly, and People Will Take You at Your Word.
- Five Ways You Can Start Taking Ownership of Your Work
  - ✓ Ask what you're doing for Your Business Right Now.
  - ✓ Have a Planning and Share it With Everyone Who Will Listen.
  - ✓ Know Your Values and Put Them in Writing for New Hires.
  - ✓ Let others be Accountable Every Once in a While.
  - ✓ Listen to Your Team and Keep an Ear Out for Defensiveness.
- What to Look Out For & Avoid
  - ✓ Don't Micromanage.
  - ✓ Share the Wins and the Losses.
  - ✓ Know Where You Spend Your Time.

8.6 TIME AND STRESS MANAGEMENT

Good time management is essential if you are to handle a heavy workload without excessive stress. Time management helps you to reduce long-term stress by giving you direction when you have too much work to do.

- Myths about Stress and Time Management
  - ✓ Myth #1: All stress is bad. No, there's good and bad stress. Good stress is excitement, thrills, etc. The goal is to recognize personal signs of bad stress and deal with them.
  - ✓ Myth #2: Planning my time just takes more time. Actually, research shows the opposite.
  - ✓ Myth #3: I get more done in more time when I wisely use caffeine, sugar, alcohol or nicotine. Wrong! Research shows that the body always has to "come down" and when it does, you can't always be very effective then after the boost.
  - ✓ Myth #4: A time management problem means that there's not enough time to get done what needs to get done. No, a time management problem is not using your time to your fullest advantage, to get done what you want done.
  - ✓ Myth #5: The busier I am, the better I'm using my time. Look out! You may only be doing what's urgent, and not what's important.
  - ✓ Myth #6: I feel much harried, busy, so I must have a time management problem. Not necessarily. You should verify that you have a time management problem. This requires knowing what you really want to get done and if it is getting done or not.
  - ✓ Myth #7: I feel OK, so I must not be stressed. In reality, many adults don't even know when they're really stressed out until their bodies tell them so. They miss the early warning signs from their body, for example, headaches, still backs, twitches, etc.

It puts you in control of where you are going and helps you to increase your productivity. By being efficient in your use of time, you should enjoy your current work more, and should find that you able to maximise the time outside work to relax and enjoy life. Poor time management is a major cause of stress. Symptoms of stress caused by poor time management:

- ✓ Irritability and mood swings
- ✓ Tiredness and fatigue
- ✓ Inability to focus or concentrate. Do you ever feel like you are just trying to get yourself through the day?

- ✓ Mental block, memory lapses and forgetfulness.
- ✓ Lack of, or loss of, sleep
- ✓ At worst, withdrawal and depression

- Biggest Time Wasters
  - ✓ Interruptions. There will always be interruptions. It's how they're handled that wastes time.
  - ✓ Hopelessness. People "give in", "numb out" and "march through the day".
  - ✓ Poor delegation skills. This involves not sharing work with others.
- Wise Principles of Good Stress and Time Management
  - ✓ Learn your signs for being overstressed or having a time management problem. Ask your friends about you. Perhaps they can tell you what they see from you when you're overstressed.
  - ✓ Most people feel that they are stressed and/or have a time management problem. Verify that you really have a problem. What do you see, hear or feel that leads you to conclude that you have a time or stress problem?
  - ✓ Don't have the illusion that doing more will make you happier. Is it quantity of time that you want, or quality?
  - ✓ Stress and time management problems have many causes and usually require more than one technique to fix. You don't need a lot of techniques, usually more than one, but not a lot.
  - ✓ One of the major benefits of doing time planning is feeling that you're in control.
  - ✓ Focus on results, not on busyness.
  - ✓ It's the trying that counts - at least as much as doing the perfect technique.

Note: Follow the below links to test your stress and time management skills,

- ✓ Test Your Stress:

https://www.bemindfulonline.com/test-your-stress

- ✓ Test Your Time management Skills:

https://ucc.vt.edu/academic_support/online_study_skills_workshops/Copy_1_of_Time_Management_Quiz.html

- Priority Matrix – Time Management:

  Make a list of all your tasks and activities for the day or week. Then rate these tasks by how important or urgent they are.

  - ✓ **Low and High Urgent tasks** are those that must be done right away to avoid a major problem, such as paying the electric bill today because your electricity will be turned off tomorrow. Many people never deal with important things until they become urgent. This approach always leads to stress.
  - ✓ **High Important tasks** are those that are meaningful or important to you, such as spending time with your family, helping friends, or getting exercise. They are also tasks you must do to avoid a problem, such as paying bills or meeting a deadline at work.
  - ✓ **Low important tasks** are ones that don't need to be done or that aren't important to you.

After you have your list and have rated the items, think about how you are spending your time. If you take care of important tasks in a timely way, you won't have as many urgent tasks to worry about. For example, if you pay your bills when you get them, you won't have to juggle your finances and hurry to pay bills the day they are due. Think about how you can redirect your time to activities that are important and meaningful to you. Are you spending a lot of time on things that aren't important or urgent? Maybe there are things that you don't need to do at all.

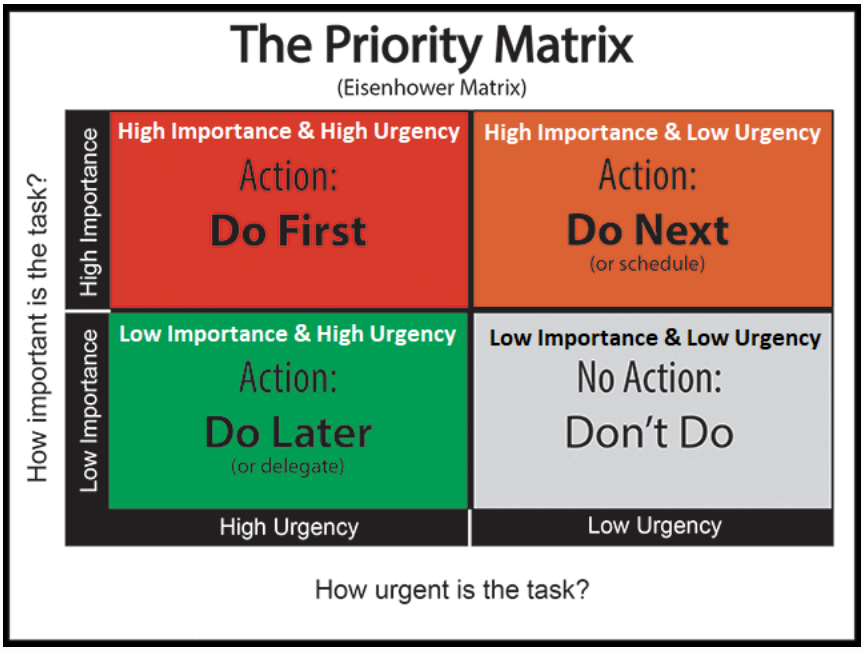


FIGURE 8-4: PRIORITY MATRIX – TIME MANAGEMENT

Note: Students to fill the priority matrix for the task related to job role.

9

Optimize Resource Utilization at Workplace

9. OPTIMIZE RESOURCE UTILIZATION AT WORKPLACE

Key Learning Objectives:

The trainees will be able to,

- Understand importance material conservation and implementation of the same at the workplace.
- Understand the various energy / electricity conservation ideas and how to implement the same during day-to-day life.
- Understand the importance of Waste Management, Recycling symbols, Waste management strategies and Outline of battery recycling concept.
- Understand different techniques of waste management.

9.1 MATERIAL CONSERVATION PRACTICES

Sustainable Materials Management approach focuses on reducing materials use and associated environmental impacts over the entire product life cycle. Sustainable Materials Management encourages activities such as substituting services for products, increasing material efficiency in the supply chain, redesigning products and packaging, and a range of other actions. Local governments benefit from these activities by reducing the amount of waste they need to manage and making better use of those materials they do receive for disposal.

FIGURE 9-1: MATERIAL LIFE - CYCLE

- Material Substitution

  There are many possibilities of material substitution by which, the use of a material resource can be restricted by finding an alternative resource. The problem in this is that many materials have extensive uses and joint uses. E.g. Copper sheet can be substituted by aluminium, which at the same time would reduce demand for soldering agents made from and lead. Aluminium is being extensively substituted for tin.

- Product Life Extension:

  This is a method by which the durability of the product is extended by deliberate design, so that the need for replacement would be postponed. It is a common practice that many modern producers design the goods for early disposal by the consumers to serve twin purpose of:

  - ✓ Boosting the sales and profits of the producing firm by encouraging consumers to go in for replacement of their goods more rapidly,
  - ✓ Reflecting consumer's apparent desire for rapid changes of their goods for the sake of novelty.

- Recycling:

  Recycling is a popular and widely practiced method throughout the world by many industrial units. This is a process by which the life of resource is extended by means of recycling it or reusing it as an input or output. This is applicable only to on-energy resources since the use of a material as an energy resource results in its useless dissipation into the atmosphere. Industrial wastes and by products can be profitably recycled. But, the profit seeking firm will make an attempt to recycle a product only when the cost of recycling is lower than use of "virgin" resource material. Further, the differential cost between recycling and using virgin resource must remain for a fairly long period. The recycling decisions depend on so many factors such as:

  - ✓ The value of the resource after recycling,
  - ✓ Reduction in pollution due to the reduction in residuals disposed of directly to the environment, and
  - ✓ Reduced demand for land for disposal purposes, releasing it for alternative social uses.

- Optimum Recycling:

  The optimum level of recycling is the point at which the extra cost of recycling does not outweigh the extra benefits. For a private firm, the decision to recycle depends upon the difference between the cost to the firm of using the 'virgin' material and the cost of using recycled material. This difference (i.e., the

latter should be appreciably low) must be a sustained one, as the firm must make some investments on the recycling plant and incur some recurring expenditure. If the firm foresees that the cost difference is not very much and situation may reverse in a few years that the cost of virgin material will be less, the firm will not go in for recycling. Further, this depends on whether the firm itself undertakes the work of recycling or is it done by some specialised agencies to whom the work can be entrusted for a sum.

- Recycling and Pollution Taxes:

  The above analysis of optimum recycling relates to ratios for a given output. It is often said that pollution taxes will be levied to encourage recycling of the resources. We shall make an attempt to integrate the above analysis with pollution taxes.

- Waste Reduction:

  The problem relating to conservation of resources exhibit in two ways, one to consume or exploit the resources in a minimal way and the other is to avoid or reduce wastage in the process of production. If greater attention is paid to the latter, i.e., waste reduction, it will automatically ensure lesser exploitation of resources. Waste reduction can be achieved by appropriately redesigning industrial processes, so that there will be technological efficiency in utilizing the resource and avoidance of waste to the minimum. Further, the waste of one industry can be used as the raw material of another industry. In such a case, marketability of industrial wastes should be explored in the place of recycling. E.g. Sugar industry can be cited as an excellent example of either using its own wastes or marketing the waste materials. The bagasse of the sugar mills (which is a by-product) is sold to paper mills where bagasse is the main raw material for manufacture of papers.

9.2 ENERGY/ELECTRICITY CONSERVATION PRACTICES

Energy conservation is one of the words you are hearing more and more these days. Unfortunately, a lot of the places you will hear about it will be in ads marketing products or lifestyle habits that may have nothing to do with actual energy conservation. Without energy conservation, the world will deplete its natural resources. While some people don't see that as an issue because it will take many decades to happen and they foresee that by the time the natural resource is gone there will be an alternative; the depletion also comes at the cost of creating an enormous destructive waste product that then impacts the rest of life. The goal with energy conservation techniques is to reduce demand, protect and replenish supplies, develop and use alternative energy sources, and to clean up the damage from the prior energy processes. Energy conservation is something you can put into practice immediately, either at very little or no cost to you. Here are energy conservation ideas you can get started with today.

- Adjust your day-to-day behaviour

  To reduce energy consumption in your home, you do not necessarily need to go out and purchase energy efficient products. Energy conservation can be as simple as turning off lights or appliances when you do not need them. You can also use energy-intensive appliances less by performing household tasks manually, such as hang-drying your clothes instead of putting them in the dryer, or washing dishes by hand. The behaviour adjustments that have the highest potential for utility savings are turning down the heat on your thermostat in the winter and using your air conditioner less in the summer. Heating and cooling costs constitute nearly half of an average home's utility bills, so these reductions in the intensity and frequency of heating and cooling offer the greatest savings. There are tools you can use to figure out where most of your electricity is going in your home and which appliances are using the most electricity on a day-to-day basis.

- Replace your light bulbs

  Traditional incandescent light bulbs consume an excessive amount of electricity and must be replaced more often than their energy efficient alternatives. Halogen incandescent bulbs, compact fluorescent lights (CFLs), and light-emitting diode bulbs (LEDs) use anywhere from 25-80 percent less electricity and last 3 to 25 times longer than traditional bulbs. Although energy efficient bulbs are more expensive off the shelf, their efficient energy use and longer lifetimes mean that they cost less in the long run.

- Use smart power strips

  "Phantom loads," or the electricity used by electronics when they are turned off or in standby mode, are a major source of energy waste. In fact, it is estimated that 75% of the energy used to power household electronics is consumed when they are switched off, which can cost you up to $200 per year. Smart power strips, also known as advanced power strips, eliminate the problem of phantom loads by shutting off the power to electronics when they are not in use. Smart power strips can be set to turn off at an assigned time, during a period of inactivity, through remote switches, or based on the status of a "master" device.

- Install a programmable or smart thermostat

  A programmable thermostat can be set to automatically turn off or reduce heating and cooling during the times when you are asleep or away. When you install a programmable thermostat, you eliminate wasteful energy use from heating and cooling without upgrading your HVAC system. On average, a programmable thermostat can save you $180 per year. Programmable thermostats come in different models that can be set to fit your weekly schedule. Additional features of programmable thermostats can include indicators for when to replace air filters or HVAC system problems, which also improve the efficiency of your heating and cooling system.

- Purchase energy efficient appliances

  On average, appliances are responsible for roughly 13% of total household energy use. When purchasing an appliance, you should pay attention to two numbers: the initial purchase price and the annual operating cost. Although energy efficient appliances might have higher upfront purchase prices, their operating costs are often 9-25% lower than conventional models. When purchasing an energy efficient appliance, you should look for appliances with the ENERGY STAR label, which is a federal guarantee that the appliance will consume less energy during use and when on standby than standard models. Energy savings differ based on the specific appliance. For example, ENERGY STAR certified clothes washers consume 25% less energy and 45% less water than conventional ones, whereas ENERGY STAR refrigerators use only 9% less energy.

- Reduce your water heating expenses

  Water heating is a major contributor to your total energy consumption. Other than purchasing an energy efficient water heater, there are three methods of reducing your water heating expenses: you can simply use less hot water, turn down the thermostat on your water heater, or insulate your water heater and the first six feet of hot and cold water pipes.

  If you are considering replacing your water heater with an efficient model, you should keep in mind two factors: the type of water heater that meets your needs and the type of fuel it will use. For example, tank less water heaters are energy efficient, but they are also a poor choice for large families as they cannot handle multiple and simultaneous uses of hot water. Efficient water heaters can be anywhere between 8% and 300% more energy efficient than a conventional storage water heater.

- Install energy efficient windows

  Windows are significant source of energy waste - they can add up to 10-25% of your total heating bill. To prevent heat loss through your windows, you can replace single-pane windows with double-pane products instead. For homes in colder regions, gas-filled windows with "low-e" coatings can significantly reduce your heating expenses. In addition, interior or exterior storm windows can reduce unnecessary heat loss by 10 to 20 percent. You should especially consider storm windows if your region experiences frequent extreme weather events.

  In warmer climates, heat gain through windows may be a problem. In addition to minimizing heat loss, low-e coatings on windows can reduce heat gain by reflecting more light and lowering the amount of thermal energy that enters your home. Depending on where you live, ENERGY STAR windows can save you $20-$95 each year on your utility bills. Window shades, shutters, screens, and awnings can also

provide an extra layer of insulation between your home and outside temperatures, leading to even more energy conservation.

- Upgrade your HVAC system

  An HVAC system is composed of heating, ventilation, and air conditioning equipment. Heating alone is responsible for more than 40% of home energy use.

  Air conditioning, by comparison, isn't a significant contributor to energy bills – on average, it only makes up six percent of the total energy use of your home. ENERGY STAR central air conditioning units are eight percent more efficient than conventional models. Air conditioning systems are usually integrated with heating systems, which means that you should purchase your new furnace and air conditioner at the same time in order to ensure that the air conditioner performs at its maximum rated energy efficiency.

  Upgrades to the third component of an HVAC system – ventilation – can also improve your energy efficiency. A ventilation system is composed of a network of ducts, which distributes hot and cold air throughout your home. If these ducts are not properly sealed or insulated, the resulting energy waste can add hundreds of dollars to your annual heating and cooling expenses. Proper insulation and maintenance on your ventilation system can reduce your heating and cooling expenses by up to 20%.

- Weatherize your home

  Weatherizing, or sealing air leaks around your home, is a great way to reduce your heating and cooling expenses. The most common sources of air leaks into your home are vents, windows, and doors. To prevent these leaks, you should ensure that there are no cracks or openings between the wall and vent, window, or doorframe.

  To seal air leaks between stationary objects, such as the wall and window frame, you can apply caulk. For cracks between moving objects, such as operable windows and doors, you can apply weather stripping. Weather stripping and caulking are simple air sealing techniques that typically offer a return on investment in less than a year. Air leaks can also occur through openings in the wall, floor, and ceiling from plumbing, ducting, or electrical wiring.

  Air leaking out of your home is most often from the home interior into your attic through small openings. Whether it is through ducts, light fixtures, or the attic hatch, hot air will rise and escape through small openings. As the natural flow of heat is from warmer to cooler areas, these small openings can make your heating bill even higher if your attic is not sufficiently insulated. To reap the full amount of savings from weatherization, you should consider fully insulating your home.

- Insulate your home

  Insulation plays a key role in lowering your utility bills through retaining heat during the winter and keeping heat out of your home during the summer. The recommended level of heat resistance, or "R-value," for your insulation depends on where you live. In warmer climates, the recommended R-value is much lower than for buildings located in colder regions like the Northeast.

  The level of insulation you should install depends on the area of your house. Your attic, walls, floors, basement, and crawlspace are the five main areas where you should consider adding insulation. Use the Home Energy Saver tool for recommendations based on the specifications of your home, or find general regional recommendations on the Department of Energy's webpage on insulation.

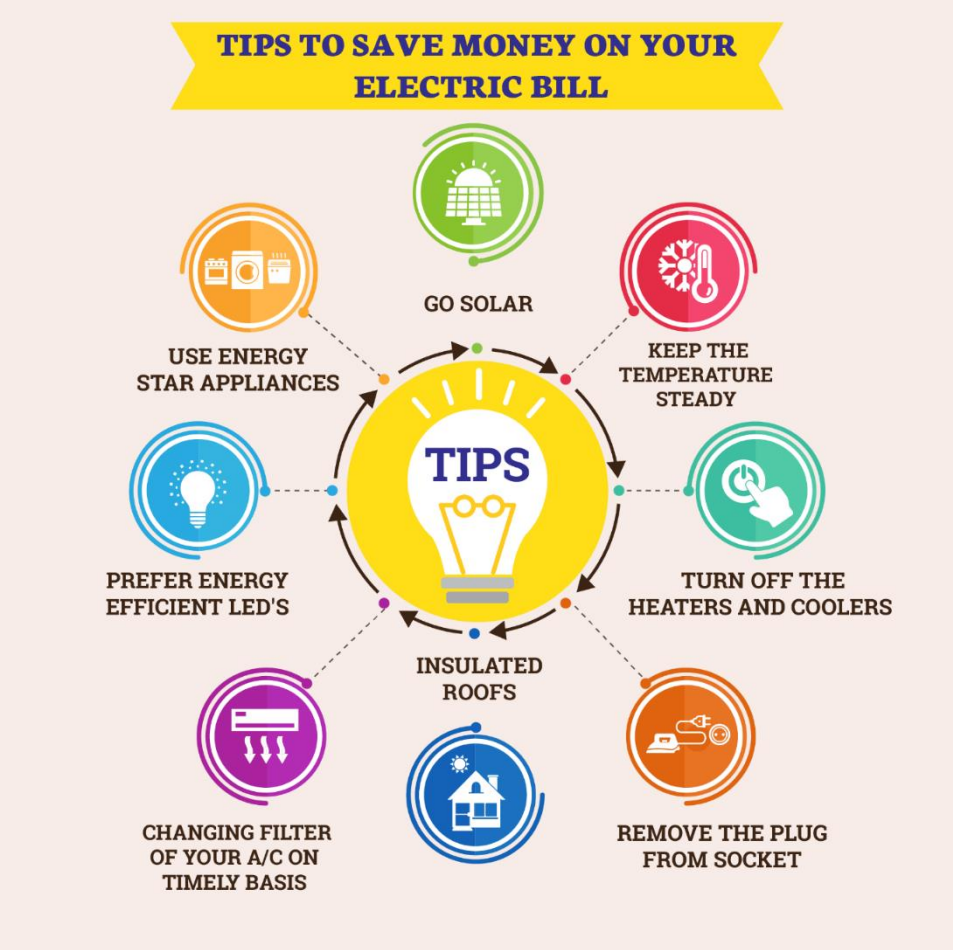


FIGURE 9-2: ENERGY CONSERVATION PRACTICES

- Key takeaways
  - ✓ Energy conservation allows you to continue your habits but with slight tweaks, like upgrading appliances or unplugging appliances, to reduce the energy used.
  - ✓ If your utility bills you with time-of-use rates, changing your energy use hours to off-peak times can save you even more.

- ✓ Investing in an energy-efficient home with new windows or appliances comes with a high upfront cost but it will save you money in the long term.
- ✓ Pairing energy conservation with solar panels will maximize your savings.

9.3 EFFECTIVE WASTE MANAGEMENT / RECYCLING PRACTICES

Traditionally, waste is viewed as an unnecessary element arising from the activities of any industry. In reality, waste is a misplaced resource, existing at a wrong place at a wrong time. Waste is also the inefficient use of utilities such as electricity, water, and fuel, which are often considered unavoidable overheads. The costs of these wastes are generally underestimated by managers. It is important to realise that the cost of waste is not only the cost of waste disposal, but also other costs such as:

- ✓ Disposal cost
- ✓ Inefficient energy use cost
- ✓ Purchase cost of wasted raw material
- ✓ Production cost for the waste material
- ✓ Management time spent on waste material
- ✓ Lost revenue for what could have been a product instead of waste
- ✓ Potential liabilities due to waste.

What is waste management?

Waste management can be defined as "systematically reducing waste at source". It means:

- Prevention and/or reduction of waste generated
- Efficient use of raw materials and packaging
- Efficient use of fuel, electricity, and water
- Improving the quality of waste generated to facilitate recycling and/or reduce hazard
- Encouraging re-use, recycling, and recovery.

Waste management is also known by other terms such as waste reduction, pollution prevention, source reduction and cleaner technology. It makes use of managerial and/or technical interventions to make industrial operations inherently pollution free. it should also be clearly understood that Waste management, however attractive, is not a panacea for all environmental problems and may have to be supported by conventional

treatment/disposal solutions. Waste management is best practiced by reducing the generation of waste at the source itself. After exhausting the source reduction opportunities, attempts should be made to recycle the waste within the unit. Finally, modification or reformulation of products to manufacture it with least waste generation should be considered.

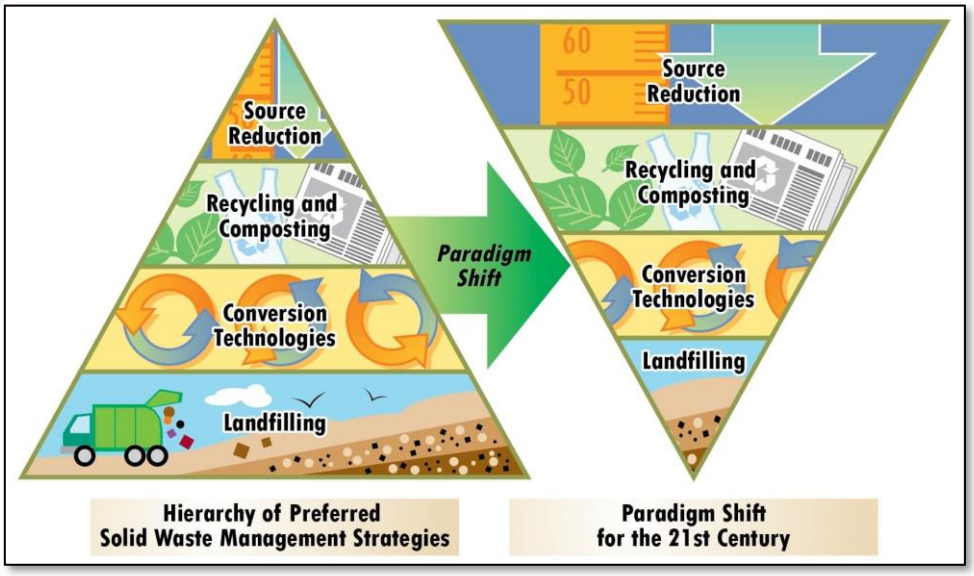


FIGURE 9-3: EVOLUTION OF WASTE MANAGEMENT

Four techniques of waste management are briefly discussed below:

- Good Housekeeping-

  Systems to prevent leakages & spillages through preventive maintenance schedules and routine equipment inspections. Also, well-written working instructions, supervision, awareness and regular training of workforce would facilitate good housekeeping.

- Process Change:

  ✓ **Input Material Change** - Substitution of input materials by eco-friendly (nontoxic or less toxic than existing and renewable) material preferably having longer service time.

  ✓ **Better Process Control** - Modifications of the working procedures, machine-operating instructions and process record keeping in order to run the processes at higher efficiency and with lower waste generation and emissions.

  ✓ **Equipment Modification** - Modification of existing production equipment and utilities, for instance, by the addition of measuring and controlling devices, to run the processes at higher efficiency and lower waste and emission generation rates.

- ✓ **Technology Change** - Replacement of the technology, processing sequence and/or synthesis route, to minimise waste and emission generation during production.

- Recycling
  - ✓ On-site Recovery and Reuse - Reuse of wasted materials in the same process or for another useful application within the industry.
  - ✓ Production of Useful by-product - Modification of the waste generation process in order to transform the wasted material into a material that can be reused or recycled for another application within or outside the company.

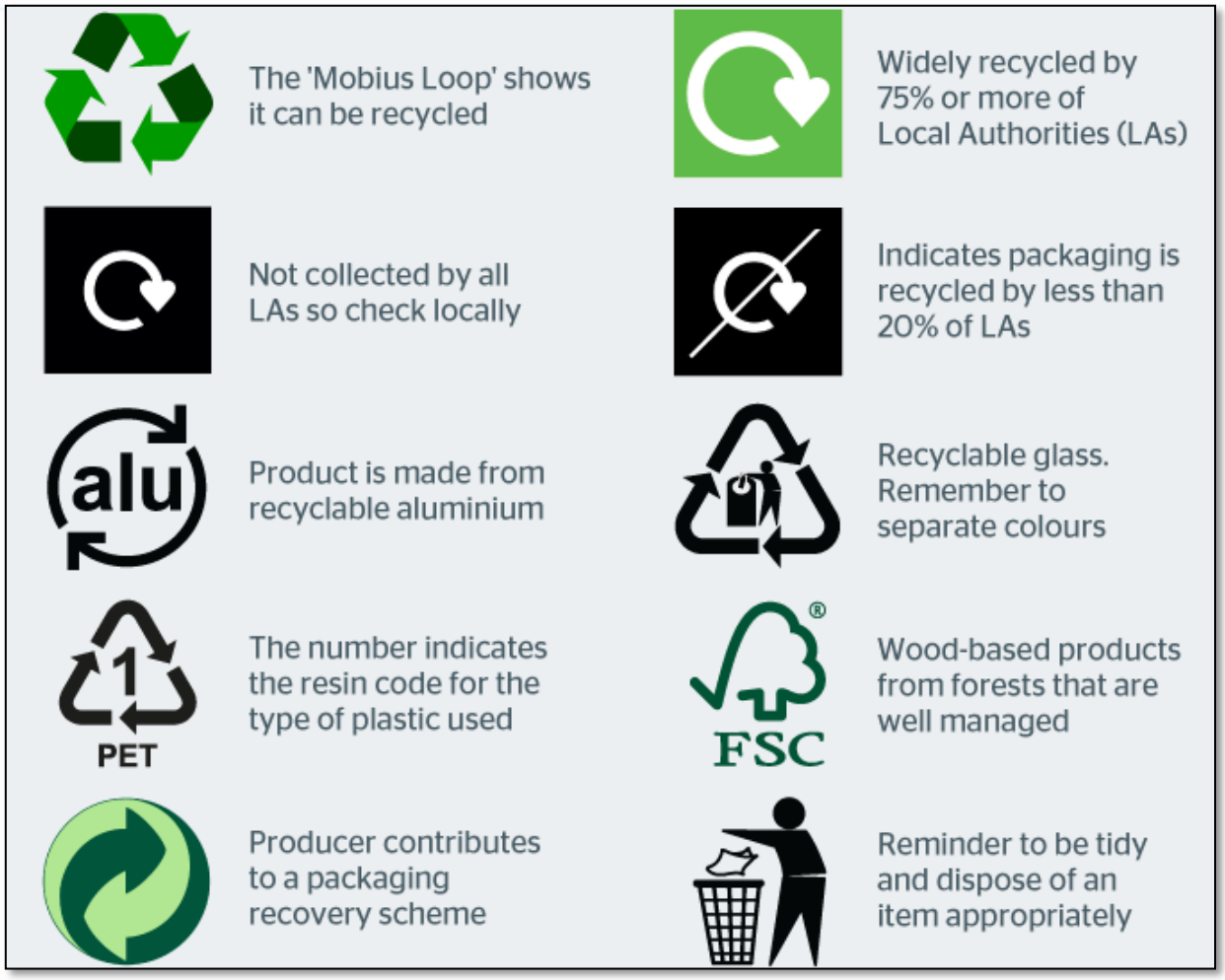


FIGURE 9-4: RECYCLING SYMBOLS

- Product Modification

  Characteristics of the product can be modified to minimise the environmental impacts of its production or those of the product itself during or after its use (disposal).

➢ EV Battery Recycling

Battery recycling is aimed at reducing the number of batteries disposed of as municipal solid waste. It is the best approach to end-of-life management of spent batteries, mainly for environmental, but also for resource conservation and economic reasons. Battery recycling plants require the sorting of batteries according to their chemistry. Some sorting must be done before the batteries arrive at the recycling plant. Nickel–cadmium, nickel–metal hydride, lithium-ion, and lead–acid batteries are placed in designated boxes at the collection point. Battery recyclers claim that if a steady stream of batteries, sorted by chemistry, were made available at no charge, recycling would be profitable. But preparation and transportation add to the cost.

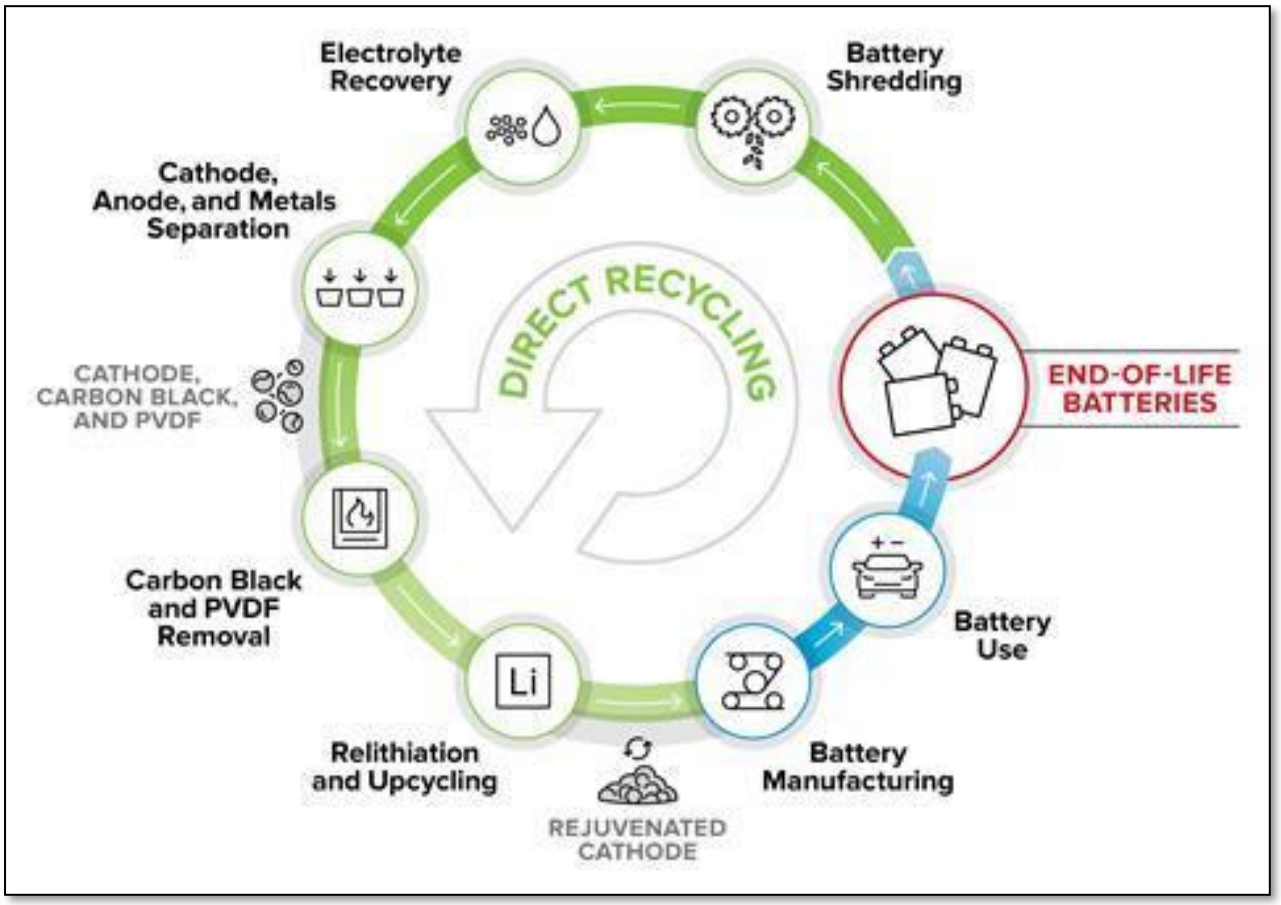


FIGURE 9-5: LITHIUM ION BATTERY RECYCLING PROCESS

- Examples of Battery Reuse and Recycling
  - ✓ **General Motors used-battery electric storage system project with ABB**. Used Chevrolet Volt batteries are helping keep the lights on at the new General Motors (GM) Enterprise Data Centre at GM's Milford Proving Ground in the US state of Michigan.
  - ✓ **BMW used-battery electric storage system project with Bosch**. Electro-mobility and power storage are two core elements of the move to alternative forms of energy. A project is bringing the

German-based multinational engineering and electronics company Bosch together with the BMW Group and Swedish power company Vattenfall to drive progress on both technologies by interconnecting used batteries from electric vehicles to form a large-scale ESS in Hamburg. The energy produced, available within seconds, can help keep the power grid stable.

- ✓ **Renault used-battery project with Power Vault**. Automakers like Renault have introduced a new business model within the framework of battery pack reusability. In this model, the battery pack is leased to the vehicle owner, while actual ownership is retained by the manufacturer. When these battery packs reach the end of their operational life, the automaker replaces them with new battery packs at a fraction of the cost of the actual battery. Two new energy storage units made by Connected Energy of the UK use old Renault electric vehicle batteries and were recently installed at fast-charging stations on highways in Belgium and Germany.
- ✓ **Nissan used-battery ESS project with 4R Energy**. A joint venture between Sumitomo and Nissan called 4R Energy—"4R" stands for "Reuse, Resell, Refabricate, and Recycle"—uses 16 lithium-ion batteries from electric vehicles to help monitor energy fluctuations and store the solar farm's energy output.

10

Useful Resources

10. USEFUL RESOURCES

Issued by	Title of the document	Link
Ministry of Heavy Industries	National Electric Mobility Mission Plan	https://heavyindustries.gov.in/writereaddata/Content/NEMMP2020.pdf
Ministry of Heavy Industries	Faster Adoption and Manufacturing of (Hybrid and) Electric Vehicles Scheme	https://heavyindustries.gov.in/UserView/index?mid=1378
Ministry of Power	Guidelines for EV Charging	https://powermin.gov.in/sites/default/files/webform/notices/Final_Consolidated_EVCI_Guidelines_January_2022_with_ANNEXURES.pdf
Central Electricity Authority	Safety Guidelines for Electric Vehicle Charging Stations	https://cea.nic.in/wp-content/uploads/2020/04/measures_safety_2019-1.pdf
Ministry of Housing and Urban Affairs	Amendments in Model Building Byelaws for Electric Vehicles	https://mohua.gov.in/upload/whatsnew/5c6e472b20d0aGuidelines%20(EVCI).pdf
Niti Aayog	Handbook of Electric Vehicle Charging Infrastructure Implementation	:https://www.niti.gov.in/sites/default/files/2021-08/HandbookforEVChargingInfrastructureImplementation081221.pdf
ARAI	Electric Vehicle Conductive DC charging standard ARAI AS 138 Part 2	https://cea.nic.in/wp-content/uploads/2020/04/arai_138_2.pdf
ARAI	Electric Vehicle Conductive AC charging standard ARAI AS 138 Part 1	https://cea.nic.in/wp-content/uploads/2020/04/arai_138_1.pdf
Niti Aayog, GIZ & IIT Bombay	Fundamentals of EV charging technology and its grid integration	https://www.niti.gov.in/sites/default/files/2021-09/Report1-Fundamentals-ofElectricVehicleChargingTechnology-and-its-Grid-Integration_GIZ-IITB.pdf
Dialogue and Development Commission, Delhi & WRI	Residential EV Charging Guidebook	https://ddc.delhi.gov.in/events/residential-ev-charging-guidebook
NDC Transport Initiative for Asia	EV Charging Guidebook for Shopping Malls	https://www.ndctransportinitiativeforasia.org/resources-list/guidebook-india-shoppingmall-charging
NDC Transport Initiative for Asia	Workplace charging guidebook	https://www.ndctransportinitiativeforasia.org/resources-list/guidebook-india-workplace-charging
USAIDs GTG RISE Initiative	Electric Vehicle Charging Infrastructure and Impacts on Distribution Network	https://indiaesa.info/media/downloadfiles/EV-White-paper-Revised-13-07-2020._190473696.pdf
USAIDs GTG RISE Initiative	Preparing Distribution Utilities for Utility Scale Solar and Electric Vehicles	https://www.nrel.gov/docs/fy20osti/75973.pdf
BSES Delhi	Certificate for Grid Connectivity for EV Charging Stations	https://www.bsesdelhi.com/documents/55701/11987/20035/EVcharging_Certification_format_v2_clean.pdf

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