

Electric Vehicle: Fire Risk Study; Contributors and Way Forward

Soheb Mansoori

Consulting Senior Fire Engineer, Bachelor of Fire Engineering, Dip. Chemical Engineering,
International General Certificate – NEBOSH (Risk Assessor)

Abstract: *Electric Vehicle (EV) revolution is no longer just a vision of tomorrow—it is happening right now, shaping the way we travel, live, and think about sustainability. India is found to be front runner while targeted to be shift from the conventional based transportation to a clean fuel based sustainable future. Electric vehicles (EVs) are powered by a combination of advanced components that work together to deliver efficient, clean transportation. At the core is the electric motor, driven by energy stored in a battery pack, typically lithium - ion. EVs feature regenerative braking systems to recover energy, thermal management systems to prevent overheating, and simplified single - speed transmissions due to the motor's instant torque. Embedded with technologies and monitoring capabilities, is it really hazards are present if so!! Then What are Those? Lithium - ion batteries play a key role in recent advancement of electric vehicle journey from concept to the road where, in the past concern was raised about the Fire safety and reliability of energy storage devices (battery). While energy storage technology is used within industrial practice for the decade possesses limited hazard with design and operational mitigation measures. However, it is learnt from past investigation that battery thermal run away is not only the cause, but there are also associate elements which are crucial for a safe operation. This article is focused on the other aspect of technology, design and vicinity which shall also be focused for a safe existence of Electric Vehicle within the different climate and operating condition like in India.*

Keywords: Electric vehicles, lithium - ion batteries, Heat release rate, safety measures, clean – fuel

1. Introduction

India eyeing a rapid growth and aiming to reliant on 30% of total sale of vehicles to electric vehicles by 2030. While focused on development it is crucial to make it safe for use. With supportive policies, technological advancements, and increasing awareness, India's EV market is poised for significant growth, contributing to global sustainability goals. Where, lack in current infrastructure to manage the demand and suffix challenges associated with it.

Electric Vehicle Risk

Electric vehicle is manufactured with series of components consists of; wiring, electric motors, battery packs, power electric controller, onboard charger, charging port, thermal management system, transmission system, regenerative braking system, auxiliary system etc.

There are listed component which are subjected to failure inclusive of hazard like short circuit which result in ignition and fire. Parallely, Lithium - ion batteries is one key high - risk element, where lithium - ion battery cells, which combine flammable electrolyte and significantly stored energy, can lead to a fire or explosion from a single - point failure.

If a battery cell creates more heat than it can effectively dissipate it can lead to a rapid, uncontrolled release of heat energy, known as 'thermal runaway', that can result in a fire or explosion.

When a battery cell vents or ruptures due to thermal runaway, immediate ignition of the emitted gases can occur. Alternatively, the gases may spread out unignited, with the potential for a deflagration (very rapid combustion) or explosion if an external ignition source is encountered.

Observed Fire Events & Contributing Factor: India

In India, recent electric vehicle (EV) fires, particularly involving two - wheelers, have raised significant safety concerns. These incidents are primarily linked to issues such as battery overheating, poor manufacturing practices, and inadequate testing of EVs under Indian climate conditions. Most fires stem from lithium - ion battery thermal runaway, exacerbated by India's elevated temperatures and rough handling conditions.

The hazard identified are not only design based but also involving the operational deficiency. The habitat risk with electric vehicle weakens operational flexibility and increase in hazard such as catastrophic fire involving radical consequences due to surrounding infrastructure and poor management.





Figure: Fire Event in India

Associate infrastructure such as showroom, charging station, storage area, parking facilities falls short to cater the inherent risk of electric vehicles.

Inappropriate maintenance regime and facilities which are paramount for any technology to make safe and reliant to use.

Consequences: Heat is Risk

International Research found on the internet suggest Medium Cars (1,360 - 1,690kg) gave a mean peak HRR of 6,843kW at 37.2 minutes. Gehandler (2017) [21] quotes Ingason (2015) who found the fire load of modern cars to be between 4 - 8MW. Other recent meta studies find HRR ranges between 1.5 - 8.0 MW, but most medium sized cars have HRR less than 5MW.

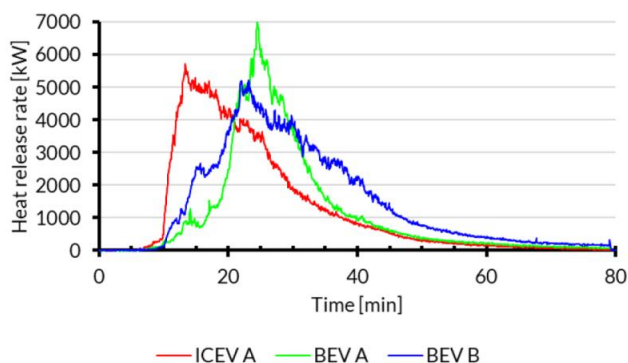
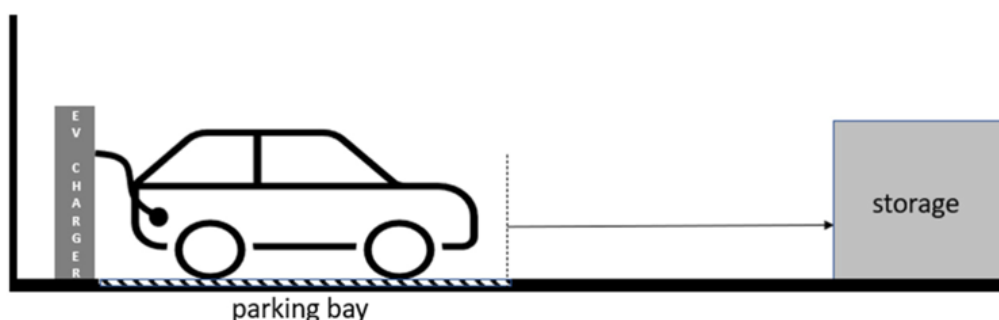


Figure: Heat release rate of a conventional car (red line) and BEVs (blue and green line)

*Reference: Fire tests with lithium - ion battery electric vehicles in road tunnels <https://www.sciencedirect.com/science/article/pii/S0379711222001722?via%3Dihub>

Such amount of rapid release of heat can cause potential consequences not fire involving EV's but easily escalate to surrounding vicinity



Electric Vehicle Growing Technology

Inbuilt design safety and mitigation measure reduce requiring of additional measure and risk from an operational lifecycle standpoint; increase reliability and safety while reducing additional operational cost. Below are key advancement to achieve rigorous safety but not limited to:

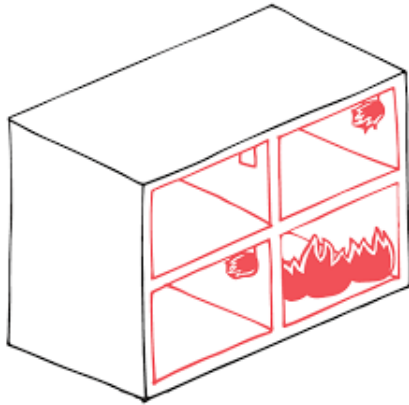
- **Improved Battery Technology and Management:** Advanced thermal management to prevent overheating, especially during high ambient temperatures with software monitoring capabilities such as charging, discharging and temperature.
- **Stringent Manufacturing Standards:** Ensuring a minimal safety standard for all components including wiring, PEC's, charger etc with rigorous testing and quality assurance.
- **Regulatory Oversight:** Implement and enforce strict safety regulations for EV manufacturers. Periodic audits and recalls for non - compliance are essential.
- **Advanced Safety Features:** Implementation of Real time diagnostics and integration of emergency protocol during a detection of faulty condition which can result in thermal runaway.

Safe Vicinity for Electric Vehicles

Infrastructure plays a crucial role in the safety, reliability, and growth of electric vehicles (EVs), particularly in developing and adopting technology nation like India. Key below first principle of fire safety should be incorporated to maintain a safe environment for EV's. To achieve these principles should be implemented in the charging, storage, car park facilities which help to protect people, property and environment:

Separation of EVs Parking Bay: Maintain safe distance from any combustible source will help in managing risk of fire spread.

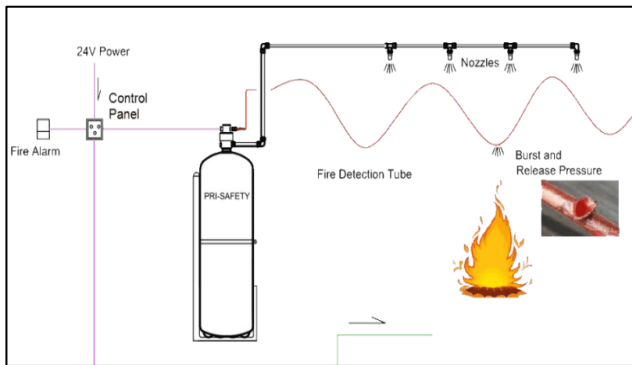
Fire Resistance / Compartmentation: Separation of occupancy where electric vehicles are intended to stored/parked.



Means of Egress: Independent and readily available means of egress.



Fire Protection and Suppression: Installation and maintenance of suppression systems



Firefighting: Readily available Fire service access



2. Conclusion

The increase in number of electric driven vehicles and rapid transition into technologies require a robust integration of design mitigation measures based not only on electrical vehicle but also on associate infrastructure.

The current industry focused on to achieve the market cap with the EV's model attract consumer by comparing disadvantages of conventional fuel - based vehicle with EV's. However, enforcement bodies require to develop the governing laws for quality and safety assurance of EV's manufacturing with coherently developing infrastructure.

Encashment into research and development which focused on opportunity, potentials and challenges associate with EV's where one of the examples is the current standards of the energy storage device (battery) is based on Li - Ion technology, the combustion behavior of which is known to differ to that of conventional fuels, and which is likely to result in more difficult firefighting conditions. Investigations to date have focused on fire tests of individual battery cells or packs and have not been backed up by a full - scale experiment with BEV.

Fire knowledge is still developing, and it is important to keep EV fire research and fire statistics under review.

References

- [1] [https://economictimes.indiatimes.com/industry/renewables/rs - 63 - lakh - volvo - c40 - recharge - electric - suv - goes - up - in - smoke - putting - evs - in - spotlight - again/articleshow/107226580.cms?from=mdr](https://economictimes.indiatimes.com/industry/renewables/rs-63-lakh-volvo-c40-recharge-electric-suv-goes-up-in-smoke-putting-evs-in-spotlight-again/articleshow/107226580.cms?from=mdr)
- [2] *Fire tests with lithium - ion battery electric vehicles in road tunnels* <https://www.sciencedirect.com/science/article/pii/S0379711222001722?via%3Dihub>