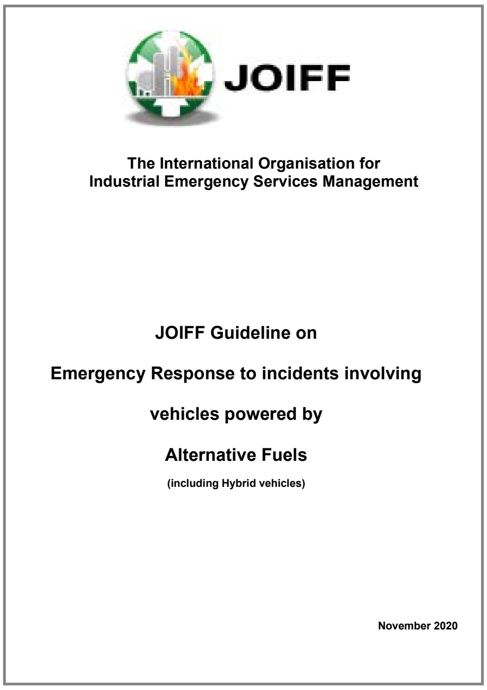
JOIFF Guideline on emergency response to incidents involving vehicles powered by alternative fuels, including hybrid vehicles


JOIFF

The International Organisation for
Industrial Emergency Services Management

JOIFF Guideline on

Emergency Response to incidents involving

vehicles powered by

Alternative Fuels

(including Hybrid vehicles)

November 2020

JOIFF, the International Organisation for Industrial Emergency Services Management, through their shared learning committee, compiled this Guideline to assist emergency services in responding to incidents involving vehicles powered by alternative fuels including hybrid vehicles. JOIFF gave special permission to Fire and Rescue International to publish the Guideline in order to assist our emergency services in dealing with the challenges they face during these incidents.

Due to the length of the Guideline, it will be published in three sections, this being the second section of the guideline.

Section 5: Operational response for fires/incidents involving electrically powered vehicles

Responders to a fire/ incident involving a hybrid or an electrically powered vehicle should be wearing full appropriate personal protective equipment (PPE) including fully charged breathing apparatus.

The following steps are recommended:

5.1 Identify the vehicle

On arrival at the scene, the type or make of vehicle may not be immediately obvious due to the many new types and makes of vehicle now being used. This may increase the time before responders can begin the actions required to mitigate the incident.

To assist in vehicle identification, a comprehensive list of vehicles is available from the European New Car Assessment Programme (NCAP) who, in association with International Association of Fire and Rescue Services (CTIF), have produced a free app called "Euro Rescue". This app, which can be downloaded from Google play and the Apple App Store, contains 'Rescue Sheets and Emergency Response Guides', which can be installed on a mobile device.

5.2 Immobilise the vehicle

Vehicles with electric motors as part of their propulsion, provide no audible indicators and when stationary, it may not be obvious that the engine is still running and it will move as soon as the accelerator is depressed. Electric vehicles should be chocked as soon as possible to prevent any inadvertent movement of the vehicle. Although a good preventative measure, chocking alone may not prevent movement if the drive system is engaged. If possible, setting the emergency brake and placing the vehicle in park can add additional protection against inadvertent movement.

5.3 Disable the vehicle

The status of the vehicle can be determined by viewing the dash display, the position of the key in the ignition and/or the power button to see if the indicator light is lit. If the vehicle is "on", turn the key to the "off" position.

Some electric vehicles operate by a proximity key. If the proximity key is within range of the vehicle - usually less than five metres (16 feet) - the vehicle is powered "on" by a button on the dash. Turn the vehicle "off" by pressing this button. Then, place the proximity key beyond the range of the vehicle, typically greater than five metres (16 feet), in a safe location in the event that it may be required to restart the vehicle if the fire is quickly extinguished.

5.4 Extrication considerations
When the vehicle is immobilised and disabled, vehicle extrication can commence. Always stabilise the vehicle before beginning extrication.

A damaged high voltage battery may emit corrosive, toxic and flammable fumes so responders should use ventilation techniques to protect the occupants of the vehicle and prevent the build-up of toxic and flammable vapours in the passenger compartment. If toxic and/or flammable vapours are present in the vicinity of persons trapped, it may be considered necessary to supply them with a means of breathing protection, preferably a self-contained breathing apparatus or an external supply of air with a full face mask with a suitable filter. In this condition, responders with charged attack lines should be in close proximity to take whatever steps may be necessary to protect personnel.

Caution must be taken when using conventional extrication techniques as they may cause damage to the vehicle's battery fuel cells. Manufacturers usually route fuel pipes and high voltage cabling in electric vehicles in protected areas under the vehicle or within the vehicle panels.

Responders should constantly monitor for indications that a damaged battery may be overheating, eg sparking, emitting smoke, or making bubbling sounds, and deal with any fires due to these conditions.

5.5 Extinguishment considerations
5.5.1 Li-ion batteries
When a li-ion battery ignites, it can produce large emissions of what appears to be white smoke, which will be the first sign of a thermal runaway event. The smoke is likely to be flammable and toxic and it may ignite at any time. If a fire develops and visible flames appear, a decision should be made as to whether to attempt to suppress the fire or to concentrate on protecting exposures and surrounding materials and allow the battery to burn until it self-extinguishes. If the fire is allowed to burn itself out the chemicals released will be consumed by the fire and the remains of the battery may contain considerable amounts of Lithium hydroxide, a corrosive liquid.

As a fire progresses, gasses venting from cells can exceed 600°C (1 110°F) and can include violent eruptions as some types of cells will hold the pressure in the casing for some time and when the outer casing fails it will vent the gasses. If the gasses collect in an inside space, eg vehicle passenger compartment, luggage hold, boat/ship, warehouse, garage, energy storage system etc a powerful gas explosion may occur with battery debris. If there is high risk of explosion, evacuation to a safe distance may need to be necessary.

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- Vented electrolyte is flammable and may ignite on contact with an ignition source such as an open flame, spark, a sufficiently heated surface or contact with cells undergoing a thermal runaway reaction.

Always take into account that ignition of vented electrolyte in an enclosed space may lead to an explosion.

In an explosive atmosphere, if the jet fumes are already ignited, they should be allowed to burn if it is safely possible to do so, whilst ventilating and cooling continually until the temperature of the battery cools down.

The process of failure of a li-ion battery results in some very toxic chemicals and they can mix with fire water to penetrate the ground and go into the ground water which can lead to environmental damage.

5.5.2 Extinguishment

Extinguishing a fire in a li-ion battery can take a prolonged period. If water is the chosen medium to deal with the incident, it is likely that it will be necessary to establish a sustained water supply through a hydrant or static water source. A high voltage battery fire could require 12 000 litres (2 600 gallons) of water or more, depending on the size and location of the battery.

Because high voltage batteries are in protective cases, it is difficult to get any extinguishing agent directly onto the burning cells. Cells have limited ability to transfer heat to their nearest neighbours so if possible, the aim should be to remove heat from between the cells. The application of large volumes of water may cool the high voltage battery sufficiently to prevent the propagation of fire to adjacent cells and continuous application of water on a localised area of the battery for a prolonged period of time before moving to another section of the battery, may provide for quicker extinguishment.

To properly cool a high voltage battery pack and prevent/reduce the risk of re-ignition, continue to apply water even after visible flame is no longer present.

Lack of barriers between cells in some batteries can result in a deep seated and inaccessible fire, which in practice, would require the use of more water to cool and contain the fire. The use of copious amounts of water potentially introduces the unwanted effect of shorting out other cells, thereby perpetuating the fire.

Periodically check for signs of heat using a thermal imaging camera.

5.5.3 Extinguishing media

Water or other standard agents such as dry powder, CO_2 and Foam can be used to fight fires in electric vehicles when the batteries are not involved. When the batteries are involved, dry powder, CO_2 and foam may extinguish the flames but they will not stop thermal runaway so water by itself or with salt and/or certain additives may be the most suitable medium for dealing with fires involving li-ion batteries.

Under certain conditions, isolating the damaged vehicle by immersing it in a container filled with water at the incident location or a spot nearby where it causes no blockage or risk may have to be considered.

Immersing a battery in water only cools it down and so may stop a thermal runaway but because the water does nothing to reduce the amount of energy in the battery, this energy may restart a thermal runaway in an unstable pack.

Salt water drains the battery of its energy, as the energy is used for electrolysis of the salt (NaCl), so using salt water is the easiest way to take the energy out of a pack so that reignition can no longer take place. Salt water does not have to be sea water, it can be water mixed with road or kitchen salt.

Note

At the time of writing this Guideline, reports were received of ongoing testing by vehicle manufacturers on whether the use of a water/additive cutting lance will be of use in firefighting operations to permit quick access to the cell/module via the floor pan of the vehicle from the passenger compartment, in order to extinguish and prevent thermal runaway. It has been reported that during testing there has not been any electrical conductivity recorded to the user of the lance.

5.5.4 High voltage hazards

During all phases of any response to incidents including during the overhaul phase, responders should avoid contact with any high voltage component until they are neutralised.
Until the battery has been deenergised, responders should not attempt to cut, breach or remove the high voltage battery or any high voltage component nor drive prying tools into any area that may house or cover high voltage components as this could pose risk from severe shock/injury/electrocution.

Under normal conditions of use, high voltage batteries, cables and the electric motor do not pose an electrical hazard as reputable manufacturers incorporate safeguards to help ensure that a high voltage battery and cables are kept safe and secure during expected conditions of use. However, if the outer enclosure, pod/module enclosures and/or safety circuits of a high voltage battery and cables have been damaged, a significant risk of high voltage that can cause injury or death is likely to exist and appropriate precautions should be taken against exposure to the risk.

Responders should avoid contact with any electrical cables and components that have high voltage warning labels.

Warning labels may have been burnt by the fire or been rendered illegible in other ways, so standard operating procedures (SOPs)/standard operating guidelines (SOGs) should be that responders should not touch any electric drive or drive system component nor should they attempt to breach (open up) a high voltage battery or its casing for any reason.

Batteries in some electric vehicles are located relatively inaccessibly between the vehicle's under carriage and passenger compartment where it can be difficult, if not impossible, to access to apply water.

Cutting holes in the vehicle floor to expose the battery can be dangerous as the fire may spread quicker, causing damage and beginning the thermal runaway process in more of the cells. Also, there is the extreme hazard of cutting into areas of the vehicle where high voltage still remains.

Many high voltage components are directly accessible from the engine compartment. Responders should not attempt to force entry into the engine compartment nor should they attempt to spike or cut the bonnet (hood) or wheel guards (fenders) with a piercing nozzle, cutting tool or prying tool due to the risk of severe shock or electrocution. If responders are unable to gain access to the engine compartment/electric motor, fire suppression tactics should be employed until the fire is completely extinguished.

5.5.5 Using portable fire extinguishers on fires involving Lithium batteries

Lithium batteries can be primary or secondary (see Clause 3.2). Fires involving primary Lithium batteries are classified as Class D Metal Fires. Portable fire extinguishers designed to deal with incipient Class D fires in primary cells contain specialist dry powders that fuse the powder to form a crust, which excludes the oxygen from the surface of the molten metal. A specific agent is added to the powder to prevent it sinking into the surface of the molten metal.

Using a portable fire extinguisher on a fire involving li-ion batteries can be extremely hazardous. Li-ion batteries do not contain any metallic Lithium therefore a Class D extinguishing medium will not be successful in extinguishing a fire in these batteries. Standard dry powders are not effective on fires involving li-ion batteries and foam or CO_2 will have limited cooling effect, will not stop thermal runaway and may cause a chemical reaction.
Some manufacturers of portable fire extinguishers recommend extinguishment by using a portable fire extinguisher with water mist mixed with certain chemical additives but applying small amounts of water on such fires can result in release of toxic and flammable gasses.

If the fire is a small fire, it may be advisable to let the fire burn out by itself. The recommended method of dealing with a fire involving a small battery, is to submerge the battery in water.

Portable fire extinguishers are designed to be used primarily on incipient fires and they have limited capacity. Anyone expected to use a portable fire extinguisher on a fire involving batteries should be given suitable training as such fires can escalate very quickly and can burn at high temperatures.

If attempts to extinguish a fire involving a battery with a portable fire extinguisher have not been successful, personnel should rapidly distance themselves from the scene.

5.6 Overhaul (post fire/incident) operations

Responders dealing with overhaul should wear full appropriate personal protective equipment (PPE) including fully charged breathing apparatus due to the dangers of re-ignition and/or release of gasses and particles that contain toxins and carcinogens during the overhaul process.

Following firefighting operations, responders should verify that the vehicle has been properly immobilised and disabled and if these tasks have not already been completed, the appropriate steps should be taken to do so.

Li-ion batteries involved in a fire could reignite after extinguishment anywhere from several hours to a day or more following extinguishment. Re-ignition of fire in a high voltage battery pack is typically accompanied by "whooshing" or "popping" sounds, followed by off-gassing of white smoke and/or electrical arcs/sparks which causes the re-ignition and responders should carefully observe the high voltage battery compartment to ensure it is not emitting smoke, sparking or making bubbling sounds.

Be aware that if the battery pack contains cylindrical cells and it has been opened due to the incident, cells that will catch fire may be ejected for some distance, causing personal injury to responders and secondary fires.

Using a thermal imaging camera to assess the temperature of the battery will assist in determining if it is producing heat.

After a fire, a battery module or system may contain intact cells that still have DC voltage, meaning there is a persisting electrical hazard due to stranded energy. Responders should not try to discharge batteries; this is a specialised task and under appropriate conditions, specialists can test, handle and remove the battery's energised li-ion cells and/or drain the amount of energy trapped in the unstable battery. Contact the manufacturer's representative for assistance in de-energising a high voltage battery and to determine the final disposition and storage of the vehicle.

5.7 Removal of a vehicle with an unstable battery pack

When it is considered that the overhaul is completed and the vehicle is in a condition to be removed from the incident site, the vehicle should be recovered and transported to a safe location where it can be monitored until it is verified that the battery has been de-energised. Some manufacturers recommend de-energising damaged batteries by submerging them for several days in a saltwater bath until the bubbles stop, indicating that the chemical reaction inside the battery has ceased. Transporting a damaged electrically powered vehicle with an unstable battery pack immersed in water will result in an unstable recovery vehicle so it may have to remain at the scene of the incident for several days.

Removal should be on a flatbed truck and if this is not possible, it should be towed with its drive wheels off the ground; for some vehicles, towing with drive wheels on the ground poses a risk of fire in the high voltage electrical system.

If at the scene of the incident, the battery pack does not actually burn and if it is safe to do so, it may be possible to transport the container in a dry state under a fire blanket to a suitable location where the container can be filled with water and the battery pack submerged as soon as it has been unloaded.

The National Fire Protection Association (USA) recommends that vehicles containing a damaged or burned li-ion battery should not be stored in or within 15 metres (50 feet) of a structure or other vehicle until the battery can be discharged.

Next edition

The next edition will feature Section 6, which deals with Hydrogen powered vehicles, Section 7, which features gaseous fuel vehicles, Section 8, which focusses on training, insurance and media; Section 9 (Appendix 1), which shares useful sources of information and Section 10 (Appendix 2), which focusses on ISO 17840.

Visit the JOIFF web site for information on membership: www.joiff.com or watch their introductory video: https://www.youtube.com/watch?v=lkzpYzrSHf4.

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