I.
Characteristic

1) Road vehicles with an electric drive use pure electricity ("EV" electric vehicles) or a combination of it with an internal classic engine - a hybrid vehicles ("EV-H"). Traction batteries are currently most often made of lithium cells. They can be damaged by mechanical, electrical or thermal stress. The more charged the cells are, the greater the risk of a fire and the release of a large amount of energy in a fire.
2) Traction batteries, electric drive and charging systems of vehicles, work with life-threatening voltage, these are commonly referred to as "HV part" - high voltage part of the vehicle. Most often, their voltage ranges from 400 V to 800 V, but thanks to the galvanic separation, the potential against the ground is zero, so it can be extinguished as a device without voltage. This is different if the vehicle is connected to an external power source (via a charging cable), as the external power source does not need to be galvanically isolated from ground. In this case, it is necessary to take into account a higher risk of electric shock, just as when extinguishing any electrical appliance connected to the distribution of the public voltage network (up to 400 V).

II.
Tasks and activity procedure

3) When affecting vehicles with an electric drive, it is in addition to standard procedures for extinguishing or rescuing and rescuing people, it is necessary to determine the type of drive of the vehicle, deactivate the HV part of the vehicle and determine any damage to the traction battery. To significantly reduce the risk of electric shock, it is necessary to disconnect the charging station and disconnect the vehicle connected to it. The vehicle must always be provided against movement. It is always necessary to take into account the possibility of sudden ignition of the battery.
4) Electric vehicles can be identified by:
   a) when receiving an emergency call: by extracting the caller, using data from the E-Call system, lustration according to the registration number with the assistance of the Police;
   b) by to the factory marking, "EL", marking with a pictogram, etc.;
   c) the presence of a charging connector;
   d) due to the absence of a device for removing fumes from the combustion engine (exhaust);
   e) according to the markings in the engine compartment: labels, signs, orange cables and connectors;
   f) according to markings in the interior: inscriptions, dashboard indicators, "B" shift mode, etc.;
   g) using applications for vehicle identification, e.g. "Euro RESCUE“.
5) HV part can be deactivate:
   a) automatically, e.g. after activating the airbags;

b) by disconnecting the 12V battery – in a passenger vehicle it may lead to the deactivation of the HV part, but this is not ensured by all manufacturers;
c) by disconnecting the service connectors intended for disconnecting the HV part;
d) by disconnecting the marked fuses in the vehicle's fuse box;
e) by cutting the marked loops intended to disconnect the HV part of the vehicle.

6) One of the above options is sufficient to disconnect the HV part of the vehicle. Life-threatening voltage will still be inside the battery case and in the capacitor circuit of the HV part, which discharges gradually. It is therefore always necessary to approach the HV part as if it were live.

7) Due to the possibility of ignition of a damaged vehicle traction battery, the priority is to detect such damage, secure the vehicle and its surroundings, or carry out its transport from the interior spaces of the objects to the open space or spaces designated for this purpose and thereby exclude the occurrence of further damage.

8) In passenger EVs, traction batteries are most often located in the chassis part under the floor of the vehicle and in the area of the central tunnel. For the EV-H, in the space under or behind the rear seats, under the luggage compartment, or in the chassis part near the rear axle. On a bus, a common place to store batteries is the roof. For trucks, it is the chassis part and the space behind the cabin.

9) Through research, we find out (for the traction battery):
   a) mechanical damage;
   b) audible hissing, cracking;
   c) outflow of liquids;
   d) heating;
   e) smoke generation.

III.
Water jet cooling

10) If smoke is emitted from the traction battery, or if there is an observed increase in temperature, or if the temperature exceeds 80°C (on the cover) or more, this is an immediate threat and it is necessary to start stabilizing it by cooling, ideally from several sides. The goal is to cool the battery down to ambient temperature. We apply water inside the battery or on its metal cover for about 10 minutes. Then we monitor the battery status for about 5 minutes. If the battery heats up on its own or smokes from it, repeat the cooling for another 10 minutes (we repeat this until the temperature drops).

11) After the battery has successfully cooled down, we will wait another min. 45 minutes in place and we monitor the battery to see if it re-heats itself or if smoke is produced. We use a thermal camera, non-contact thermometer, etc. to monitor the battery status.

IV.
Vehicle fire

12) We extinguish the fire of a vehicle connected to the charger as a live device, until it is disconnected from the charging station. If the vehicle is not connected to the charging station, it is possible to choose water and other suitable extinguishing agents for extinguishing.

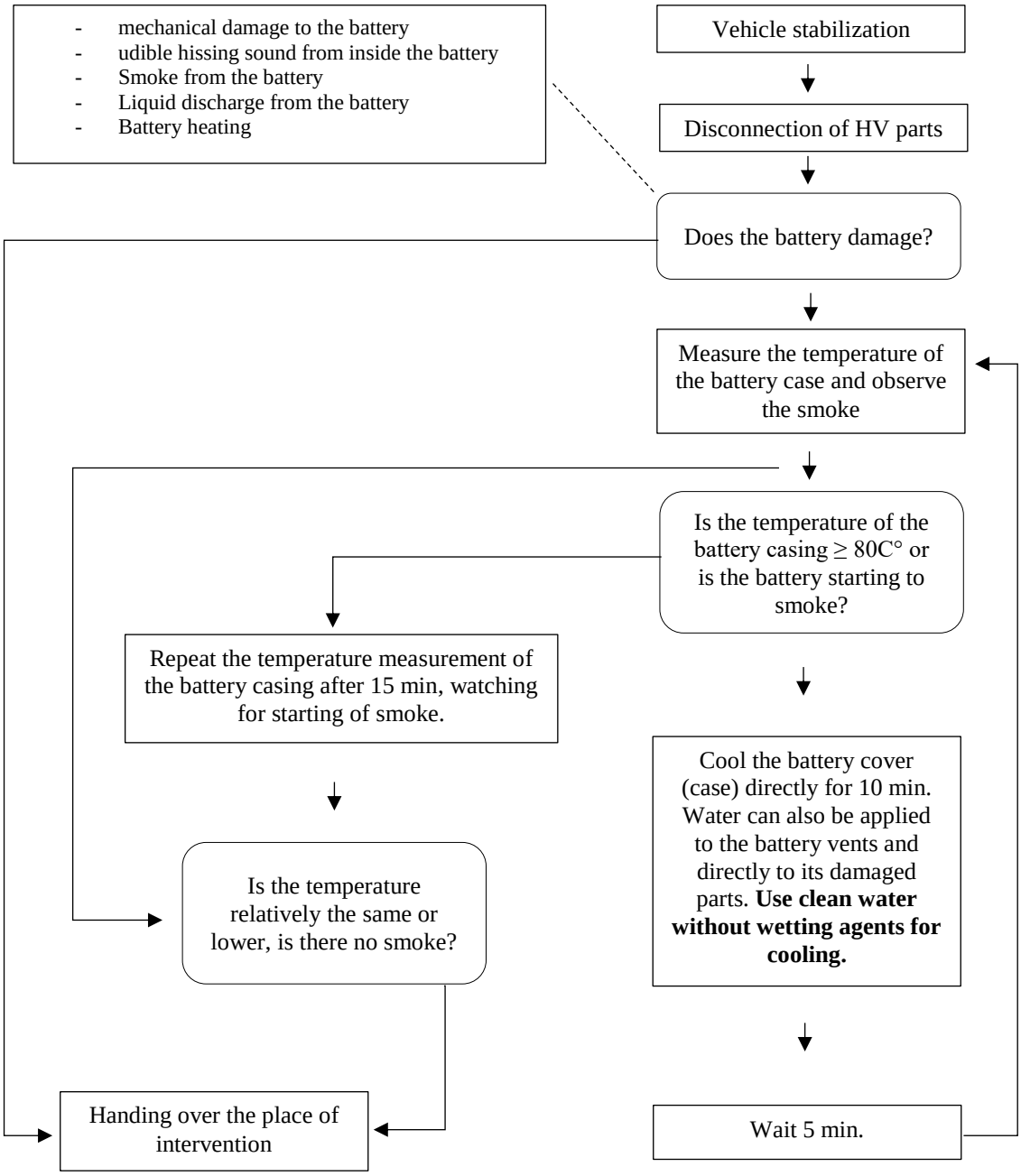
13) In the event of a traction battery catching fire, it is necessary to apply a fire extinguisher to the inner part of the battery for effective extinguishing. At the same time, we choose the place of entry according to the manufacturer's recommendations or in the part of the battery

that is most damaged by fire. When extinguishing a traction battery using a device for extinguishing and cutting with a water jet (Cold Cut System) or other suitable equipment, it is necessary to take into account the possibility of the spread of the burning reaction to other cells as a result of their mechanical damage. Due to the increased risk, it is necessary to protect the firefighter who intervenes with a fuse C current.

14) After extinguishing the fire of the electric vehicle, we check the temperature of the traction battery (with a thermal camera) and, if necessary, stabilize it by cooling it with water using the following methods:
    a) water jet cooling, see Article III. and the algorithm below;
    b) cooling in a water bath (e.g. in KHP+E) see an article V.

15) In cases where it is not possible to use the above-mentioned cooling method effectively and the traction battery catches fire again and the spread of the fire outside the affected vehicle can be prevented, it is possible to let the traction battery burn out. Subsequently, it is possible to hand over the place of intervention. In order to prevent the creation of an explosive atmosphere, it is necessary to create conditions for the escape of gases from closed parts of the vehicle (interior, luggage compartments, etc.), e.g. by opening covers, doors, windows, etc.

16) After the battery has been successfully extinguished and cooled down, we will wait another min. 45 minutes on site and we monitor the battery. If there is no self-heating or smoke generation, the place of intervention can be handed over according to Article VI.



Algorithm for cooling the traction battery with a water stream

V.
Cooling in a water bath

17) To cool the traction batteries in the water bath, we use KHP+E, or another specially designed or improvised device (hereinafter referred to as the "container"). We set up the container in an open space with the assumption that it will be set up for several days.

18) Before submerging a passenger vehicle, it is necessary to create conditions for the escape of gases from closed parts of the vehicle (interior, luggage compartments, etc.) in order to prevent the creation of an explosive atmosphere by opening covers, windows, etc.

19) The passenger vehicle can be pushed or pulled into the container using a winch, or stored from above with the help of a car crane, hydraulic arm, etc. The container is filled in such a way that the battery, including its upper part, is flooded.

20) The vehicle is left in the water for as long as necessary, until the self-heating and evolution of gases from the battery (microbubbling) stops. After these phenomena cease, the vehicle can be removed.

21) Contaminated cooling water from the water container is handed over directly to a professional entity for disposal. The costs for this liquidation can be applied as part of the payments to the relevant insurance company, or the owner of the vehicle takes care of this directly

VI.
Handing over the place of intervention

22) As part of handing over the scene of an intervention after a fire, the intervention commander will consider ordering the following measures aimed at eliminating the risk of a fire reoccurrence:

   a) park the vehicle with an electric drive in an open area min. 5 meters from building structures, flammable materials and ensure continuous supervision for min. 48 hours or

   b) park the vehicle with an electric drive in an open area min. 15 meters from building structures and combustible materials for a period of min. 48 hours (without the need for continuous supervision), or

   c) installation in equipment, means for cooling, or spaces designated for this purpose (e.g. quarantine places in services, warehouses, production, etc.) under conditions determined, e.g., by operating rules, instructions for use, etc.

VII.
Other recommendations

23) When handling the vehicle or extricating it, we always choose such a procedure that the "HV" part and its components are not disturbed or mechanically stressed in any way. It is forbidden to cut the "HV" cables of the distribution outside the marked loops, otherwise it can lead to the destruction of the jaws of the tool, to electric shock and to the occurrence of fire.

24) When a vehicle with an electric drive sinks below the surface of the water (e.g. as a result of an accident), we can additionally identify the vehicle by the evolution of gases observable in the immediate vicinity and above the submerged vehicle. If there is a violent reaction (violation of the integrity of the battery, the development of smoke above the water level, etc.), it is necessary to pull out the vehicle and wait until the reaction stops.

25) When working in water, it is recommended to use dry suits equipped with dry gloves, use full-face masks when deploying a diving group.

26) After pulling the vehicle with an electric drive out of the water, it may catch fire, therefore it is necessary to choose the parking place of the vehicle appropriately and to secure it in advance. Alternatively, prepare a suitable means, e.g. KHP+E, into which the vehicle can be safely parked.

27) The above-mentioned procedures can be used even if the object of the intervention is also other equipment containing lithium batteries, or individual lithium cells and their assemblies, occurring during the intervention, for example, in service centers, warehouses, or production facilities. Here, it is also possible to use spaces (quarantine places) and special means (special boxes, containers, etc.) intended for setting up, storing or cooling damaged devices for intervention and the batteries themselves. Fires of e.g. e-bikes, e-scooters, etc. can be solved in a similar way.

28) Due to the high toxicity and flammability of the products of thermal decomposition of traction battery cells, especially in the event of their fire or overheating, it is mandatory to use insulating breathing apparatus and tactical procedures for intervention in the presence of flammable gases and vapors. The recommendation also applies in cases where, due to the circumstances, a sudden violent ignition of the traction battery with destruction of the package can be expected (traffic accident, etc.)

VIII.
Expected peculiarities

29) The following complications must be considered during the intervention:

a) incorrect or missing indication of the type of drive of the vehicle;
b) spontaneous movement of the vehicle;
c) poorly accessible 12V battery or elements for disconnecting the HV part;
d) the possibility of a sudden ignition of the traction battery;
e) possibility of electric shock;
f) total higher weight of the vehicle;
g) poorly marked or inaccessible charger switch;
h) jammed or locked charger connector in the vehicle socket;
i) development of toxic combustion products or flammable gases;
j) re-ignited after extinguishing and cooling;
k) higher consumption of water and breathing apparatus;
l) flying off burning or overheated (500 °C) cells and their parts;
m) firefighting and cooling waters are strongly alkaline;
n) leakage of a large amount of electrolyte;
o) due to the contamination of emergency clothing with dangerous substances, carry out their decontamination in a wet form;
p) for the renewal of closed spaces (especially garages), it is necessary to carry out air monitoring;
q) discharge of contaminated firefighting water;
r) splashing of the interveners with contaminated water;
s) technically demanding handling of a vehicle wreck