Safety Aspects for the Transport of Alternative Powered Vehicles on RORO Ferries

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Abstract

Within the efforts to cope with the climate change problem more and more vehicles powered with alternative fuels, as for instance compressed natural gas or autogas, are on the market. Beside there is a boom of electric cars. Therefore, such vehicles are increasingly transported in the usual ferry traffic on Roll-on Roll-of (RORO) ships. In addition, ferry boat users start to ask for the possibility to charge their E-cars during the voyage. With this background new concepts have to be developed to ensure a safe transport of alternative powered vehicles on car decks of RORO-ships, especially according to early detection of dangerous situations and firefighting provisions. The technical and organizational preconditions for a safe charging have to be identified. This article summarizes the results of the ALBERO research project, that dealt with these topics.

Keywords: alternative powered vehicles, electric cars, ferry transport, gas detection, charging on board

Introduction

Ferries have been transporting vehicles across seas for decades. The surrounding on board a ship differs from the typical state on shore: Movements and permanent vibrations are acting to the transported cars. The humid and salty conditions imply special challenges to materials. Because of the construction of steel there are other circumstances in connection with dangers from electric current. The new mixture of car types including alternative powered vehicles requires a rethinking and adapting of the safety concepts on board. There is also a new challenge that ferry companies have to face: passengers want to use the transit time to charge their electric cars. The project ALBERO identified the special conditions at a ferry boat and developed concepts for a safe transport and charging.

Presorting and positioning concept

The different kinds of alternative powered cars require adapted safety measures. Especially there are differences between cars with alternative gaseous fuels and electric cars. An important precondition to act in an effective way would be to know the actual situation of transported cars for each ferry departure. It will be a basic recommendation of the ALBERO project to record the type of car already during the booking process. This would give an important overview to the ships command about the situation on board.

If the safety measures differ it could be meaningful to establish a parking system on the ferry which contains dedicated parking positions for the different kinds of alternative cars. One possibility would be to place such cars at dedicated positions on board where the special hazards could be handled more easily, for instance on open deck to have a permanent natural ventilation for gas driven cars. The other possibility would be to equip special parking positions with adapted early detection, ventilation and firefighting systems.

So far, it is not possible for the ferry loading guides to recognize the kind of car while just passing by. So, it will be another recommendation of the ALBERRO's consortium to have a permanent labelling, e.g. at the licence plate, where the kind of alternative powered car can be identified within seconds. As long as such solutions are not established, it could be necessary to pre-sort the different kinds of cars in separated lanes already in the port area to ensure a quick loading of the ferry decks, if dedicated parking positions or safety measures should be used. Another possibility would be the clearly visible identification of the type of car, e.g. by an inserted sign behind the windshield.

Special hazards on Board

Gas powered cars:

Some shore based good working safety measures are partially counterproductive on board. Gas powered cars are equipped with safety valves which open at a set overpressure and release gas to avoid the tank`s rupture. If that happens at a closed car deck of a ferry, it could cause a risk of explosion. While the land-based fire brigade can adapt its extinguishing agents and equipment to the type of fire, there is no choice at a car deck - it is only equipped with a water-based sprinkler system.

Electric cars:

According to the statistics so far electric cars do not burn more often than conventional cars [1], [2], but the effects of such a fire are different:

- The electric car fire is more difficult to extinguish. Therefore, the fire lasts longer and the danger of spreading to surroundings is higher. This is especially true for the narrow parking situation during a fully booked voyage.
- This time, large quantities of water are recommended for extinguishing electric vehicles – onboard of ships this could cause problems concerning the stability of the vessel. Another aspect is the use of salty seawater for the water extinguishing systems on a ferry. Is it a good idea to apply that to electric cars? – a question which should be investigated in detail.
- There is a high risk of re-ignition even hours after the fire was put out. To avoid this, the water cooling should be continued even after the fire had been extinguished. On shore electric cars more and more are transferred into a water-filled container after a fire to prevent re-ignition – a method which is not practicable on board.
- If there is an accident on land the damaged car could be isolated from other cars just by moving away the cars nearby. Usually it would not be possible to separate the incident car, which is another reason for the higher risk of spreading of the fire.
- Toxic and corrosive gases can be released which are different from typical fume gases [3]. Firefighting crew possibly would need special protective equipment to approach to a gassing or burning electric car.

Fig. 1. Narrow parking situation at a closed ferry car deck.

Adapted safety measures

Gas powered cars:

The common gases to power a car are today Compressed Natural Gas (CNG) or Liquefied Natural Gas (LNG), which means in both cases methane, once as a compressed gas and once as a deep cold liquid. Also, autogas or LPG (Liquefied Petrol Gas) is used – a mixture of propane and butane. These gases can be detected well with conventional gas sensors.

Nevertheless, the early detection of explosive gases is a special challenge at a ferry car deck because at least during the loading and unloading of the ferry there is a mixture of exhaust gases from the cars entering or leaving the ferry deck, which overlaps the gases to be measured. During the voyage an air exchange rate of 10 per hour is required by the international maritime regulations [4]. To ensure an early measurement under this conditions either the entire car deck would have to be equipped with appropriate detection points at close intervals, which is a quite expensive variant or there are only some special positions for gas powered cars, so that the gas detector or a suction point of a sample extraction smoke system can be installed quite close to the vehicle. A third option would be to design the detection system as a mobile version, so that it could be moved into the vicinity of the gas car. An additional challenge for all safety systems is that up to a height of 45 cm above the deck floor all permanently installed electrical systems on a closed vehicle deck must be explosion-proof.

If there is a gas alarm a suitable measure could be the start of an enhanced artificial ventilation of the parking slot with the gas-powered car. In addition, the extinguishing systems should be adapted to gas fires.

Electric cars:

The main hazard deriving from electric cars is a thermal runaway of the battery resulting in a fire [5]. It would be meaningful to detect as early as possible a faulty state of the battery. First ALBERO-tests to use possible signs as for instance released gases or enhanced temperatures as base of a prewarning detection showed that it would be necessary to be very close to the cars underfloor to measure warning signals in time. It could be a better solution to use the communication between battery and battery management system of the car to give an acoustic or optical alarm of a critical battery state in time – an idea which has to be discussed with the car's manufacturers.

To prevent the spreading of an (electric car) fire it could be helpful to install separating walls. If there is a dedicated parking concept, these walls could be installed as fixed parts of the ships structure.

Otherwise, there could be mobile devices on board to separate the burning car from the surrounding in case of an emergency. This could be done manually or semi-automatically.

As long as there is no better extinguishing agent than a lot of water, electric cars should only be transported on decks above the waterline so that in case of a fire a quick drain of the water is always guaranteed.

Within the ALBERO project a mobile water spray device was developed which could be placed next to or under the car. It could be connected via a default firehose to the ships hydrant system. The idea is to bring the water closer to the Li-ion battery, which is in general placed at the car's underbody. So, the cooling could be more effective than by simply using the sprinkler nozzles at the ceiling.

Charging during voyage

Most ferry companies do not offer the possibility of charging during the voyage because of safety concerns. Others cancelled the offer after accidents during charging on board have occurred. Most of them were caused by using wrong cables [6] or by simply connecting the car with a plug for reefer trucks.

The first question to ask when thinking about charging during the voyage is how the current on board of the vessel is produced. Most ferries still run with fossil fuels, e.g. marine diesel. The charging of an electric car on board would only be ecologically, if the ship itself uses an alternative "green" propulsion, which is up to come.

Charging points on car decks have to fulfil some special aspects. They have been summarized in the ALBERO project in a catalogue of requirements. Important points are for instance:

- compatibility with the ships power grid: Most ships have other parameters for their power grids (440V, 60 Hz) than the typical household grid has (400 V, 50 Hz). It is not analysed so far, if conventional charging points can deal with that in a safe way. In addition, many ships have a different principle of grounding the power grid, for which conventional land charging stations are not designed.
- stable performance despite permanent ships movement and vibration
- protection class according to the ship's conditions
- explosion proof in special areas

So far, no standard charging point fulfils all of these requirements.

The ALBERO research project

“ALBERO” stands short for the german project title “Transport alternativ betriebener Fahrzeuge auf RORO-Fährschiffen”. The research project was funded by the German Government (Bundesministerium für Bildung und Forschung) and will run until End of 2021. Partners in the project are

- Institut für Sicherheitstechnik / Schiffssicherheit e.V. (scientific and administrative coordination)
- Fraunhofer Institut für Kommunikation, Informationsverarbeitung und Ergonomie
- Hochschule Bonn-Rhein-Sieg
- Forschungsinstitut für Kraftfahrwesen und Fahrzeugmotoren Stuttgart
- GTE Industrieelektronik GmbH
- Lloyds Register.

Among others the project is accompanied by the three ferry companies Scandlines, TT-Lines and STENA Lines and the Bundesminsterium für Verkehr und digitale Infrastruktur.

More information can be found on the website www.alberoprojekt.de

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