EXECUTIVE SUMMARY

METHODOLOGY OF BEST PRACTICES

1 INTRODUCTION

With the introduction of recent technologies in the automotive industry, there has been an increase in the number of electric vehicles (EVs) being manufactured. Within the past 10 years, EV sales went from an estimated 100,000 to 6,750,000 with a 108 percent increase from 2020 to 2021 alone. It is projected to increase within the next 10 years (Irle, 2021).

EVs have become an area of focus for the maritime industry as there have been increased fire incidents on vessels transporting these vehicles. It has been identified that there is a need for a collective best practice set. As a result, on April 27 and 28, 2022, ABS hosted virtual workshops where representatives with experience in the transport of these vehicles were invited to participate and share their experiences and best practices. Attendees in the workshops represented car manufacturers, shipowners, ship operators, flag States, P&I Clubs and independent consultants. To help focus the discussion and drive the agenda, the workshop participants were asked to complete a pre-workshop survey that queried best practices used in transporting EVs at sea.

The best practices summarized within this report apply to roll-on roll-o (ro/ro) vessels including passenger-carrying vessels and are intended to complement but not replace ship operators' existing measures for the carriage of EVs and are applicable per the configuration of each vessel.

As the leading classification society, ABS' broad experience a ords the opportunity to participate in the most

2 OVERVIEW

2.

3 CURRENT RESEARCH AND INDUSTRY BEST PRACTICES

3.1 RECENT RESEARCH

In recent years, significant research has been completed regarding the design and safety performance of batteries and electric vehicles (EVs). This section addresses recent applicable research.

IMO SUBCOMMITTEE ON SHIP SYSTEMS AND EQUIPMENT SUBMISSION PAPERS 7/6/6 AND 7/INF.11

Research and testing were completed on Nickel Manganese Cobalt (NMC) and Lithium Iron Phosphate (LFP) batteries. These tests were conducted in an enclosed space in which the batteries were positioned in a mock-up of a vehicle located in the middle and rear chassis position. The results of these field studies were presented to the International Maritime Organization (IMO) and were taken into consideration prior to creating the best practices reviewed in the workshops.

Carbon Dioxide [illegible]

BEST PRACTICES FOR EMERGENCY RESPONSE TO INCIDENTS INVOLVING ELECTRIC VEHICLES BATTERY HAZARDS: A REPORT ON FULL-SCALE TESTING RESULTS, THE FIRE PROTECTION RESEARCH FOUNDATION

Research was completed by the Fire Protection Research Foundation involving EV battery hazards. A free burn, unsuppressed high heat rate test of a standalone battery pack, and a full-scale suppression test for a battery pack in a mock-up vehicle were conducted. The full-scale fire suppression testing performed included the following data collection:

- Temperatures;
- Heat fluxes;
- Projectile observations;
- Suppression water sampling;
- Volume of suppression water flow;
- Nozzle voltage and current measurements;
- Chassis voltage and current measurements;
- Battery internal temperatures;
- Battery internal cell voltage measurements;
- Thermal imaging;
- Still photography;
- High-definition video; and
- Firefighter observations.

Based on the testing of the full-scale setup, it was concluded that the water may not be su cient in achieving full extinguishment but serves as a medium to reduce heat and cool the battery as thermal runaway subsides or is prevented by the application of water.

ALTERNATIVE FIXED-FIRE EXTINGUISHING SYSTEMS FOR RO/RO SPACES ON SHIPS (FIRESAFE II), EMSA

3.2 2022 ABS RO/RO ELECTRIC VEHICLES BEST PRACTICES SURVEY RESULTS

3.3 CURRENT INDUSTRY BEST PRACTICES

3.3.2 CHARGING PRACTICES: FERRIES

For the charging practices in the ferries category, this item was presented to the group with the intent of identifying best practices associated with the charging of EVs on passenger-carrying vessels. Figure 4 displays the survey results and best practices associated with this category.

3.3.3 CHARGING PRACTICES: PURE CARE CARRIERS/PURE CAR AND TRUCK CARRIERS

For the charging practices on PCC/PCTCs, this item was presented to the group with the intent of identifying best practices associated with charging EVs on PCC/PCTC vessels. Figure 5 displays the survey results and best practices associated with this category.

3.3.4 FIRE DETECTION

For the fire detection category, this item was presented to the group with the intent of identifying best practices associated with early fire detection for electric vehicle carriage on ro/ro vessels. Figure 6 displays the survey results and best practices associated with this category.

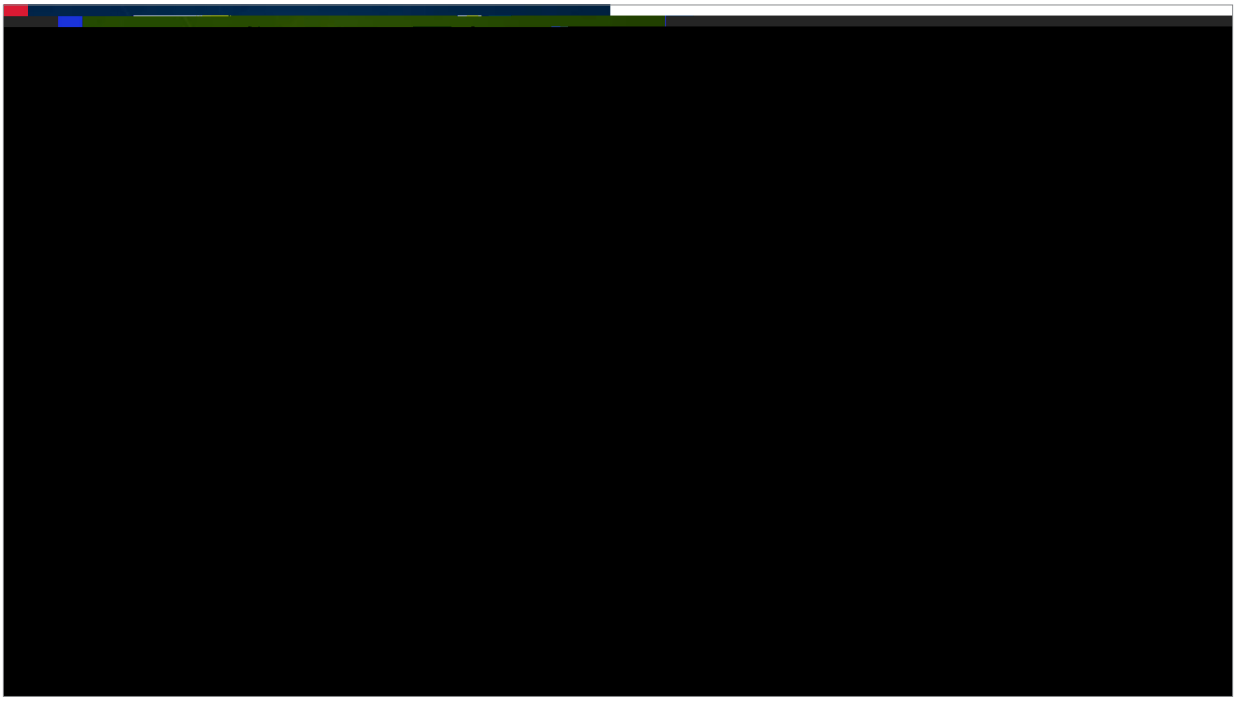

Figure 6: Fire Detection Category - Workshop Display

- Best Practice: A video monitoring system should be installed to supplement the fire detection system for cargo areas intended for the carriage of EVs. The intent is for early location identification and early activation of the applicable firefighting system.

  One hundred percent of ferry and 67 percent of PCC/PCTC category survey participants stated this was an appropriate best practice.

  The remaining survey participants stated that video monitoring systems do not provide any additional benefit beyond that provided by traditional Safety of Life at Sea (SOLAS)-required fire detection systems. Other responses included that thermal surveillance, smoke detectors or heat detectors would be more e cient than a video monitoring system. Twelve percent of survey participants stated that the free height between the ceiling of the deck and the top of the car would not be su cient for any visual surveillance.

- Best Practice: Fire patrol frequency should be increased for areas carrying EVs.

  Sixty-seven percent of ferry and 84 percent of PCC/PCTC survey participants support this statement as a best practice. The remaining responses stated the additional patrol would lead to crew fatigue and that there is no additional risk to the carriage of EVs.

- Best Practice: Portable thermal imaging devices should be provided and used by the crew performing patrols in ro/ro cargo space containing electric vessels.

  One hundred percent of ferry and 89 percent of PCC/PCTC survey participants stated this was an appropriate best practice for the vessels that allowed for this configuration. The remaining responses questioned the e ectiveness of the thermal imaging devices over traditional methods of fire detection.

3.3.5 CREW TRAINING

For the crew training category, this item was presented to the group with the intent of identifying the best practices associated with specific additional training for EV carriage on ro/ro vessels. Figure 7 displays the survey results and best practices associated with this category.

Figure 7: Crew Training Category - Workshop Display

- Best Practice: Training should be provided for crew who may respond to a fire involving EVs. Crew involved in firefighting should be capable of recognizing EVs, understand the risk posed by high voltage equipment in EVs and be aware of the possible release of toxic gas.

3.3.6 FIREFIGHTING MEASURES

For the firefighting measures category, this item was presented to the group with the intent of identifying the best

3.3.7 SPECIAL CONSIDERATIONS

The intent of this category was to address any special considerations involving EVs on ro/ro vessels that did not fall into any of the previously stated categories. Figure 9 displays the survey results and best practices associated with this category.

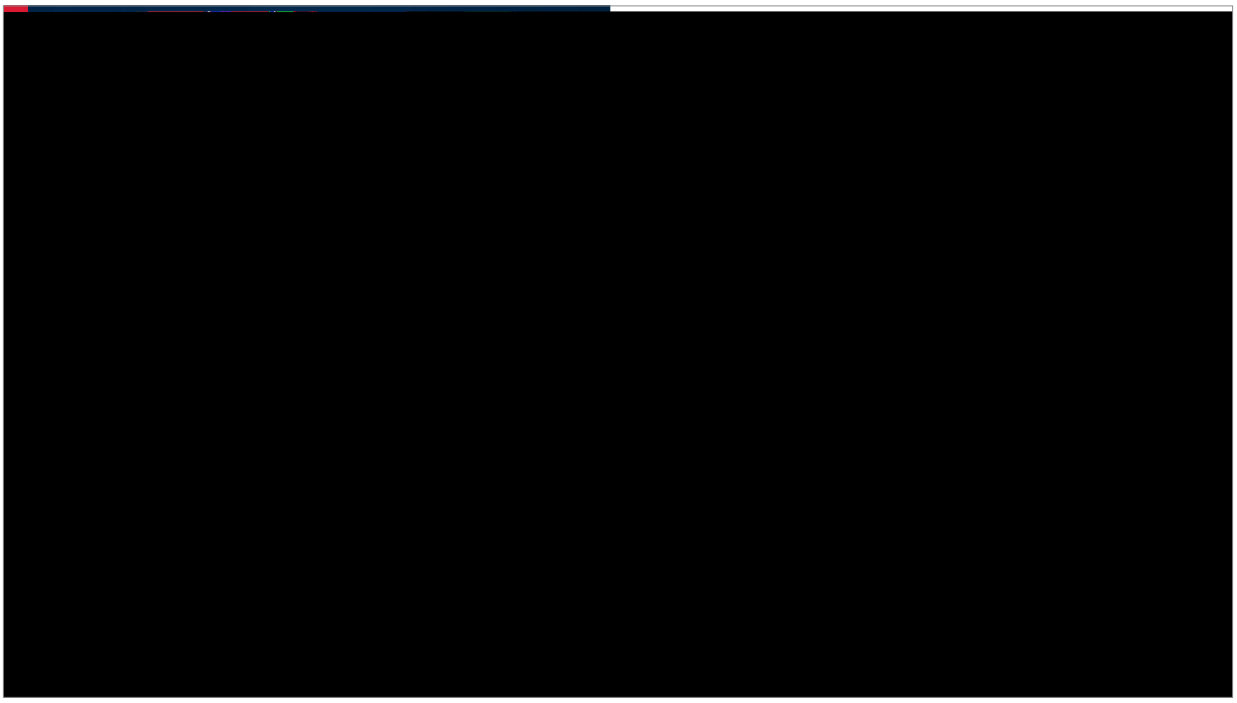

Figure 9: Special Considerations Category - Workshop Display

- Best Practice: Water lancing equipment should be provided for all vessels carrying EVs and easily accessible for vehicles stored in containers.

  One hundred percent of ferry and 76 percent of PCC/PCTC survey participants stated that this was an appropriate best practice. The remaining responses stated that lancing equipment could cause additional harm if the crew was not su ciently trained in using them.

4 PUBLICATIONS

4.

5 REFERENCES

- International Maritime Dangerous Goods (IMDG) Code, Special Provisions 961 and 962
- International Maritime Organization (IMO), Interim Guidelines for Minimizing the Incidence and Consequences of

A