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AMENDMENTS TO THE IMDG CODE AND SUPPLEMENTS

Report of the Correspondence Group on the Review of Transport Provisions for Vehicles

Submitted by United States

SUMMARY

Executive summary: This document contains the report of the Correspondence Group on the Review of Transport Provisions for Vehicles. It summarizes the outcome of six rounds of discussion on provisions for the transport of vehicles, including consideration of definitions for new, used, and damaged vehicles and potential amendments to SP 961 and SP 962.

Strategic direction, if applicable: 7

Output: n/a

Action to be taken: Paragraph 33

Related documents: CCC 8/6/1, CCC 8/6/6, CCC 8/6/10, and CCC 9/6/1

Introduction

1 The Sub-Committee on Carriage of Cargoes and Containers (CCC), at its ninth session, re-established the Correspondence Group on the Review of Transport Provisions for Vehicles under the coordination of the United States.

List of Participants

2 The Group was represented by representatives from the following Member States

Belgium	Japan
Canada	Netherlands
China	Republic of Korea
Denmark	Russian Federation
Finland	Sweden

France
Germany

United Kingdom
United States

and by observers from the following non-governmental organizations:

BIMCO
Dangerous Goods Advisory Council (DGAC)
European Maritime Safety Agency
International Association of Classification Societies (IACS)
ICHCA
IGP&I
Interferry
International Chamber of Shipping (ICS)
International Transport Workers Federation
International Union of Marine Insurance
IVODGA
The Rechargeable Battery Association
PRBA
World Shipping Council (WSC)

Terms of Reference

3 The Correspondence Group was instructed to:

.1 continue consideration of amendments to transport provisions for vehicles, taking into account the discussions at CCC 8 on documents CCC 8/6/1, CCC 8/6/6 and CCC 8/6/10, discussions at CCC 9 on document CCC 9/6/1, and the relevant work at the SSE Sub-Committee.

.2 based on root cause analysis of previous incidents and identified risks and hazards, develop recommendations for the IMDG Code provisions concerning the transport of vehicles, as follows:

.1 provisions for vehicles transported in CTUs, for the following vehicles:

- .1 new;
- .2 used; and
- .3 damaged;

.2 provisions for the following vehicles transported in vehicle, special category and ro-ro spaces:

- .1 new;
- .2 in use;
- .3 used; and
- .4 damaged;

.3 provisions for electric and hybrid vehicles; and

.3 submit a report to CCC 10.

Process of the work

4 The Correspondence Group conducted its work through six rounds of correspondence. To revive the group and align everyone, the first round consisted of a review and edits to the definitions proposed by the previous Correspondence Group in CCC 9/6/1. This was found to be challenging but it re-focused the efforts of the participants. Subsequent rounds focused on individual vehicle system components to keep the scope of the correspondence focused. Lastly, the work of all the rounds was consolidated and prepared as

draft amendments to existing special provisions 961 and 962. Parallel to this effort of developing draft amendments, members of the Correspondence Group were asked to provide after action incident reports to conduct a root cause analysis. Two participants worked together to compile the data and provided a report of the analysis for the Group's review (see paragraph 31 and Appendix 1).

Results of round 1 questionnaire on the definitions

5 The first round started by asking if the definitions would need to be different based on the vehicle being transported via Ro-Ro or inside a CTU. The Group did not respond to this question, so it was asked again in round 2. The group also noted that if a term is not used in the drafted amendments to the special provisions (i.e., prototype vehicle), then a definition for that term may not be required in the drafted text. Half of the responses received were satisfied with the text proposed in CCC 9/6/1, yet there was some bracketed text that continued to be considered into round 2. A summary of the discussion for each definition is provided in the following paragraphs.

New Vehicles

6 When considering the definition of "new vehicle" it was understood that a vehicle driven from one lot to another for storage at a dealership would not preclude it from being considered "new". A review of the previous discussions on including mileage limits within the definition resulted in the same conclusion to not have mileage be a characteristic of the definition. Additionally, it was agreed that a vehicle may need to be driven to reach an end destination and that if the vehicle becomes damaged along that journey, the risks of transporting do change, and that vehicle would need to be classified as damaged. Further, there was additional discussion about including ownership in the definition of "new vehicle". Ultimately, no major changes were made from the definition proposed in CCC 9/6/1.

New vehicle- a vehicle which has never been owned, except by a manufacturer, distributor, or dealer, nor has ever been registered to [an owner or entity] [a private person or to an economic operator], and [is undamaged] [the vehicle has no damage or defect].

Prototype Vehicles

7 The Group noted that the definition for "prototype vehicle" needs to cover the full range of prototype vehicles (i.e., petroleum powered, EV and hybrid). The group was reminded and agreed that a prototype battery installed in a vehicle would be subject to special provision 388, and that the complete vehicle itself could be the prototype. The Group also acknowledged that the definition may not be necessary if no specific provisions apply to "prototype vehicles" in the drafted text of the special provision.

Prototype vehicle- a new or used vehicle that has not received approval by the Competent Authority; if the battery is a prototype, it must be tested to UN 38.3 or approved by the Competent Authority.

Used and In-Use Vehicles

8 The majority view was that no change to the proposed definition in CCC 9/6/1 is necessary for "used" vehicles; however, a comment was received that this round the chair

forgot to include the previously discussed “in-use vehicle” definition. The Group agreed that a distinction may be needed between a “used vehicle”, which is a vehicle being transported without an operator and an “in-use vehicle” which would include a vehicle being transported with an operator present. Further, an “in-use vehicle” would not be transported inside a CTU and would only be on a Ro-Pax vessel.

Used vehicle- a vehicle which does not meet the definition of new or damaged.

In use vehicle- a “used vehicle” that is accompanied by an operator.

Damaged Vehicles

9 Several suggested changes were proposed for the definition of “damaged vehicle” as prepared in CCC 9/6/1, and the proposed definition is not considered finalized by the Group. Similar to discussions on other types of vehicles, it was noted the text of the definition may require revision based on the final text of the draft amendments to the special provisions. The Group also noted that the use of “damaged” in the definition to describe the battery may cause confusion, and other words such as “swollen”, “melted”, “bulging” may be better suited or the use of an “e.g.”.

Damaged vehicle – a vehicle that requires repair beyond routine [defined by the manufacturer] [mechanical and electrical] maintenance. This may include any one of the following:

- .1 Requires repair beyond routine maintenance.
- .2 Cannot be operated under its own power safely (e.g., has deployed airbags, declared a [salvage][scrap] vehicle).
- .3 Does not drive under its own power.
- .4 Has sustained damage to the radiator, engine, or [fuel tank] [energy source or energy storage] (e.g. leaking fluids).
- .5 Has broken or bent axles.
- .6 Is incapable of accessing the engine or battery space.
- .7 Has safety warnings displayed (e.g., Battery Warning, Temperature Warning, and Check Engine lights are illuminated on the dashboard).

In the case of EV or HEV vehicles, the following criteria may also apply:

- .8 Has obvious signs of battery pack deformation or puncture [battery pack is damaged/defective/deformed or punctured].
- .9 Has been through an adverse weather event (e.g., flood, hurricane, exposure to saltwater).

Results of round 2 questionnaire on the definitions

10 Due to no view being expressed, round 2 of the Correspondence Group began by asking, “Do you think that the definitions will need to be different for vehicles that are transported via Ro-Ro versus in CTUs? [yes, and why] [no]”. The majority response was no. The next step was commenting on the bracketed text remaining in the round 1 definitions. “New” and “used” vehicle definitions received no major comments. For the “in-use vehicle” definition, it was noted that additional text indicating supervising and specifically being driven onboard a vessel may need to be considered in the future. The majority view for all definitions are as follows:

New vehicle- a vehicle which has never been owned, except by a manufacturer, distributor, or dealer, nor has ever been registered to an owner or entity and is not damaged.

Prototype vehicle- a new or used vehicle that has not received approval by the Competent Authority; if the battery is a prototype, it must be tested to UN 38.3 or approved by the Competent Authority.

Used vehicle- a vehicle which does not meet the definition of new or damaged.

In use vehicle- a “used vehicle” that is accompanied by an operator.

Damaged vehicle – a vehicle that requires repair beyond routine mechanical and/or electrical maintenance as defined by the manufacturer. This may include any one of the following:

- .1 Cannot be operated under its own power safely (e.g., has deployed airbags, declared a salvage or scrap vehicle).
 - .2 Has sustained damage to the radiator, engine, or energy source (e.g. leaking fluids).
 - .3 Has broken or bent axles.
 - .4 Is incapable of accessing the engine or battery space.
 - .5 Has safety warnings displayed (e.g., Battery Warning, Temperature Warning, and Check Engine lights are illuminated on the dashboard).
- In the case of EV or HEV vehicles, the following criteria may also apply:
- .8 Has obvious signs of battery pack deformation or puncture (e.g., the battery is damaged, deformed or punctured).
 - .9 Has been submerged during an adverse weather event (e.g., flood, hurricane, exposure to saltwater).

11 The second round finished with asking participants to comment on “warning display/lights” referenced in the definition for “damaged vehicle” and to provide examples. There was no universal response, but comments received included recognition that there are international provisions for road vehicles and their On-Board Diagnostic systems. Further, a participant commented that the dashboard may not illuminate if it is damaged or defective, and that the lights may require interpretation; and thus, they may not be suitable for our needs.

Results of round 3 questionnaire on the current special provisions 961 and 962

12 Round three reviewed the existing special provisions 961 and 962 subparagraph by subparagraph to:

- 1. understand if the group felt that we should keep the provisions or not;
- 2. determine if modification of the provisions is required or not; and
- 3. understand if the subparagraph applies to new, prototype, used, in-use or damaged vehicles.

13 The majority view expressed by the Group was a preference to keep the current provisions, in lieu of creating a new special provision. The view on modification to the existing SP 961 and SP 962 was evenly split. A majority agreed that the current regulations apply to all the different categories of vehicles (i.e. new, used, etc.).

14 The second part of round three asked participants if they would like to incorporate individual provisions from paper CCC 8/6/6 (i.e., state of charge for batteries, not allowing the battery to be in a damaged vehicle, etc.). The majority was in favour of incorporating those new provisions into the existing special provisions as amendments to the text.

15 The third part of round three asked participants about special provision 388. There were minimal responses to this question, but those who responded noted that nothing needed to be addressed by this Correspondence Group.

16 Significant comments received during round three, and not otherwise addressed above are summarized:

- The current format of SP 961 and 962 can be confusing to the user, consider a different format or simplification on how to determine applicability of the provisions to the consignment.
- It should be considered if a proposal is necessary to the UN Subcommittee of Experts on the Transportation of Dangerous Goods to assign a separate UN number to prototype vehicles.
- There could be confusion between a prototype battery and the vehicle itself being a prototype, or even a prototype battery in a prototype vehicle.
- The origin of fuel's flash point of 38 degrees C needs further consideration. In the IMDG code the flash point of 60 degrees C is considered. It is also noted that the quantity of fuel in the tank, (Ref. SSE-10/INF.8 Study by China) quantity of fuel is directly proportional to the severity of a fire. Further, the quarter tank of fuel versus the 250 litres based on flashpoint can be confusing and needs further consideration by the Group.
- The Group needs to consider what methods are used to protect a battery from short circuit and make sure that the language is uniform if it will be repeated in different parts of the provisions.
- The Group needs to consider who is doing the visual inspection, what training is required for the inspector, and when the inspection shall take place.
- The Group needs to consider if placarding is required when vehicles are transported inside CTUs.
- The Group needs to consider that all batteries except non-damaged batteries for driving should be removed and transported separately from the vehicle and comply with the existing IMDG Code.

Results of round 4 and 5 questionnaires on the electrical system

17 Round four focused on the electrical systems of vehicles. There were varied views on what "installed batteries" in the existing special provisions meant and the Group considered if the text needed to be revised. Some participants wanted to distinguish between batteries used for propulsion and those that run the electrical system (i.e., lights, radio, etc.). No clear recommendations regarding amendments to the special provisions were formed during this round.

18 Round five again focused on the electrical systems of vehicles. The first question of the round asked participants on their view of the Coordinator's additional clarifying wording for "installed" batteries, which was based on the comments received in round 4. The coordinator's wording, "Installed batteries are ancillary batteries that do not provide propulsion but may provide energy for the starter, lights, radio, etc.". The majority agreed with this proposed wording.

19 The second question in this round asked about short circuit and the specific wording in the current provisions. The majority views expressed a desire to include additional explanatory text and to align it to the wording in SP 962, "installed batteries shall be protected from damage, short circuit, and accidental activation during transport".

20 The third question of round 5 asked if anything additional should be required for installed batteries in new vehicles. The Group had an even split of views on the need for further provisions being drafted. Those with views supporting provisions indicated a

preference for any new provisions to align with the current provisions having a minimum of protection from short circuit without further clarification.

21 The fourth question in round 5 asked about installed batteries in used vehicles. The majority agreed that these batteries should be protected from short circuit as is currently required in the special provisions. A majority view also recommended that the battery should be disconnected prior to transport, meaning the battery cables should be safety secured for transport. The Group noted this could be accomplished by the terminals being taped, capped or insulated. The Group also had a majority view that the battery cables shall be free from fraying and damage. Here the Group specified that damage included corrosion, crimping, melting and exposed metal. The Group supported a requirement for verifying that a vehicle is not subject to a recall, and if the vehicle is recalled the Group agreed that the vehicle would be required to be transported under the damaged provisions. Views were expressed that vehicles subject to recalls should only qualify as “damaged” if the recall is a safety issue directly related to the safe carriage of the vehicle.

22 The fifth question of round five asked about installed batteries in damaged vehicles. The participants reached consensus and agreed that installed batteries should be removed from damaged vehicles prior to transport. The majority agreed the removed battery should not be allowed in the vehicle during transport.

23 The sixth question of round five asked “Do you agree that a provision needs to be added for propulsion batteries?”. The majority agreed that there should be provisions. The majority also thought there should be no difference between fully electrical and hybrid electrical vehicles regarding the propulsion battery. The majority agreed that no additional descriptive text is required for propulsion batteries.

24 The seventh question was on the propulsion battery in new electric and hybrid vehicles. The Group was asked to brainstorm what requirements should be applied. The following suggested requirements were proposed:

- The battery management system needs to be inspected.
- The vehicle should not have illuminated warning lights.
- A safety certificate should be given to the carrier.

25 Additionally, the Group commented that the drafted text should require that the main electrical master switch shall be shut off prior to transport and that a state of charge limit be added to the provision. Regarding the limit for state of charge, the Group proposed values in the range of 25 to 70%, with 30% being the most common recommendation. Some participants expressed a view that state of charge was not necessary when vehicles are transported on a RoRo vessel and any state of charge limit should only apply to transportation within a CTU. Other participants expressed a view that establishing any state of charge limit should be postponed until further scientific studies were conducted. Some participants supported alignment with International Air Transport Association and the results of 29th meeting of the Dangerous Goods Pannel at International Civil Aviation Organization. Others responded that there needed to be discussion about gauge reading versus actual charge level prior to drafting the requirement.

26 The eighth question in round five was what draft provisions are required for the propulsion battery in used electric and hybrid vehicles. The majority thought it should align with the requirements of new electric and hybrid vehicles and that they should not be the same as ancillary batteries.

27 The final question of round five asked about requirements for propulsion batteries in damaged electric and hybrid vehicles. The majority thought the requirements should be the

same as ancillary batteries in damaged electric and hybrid vehicles. The following requirements were noted:

- The propulsion battery shall be transported separately and not in the vehicle.
- The propulsion battery shall be transported according to the IMDG Code without a special provision.
- A damage/defective label shall be given to the carrier along with the safety certificate.

Results of round 6 consolidated and draft amendments

28 In round six, the group moved away from questionnaires and the coordinator prepared draft text amending the existing special provisions based on the discussions and agreements reached in the previous rounds. There was confusion regarding where the proposed text came from, with some participants not realizing that the new text was pulled from previous rounds of the Correspondence Group. This confusion resulted in some participants providing comments on the existing text and not the text added from the previous rounds. Many comments received were to just remove large block of text in its entirety, inclusive of existing text. The coordinator attempted to only make edits if multiple participants commented on a particular piece of text that was from these rounds of correspondence. The consolidated text of round six is as follows:

29 For the purpose of this provision the following definitions apply:

New vehicle- a vehicle which has never been owned, except by a manufacturer, distributor, or dealer, nor has ever been registered to an owner or entity and is not damaged.

Used vehicle- a vehicle which does not meet the definition of new, in use or damaged vehicle.

In- use vehicle- any “used vehicle” that is accompanied by an operator.

Damaged vehicle – a vehicle that requires repair beyond routine mechanical and/or electrical maintenance as defined by the manufacturer. This may include any one of the following:

- .1 Cannot be operated under its own power safely (e.g., has deployed airbags, declared a salvage or scrap vehicle).
- .2 Has sustained damage to the radiator, engine, or energy source (e.g. leaking fluids).
- .3 Has broken or bent axles.
- .4 Is incapable of accessing the engine or battery space.
- .5 Has safety warnings displayed (e.g., Battery Warning, Temperature Warning, and or Check Engine lights are illuminated on the dashboard).

In the case of EV or HEV vehicles, the following criteria may also apply:

- .8 Has obvious signs of battery pack deformation or puncture (e.g., the battery is damaged, deformed or punctured).
- .9 Has been submerged during an adverse weather event (e.g., flood, hurricane, exposure to saltwater).
- .10 Recalled associated with the electrical system or affecting the safety of the vehicle during transportation that have not had the recall addressed.

SP 961

Vehicles, except damaged vehicles, are not subject to the provisions of this Code if any of the following conditions are met:

- .1 vehicles are stowed on the vehicle, special category and ro-ro spaces or on the weather deck of a ro-ro ship or a cargo space designated by the Administration (flag State) in accordance with SOLAS 74, chapter II-2, regulation 20 as specifically designed and approved for the carriage of vehicles, and there are no signs of leakage from the any battery, engine,

fuel cell, compressed gas cylinder or accumulator, or fuel tank when applicable. If any of these conditions apply, the vehicle is considered damaged and may be transported according to SP 962. When packed in a cargo transport unit the exception does not apply to container cargo spaces of a ro-ro ship.

NOTE 1: This SP 961.1 exception does not apply to any vehicle packed into a cargo transport unit which is then loaded to a vehicle, special category or Ro-Ro space.

In addition, for vehicles powered solely by lithium batteries and hybrid electric vehicles powered by both an internal combustion engine and lithium metal or ion batteries, the lithium batteries shall meet the provisions of 2.9.4, except that 2.9.4.1 and 2.9.4.7 do not apply when pre-production prototype batteries or batteries of a small production run, consisting of not more than 100 batteries, are installed in the vehicle and the vehicle is manufactured and approved according to the provisions applied in the country of manufacture or country of use. Where a lithium battery installed in a vehicle is damaged or defective the vehicle cannot take this exception, see SP 962. Further, the battery shall be removed and shall not be transported in the vehicle, see SP 376. These vehicle's battery management system or dashboard shall be checked by the consignor and indicating no faults or issues with the electrical system. The main electrical master switch shall be turned off. Further, the state of charge of the battery shall be less than 30% if verified by manufacturer or less than 25% on the vehicle's gauge.] [Vehicles that have a recall associated with the electrical system or affecting the safety of the vehicle during transportation that have not had the recall addressed, shall be shipped as damaged and must meet the requirements of SP 962.]

.2 vehicles powered by a flammable liquid fuel with a flashpoint of 38°C or above, there are no leaks in any portion of the fuel system, and the fuel tank(s) contains 450 L of fuel or less. and installed batteries are disconnected and protected from short-circuit.

.3 vehicles powered by a flammable liquid fuel with a flashpoint less than 38°C, the fuel tank(s) are empty and installed batteries are disconnected and protected from short circuit. Vehicles are considered to be empty of flammable liquid fuel when the fuel tank has been drained and the vehicles cannot be operated due to a lack of fuel. Engine components such as fuel lines, fuel filters and injectors do not need to be cleaned, drained or purged to be considered empty. The fuel tank does not need to be cleaned or purged;

3.b Installed batteries are ancillary batteries that do not provide propulsion but may provide energy for the starter, lights, radio, etc. Installed batteries shall be disconnected and protected from short circuit, damage and accidental activation. For new vehicles, the installed batteries must be protected from short circuit, and for used vehicles, the installed batteries must be disconnected. The battery cables shall be free from fraying and damage. The terminals shall be capped or insulated to prevent accidental activation.

.4 vehicles powered by a flammable gas (liquefied or compressed), the fuel tank(s) are empty and the positive pressure in the tank does not exceed 2 bar, the fuel shut-off or isolation valve is closed and secured, and installed batteries are disconnected and protected from short circuit and accidental activation;

.5 Electric and hybrid electric vehicles loaded in a cargo transport unit are subject to SP 962. Vehicles loaded in a cargo transport unit which are vehicles solely powered by a wet or dry electric storage battery or a sodium battery, and the battery is protected from short circuit. These vehicle's battery management system or dashboard shall be checked and indicating no faults or issues with the electrical system. The main electrical master switch shall be turned off. Further, the state of charge of the battery shall be less than 30% if verified by the manufacturer or less than 25% on the vehicle's gauge.

962

Repeat the definitions.

Vehicles, not meeting the conditions of special provision 961 shall be assigned to class 9 and shall meet the following requirements:

.1 vehicles shall not show signs of leakage from batteries, engines, fuel cells, compressed gas cylinders or accumulators, or fuel tank(s) when applicable;

.2 for flammable liquid powered vehicles the fuel tank(s) containing the flammable liquid shall not be more than one fourth full and in any case the flammable liquid shall not exceed 250 L unless otherwise approved by the competent authority;

.3 for flammable gas-powered vehicles, the fuel shut-off valve of the fuel tank(s) shall be securely closed;

.4x Damaged vehicles shall have all batteries removed. The removed batteries are not allowed to be transported within the vehicle or in the same CTU as the vehicle and shall be transported separately, per SP 376.

.4 installed batteries shall be disconnected and protected from damage, short circuit, and accidental activation during transport. Lithium batteries shall meet the provisions of 2.9.4, except that 2.9.4.1 and 2.9.4.7 do not apply when pre-production prototype batteries or batteries of a small production run, consisting of not more than 100 batteries, are installed in the vehicle and the vehicle is manufactured and approved according to the provisions applied in the country of manufacture or country of use. Where a lithium battery installed in a vehicle is damaged or defective, the battery shall be removed and transported according to SP 376, unless otherwise approved by the competent Authority.

.5 Damaged vehicles shall have all batteries removed. The removed batteries are not allowed to be transported within the vehicle and shall be transported separately. Damaged or defective batteries shall be transported according to SP 376, unless otherwise approved by the competent Authority.

The provisions of this Code relevant to marking, labelling, placarding and marine pollutants shall not apply except when vehicles are packed in cargo transport units. When vehicles are packed in a cargo transport unit, the provisions of this Code relevant to the marking, labelling placarding related to cargo transport units and marine pollutants shall apply.

Root Cause Analysis

30 To address the second term of reference, during round 2 and 4 of the Correspondence Group, the coordinator requested that participants provide a list of incidents and any official investigation reports related to those incidents. The Group compiled a list of 100 shipboard fire cases. Participants from two delegations volunteered to analyse the data and provided a report to the Correspondence Group. This report can be found in Appendix 1.

Conclusions

31 While the Correspondence Group made significant progress toward completing the second term of reference, some participants expressed views that the incident analysis was incomplete and not fully discussed by the Group. A view was expressed that the analysis was

all encompassing including refrigerated freight, but that the Group focused on consumer vehicles with its draft amendments and non-consumer vehicles should be considered in future work. Further, it was noted that the analysis did not include trade data, just official incident reports, in accordance with the terms of reference.

32 It was widely acknowledged that the Correspondence Group did address each of the terms of reference but did not satisfactorily achieve each TOR goal. For example, additional work is necessary to consider and potentially develop draft text addressing refrigerated vehicles and other heavy industrial vehicles within the special provisions. As such, the coordinator and several participants recommend that these issues be considered during the expected working group on IMDG Code matters during CCC 10, with a focus on addressing the unresolved discussion points throughout the correspondence rounds, particularly those from round six. A more thorough review of the drafted text for SP 961 and SP 962 could be addressed in the working group, along with consideration on re-establishing a Correspondence Group to progress the work. If there is support, it is recommended that the working group draft new Terms of Reference.

Action requested of the Sub-Committee

33 The Sub-Committee is invited to approve the report in general, note the progress of the group, consider the recommendation to continue the work as described in paragraph 32, and take action as appropriate.

Appendix 1: Root Cause Analysis

Detailed analysis of incidents investigation reports

Background

The Correspondence Group had in its Terms of Reference (CCC 9/14, Para 6.57.2) to develop recommendations for the IMDG Code provisions concerning the transport of vehicles, based on root cause analysis of previous incidents, and identified risks and hazards. In that context, the Correspondence Group has compiled a list of 100 ship fire cases. Participants from 2 delegations volunteered to analyse the data and below is the summary of the analysis.

Analysis methodology

The analysis took place in two stages.

Stage-1

Preliminary analysis, where all available data were collected from various sources including GISIS, various flag administration's official web pages etc. The available investigation reports were skimmed to identify the root causes. The same has been circulated to the participants of the Correspondence Group as Round-4. Some of the delegates provided some inputs at this stage, which included corrections and additional information. Post consolidation, the available data containing 100 cases were cleaned to exclude machinery space fires, fires due to ship's electric systems and any other reasons that were not related to the vehicle itself.

At the end of this stage, the sample size has reduced to 38 which included a combination of RORO, ROPAX, ROCARGO vessel types. Some of the ROCARGO vessels were also classed as passenger vessels. One of the reports (MV. LISCO GLORIA) mentioned 4 more ferry fires which was also considered. The final number of cases summed up to 41.

Stage-2

Detailed analysis. This stage included an in-depth review of the investigation reports of the 41 cases identified in stage 1. In this stage, the details were extracted out of the investigation reports specifically with respect to location of accident (At Sea/ In Port), Vehicle type (New / Used / In-Use/ Damaged), Category of fire (Vehicle's electric component / Mechanical component), Suspected part, Cause of fire (reason), Vehicle fuel type (ICEV/ EV/ Hybrid), Vehicle recall (Yes/No), and root cause identification method (Deterministic/ Probabilistic).

It has been observed, in some of the investigations, the exact part/ component/ reason that caused the fire could not be determined. Hence the investigators have arrived at a conclusion taking a probabilistic approach. In some other cases, since it was impossible to investigate the exact reason of fire, the investigators have used the technique laid out in NFPA921 to identify the probable cause of fire.

Block diagram of the ICEV electric and mechanical system

For easy understanding of the readers, below images has been inserted identifying various parts of the vehicles that are involved in starting the vehicle (Internal Combustion Engine Vehicle- ICEV & Battery Electric Vehicle- BEV).

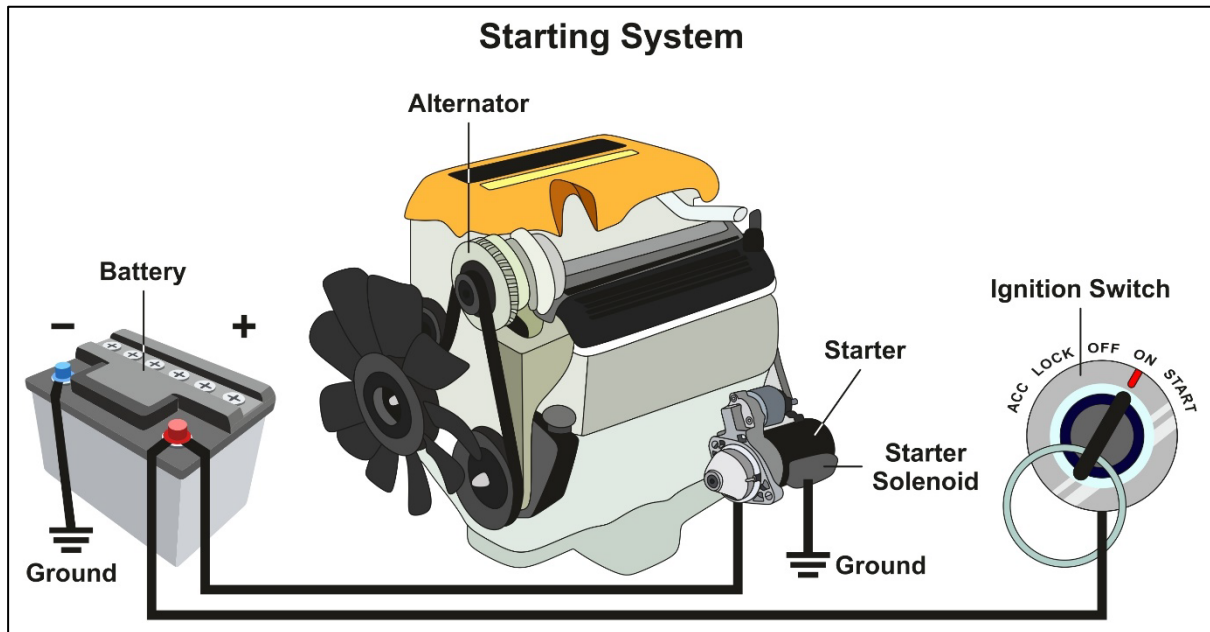


Fig 1: Starting system of a typical ICE vehicle. © shutterstock.com

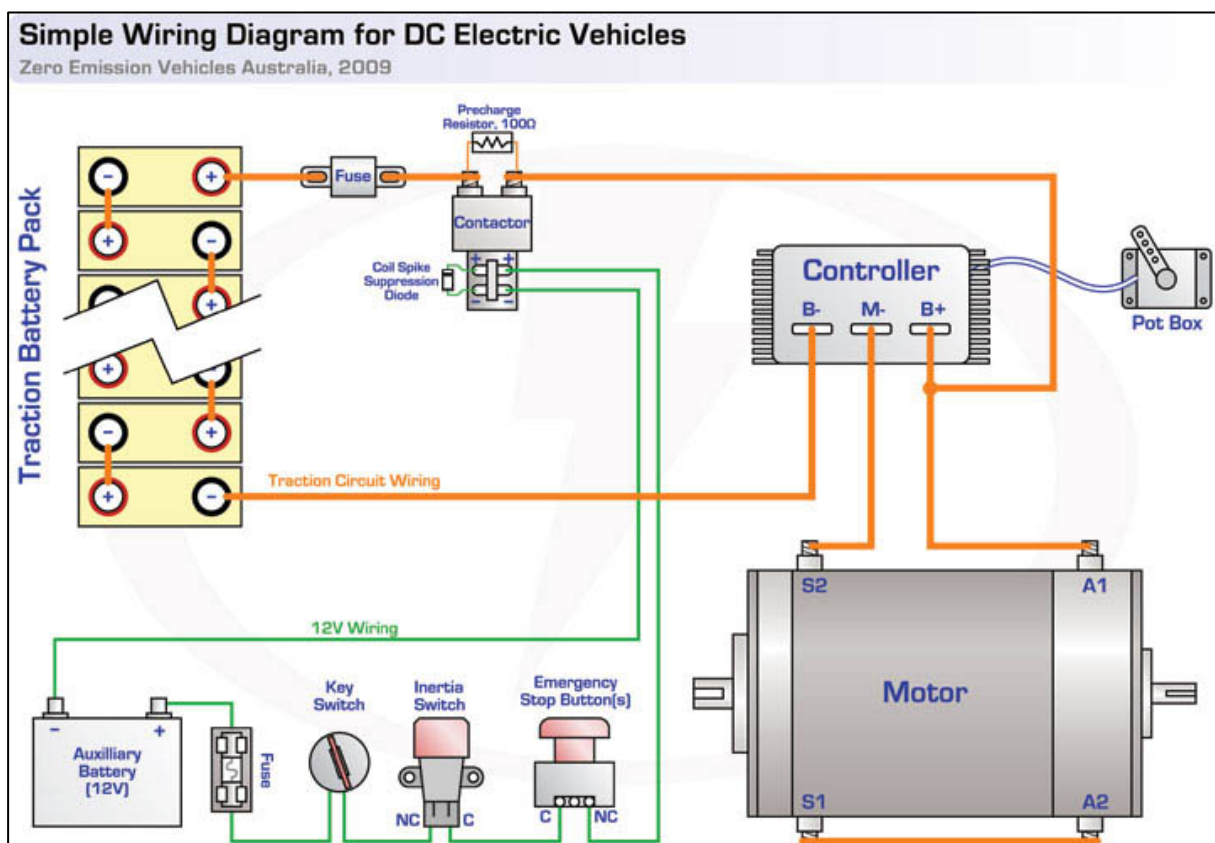


Fig 2: Circuit diagram of a typical Electric vehicle. © www.evworks.com.au

Summary of the analysis

This section presents the causes of fires mentioned in official investigation reports. The suspected vehicle parts are highlighted in bold, with their respective vessel name-referenced.

- 1 MV. ATLANTIC CARTIER
(Goods/ Contents inside the truck)
- 2 MV. AUTOBANNER

- 3 Electrical risk factors combined with more quantity of fuel in the tank (**Unknown**)
MV. BRITANNIA SEAWAYS
Cargo shift (Tank container) along with Sparks from damaged power cables of starting batteries of 2 lorries (**Starter/Ancillary battery & damaged power cables**)
- 4 MV. COMMODORE CLIPPER
Overheating due to an electric fault between the shipboard power supply and the Reefer Unit (**Reefer unit**)
- 5 MV. CORONA SEAWAYS
The heavy-duty cable connecting the battery to the engine starter motor main solenoid was live and permitted unintended electrical arcing inside the starter motor solenoid (**Starter/Ancillary battery system**)
- 6 MV. COURAGE
Brake fluid leak & electrical arcing in the automatic braking system (ABS) module (**Automatic Braking System- ABS**)
- 7 MV. FELICITY ACE
Defective battery cell due to high temperature, damage during assembling of the vehicle or a crack on insulation between the anode and the cathode causing a large, short circuit (**Drivetrain battery/ Propulsion battery system**)
- 8 MV. GALLIPOLI SEAWAYS
The electrical isolation switch was not turned 'off' after loading which has caused an electrical fire (**Starter/Ancillary battery system**)
- 9 MV. HOEGH XIAMEN
.1 Electrical arcing between terminals of installed battery. Battery terminal posts that were not protected with plastic caps which lead battery cable lugs to .2 rest on the battery terminals (**Starter/Ancillary battery system**)
Leakage of electrolyte from the installed battery (**Starter/Ancillary battery system**)
.3 Leakage of unknown fluid from cabin on the passenger side (**Unknown fluid**)
- 10 MV. HONOUR
Fault in the starter motor solenoid in one of the personally owned vehicles being transported in the vessel's cargo space (**Starter motor**)
- 11 MV. KRITI II
Electric arc at reefer connection (**Reefer unit**)
- 12 MV. MECKLENBURG-VORPOMMERN
Battery located under the passenger seat & Contents of the vehicle including used car engines (**Extra batteries & machines inside vehicle – contents**)
- 13 MV. MIGNON
Short circuit in the starting motor of a used car (**Starter motor**)
- 14 MV. PEARL OF SCANDINAVIA
Electric car being charged during voyage. Battery pack in the rear end of the electric car caught fire (**non-branded prototype Electric Vehicle**)
- 15 MV. PETER PAN
Truck loaded with Aluminium powder started the fire (**Cargo inside the truck - contents**)
- 16 MV. SCHLESWIG- HOLSTEIN
(**Reefer Unit**)
- 17 MV. SILVER SKY
Fully packed Camper van with microwave, gas bottles etc. could be the specific reason for fire. Explosive nature inside the camper van (**Camper van-contents**)
- 18 MV. SORRENTO
Malfunctioning of Reefer unit connected to ship's power supply (**Reefer unit**)
- 19 MV. STENA SCANDICA
Short circuit had occurred in the fuse box. Arc flash had occurred due to failed insulation on the fuse box of a truck (**Reefer unit - Fuse Box**)

- 20 MV. STENA SPIRIT
Blocking of a V-belt tensioner belt wheel during the reefer unit's operation and ignition of belts or short-circuit currents due to overload of the unit during operation with a faulty tensioner **(Reefer unit)**
- 21 MV. SUPERFAST III
Unknown sources from refrigerated trailer **(Reefer unit)**
- 22 MV. UND ADRIYATIK
Malfunction in the electrical heating system of truck **(electrical heating system)**
- 23 MV. VICTORIA SEAWAYS
Electric arcing by poor insulation of power wires of used car **(Starter/Ancillary battery & damaged power cables)**
- 24 MV. VINCENZO FLORIO
Cargo shifting on the cargo deck **(Unknown)**

Suggested safety precautions

This section presents consolidation of safety precautions suggested for shipment of vehicles from some investigation reports, with a vessel name referenced.

- 1 MV. AUTOBANNER
 - .1 When electrical wires powered by batteries and connectors become old or are poorly maintained, they become frayed or badly connected, leading to disconnection, short circuit, or overload, which can start a fire that moves onto other cords, compartments, or the engine through oil sludge on the surface of the vehicle's components.
 - .2 When a car is driven without enough coolant or engine oil even after stopping the engine, dust or oil sludge can ignite because of the overheated engine, or the fuel line can leak, resulting in a mechanical fire when the car is parked.
 - .3 As for second-hand cars, if possible, it is imperative to check that there are appropriate amounts of engine coolant and oil, disconnect the battery terminals, and minimize the use of fuel.
 - .4 It is necessary to keep the hood of the cars unlocked after loading them in order to allow for effective responses to fires inside the cars onboard. By doing so, when a fire breaks out, it can be rapidly extinguished by lifting the unlocked hood.
- 2 MV. ATLANTIC CARTIER
 - .1 The car manufacturers admitted the level of quality management when shipping brand new cars. These could form the basis for declaration to be made by shipper to the carrier before any shipment of vehicles.
 - .2 Regarding brand new vehicles, the vehicle manufacturer has stated the safety standards the shipment has complied with:
 - Brand new cars are in transport mode, where there is no designed circuitry that consumes energy to cause ignition;
 - Even when not in transport mode- there are no hotspots or other electrical nodes to source ignition;
 - The brand-new cars have not got any manufacturing defects;
 - Each vehicle was thoroughly tested in factory; and
 - There were no wear and tear or possibility of owner's abuse or neglect.
- 3 MV. CORONA SEAWAYS
 - .1 The Code of Practice – Roll-On/Roll-Off Ships – Stowage and Securing of Vehicles, Section 1.1 identifies that a principal source of danger to ships and persons is the unsatisfactory condition or design of vehicles presented for shipment. Section 2.2 states: 'Before being accepted for shipment, every freight vehicle should be inspected externally by a responsible person'.

.2 The Code of Safe Working Practices for Merchant Seamen (COSWP) – Chapter 32 Ro-Ro Ferries paragraph 32.3.2 also covers the need to run ventilation fans while vehicles are on board. Section 32.7 – Inspection of Vehicles states: ‘Before being accepted for shipment, every freight vehicle should be inspected externally by a competent and responsible person or persons to check that it is in a satisfactory condition for shipment....’.

.3 Electrical systems that have been idle and are then connected to charged batteries are particularly vulnerable. If the battery had been totally isolated, the risk would have been considerably reduced.

4 MV. COURAGE

The two end connectors (a positive and a negative) of the ABS module need to be protected from localized arcing damage.

5 MV. FELICITY ACE

.1 Shipper should carry out risk assessment on battery condition standards needed for sea transport and prolonged vehicle switched off mode and issue clear fire prevention and extinguishing protocols on electrical vehicles.

.2 Pre- loading inspections carried out by a surveyor subcontracted by charterers only cover exterior and some interior parts of the vehicles but not engine or electric items.

6 MV. GALLIPOLI SEAWAYS

Vehicle manufacturers should advise the carriers and terminals by providing written information about the procedures, principles, and rules to be considered in the transport of hybrid and electrically powered vehicles by sea.

7 MV. GOLDEN FAN

Consider a final visual check of stowed vehicles prior closing watertight doors.

8 MV. Hoegh Xiamen

Factors such as deteriorated electrical connections, brittle and cracked electrical cables, chafed electrical wiring harnesses, deposits of electrically conductive road grime, and idle electrical systems that are more prone to failure have the potential to cause fires.

9 MV. KRITI II

Examine the need to supplement the current regulatory framework, which concerns the loading, stowage and transport of trucks/vehicles by ships, in terms of safety that emerged from the present technical investigation, including reefer safety precautions, and consist of the following:

- Establishment of a system of periodic checks and certification of the equipment of refrigerator trucks/vehicles, which operate during their transport by ships;
- Establishing a fire resistance requirement for truck covers during their transport by ships;
- Proper stowage of transported vehicles in the ships' garage areas by separating refrigerated trucks/vehicles from general cargo trucks/vehicles; and
- Requirement to install fireproof boxes at the points of connection of the extensions with the ship's power outlets and the outlets of the truck/vehicle refrigerators.

10 MV. MIGNON

.1 The negative poles of the batteries need to be disconnected in order to render the car's electrical system powerless, which prevents the occurrence of short circuits in electrical components.

.2 The investigation shows that checks of used vehicles are only conducted in certain ports.

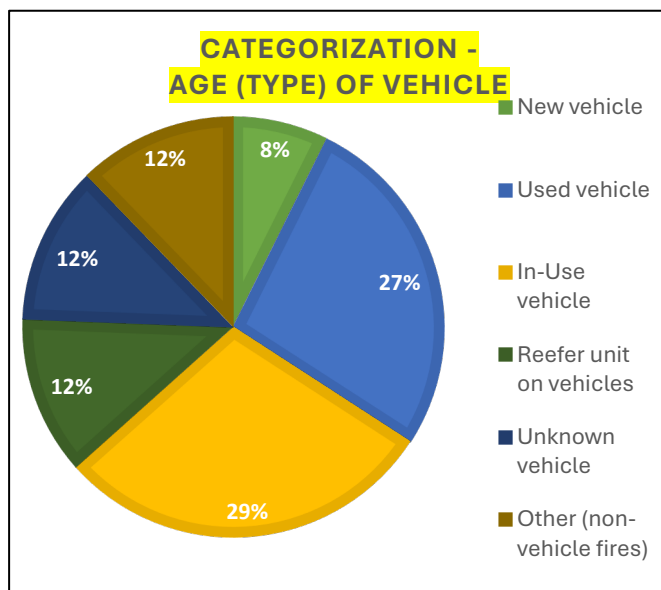
- .3 Closing the windows of a vehicle significantly reduces the risk of fire spread. A fire can still arise in the passenger compartment of a vehicle, but it will be more difficult for the fire to develop if the windows and doors are closed. The oxygen is then insufficient to produce the maximum heat release rate and the heat of the fire cannot reach the levels that would cause the windows to crack and break.
- 11 MV. NORMAN ATLANTIC and MV. SORRENTO
- .1 Minimum distance among the vehicles lashed in the garage and for enabling the operational and safe passage of the fire-fighting team on board shall be established.
- .2 A detailed list of the cargo to be loaded shall be provided in advance, considering the ship operational features, including size, weight and any other technical requirements (including the notification of the exact number of trucks that would require connection to the vessel's electrical power etc...) so that the cargo plan can be prepared before the departure.
- 12 MV. STENA SPIRIT
- .1 Establish add in the crew procedures pertaining to the loading of refrigerator trucks onto the ship and the supervision of them during the cruise, or in the fire patrol procedures the requirement to instantly summon the driver of the vehicle after smoke/fire has been detected and the vehicle has been identified as the source of the smoke/fire.
- .2 In all ro-ro cargo spaces, for vehicles, separate rows should be indicated for parking (placing in order) of refrigerator vehicles and the relevant number of spaces should be ensured for access for the handling (inspection) of these vehicles while the ship is at sea; the path on one side of the indicated row of vehicles should be at least 600 mm so that it would facilitate easy access to the vehicle by fire fighters in special breathing apparatuses and protective clothing during rescue and fire extinguishing operations in emergency situations, such as vehicle fire
- 13 MV. UND ADRIYATIK
- .1 It is advised, not to stow dangerous cargo loaded trucks and trailers on deck near to or under the escape routes in any circumstance.
- .2 The vehicles shall provide fire safety measures within themselves before they enter into ro-ro vessels in order to comply with basic fire safety rules.
- 14 MV. VICTORIA SEAWAYS
- Disconnection of batteries should be verified by responsible persons before the ship leaves the port.

Over all comments

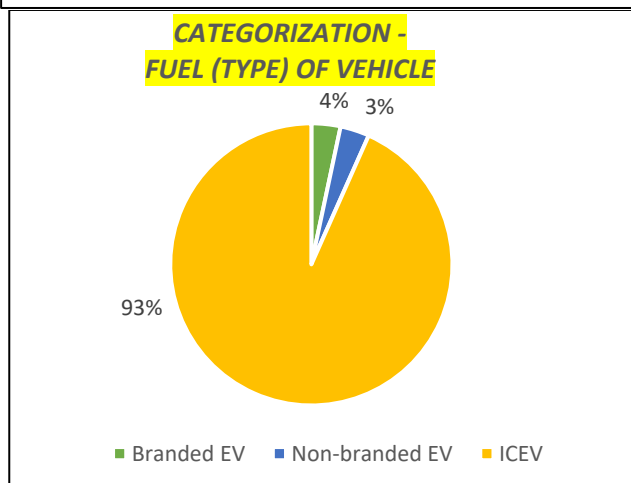
1) Categorization based on type of vehicle that caused fire:

In-use vehicles have contributed to 42% of the fires and in 27% of the cases, fire has happened due to used vehicles. It can also be observed, 7% has been contributed by new vehicles. 1 fire incident has been caused by a vehicle being recalled by the manufacturer (MV. COURAGE).

Type/ Age	Number of cases
<i>New vehicle</i>	3
<i>Used vehicle</i>	11
In-Use vehicle	12



Reefer unit on vehicles	5
Unknown vehicle	5
Other (non-vehicle fires)	5

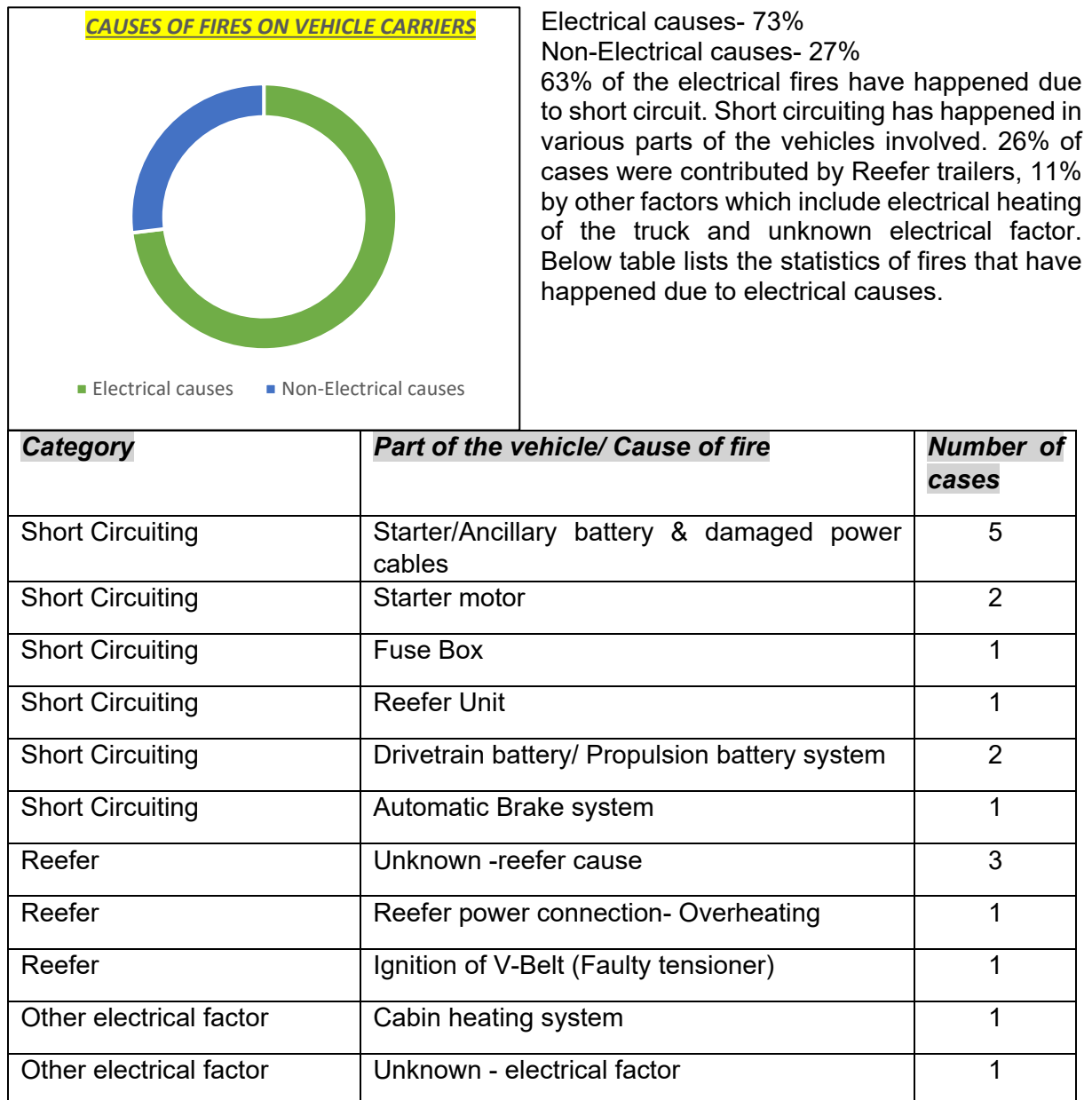


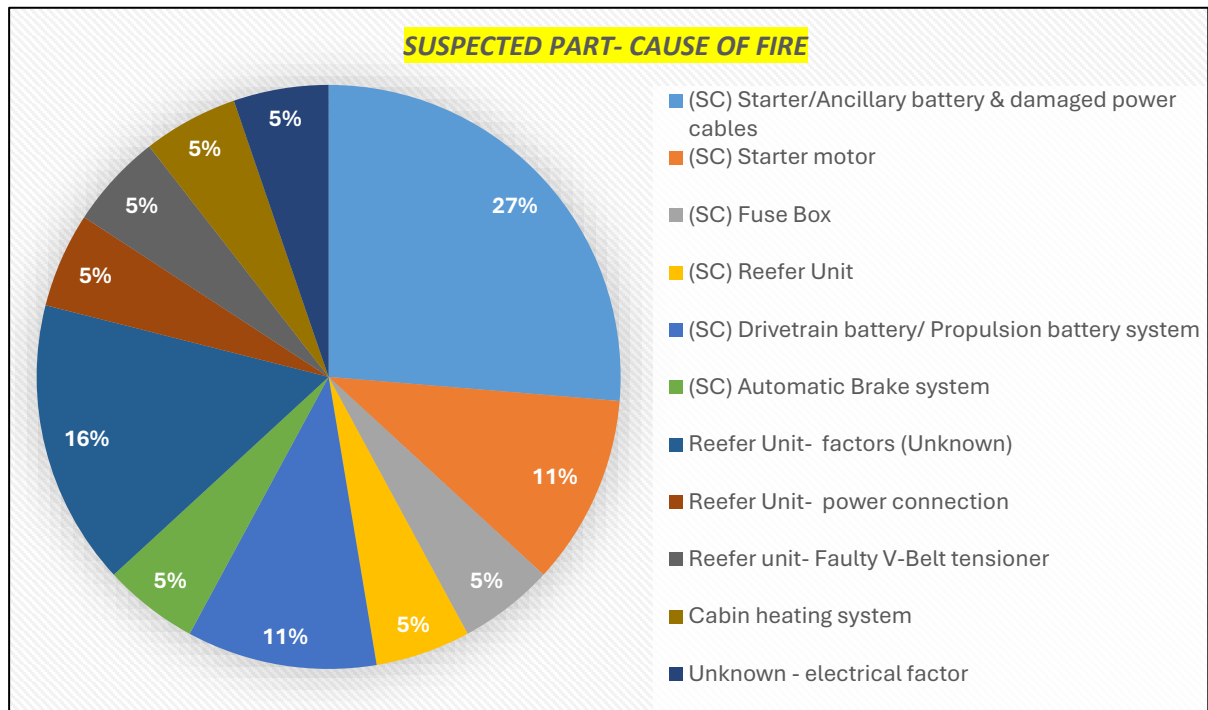
Type/ Fuel	Number of cases
Branded Electric Vehicle	1
Non-Branded Electric Vehicle	1
Internal Combustion Engine Vehicle (ICEV)	28

The term 'non/branded electric vehicle' has been used to differentiate a typical EV (manufactured) and an EV which has been converted from an ICEV by the passenger. (MV. PEARL OF SCANDINAVIA). The non-branded electric vehicle does not mean a prototype vehicle.

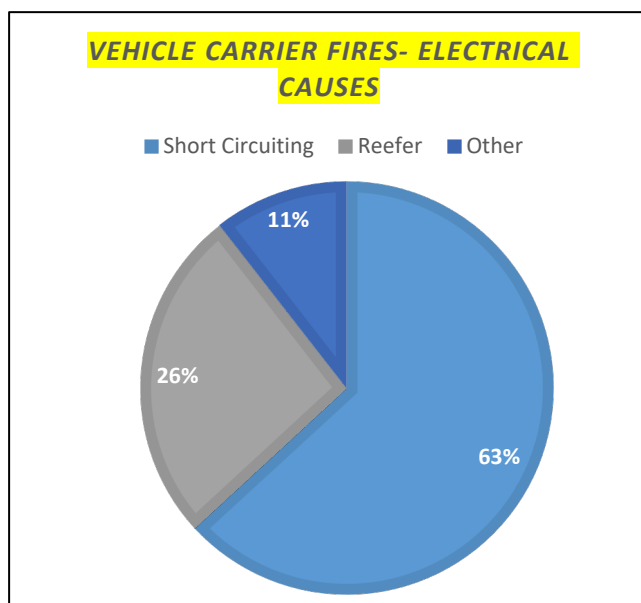
2) Categorization based on nature of fire source:

Based on the analysis, 62% of the investigation reports have identified the part of the vehicle that caused fire with some or more level of certainty. Below is the summary of summary of individual causes of fire.





*(SC) in the above statistical diagram refers to Short Circuit.



Non- electrical factors:

Non-electrical factors that have contributed to fire were self-ignition of the contents, cargo shifting and other unknown factors.

Non- electrical cause	Number of cases
Self-Ignition of contents	3
Unknown	3
Cargo Shifting	1