Accident Investigation Board Norway

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REPORT Road 2017/04

REPORT ON FIRES IN GAS-POWERED BUSES IN HORGVEGEN, RANHEIM, TRONDHEIM ON 17 DECEMBER 2016 AND AT FLATÅSTOPPEN, TRONDHEIM ON 23 NOVEMBER 2016

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Photos: AIBN

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REPORT ON BUS FIRES

Date and time:	23 November 2016 at 9:15	17 December 2016 at 9:30
Scene of the accident:	Flatåstoppen 1, Trondheim	Nedre Humlehaugen Vest, Horgvegen, Ranheim in Trondheim
Road no, main section (hp), km:	1601 KV 3055 HP1 m948	1601 KV 6130 HP7 m209
Type of accident:	Bus fire	Bus fire
Vehicle type and combination:	Solaris Inter-city 2010 model Gas-powered (CNG) bus	Solaris Inter-city 2010 model Gas-powered (CNG) bus
Type of transport:	Passenger transport	Passenger transport

NOTIFICATION OF THE ACCIDENT

The police notified the Accident Investigation Board Norway (AIBN) of both fires on 17 December 2017. The AIBN obtained further information about the incidents and it carried out technical examinations of the buses in Trondheim on 10 and 11 January 2017, in cooperation with the National Criminal Investigation Service (Kripos). On 16 February 2017, the AIBN informed the affected parties that it would conduct a safety investigation of the fires.

SUMMARY

Two very similar fires with gas-powered (CNG) buses occurred in Trondheim in November and December 2016. Both fires probably started in the LED lights that illuminated the rear licence plate of the buses. SHT undertook examinations and tests of several new and used licence plate lights, as well as conducted tests of short-circuited lights of the same type. SHT has also examined the electrical system on a similar bus.

SHT's investigation of the used LED-lights revealed cracks that were not compatible with normal impact of fastening, or normal use. The lights have most likely had cracks that did not prevent moisture intrusion into the lights. Moisture with subsequent corrosion in circuit board components in LED light is therefore a probable source of ignition in both fires. The light manufacturer has confirmed that the cracks in the lights probably had occurred due to insufficient heat treatment during production, and as a result, the manufacturer has changed this process.

The investigation also showed that the fuses in the electrical system were too large in relation to the light manufacturer's recommendations for the licence plate lights. Thus, the fuses were not an effective barrier to fire in the event of faults in single components.

As a result of the investigation, SHT believes that the regulations for the design of electrical systems in vehicles do not adequately protect fires. There is no requirement for the manufacturer of the lights should state the fuse rating when selling the lights, just the voltage and power. The regulations does not specify which additional capacity a single-fuse circuit and several consumers may have.

Furthermore, the sound reducing material used in the two buses were not compatible with good fire resistance, and it contributed to the fire in both cases. It is likely to assume that both fires would be fully developed fires, without fire rescue from the fire department, even with internal fire extinguishing system triggered and the use of handheld extinguisher in the fire on December 17.

The AIBN issues two safety recommendations as a result of this investigation.

1. FACTUAL INFORMATION

1.1 Sequence of events

1.1.1 Fire in a bus while driving near Ranheim in Trondheim on 17 December 2016

In the morning of 17 December 2016, the bus was in service at Ranheim with three passengers on board when a fire arose in the rear of the vehicle. When the bus stopped at Nedre Humlehaugen Vest bus stop, a car approaching from behind informed the bus driver that the rear of the bus was on fire. The bus driver turned off the main power switch, closed the gas supply and evacuated the passengers. He then attempted to put out the fire with the available fire extinguisher. However, he was unable to stop the fire from developing, and therefore called the fire service immediately. The extinguishing system in the engine compartment was activated, and this limited the development of the fire somewhat.

Figure 1: Fire damage to the rear of the bus, the engine compartment cover is lying on the ground behind the bus and the fire extinguisher is empty. Photo: The police

Figure 2: Close-up of the fire damage to the rear of the bus. Photo: The police

The police and fire service were notified at 09.35 and arrived at the scene approximately two minutes later. The fire service then extinguished the fire immediately. Only the area at the rear of the bus was on fire, and the gas tanks were not damaged. No persons were injured.

1.1.2 Fire in a bus at a turning circle near Flatåstoppen in Trondheim on 23 November 2016

In the morning of 23 November 2016 at the final stop at Flatåsen, a bus was stationary with the engine, internal lighting and main lights turned off. The bus driver was conducting an external inspection of the vehicle, and a passenger was boarding the bus. At the same time, the driver noticed a person who waved and pointed to the rear of the bus from a distance. The bus driver became aware of smoke and flames from the rear of the bus near the engine compartment, and immediately notified the fire service before he asked the passenger to leave the bus and move away. He took the available fire extinguisher, but was unable to put out the fire in the vehicle due to the strong heat and fire developing. Together, the driver and the person who first discovered the fire directed the traffic around the scene of the incident. The bus driver deemed it too unsafe to approach the vehicle's external main power switch to turn it off. The extinguishing system in the engine compartment was activated, but did not prevent the fire from developing.

Figure 3: First photo of the fire, taken at 9:15. Photo: Helge Harsvik

Figure 4: The fire service's extinguishing efforts, at 9:24. Photo: Helge Harsvik

Figure 5: The bus after the fire had been extinguished. Photo: The police

The police, ambulance and fire services arrived approximately ten minutes after the emergency call. The police established a safety zone of approximately 50 metres around the bus and evacuated residents from nearby houses. The fire service managed to put out the fire quickly and were able to report that the fire had not affected the gas tanks, which were located on the roof of the bus. No persons were injured.

1.2 Starting point and spread of fire in the buses

The AIBN carried out a technical examination of the buses in Trondheim on 10 and 11 January 2015 together with representatives from Kripos. No damage to the gas system or engine was found in either of the buses. Based on burn marks found in both buses, the fire was assumed to have started inside the engine compartment below the rear hatch. This space contained cables for several rear lights and feedthroughs for two licence plate lights that illuminated the buses' rear licence plates. There were burn marks on the outside, and marks of the fire having spread through the insulation material on the inside of the rear hatch and up towards the passenger compartment.

Figure 6: From the fire on 17 December 2016. Rear hatch placed in the position it was in before the fire. Photo: The police

Figure 7: From the fore on 17 December 2016. Melted plastic in the engine compartment and insulation burnt in a V shape on the inside of the rear hatch. Photo: The police

Figure 8: Fire on 13 November 2016. Damage to the engine compartment. Photo: AIBN

Figure 9: Fire on 13 November 2016. Fire damage to the interior, looking towards the rear of the bus. Photo: AIBN

In both buses, the licence plate lights were charred, and the circuit board was visibly deformed at the contact points. In the bus that caught fire on 17 December 2016, the fuse for the licence plate light circuit was still intact, while the cables were burnt through and showed arcing damage.

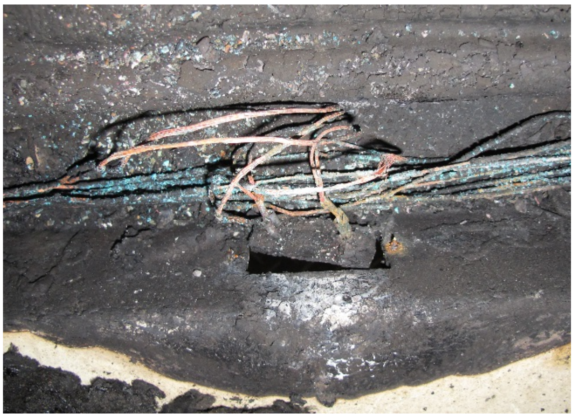

Figure 10: Licence plate light from the fire on 17 December 2016 with arcing damage to the circuit. Photo: AIBN

Figure 11: Licence plate light from the fire on 13 November 2016. Photo: AIBN

The examination of the bus that caught fire on 17 December 2016 showed several blown fuses. These fuses belonged to the heat pump, the gear box, the rear door control system, suspension, one of the main battery fuses, and several fuses for the engine control system. These blown fuses could not be related to a cause of fire, but were assumed to be caused by a fire that was already developing.

The 15 A fuse for the circuit for the licence plate lights was intact.

1.3 Vehicle and load

1.3.1 General information about the buses

The buses were 2010 model Solaris Inter-city buses, environmental class Euro 5T. They were both gas-powered (CNG). Both buses had been individually approved in Norway. The buses operated as part of the public transport system in the city of Trondheim and the surrounding areas. They were owned by the company Nettbuss AS, which also carried out daily checks and inspections of the buses, in addition to simple maintenance and cleaning using a pressure washer.

The buses had no known technical faults, but the bus that caught fire at Flatåstoppen had previously suffered an engine failure resulting from a defective dynamo.

The bus that caught fire on Horgvegen at Ranheim had its last periodic roadworthiness test (‘EU inspection’) on 18 March 2016, when it had travelled a total of 344,098 km. The bus that caught fire at Flatåstoppen had its last periodic roadworthiness test on 29 February 2016, at which date it had travelled a total of 316,360 km.

1.3.2 The electrical system

The electrical system was charged by a dynamo and a 24-volt battery pack that supplied power to the various consumers. The fuse box was located in the roof of the bus, along with all cables and pertaining fuses. The cable network branches out through various distributions of the Siemens VDO multiplexer type.[1] Five such units were installed in each vehicle, and the power supply for the rear licence plate lights was connected via such a multiplexer.

Figure 12: Fuse box, multiplexers and wiring in the buses in question. Photo: AIBN

The input circuit for the multiplexer was protected by a 15 A fuse and the power was distributed to a group of six outgoing circuits in the multiplexer. The six outgoing circuits in the group had a wire cross section of 0.75 mm^2 and were dimensioned for 3 A each, and were only protected by the 15 A fuse on the input circuit and the multiplexer's internal earth-fault protection.[2]

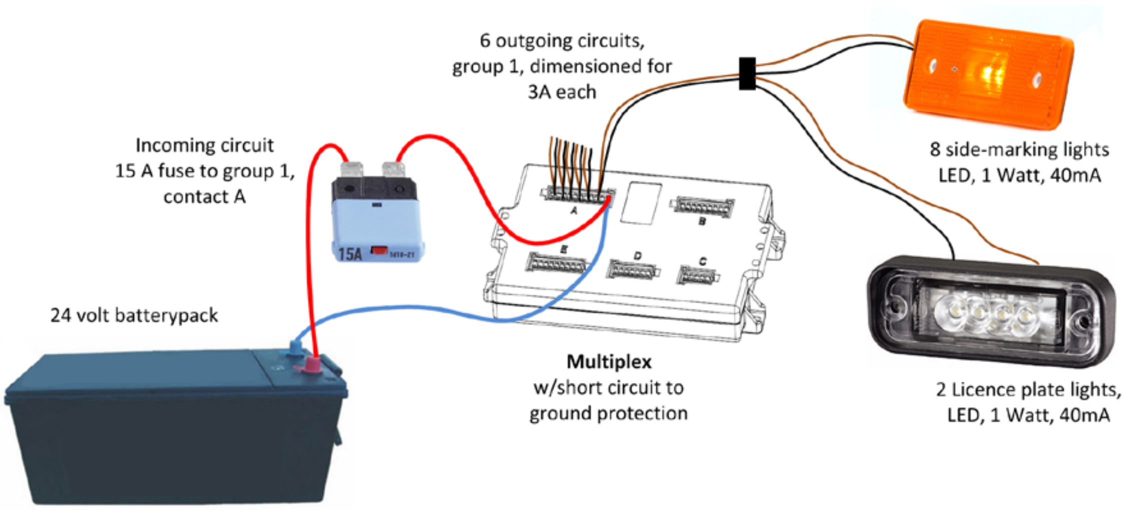

Figure 13: Simplified sketch of the electrical system from the battery to the licence plate lights. Sketch: AIBN

The incoming circuit for this group would not be broken by turning off the main power switch, but would be broken by disconnecting the earthing for the entire electrical system.

The multiplexer would nevertheless have delivered voltage as soon as the earth-fault protection had cooled down, provided that the 15 A fuse had not blown or broken. The

[1] A multiplexer (mux) is a unit that can receive data input and distribute tasks/functions to several electrical outputs.

[2] The multiplexer had a thermal earth-fault circuit breaker that would cut the power if the electric current exceeded 44 A in under 3 ms, but automatically reconnect after cooling down. No warning was given that the earth-fault protection had been triggered.

earth-fault protection was of a mechanical type that gave no warning when it was triggered.

The licence plate light circuit had branches going to two licence plate lights in addition to eight side marker lights with LED technology, all of 1 W each. The theoretical electric current in this circuit was 0.4 A.

1.3.3 The licence plate lights

The licence plate lights installed in both buses were LED[3] lights manufactured by Hella. The lights had been installed on both buses during the first half of 2016 as replacements for the original licence plate lights, which were incandescent light bulbs.

The licence plate lights could operate using either a 12-volt or a 24-volt system. In this case, they were connected to a 24-volt circuit with a current of 40 mA (0.04 A) and a power rating of 1 W.

The lights had an IP rating of 6K9K, which indicated that they were dustproof and capable of withstanding high-pressure jets and high temperatures. The lights were also equipped with polarity reversal protection, which, in practice, means that it is irrelevant how the lights are connected to the circuit. The lights were ECE-approved, CE-marked and also had ADR transport approval. They had no internal fuse.

The lights were moulded in one piece from a combination of plexiglass and various polypropylene (thermoplastic) products. These plastic products are commonly used in electric components and were classified as HB, a low flame-retardant classification based on the UL 94 standard.[4]

These licence plate lights were marketed as a good replacement for incandescent bulbs in licence plate lights.

In Hella's product catalogue,[5] the following was stated about the LED licence plate lights under the heading 'Technical information':

> [Excerpt] *The individual light functions may only be operated with a vehicle fuse of max. 3A. In the case of onboard current limitation with the values specified above by the onboard control unit an additional fuse for the lamp is not required.*

The mounting instructions[6] for the licence plate lights describe how the lights are to be mounted and that each light can be secured with two screws to a maximum torque of 1.5 Nm, but they do not describe what type of fuses are necessary to protect the licence plate lights.

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[3] LED: light-emitting diode. Light-emitting diode supplied with a transformed direct current of 1.8–3.5 V, depending on the light colour.

[4] 'Standard for Safety of Flammability of Plastic Materials for Parts in Devices and Appliances testing', published by Underwriters Laboratories, USA.

[5] http://cat.hella.com/web/public/hella/en_GB/$catalogue/2/$product/2KA%2B010%2B278-011_2489/datasheet.xhtml

[6] http://cat.hella.com/pim43/upload/HellaDocs/datasheet/base/460_874-01.pdf

Figure 14: LED licence plate lights. Source: Hella

1.3.4 Insulation material on the inside of the rear hatches

In both buses, the insulation material on the inside of the rear hatches of the engine compartment was of the type T26F/PA/CARBONFLEECE. Information from the material safety data sheets for these insulation mats show that they have been tested for vertical fire spread (< 100 mm/min). The insulation mat primarily consisted of polyurethane, which can ignite, melt and drip if exposed to a source of ignition or sufficiently high temperatures. According to the material safety data sheet, the mats are capable of withstanding a constant temperature of 120 °C, and up to 180 °C for short periods.

Following a campaign by Solaris, the buses had been retrofitted with extra soundproofing insulation at the rear axles after manufacture, but this did not include additional insulation of the rear hatch.

Figure 15: Right side of the V-shaped burn in the insulation on the rear hatch on 17 December 2016. Photo: AIBN

1.3.5 Ignition sources in the engine compartment

There are many hot surfaces in the engine compartment that could potentially be a source of ignition if a flammable material were to come into contact with them. Hydraulic or electric components in buses are potential sources of ignition if they are faulty or damaged. Originally, a lamp was installed in the engine rooms to illuminate the engine room, but this lamp had been dismantled and removed. This had been done on all buses following Solaris's own investigation into the fire on 23 November 2016, where a faulty engine room lamp was assumed to be the source of ignition.

1.4 Acts and regulations

1.4.1 Electrical equipment in vehicles

The Regulations of 4 October 1994 No 918 relating to technical requirements for and approval of vehicles, parts and equipment (the Motor Vehicle Regulations) define technical requirements for licence plate lighting for vehicles. The following is an excerpt from Section 27-1, General provisions concerning electrical equipment and electromagnetic noise:

> *The electrical wiring shall be adequately dimensioned for the electric current it is intended to carry. Wires shall be well insulated, and shall be installed and fastened in such a way that they are not exposed to harmful mechanical or chemical stress or harmful heat. Fuses shall be correctly dimensioned.*

The buses were built in accordance with the requirements set out in ECE 107, under which circuits shall include a fuse or a circuit breaker, and several circuits may be protected by a common fuse or a common circuit-breaker, provided that their rated capacity does not exceed the capacity of the fuse or circuit-breaker. The specifications for licence plate lights referred to in the Norwegian regulations are UNECE regulations ECE 4 (licence plate lights) and ECE 128 (LED technology). The regulations contain requirements for testing and approval of lights as well as requirements for information about the voltage and power (volt and watt).

1.4.2 Requirements for materials used in the interior, insulation etc.

The fire requirements for materials used in bus interiors were regulated in UNECE Regulation ECE 118 adopted in December 2015. In December 2016 the Regulation was updated to include materials used in engine compartments, along with fire testing for vertical surfaces in buses. The Regulation became mandatory for components with effect from 26 July 2016 and for new vehicles with effect from 26 July 2017, and, as from 26 July 2020, it will apply to all vehicles on first-time registration. The Regulation does not require fire testing of metal structures, windows, materials' smoke emission or toxicity.

1.5 Examination of licence plate lights and the electrical system of a similar bus and fire testing

1.5.1 Examination of discarded licence plate lights

The AIBN observed cracks in the plexiglass of several used and discarded lights that could not be related to impacts from installation or naturally occurring mechanical stress. In lights where cracks were observed, the internal circuit boards were also visibly corroded.

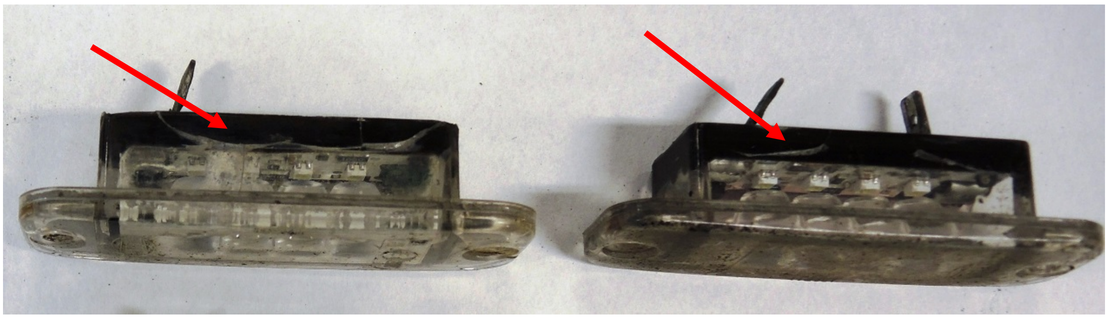

Figure 16: Used licence plate lights. The arrows indicate the longitudinal cracks in the plexiglass. Photo: AIBN

1.5.2 Examination of the electrical system of a similar bus

A bus with a similar electrical system was examined in order to observe different loads on the licence plate lighting circuit, and all circuits protected by the same 15 A fuse before the multiplexer. In a ‘normal situation’, all the circuits in the same group had a total amperage of approximately 0.3 A. Another 5.2 A of current was added to the circuit in order to check whether there were signals/warnings when the current in the circuit exceeded 3 A. The multiplexer did not give any indication of overload at this level.

Figure 17: During operation, all the circuits connected to group 1, output A in the bus's multiplexer used 0.3 A. Photo: AIBN

Figure 18: The licence plate lighting circuit at 5.5 A, more than the consumption at the time of the fire in the licence plate light. Photo: AIBN

Since the wiring from the multiplexer has such a small cross-section, no tests were conducted with loads in excess of 15 A in the fuse circuit. The relevant fuse was removed, and this triggered sound and text warnings on the driver's dashboard. At the same time, it was observed that the doors could only be opened manually. It is not known whether this was also the case in the buses that caught fire.

1.5.3 Fire testing

Unused licence plate lights were filled with a salt water solution and sealed, and voltage was then applied from a 24-volt battery pack connected to a charger, corresponding to a bus in operation. The salt water solution was used to simulate and accelerate corrosion.

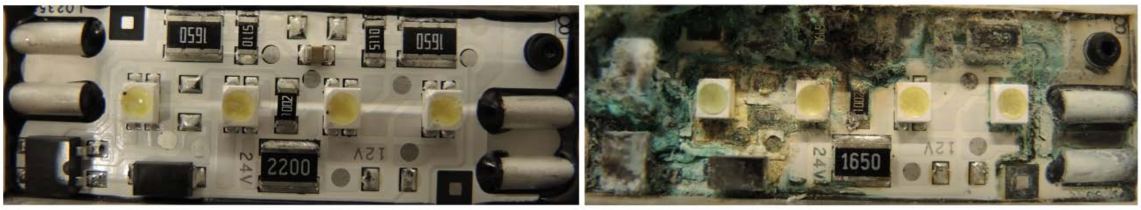

Figure 19: The interior of a new LED light shown on the left, and on the right a defective and corroded one. Photo: AIBN

The salt water solution caused some licence plate lights to stop working, and in several cases arcing occurred and caused the light to catch fire. The amperage in the lights was logged during the tests, and currents ranging from 2.5 A to 6 A were measured when the licence plate lights ignited. The lights that caught fire had visible deformation to their exterior surface at the contact points. Abnormal amperages were observed in the licence plate lights, regardless of whether or not they shone.

Figure 20: Fire test of licence plate lights, thermal image just before ignition, temperature approx. 257 °C. Photo: AIBN

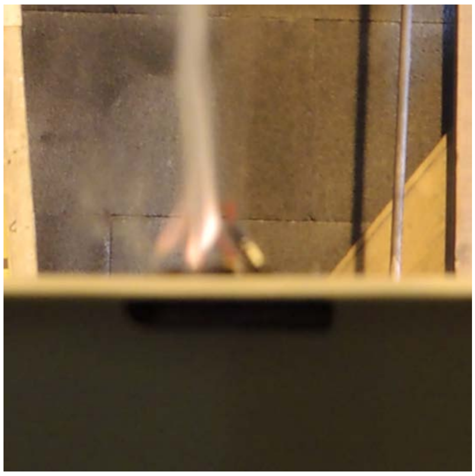

Figure 21: Licence plate light in the same experiment with visible flames. Photo: AIBN

1.6 Implemented measures

After the fires, Solaris, in cooperation with Nettbuss, disconnected all the licence plate lights on the buses. Solaris presented the findings from the examination of the buses' electrical system to the manufacturer. Solaris has updated the software in the multiplexers in the buses in Trondheim, which contain internal overload protection where the output from the MUX is cut at < 3 ms if the current reaches 10 x 3 A.

The light manufacturer, Hella, has reviewed and modified its internal requirements, production process and quality control. The cracks in the licence plate lights that the AIBN was unable to explain after its technical examination, were already known to Hella. The company has now ascertained that the weaknesses that caused cracks to develop in the plexiglass had to do with the time interval during which the licence plate lights underwent heat treatment in an oven during the moulding process in the production phase. Hella has adjusted this time interval accordingly.

The company has also started updating the mounting instructions, a printed version of which will eventually be enclosed with such lights sold to customers.

2. ANALYSIS

2.1 Introduction

A bus fire is a serious incident with a high injury/damage potential, particularly when the energy carrier is gas. The AIBN therefore chose to investigate the two fires, even though they only resulted in material damage. The buses were of the same type and from the same year of manufacture, and the incidents took place within a short time of each other.

The purpose of the investigation has been to investigate and identify the cause of the fires and how they spread, and, if possible, to identify the contributory factors behind the fires. The AIBN has also identified barriers that can be strengthened in order to prevent similar fires and further limit their spread. The AIBN's investigation did not address the evacuation or weather and driving conditions.

2.2 Cause of the fire

The investigation showed that, in connection with the fire on 17 December 2016, cracks had most likely developed in the plexiglass on one of the licence plate lights on the rear hatch some time before the fire. This allowed moisture to ingress into the light, which in turn lead to corrosion and subsequent arcing in the circuit board and ignition. The fire has probably spread through the wiring and into the sound insulation mat fastened above the licence plate light on the inside of the rear hatch. The arcing in the licence plate light has not consumed enough power to blow the fuse, but the cables above have probably gradually burnt through. This has resulted in arcing, and the multiplexer's earth-fault protection may have been triggered. Based on the fire-technical examinations and findings from the investigation, the AIBN deems the cause of the fire to be identical in both cases.

2.3 Fuse ratings in the electrical system and dimensioning

The electrical system has its own fuse protection against faults. In the event of current to the consumers or in the wiring exceeding what the system was designed for, the fuses will blow and cut the power, forming a barrier against fire, among other things. Simple tests demonstrated that a fire could occur in the licence plate lights in question at amperages as low as around 2.5 A.

In the AIBN's opinion, the fuse circuit (15 A) that protected the incoming cables to the multiplexer did not protect the outgoing cables or the licence plate lights. This fuse was thus overdimensioned, so that the currents created in the licence plate lights, which were great enough to give rise to a fire, were not detected. The AIBN also questions why six fuse circuits distributed via the multiplexer, each dimensioned for 3 A, were not separately protected. In the AIBN's opinion, the fires could probably have been avoided had the fuse circuit been dimensioned for 3 A. LED lights draw less electricity than traditional incandescent light bulbs, but are also more complex in structure. Unlike an incandescent bulb, where the current is cut as soon as the filament is broken, faults in LED lamps exposed to moisture can develop over time and create new paths for the current in the circuit board, regardless of whether or not the licence plate light is shining or not.

In connection with the sale of LED lights, manufacturers are not required to provide information about the dimensioning of fuse circuits, but only about the voltage and power for which the lights are designed. In the AIBN's opinion, this is unfortunate because it makes it more challenging to dimension the wiring for operation and for handling faults.

The AIBN considers it to be a weakness in the regulatory framework that no requirements are stipulated for the relationship between the capacity for which the wiring is dimensioned and the amperage that may be drawn by an individual component in the same network. A licence plate light that draws 40 mA during operation and 5A in the event of a fault, should not be connected to a circuit that has a load of 0.3 A during normal operation and is protected by a 15 A fuse. In this case, a faulty consumer could draw up to 14.7 A without blowing the fuse or triggering the earth-fault protection. The AIBN submits a safety recommendation on this issue.

2.4 Fire resistance in the engine compartment and possibilities for fire extinguishing

The sound insulation materials used in the two buses did not have good fire resistance. The sound insulation mats vertically installed above the licence plate lights probably contributed to the spread of the fire in that the heat caused them to melt, drip and burn, which in all likelihood added flammable material to the ignition source. Furthermore, the sound insulation material, which was vertically installed, had not been fire-tested for vertical fire spread. In the absence of the fire service's extinguishing efforts, both buses would presumably have been engulfed in a fully developed fire, even if the internal extinguishing system had been activated and a hand-held fire extinguisher used as in connection with the fire on 17 December.

The AIBN is not sure whether the type of materials used in the sound insulation mats will continue to be used after the introduction of more stringent requirements in UNECE Regulation ECE 118, and is concerned that the strict sound insulation requirements could have an outright negative effect on fire safety in that materials with poor fire resistance properties may be chosen. In an engine compartment, where a great number of ignition sources exist alongside a lot of flammable materials, there are few physical barriers to prevent a fire from spreading to the bus's passenger compartment.

The AIBN is also concerned that, even with fire detection and extinguishing systems installed, the bus driver receives no warning of an incipient fire. The starting point of the fire suggests that it should have been easy to put out, but even with a hand-held fire extinguisher the inside of the rear hatch to the engine compartment was inaccessible for extinguishing in the incipient phase.

3. CONCLUSION

3.1 Investigation results

a) In all likelihood, both fires started in the lights that illuminated the buses' rear licence plate.

b) The AIBN's investigation of the used LED lights revealed cracks that were not compatible with impacts from installation or normal use.

a) The licence plate lights probably had cracks that allowed ingress of moisture. Moisture and the resulting corrosion of components on the LED lights' circuit boards make them a probable ignition source in both fires.

b) Hella's review of the production process for the licence plate lights found that the cracks had to do with how long the lights were kept in the oven during the moulding process.

c) In its catalogue, Hella prescribes a maximum fuse circuit of 3 A for its LED lights. The licence plate circuit was connected to a multiple connector in a multiplexer protected by a 15 A fuse circuit.

d) A review of the electrical system in a corresponding Solaris bus showed that the wiring to the licence plate lights was only protected by a 15 A fuse in a circuit with a theoretical load of 0.4 A.

e) Manufacturers are not required to provide information about fuse circuits, only about voltage and power.

f) The regulatory framework does not specify the additional capacity that a circuit with a single fuse and several consumers may have.

g) The sound insulation mats placed vertically above the licence plate lights have probably contributed to the spread of the fire in that heat has caused them to melt, drip and burn, and this has probably introduced flammable material to the ignition source.

h) The vertically installed noise insulation material had not been fire-tested for vertical fire spread.

i) Turning off the main power switch did not break the licence plate light circuit. This circuit would have been broken, however, by the earth-fault circuit breaker by the batteries.

j) In the absence of the fire service's extinguishing efforts, both buses would presumably have been engulfed in a fully developed fire, even if the internal extinguishing system had been activated and a hand-held fire extinguisher used as in connection with the fire on 17 December.

4. SAFETY RECOMMENDATIONS

The investigation of this accident has identified several areas in which the AIBN deems it necessary to submit safety recommendations for the purpose of improving road safety.[7]

Safety recommendation ROAD No 2017/ 10T

Two bus fires in Trondheim in 2016 started in the LED lights that illuminated the rear licence plate on the buses. The lights have in all likelihood had cracks that stem from an error in production, which allowed moisture intrusion into the lights. The wiring of the lights was secured with a 15 A fuse, too high to prevent a flammable short circuit and far above what the light manufacturer recommends.

The Accident Investigation Board Norway recommends that Solaris Norway review and improve the dimensioning of the electrical system on existing and corresponding buses, so that fuse rates will be an effective barrier against fire in case of component failures.

Safety recommendation ROAD No 2017/ 11T

The investigation of two bus fires in Trondheim in 2016 showed that the bus's original incandescent bulbs in the licence plate lights, were replaced with new LED lights, which have other features and different construction. The wiring of the licence plate lights was secured with a 15 A fuse, far above the current required by an LED light and what the light manufacturer recommends. The Vehicle Regulations, and ECE 107, describe that the electrical system, is to be dimensioned according to the capacity of fuses and wiring, but also that several wires can be secured by a single fuse or switch. However, the rule does not specify the rest capacity for a single-fuse circuit, or multi consumer circuit.

The Accident Investigation Board Norway recommends that the Norwegian Public Roads Administration follow up the requirements of the current regulations on the design of fuses and circuits, so that this will be an effective barrier to fire in the event of errors in all types of (LED) electrical components.

Accident Investigation Board Norway

Lillestrøm, 28 September 2017

[7] The investigation report is submitted to the Ministry of Transport and Communications, which will take necessary measures to ensure that due consideration is given to the safety recommendations, cf. the Regulations of 30 June 2005 on Public Investigation and Notification of Traffic Accidents etc. Section 14.