Accident
Investigation Board
Norway

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REPORT Road 2019/06

REPORT ON RUN-OFF-THE-ROAD ACCIDENT ON THE FV 651 ROAD, SVINEROIVEGEN, NEAR RJUKAN, TINN MUNICIPALITY, 2 SEPTEMBER 2018

The Accident Investigation Board has compiled this report for the sole purpose of improving road transport safety. The object of any investigation is to identify faults or discrepancies which may endanger road transport safety, whether or not these are causal factors in the accident, and to make safety recommendations. It is not the Board's task to apportion blame or liability. Use of this report for any other purpose than for road transport safety shall be avoided.

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This report has been translated into English and published by the AIBN to facilitate access by international readers. As accurate as the translation might be, the original Norwegian text takes precedence as the report of reference.

Photos: AIBN

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REPORT ON ROAD TRAFFIC ACCIDENT

Date and time:	2 September 2018 at 13:42
Scene of the accident:	Svineroivegen, Rjukan, Tinn municipality
Road no, main section (hp), km:	Fv 651,[1] hp2 m10,641
Type of accident:	Run-off-the-road accident
Vehicle type:	Cadillac Series 62, 1959 model
Type of transport operation:	Private

NOTIFICATION OF THE ACCIDENT

The Accident Investigation Board Norway (AIBN) was not notified of the accident, but became aware of it through the media. Due to the severity of the accident, in which five people died, the AIBN dispatched personnel to the accident site the same day.

SUMMARY

On 2 September 2018, a 1959 model Cadillac with driver and four passengers was heading down from Gaustatoppen towards Rjukan on the Fv 651 road (Svineroivegen), a stretch of road with an average gradient of nearly 10% and five 180-degree hairpin bends. After descending slowly and negotiating the penultimate hairpin bend, the car gathered speed. The investigation has shown that the car lost parts of its braking power somewhere along the approximately one-kilometre-long stretch of road leading down to the scene of the accident. Hence, the car entered the final hairpin bend at too high a speed to make the turn and crashed into the rockface. All the car's occupants died as a result of the accident.

The AIBN's investigation has shown that the car's brakes had not been adequately maintained and that the brake band on the right front wheel was worn down. The brake fluid was contaminated and had a high water content and a low boiling point. The car had automatic transmission, and the gear selector was set to 'Drive' when the car was examined. Seen in conjunction with other findings, the examination indicates that the driver did not use the gears to brake the car, but used the service brakes on the long, steep descent towards Rjukan.

The AIBN believes that the combination of prolonged use of the service brakes during the descent from Gaustatoppen, the high actual weight of the car and inadequate brake maintenance contributed to the car losing parts of its braking power somewhere between the final two hairpin bends on the descent from Gaustatoppen towards Rjukan.

The car was not equipped with seatbelts, and nor were they required in this vehicle. The AIBN's investigation has shown that seatbelts could have reduced the scope of injury in this accident.

The car was first registered before 1960, and was therefore exempt from the requirement for periodic roadworthiness tests. In the AIBN's assessment, a technical inspection of the brakes would have revealed inadequate brake maintenance.

[1] Fv 3430 from 23 May 2019.

Today's periodic roadworthiness tests include a visual inspection of the brake fluid. Severely contaminated brake fluid gives cause for remarks. The brake fluid's boiling point is not checked. On this basis, the AIBN is of the opinion that a check of the brake fluid's boiling point should also be included in the periodic inspection of brakes.

The roadside terrain consisted of concrete crash barriers on the left-hand side and a hillside cutting with protruding rocks on the right-hand side. The roadside terrain constitutes a hazardous roadside obstacle, and the AIBN recommends that Telemark County Authority consider measures to improve road safety on this road.

The AIBN submits two safety recommendation following this investigation.

1. FACTUAL INFORMATION

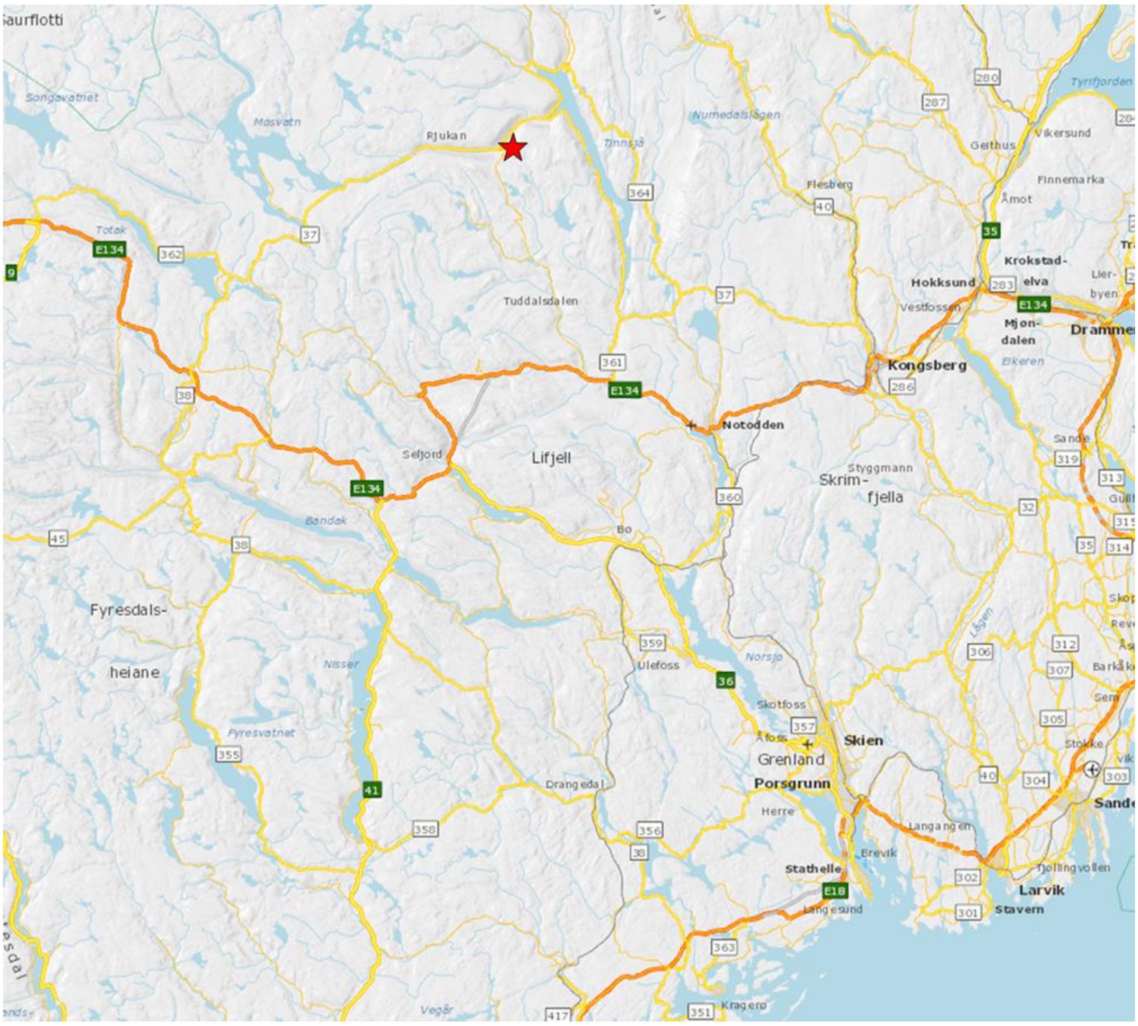

Figure 1: The accident happened on the Svineroivegen road near Rjukan. The accident site is marked with a star. Map: Road map, NPRA

1.1 Sequence of events

On 2 September 2018, a 1959 model Cadillac Series 62 was travelling from Kragerø towards Rjukan via Gaustatoppen, on the Fv 651 road. There were four passengers in the car in addition to the driver. It was a clear day and the road was bare.

The group made several stops along the way from Kragerø. The last known stop was at 13:33 where the road called Svineroivegen starts, in the first of a total of five hairpin bends on the road down to Rjukan. The stretch of road from the first hairpin bend down to the accident site is approximately 4.3 km long, with an average gradient of 9.6%; see Figure 2.

After making this final stop, the car descended slowly along the steep, narrow road, and two other cars caught up with it. The occupants of the second car behind the accident car have explained that they noticed a smell of hot brakes during the descent.

The accident car and the two other cars followed each other down to the penultimate hairpin bend on the stretch down to Rjukan. According to witnesses, the accident car gathered speed after negotiating that bend, and the occupants of the two other cars lost sight of it. They did not see the car again until they arrived at the scene of the accident, approximately one kilometre further down.

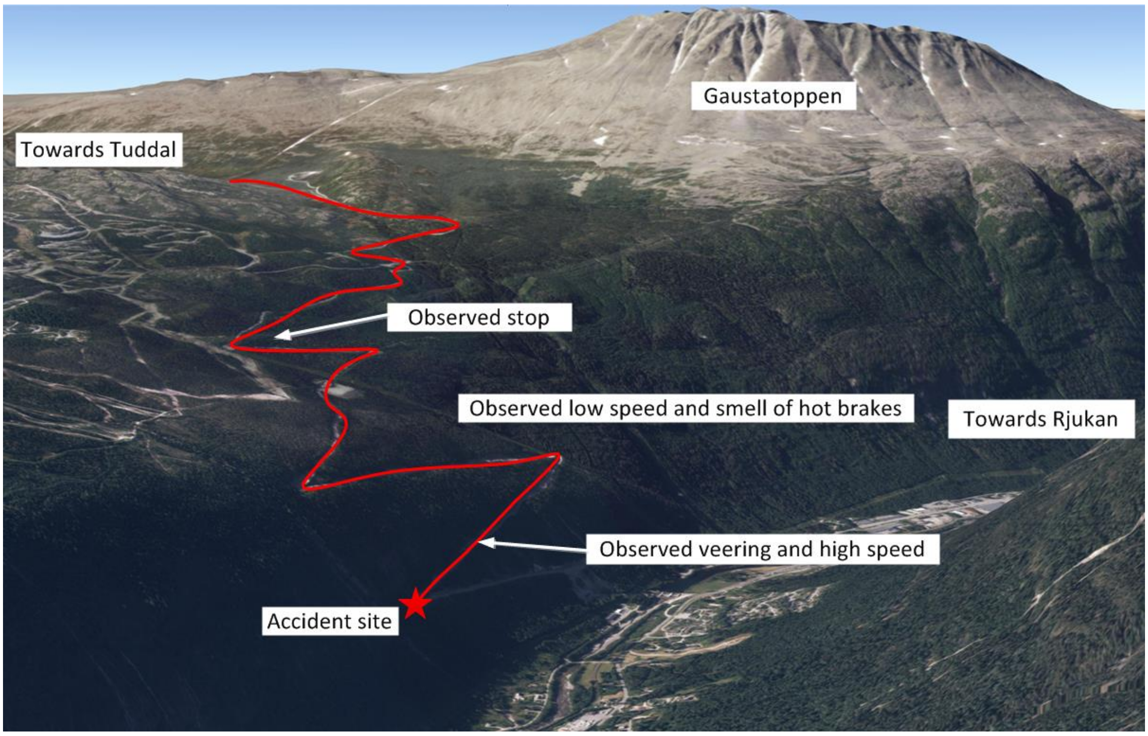

Figure 2: The red line shows the route down to the accident site. Illustration: www.norgeibilder.no, AIBN

At the same time, another passenger car containing the driver and one passenger was driving uphill from Rjukan towards Gaustatoppen. They spotted the accident car coming from the opposite direction as they were negotiating the first hairpin bend on their way up. The car veered from side to side along its half of the roadway. According to the driver of the passenger car, the accident car was going at such a high speed that it would have difficulties making the turn at the hairpin bend. The cars passed each other, and the driver of the passenger car going in the opposite direction looked in the mirror and saw that the accident car continued more or less straight on at the bend and crashed into the rockface.

1.2 Injuries

All occupants of the accident car, the driver and four passengers, died as a result of injuries sustained in the crash. Three of them died instantly.

1.3 Rescue operations

Another road user notified the Emergency Medical Communication Centre (EMCC) on the 113 emergency number at 13:42, immediately after the accident had occurred, and a triple alert was issued. At the same time as the EMCC was notified, road users at the scene administered first aid by ensuring that one of the passengers in the accident car had clear airways. Tinn fire service arrived at the scene at 13:49 and took immediate action to try to free the victims from the wreckage. Two ambulances and a doctor on duty were requisitioned from Rjukan and arrived at the scene at 13:51.

On arrival at the scene, the emergency services concluded that the driver, the front-seat passenger and the back-seat passenger on the right-hand side were dead. Of the two passengers who were still alive when the emergency services arrived, one died shortly after the emergency services had brought them out of the wreckage. An ambulance helicopter was requisitioned from Ål at 13:53 and arrived at approximately 14:23. At 14:55, the ambulance helicopter flew to Ullevål Hostpital with one of the passengers from the car. The person died from the injuries later on that same day.

Three ambulances were initially requisitioned from Skien, Notodden and Vinje, in addition to ambulance helicopters from Lørenskog and Rygge. However, these resources were demobilised when four of the five accident victims were declared dead.

1.4 Safety features and survival space

The safety equipment in the accident car was the same as when it was manufactured. This meant, among other things, that the car had no seatbelts, headrests or airbags. Nor were the front seats equipped with backrest locks.

There was survival space[2] in the car after the crash, both in the front and in the back; see Figure 3.

[2] The survival space available to the driver and passengers inside a car after deformation or indentation of the vehicle body in a collision.

Figure 3: There was survival space in both the front and back of the car after the crash. Photo: AIBN

1.5 Vehicle damage

1.5.1 Exterior damage

The front of the car suffered major deformations as a result of crashing into the rockface, increasing from a 15 cm indentation on the left-hand side to 1.7 m on the right-hand side of the car;[3] see Figure 4.The front suspension, engine, gearbox and rear axle were displaced towards the rear in the crash.

[3] According to measurements performed by the Norwegian Public Roads Administration (NPRA).

Figure 4: Deformation of the front of the accident car. Photo: AIBN

The bolt connections by which the gearbox and petrol tank were attached to the chassis were destroyed in the crash, and this caused the petrol tank to drop onto the roadway under the car.

1.5.2 Interior damage

The dashboard was deformed, and the steering wheel and steering column were bent upwards and forward; see Figure 5. Both front seats, the floor fastenings for the seat cushions and the seatbacks suffered major deformations. The seatback of the back seat came loose in the crash, but the cushion remained in place.

The bulkhead[4] sustained extensive damage throughout, especially in the lower part.

[4] The wall separating the passenger compartment from the engine compartment.

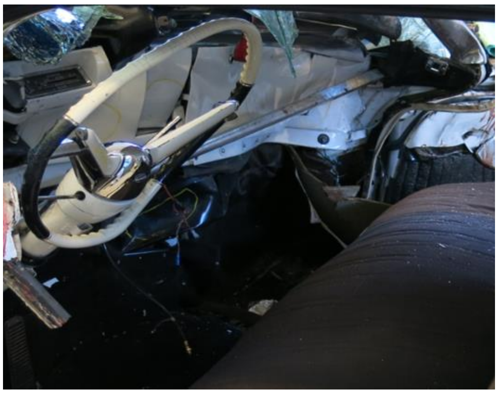

Figure 5: Deformation around driver's position. Photo: AIBN

Figure 6: Driver's position in corresponding car, a 1959 model Cadillac. Photo: AIBN

1.6 The scene of the accident

Figure 7: The hairpin bend where the accident occurred. The arrow marks the point of impact with the rockface. The tire tracks on the road are not from the accident car. Photo: AIBN

Where the accident occurred, there is a concrete crash barrier on the left-hand side of the road, when viewed in the accident car's direction of travel. In the middle of the hairpin bend, just left of the point of impact, a steel crash barrier has been erected on the right-hand side. The terrain beyond this barrier is steep and leads down to a valley.

The roadside terrain on the right-hand side of the car in the direction of travel consisted of an uneven rockface with protruding rocks. The car hit a protruding rock as it crashed into the rockface; see Figure 8.

Figure 8: There was a protruding rock where the car hit the rockface. Photo: The police

On-scene observations were recorded by representatives of the police and the NPRA on the day of the accident. Tire tracks were registered from the car’s right-hand wheel pair, which, according to the NPRA, measured 6.4 m from the rear corner of the car; see Figure 9. The AIBN inspected the scene of the accident on the following day. Several other tire tracks were found on and near the accident site, but the investigation showed that they were not left by the accident car.

Figure 9: Tire tracks from the right-hand wheel pair at the scene of the accident. Photo: NPRA

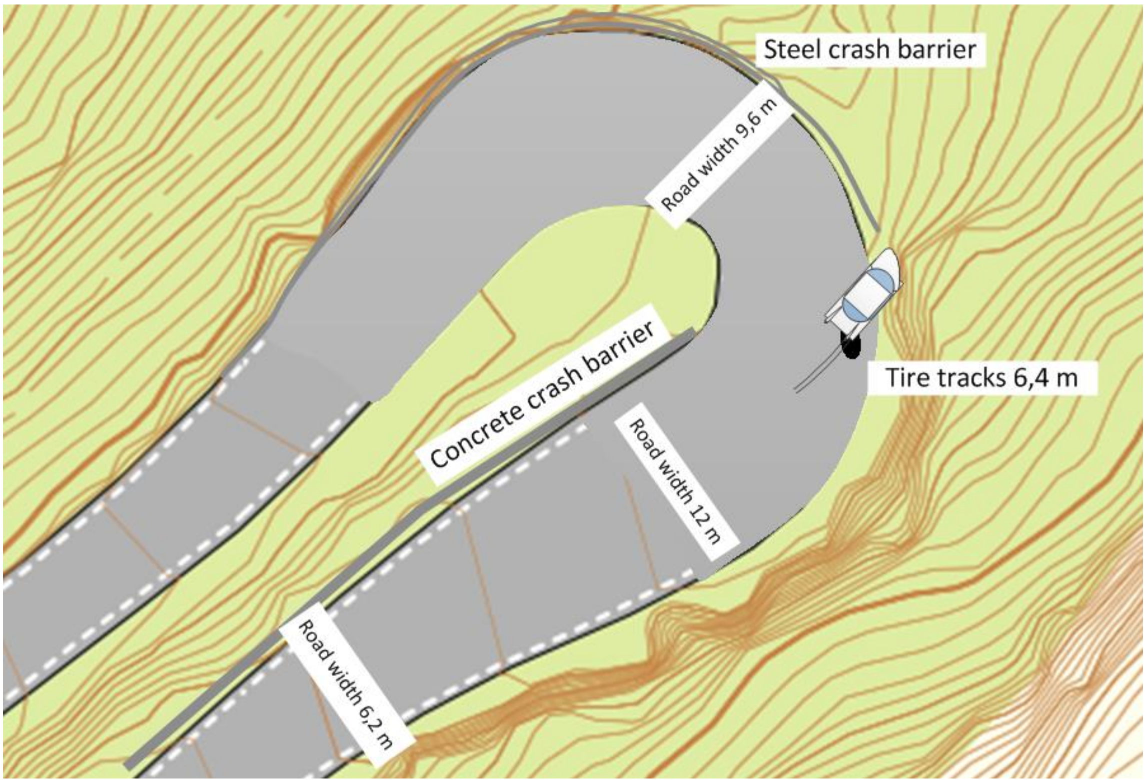

Figure 10: Schematic drawing of the accident site. Illustration: AIBN

1.7 Road users

1.7.1 Driver of the accident car

The driver was a woman, aged 50, holding a class AMBST driving licence. The driver was not the owner of the car, but had driven it several times before. Witnesses described her as an experienced and cautious driver.

According to information given to the AIBN, the driver was aware that there was a technical problem with the car's brakes.

1.7.2 Passengers

One passenger was seated in front and three in the back of the car. The front-seat passenger was a 56-year-old man, who was also the owner of the car. The passengers in the back seat were two women aged 63 and 59, respectively, and a man aged 63.

1.7.3 Driving route

The accident car had left Kragerø earlier that same day. Witness observations suggest that it had taken the following route: Kragerø, Skien, Hjuksebø, Heddal, Sauland and the Fv 651 road through Tuddal, which leads on to Svineroivegen. It would normally take just under four hours to complete this route.

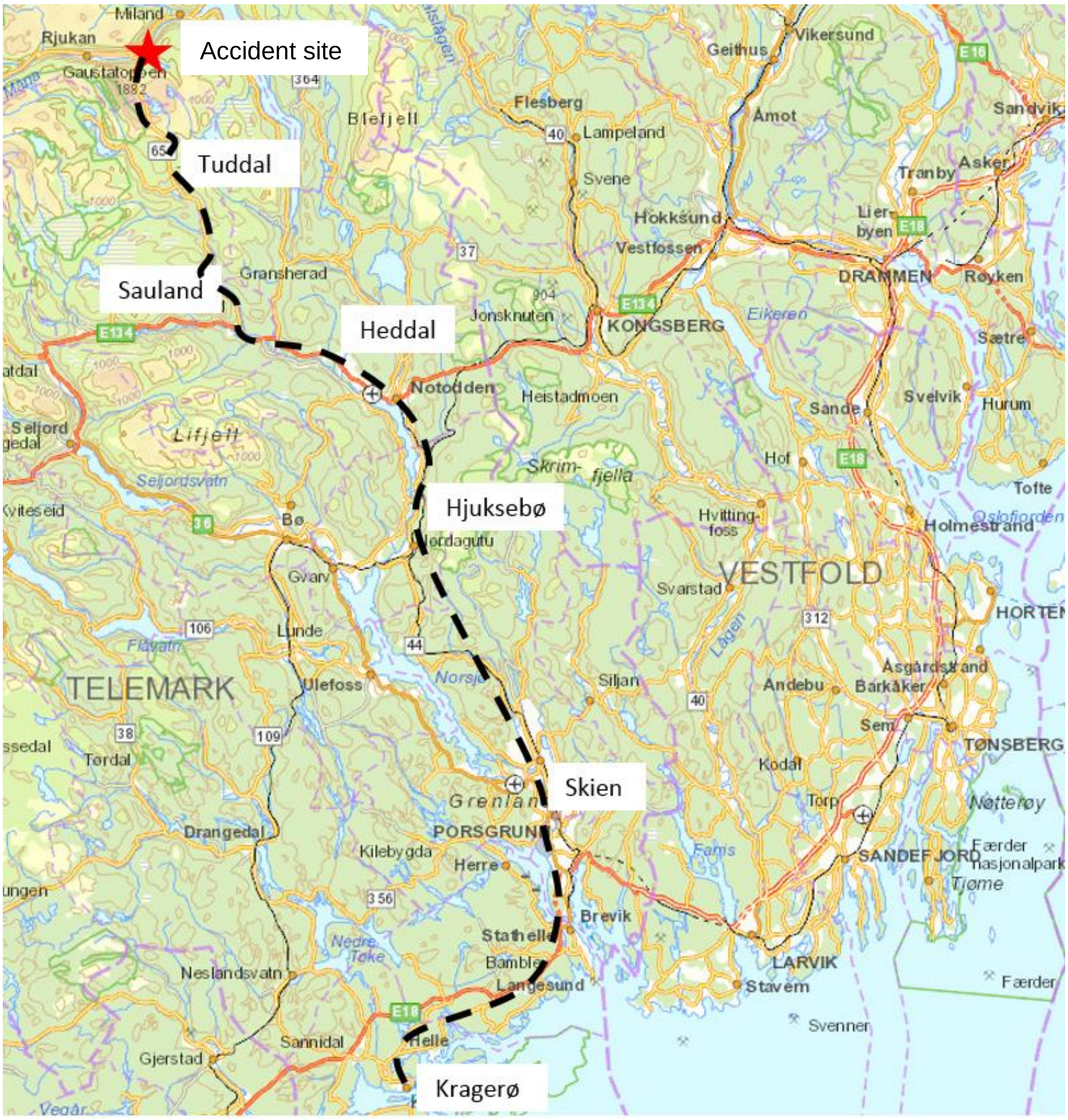

Figure 11: The driving route, according to information received by the AIBN. Map: © Norwegian Mapping Authority. Illustration: AIBN

1.8 Vehicle and load

The car was imported as a second-hand car and was first registered in Norway in 1997. The owner had owned the car since the year 2000. According to the vehicle registration certificate, the car was 5.7 metres long, but the car had been fitted with a ‘Continental kit’ at the rear, which meant that it was 40 cm longer than stated in the vehicle registration certificate. According to the vehicle registration certificate, the car had an unladen weight of 2,300 kg and a maximum authorised weight of 2,825 kg. The car was registered for six occupants; three in the front and three in the back.

Some additional equipment had been installed in the car’s boot and engine compartment. The equipment and the extension meant that the car’s unladen weight was slightly higher than stated in the vehicle registration certificate. The AIBN weighed the car, and the estimated actual weight including driver and passengers was approximately 2,700 kg at the time of the accident.

1.8.1 Technical examination of brakes

The car was equipped with a single-circuit brake system with drum brakes at both the front and rear. The brake force was more or less evenly distributed between the front and rear axle. The parking brake was operated by a foot pedal that engaged the back wheels' drum brakes.

An overview of the drum brake components is shown in Figure 12.

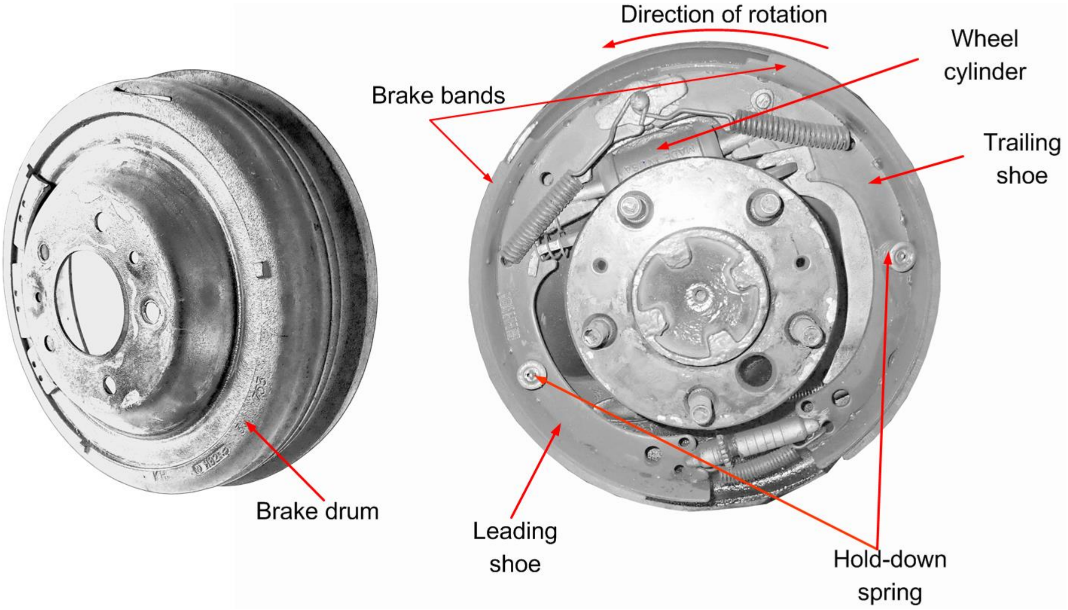

Figure 12: Overview of drum brake components (left back wheel) with the drum removed. Illustration: AIBN

1.8.1.1 *Service brakes*

The brake system was pressurised in connection with the technical examination of the car, and no leakages were found. The test shows that it took slightly longer for the brakes on the right back wheel to engage than the brakes on the other wheels.

1.8.1.2 *Rear axle brakes*

The brake drums on the back wheels were dismounted, and oil was observed to have leaked from the rear axle to the leading shoe on the left back wheel; see Figure 13.

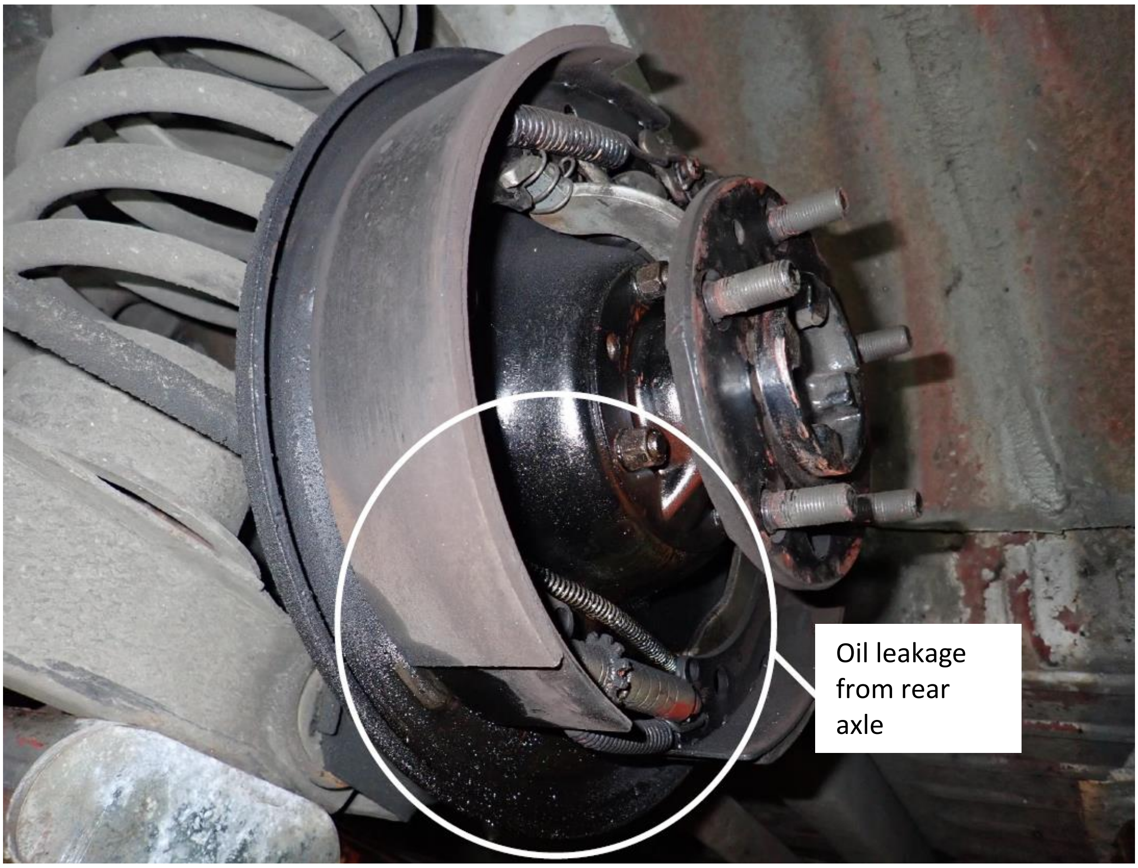

Figure 13: Brake drum dismounted from the left back wheel, where the brake shoes show evidence of the oil leakage. Photo and illustration: AIBN

The brake bands on both back wheels looked almost new, and they were approx. 6–6.5 mm thick. The brake bands had an exterior radius of approx. 148 mm, while the drums had an interior radius of 153 mm. As a result of the difference in radius between the brake bands and drums, the contact surface between the drum and brake band was reduced. This reduced contact surface could be observed on all rear brake bands.

Figure 14 shows the contact surfaces for the brake bands inside the rear brake drums. The contact surface was clearly blue/brown in colour. The rear brake drums looked new, with a small wear edge. Both wheel cylinders were checked and found to be in normal working order.

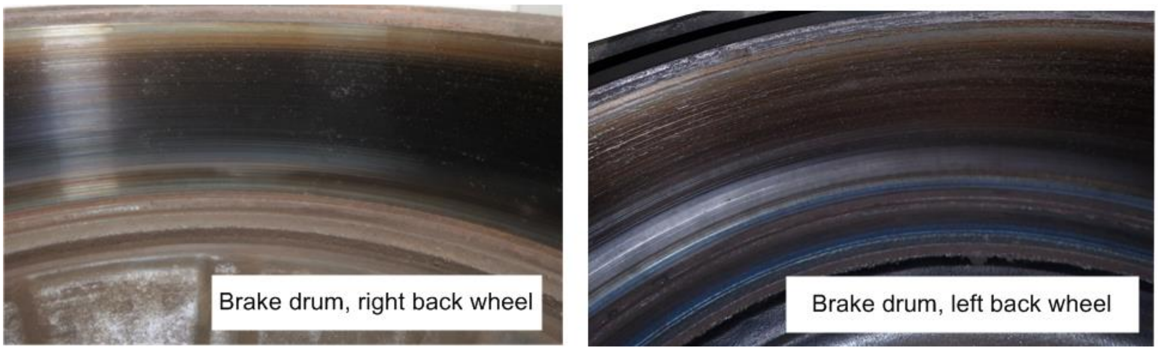

Figure 14: Rear brake drum with contact surface showing a clear blue/brown colour. Photo and illustration: AIBN

The clearance between the drum and the band was measured while the brake bands were mounted in the drums. The measurements showed a clearance of 2.9 mm on the left-hand side and 2.7 mm on the right-hand side.

1.8.1.3 *Front axle brakes*

The brake drums clearly differed in colour; see Figure 15. The drum on the right front wheel was rusty red, while the drum on the left front wheel was more or less the same colour as the car’s other brake drums.

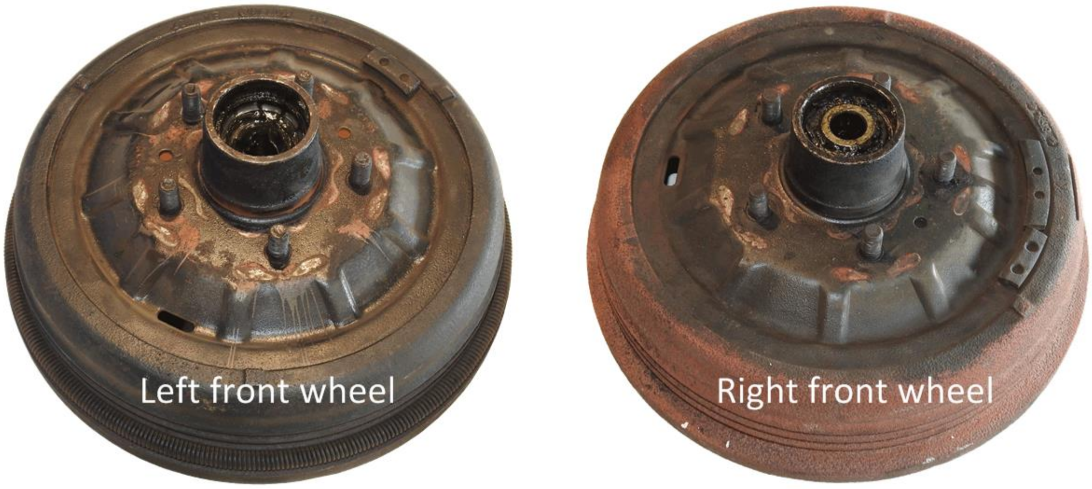

Figure 15: Front wheel brake drums. Photo: AIBN

The brake bands on the left front wheel were somewhat worn, but were attached to the brake shoes. The thickness of the bands was approx. 3–3.5 mm at the edges and slightly less in the middle. The whole contact surface of the band was in contact with the drum. There were clearly visible cracks in the bands on both brake shoes; see Figure 16. The left-hand wheel cylinder was found to be in normal working order.

Figure 16: Brake shoe, left front wheel. Photo: AIBN

The brake bands on the right front wheel were completely worn down; see Figure 17.

Figure 17: Brake band, right front wheel. The brake band on the trailing shoe was completely worn down. The brake band on the leading shoe was also worn. Photo: AIBN

The brake band on the leading shoe had come loose at the ends, and the thickness was 2 mm at the edges and slightly less in the middle. The band on the trailing shoe had come loose from the brake shoe, and clear contact marks indicated steel-to-steel contact between the shoe and the drum; see Figure 17.

Parts of the brake bands and hold-down spring that keeps the trailing shoe up against the backing plate had come loose and were found inside the brake drum when it was dismounted; see Figure 18.

Figure 18: Parts of the brake band, brake dust and the hold-down spring inside the brake drum on the right front wheel. Photo: AIBN

There was a clear difference in hold-down force between the springs on the right and left front wheel, particularly relating to the hold-down springs for the trailing shoe; see Figure 19.

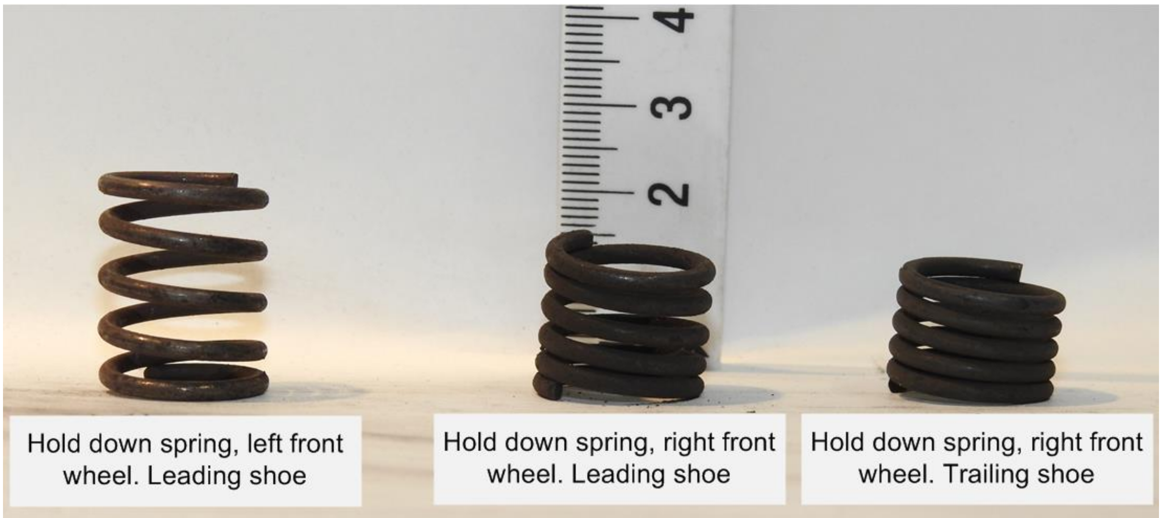

Figure 19: Difference in hold-down force between the brake shoe hold-down springs. Photo: AIBN

The clearance between the drum and the brake band was measured to be 0.2 mm on the left front wheel and 4.5 mm on the right front wheel.

The wheel cylinder on the right front wheel was dismounted, and the piston on the trailing side was stuck, while it showed normal movement on the leading side. There were sediments inside the piston housing in the wheel cylinder; see Figure 20.

Figure 20: Piston housing, right front wheel cylinder. Photo and illustration: AIBN

1.8.1.4 *Brake fluid*

According to the instruction manual, the recommended brake fluid for the car was 'Delco Super No. 11', a glycol-based brake fluid classified between DOT3 and DOT4.[5]

The requirements for brake fluids follow from Federal Motor Vehicle Safety Standard 116 (FMVSS116). Among other things, the standard specifies dry boiling point and wet boiling point (United States Code, 2019). The dry boiling point of brake fluid refers to the boiling temperature of fresh, new brake fluid from an unopened container, while the wet boiling point is defined as the temperature at which the brake fluid will begin to boil after it has absorbed 3.7% water by volume. According to FMVSS116, DOT3 and DOT4 brake fluids shall have a dry boiling point of 205 ºC and 230 ºC, respectively. The wet boiling point for DOT3 is 140 ºC and for DOT4 155 ºC (United States Code, 2019).

Brake fluid was sampled from the brake fluid reservoir placed above the main cylinder, and from each of the wheel cylinders. The brake fluid level in the reservoir was normal, but the brake fluid was severely contaminated and there was a great deal of sediment/rust in the reservoir.

The water content of the brake fluid was tested by the Norwegian Armed Forces' laboratory service (FLO), and the boiling point was tested by the AIBN. The results

[5] Brake fluids are classified by the U.S. Department of Transportation (DOT) and the Society of Automotive Engineers (SAE) in order to meet Federal Motor Vehicle Safety Standards (FMVSS).

showed that the brake fluid contained 5.4% water, while the boiling point was approx. 130–133 ºC.

1.8.1.5 *Parking brake*

The car’s parking brake was applied during the examination of the parking brake system, meaning that the foot pedal was fully depressed; see Figure 21.

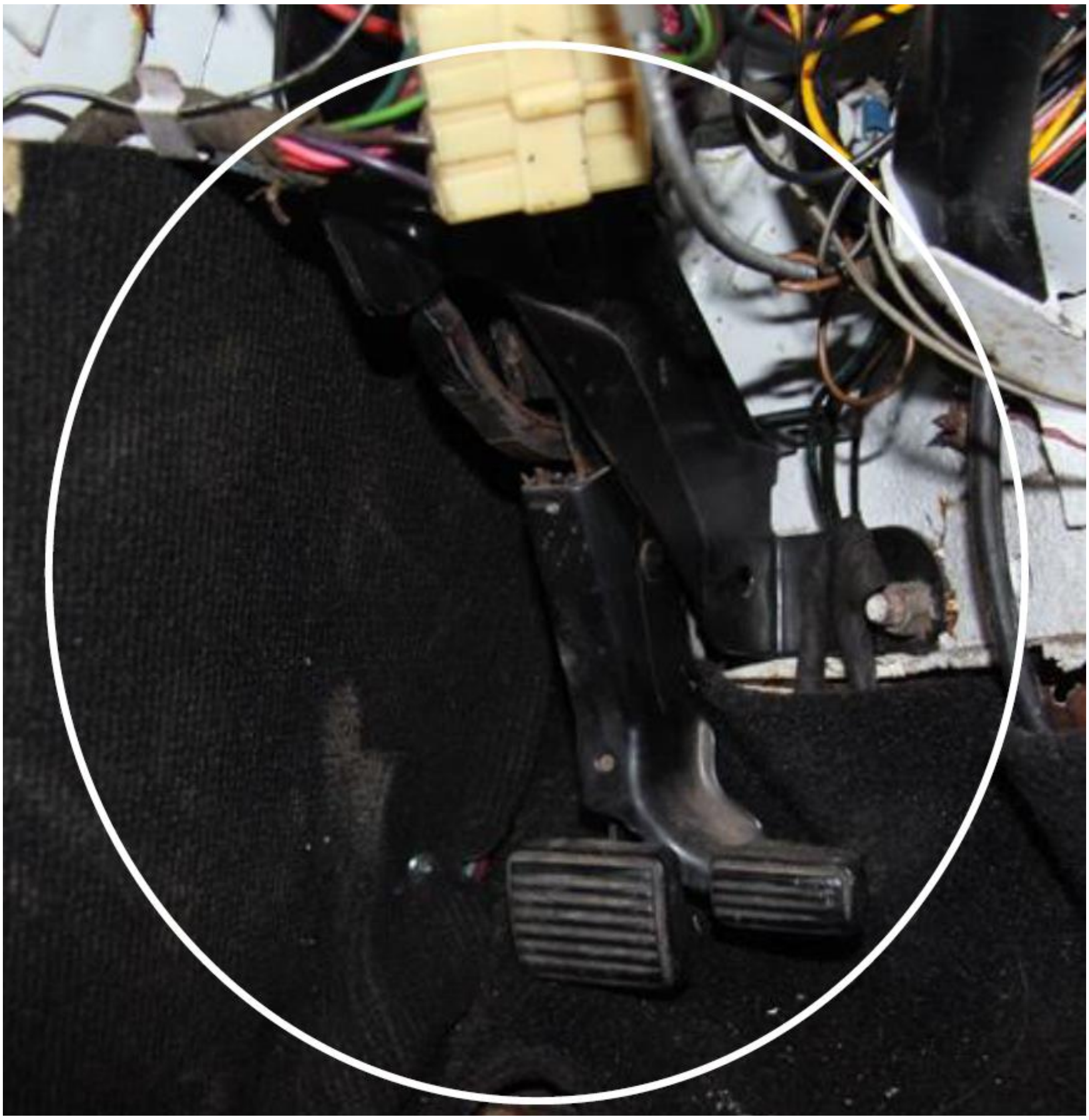

Figure 21: The parking brake pedal was fully depressed when the car was examined. Photo and illustration: NPRA

The transmission cable from the parking brake pedal to the back wheels was severed near the gear box when the car was examined. It was therefore not possible to transmit brake force from the foot pedal to the back wheels after the accident. The severed cable showed that several of the steel wires had been torn apart in more or less the same area; see Figure 22.

Figure 22: Severed cable for activating the parking brake. Photo: AIBN

A function test of the parking brake was carried out by tightening the wire from the central connection block under the car to the back wheels. The test showed brake force on both back wheels. No faults were found in the transmission from the connection block to the back wheels.

1.8.2 Carburettor

The carburettor and transmissions were checked by the NPRA, and no faults or defects were found to exist.

1.8.3 Automatic transmission

The car was fitted with a Hydra-Matic 315 automatic transmission, and, according to investigations conducted by the American Car Club of Norway (AMCAR), the gearbox had probably been overhauled. The AIBN knows that the gearbox was fitted in the car on 26 May 2017 by a garage.

According to the car's instruction manual (General Motors Corporation, 1959), the gear box has four forward gears and one reverse gear. The gear indicator has three forward positions: two different 'drive' (Dr) positions and one 'low' (L) position. The 'Dr' position closest to 'neutral' (N) is used for ordinary driving, while the 'Dr' position closest to 'L' is used for driving downhill.

The 'Dr' position closes to 'L' entails that the fourth gear is not used, and that the gear is used for braking when driving downhill. Setting the gear lever to 'L' produces a greater engine braking effect because only the first and second gears are used.

According to the car's instruction manual, 'L' is always recommended on long, steep descents (General Motors Corporation, 1959).

When the AIBN and the NPRA examined the car after the accident, they found that the gear lever was set to 'Dr' closest to 'N'.

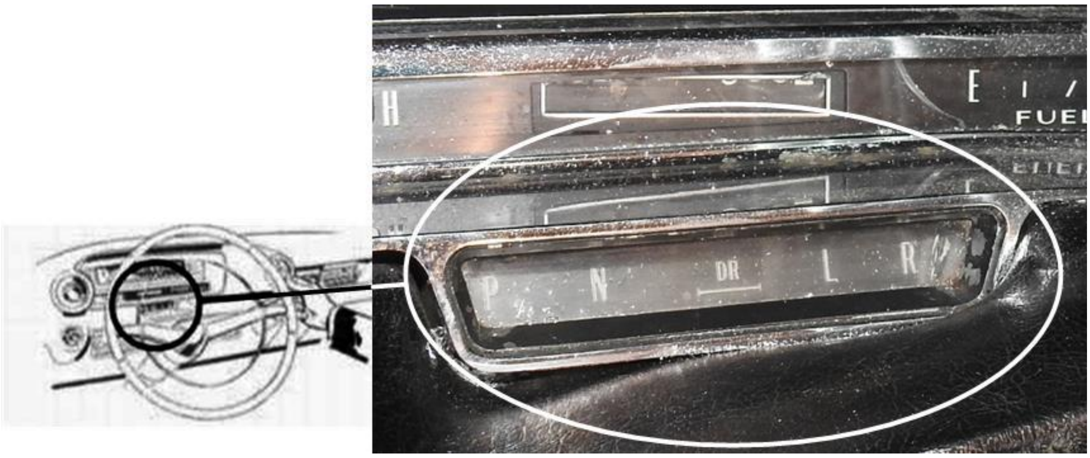

Figure 23: The illustration on the left is taken from the car's instruction manual and shows the position of the gear indicator on the dashboard. The photo on the right shows the gear indicator in the car. Illustration: AIBN

According to information from AMCAR, it is possible to switch from 'Dr' to 'L' even if the car is moving, but only when the car is travelling at a speed below approx. 70 km/h. According to AMCAR, it is also possible to put the car in reverse while moving forward.

1.8.4 Wheel suspension and steering

The AIBN is aware that a safety warning has been issued for the pitman arm in this type of car (General Motors, 1978). The number on the car's pitman arm indicates that it was covered by the recall. The steering worm was removed from the accident car, and special attention was devoted to the pitman arm. No faults or defects were found in the steering worm or pitman arm.

The rear suspension had been modified slightly in that Max-air shock absorbers had been installed, enabling shock absorption to be adjusted by changing the air pressure in the absorbers. The AIBN has not determined at what time this modification was carried out.

1.8.5 Wheels

The car was equipped with M+S tyres. The tread depth was approx. 5 mm on the back wheels and approx. 7 mm on the front wheels. The car was equipped with steel rims with small air gaps. The front rims were deformed, and the front tyres were deflated. The air pressure in the left and right rear tyres was 1.8 and 2 bar, respectively. No faults or defects were found in the tyres.

1.9 Weather and driving conditions

It was a clear day, visibility was good and the roadway was dry when the accident happened.

1.10 Road conditions

The accident occurred on the Fv 651 road, which starts in Sauland in Hjartdal municipality and ends in Rjukan in Tinn municipality (Telemark county). The road's elevation increases from 84 masl at Sauland to 1,259 masl at Flisetjønn, the highest point on the Fv 651 road. Over the distance of approximately 12.4 km from the highest point down to the accident site, the road descends approximately 877 metres. According to the NPRA's national road database (NVDB), the average gradient is 9.6% along the final 7.5 km of road.

The final 5.6 km of the Fv 651 road down to Rjukan consists of the Svineroivegen road. This part of the road was constructed in the late 1930s and carries a speed limit of 80 km/h. According to the NPRA, the annual average daily traffic (AADT)[6] was 700 vehicles per day on this section of road in 2017, and heavy goods vehicles accounted for 6%.

Svineroivegen includes five hairpin bends (180º) before the road straightens out on the descent to Rjukan. The accident occurred in the final hairpin bend of the descent. According to the NVDB, the bend had a radius of 13 metres, with a somewhat greater outer radius of an estimated 15 metres.

Approximately 7.4 km from the accident site, there is a 'Steep slope' (downhill) warning sign (sign no 104.2), with a text below indicating a gradient of 10% and 'Low gear 0–9 km'.

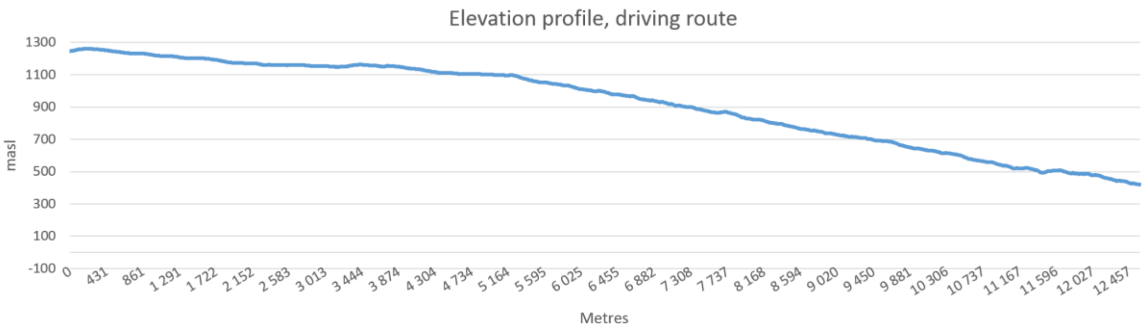

Figure 24: Elevation profile from the highest point at Flisetjønn down to the accident site. The average gradient of the final 7.5 km of road down to the accident site is 9.6%. Illustration: © Norwegian Mapping Authority

[6] The total number of vehicles passing a given point on a section of road (total for both directions of travel) through the year, divided by the number of days in the year, i.e. an average figure for daily traffic.

Figure 25: Map showing the measured distance for the elevation profile. The marked section shows the descent from the highest point on the Fv 651 road down to the accident site, and is 12.4 km long. The accident site is marked with a red star. Map: © Norwegian Mapping Authority

The AIBN carried out intermittent measurements of the road down to approx. 300 metres after the accident site. The measurements showed that the road width varied between 5.5 and 6.45 metres down to the hairpin bend, after which it gradually increased from 7.25 to 12.45 metres. According to the NPRA's road markings manual (*Håndbok N302 Vegoppmerking*), Svineroivegen is too narrow to have a marked centre line, but the roadway is marked with a broken edge line *(Statens vegvesen, 2015)*.

The section of road from the penultimate hairpin bend down to the accident site was approximately 1.2 km long. The section has several gentle bends to the right and left, with curve radii ranging from 123 to 614 metres, according to the NVDB.

Along this stretch of road, the left-hand roadside had a crash barrier against steeply sloping terrain and the right-hand roadside was a hillside cutting of bare blasted rock. The distance from the right-hand edge line to the cutting varied from 210 cm to 280 cm.[7] The site where the accident car ran off the roadway, the distance from the edge line to the cutting was approx. 1.5 metres. The rockface was uneven, with protruding rocks.

Between the edge line and the hillside cutting, there was a ditch of varying breadth and depth, mostly in the range between 35 and 60 cm. The extent to which gravel was laid between the tarmacked shoulder and the ditch varied.

A barrier had been erected against the sloping terrain, consisting of steel railings on wooden posts along the first part of this stretch from the penultimate hairpin bend to approx. 750 metres from the accident site, where it was relieved by a 90 cm high concrete crash barrier. The width of the shoulder between the edge line and the concrete barrier varied, but was for the most part 30 cm.

[7] Measurements conducted 300, 200, 100, 50, 30 and 17 metres from the place where the car hit the rockface.

Figure 26: Road shape and roadside terrain approx. 100 metres from the accident site. Photo: AIBN

Figure 27: Road environment 400 metres from the accident site. Photo: AIBN

According to information from the NPRA, rockfall protection of this stretch of road had been carried out in 2008–09, and the ditches were made slightly wider to better accommodate water and prevent ice blockage.[8] The concrete crash barriers on the left-

[8] Frozen freely flowing water.

hand side of the descent were erected afterwards. There are currently no plans to upgrade the road.

1.11 Medical factors

Blood samples taken in connection with the post mortem examination of the driver found traces of medication, and the AIBN requested an expert assessment of how this may have affected the driver. The expert assessment was carried out by the Department of Forensic Medicine at Oslo University Hospital.

The report states that the concentration is most likely the result of post mortem redistribution[9] and the injuries caused by the crash, combined with blood sampling from a central site. The expert assessment states that the medication may to some degree have affected the driver's ability to drive a car, but that great uncertainty is attached to such an assessment.

No traces of ethanol or other medication were found.

1.12 Laws and regulations

The legal framework for use and inspection of vehicles as well as sanctions for violations are largely regulated by the Act of 18 June 1965 No 4 relating to road traffic (the Road Traffic Act) and pertaining rules and regulations, and by the Act of 21 June 1963 No 23 relating to roads (the Road Act).

1.12.1 Requirements of driver and owner

The Regulations of 1 March 1986 No 747 relating to pedestrian and vehicle traffic (the Traffic Rules) contain guidelines for the duties and responsibilities of drivers applicable to all motor vehicle traffic on Norwegian roads, including requirements for conduct and competence.

1.12.1.1 *Responsibility for vehicle condition*

The Road Traffic Act Section 23 *The driver's responsibility for the condition of the vehicle etc.* regulates the relationship between the driver and owner's responsibility for the condition of the vehicle. According to Section 23, before putting the vehicle in motion, the driver shall make sure that the vehicle is in the proper and prescribed condition and that it is loaded in the proper and prescribed manner. The driver shall also make sure that the vehicle is in proper condition and safely loaded during use.

The owner of a vehicle or the person who is in charge of the vehicle on the owner's behalf is obliged to make sure that the vehicle is not used if it is not in proper condition.

1.12.2 Requirements for the car involved in the accident

1.12.2.1 *Motor vehicle regulations of 1942*

The Regulations of 1942 relating to motor vehicles apply to all vehicles with engine propulsion that are designated for the transport of passengers or goods, including motor

[9] Bodily processes that occur post mortem.

sledges and trackless trams (trolley buses). The regulations set out requirements for motor vehicle size, construction and equipment.

1.12.3 General requirements relating to vehicles

1.12.3.1 *Regulations relating to technical requirements for and approval of motor vehicles, parts and equipment (the Motor Vehicle Regulations)*

The Regulations of 4 October 1994 No 918 relating to technical requirements for and approval of motor vehicles, parts and equipment (the Motor Vehicle Regulations) apply to vehicles first registered in Norway on 1 January 1995 or later.

Section 1-5 *Requirements for vehicles/equipment in use* sets out the requirement that vehicles and equipment in use shall be kept in such condition/maintained so that they at all times meet the requirements that applied upon first-time registration in Norway, unless otherwise prescribed in individual chapters of the regulations.

Section 1-7 *Exemption for imported second-hand vehicles* exempts second-hand vehicles from the requirement set out in Section 1-5. A vehicle that has been registered in another country shall meet the requirements that applied in Norway at the time the vehicle was registered or taken into use in the other country.

Section 1-9 *Vehicles worthy of preservation* describes exemptions that apply to vehicles worthy of preservation. In order to be registered as worthy of preservation, the vehicle must be older than 30 years[10] and must largely have retained its original design. This means that the vehicle must not have been materially altered, neither technically nor in appearance, regardless of whether the purpose was to follow fashion or to improve the vehicle's roadworthiness with a view to road safety.

If the car is registered as worthy of preservation, this entails limitations on use, normally described in the vehicle registration certificate with the wording '*Must only be used*
- For special occasions such as historic vehicle events and races
- Otherwise occasionally when the use does not cause unnecessary danger or inconvenience to other traffic'.

1.12.4 Retrofitting of seat belts – practical interpretation of Section 1-9 of the Regulations

The AIBN obtained information from the Directorate of Public Roads, the American Car Club of Norway (AMCAR) and the Norwegian Federation of Historic Vehicle Clubs (LMK) about practice regarding retrofitting of seatbelts. According to those interviewed, it is well known that retrofitted seatbelts do not prevent older cars from being approved as worthy of preservation. Seatbelts must be installed in accordance with requirements set out in Section 16-6 of the Motor Vehicles Regulations, and approved by the NPRA.

1.12.5 Requirement for technical inspection of vehicles older than 30 years

1.12.5.1 *Regulations relating to periodic roadworthiness tests for motor vehicles*

Cars registered for the first time after 1 January 1960 are covered by the Regulations of 13 May 2009 No 591 relating to periodic roadworthiness tests for motor vehicles and

[10] Vehicles younger than 30 years that have largely retained their original design and are of 'special interest' may in some cases also be registered as worthy of preservation.

their trailers. The regulations were revised in 2016, in accordance with the Regulations of 11 April 2016 No 368 amending the Regulations relating to periodic roadworthiness tests for motor vehicles and their trailers. The amendment entailed an adjustment of the test interval for cars older than 30 years, provided that they were registered as worthy of preservation. The amendment entered into force on 1 October 2016.

Section 5 *Intervals of periodic roadworthiness test* requires periodic roadworthiness tests at five-year intervals for vehicles older than 30 years, and exempts cars older than 50 years from undergoing such tests, provided that the vehicles are registered as worthy of preservation pursuant to Section 1-9 of the Regulations, and have undergone an approved periodic roadworthiness test the year they turned 30 or 50 years, respectively. If the car is not registered as worthy of preservation, regular intervals for periodic roadworthiness tests apply.

The car involved in this accident was first registered in 1959, which falls outside the scope of application of the regulations. The car was therefore not covered by the requirement for periodic roadworthiness tests, even though it was not registered as worthy of preservation.

As an appendix to the Regulations of 13 May 2009 No 591, the NPRA has prepared inspection instructions for periodic roadworthiness tests for vehicles in line with the requirements of Directive 2014/45/EU. The instructions include provisions on checkpoints, inspection method, main reasons for remarks and assessment.

Chapter 1 of the inspection instructions concerns brake systems and consists of a total of 24 checkpoints. Only checkpoints of relevance to the vehicle in question are covered in the test. Checkpoints of particular relevance to the car involved in this accident include:

- Inspection of brake bands and brake pads (point 1.1.13). The inspection is carried out in the form of a visual inspection through inspection holes in the backing plate, if such holes exist. The main reasons for remarks are excessive wear on brake linings, soiled brake linings (oil, grease etc.), lacking or incorrectly fitted brake bands or brake pads, or loose brake linings.

- Brake tests are used to test the braking power (point 1.2.2). In the case of hydraulic brakes, the braking power is tested by gradually increasing the brake force on each axle in a series of brake tests. Remarks are issued if the braking power is below the requirement for the type of vehicle concerned or if it constitutes a danger to traffic.

- The brake fluid (point 1.8) is checked by a visual inspection. The vehicle will not be approved if the brake fluid is seriously contaminated or contains a great deal of sediment.

1.12.6 Requirements for road geometry and roadside terrain

Svineroivegen was constructed in the late 1930s, and given the year of construction and upgrade history, no formal requirements apply to the road geometry or roadside terrain. See section 1.12.7 for a description of roadside terrain requirements for newer roads.

1.12.7 Roadside terrain requirements for newer roads

The NPRA Manual N101 *Rekkverk og vegens sideområder* ('Crash barriers and roadside terrain') (Statens vegvesen, 2014) contains general guidelines for the choice and installation of crash barriers and requirements for roadside terrain. The manual applies to all types of road and street projects, both new infrastructure and alteration projects. According to the manual, it should apply to major upgrades of existing roads and have an advisory capacity only in connection with minor upgrades.

1.12.7.1 *Safety zone*

For safety reasons, the NPRA has defined a safety zone from the roadway edge. The safety zone is an area outside the roadway that must be free of any hazards such as hazardous roadside obstacles, hazardous slopes etc. Hazards within the safety zone must either be removed, replaced by flexible barriers or protected by crash barriers or crash cushions. The safety zone along a road is defined based on the AADT and speed limit.

In order for Svineroivegen to meet the safety zone requirements in the manual, it would, based on the AADT and speed limit, have to have a safety zone of 5 metres.

1.12.7.2 *Crash barriers*

According to Manual N101 (2014), crash barriers must be installed where the safety zone contains one or more hazards and where a collision with the barrier is likely to be less severe than a collision with the hazard behind it. Hazards can be fixed roadside obstacles entailing a serious risk of injury in a collision, or hazardous slopes with a configuration that would cause the vehicle to roll over or stop abruptly in a run-off-the road accident.

1.12.7.3 *Rockfaces*

According to Manual N101 (2014), to avoid the use of crash barriers, rockfaces should be blasted with an as even surface as possible out of considerations for vehicles that run off the road. Protruding sections with sharp edges on parts of the rockface that could come into contact with cars and thus cause an abrupt stop resulting in serious injuries should therefore be avoided. No section should protrude more than 0.3 metres in the relevant areas. If this is not financially feasible, the rockface shall be handled as a hazardous roadside obstacle as regards distance to the hazard and the need for crash barriers inside the safety zone.

1.13 Authorities, organisations and leadership

1.13.1 The Directorate of Public Roads

The Directorate of Public Roads is responsible for strategic and overriding planning, budgets, follow-up and resource management relating to national roads, and has overriding responsibility for road users and vehicles. It is also responsible for international activities. The Directorate of Public Roads is organised in five departments with subordinate sections and three staff entities.

1.13.1.1 *Road Users and Vehicles Department*

The Road Users and Vehicles Department is an authority under the Directorate of Public Roads with responsibility for vehicle inspections and driving tests in addition to supervisory tasks. The department is authorised to develop and approve regulations and make decisions concerning road users and vehicles. The department is also authorised to adopt public-road regulations in certain areas, and enforce laws and regulations on national roads. The department consists of five technical departments and a staff function.

1.13.2 Telemark County Authority

Telemark County Authority owns the county road network and is responsible for overall planning of transport and communications in Telemark county. Ownership of some of the roads was transferred from the NPRA to Telemark County Authority in connection with the 2010 administrative reform. The County Authority is also responsible for prioritisation of investments and major maintenance measures on the county road network.

Organisational responsibility for the county road network rests with the Department for Transport and Regional Development.

1.13.3 Organisations for owners of older vehicles

The Norwegian Federation of Historic Vehicle Clubs (LMK) is an umbrella organisation for clubs whose object is to promote the preservation and understanding of and knowledge about historic vehicles aged 30 years and older. It also aims to promote good cooperation and a uniform approach among the clubs, and to encourage the authorities to facilitate the use and preservation of such vehicles.

The American Car Club of Norway (AMCAR) is an organisation for Norwegian motor-hobby car owners. The organisation aims to unite its members around the areas of interest it represents, work to develop its members' driving skills, raise the standard of the vehicles and promote road safety. AMCAR considers it a duty to raise its members' knowledge of their own cars and offers technical assistance to members. It also assists with registration data, technical troubleshooting, questions about import, and buying and selling.

1.14 Other information

1.14.1 Re-registered cars older than 30 years – number of vehicles and status as regards periodic roadworthiness tests

According to information received from the NPRA on 14 August 2019, there were 75,770 re-registered cars in Norway that had undergone first-time registration between 1960 and 1989. Of this number, 19% (14,761) were registered as worthy of preservation. In principle, this means that the car must undergo a roadworthiness test every five years if the car is 30–50 years old, and that it is exempt from this requirement if it is older than 50 years. This basically means that the cars must be approved the year they turn 30 or 50 years old (or more), respectively. Cars registered as worthy of preservation are also subject to limitations on use.

According to the NPRA, as of the date mentioned above, there were 25,605 re-registered cars that had been registered for the first time between 1960 and 1969. Of this number, 18% (4,679) were registered as worthy of preservation and potentially exempt from roadworthiness tests. A total of 3,719 of the 4,679 cars were exempt.

A total of 10,940 cars were first registered before 1960 and thereby exempt from roadworthiness tests because the date of first-time registration falls outside the scope of application of the Regulations relating to periodic roadworthiness tests for motor vehicles.

Based on these numbers, 14,659 re-registered cars in Norway were exempt from roadworthiness tests as of 14 August 2019.

1.14.2 Use, road incidents and technical expertise of owners

According to a user survey conducted by the international car organisation Fédération Internationale Véhicules Anciens (FIVA) in 2014, cars older than 30 years are used an average of 30 days a year and driven less than 2,500 km per year (FIVA, 2014).

As regards road accidents and incidents, the NPRA stated in the consultation paper on proposed amendments to the Regulations relating to periodic roadworthiness tests for motor vehicles (*Høring om endring av forskrift om periodisk kontroll*) that information from the insurance companies indicates that few road incidents are registered involving vehicles older than 30 years (Statens vegvesen, 2015).

Cars older than 30 years are often ‘hobby cars’, which, traditionally, are largely repaired and maintained by the owners themselves. According to information from AMCAR and LMK, however, the group owning vehicles older than 30 years is changing. While it used to consist of technically interested and competent people, the organisations now see a trend towards such cars being bought as status symbols or as an investment, without the owners necessarily having any competence or interest in the technical aspects of the cars.

1.14.3 Possibility of retrofitting seatbelts in a 1959 model Cadillac

According to *The Cadillac Serviceman*, a magazine published by the General Motors factory on a regular basis that contained information not covered by the factory shop manual, it was possible to install seatbelts in the car. According to the issue published in November 1959, the service procedure for installing seatbelts had been simplified by making recesses in the floor and body to indicate where the seatbelt installation bolts should be located (General Motors, 1959).

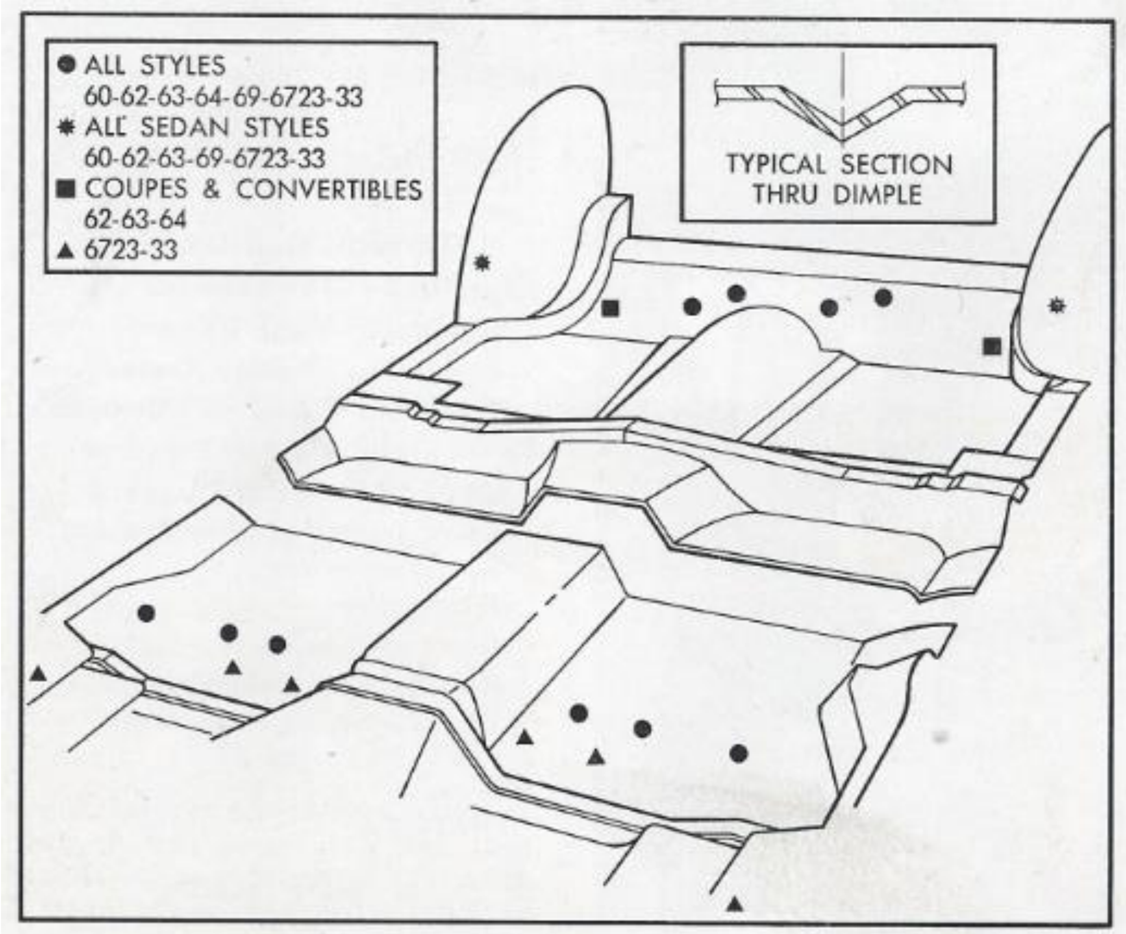

Figure 28: The points on the figure show where the seatbelt installation bolts were to be located. Source: The Cadillac Serviceman, November 1959

1.14.4 Accident statistics – hazardous roadside terrain

According to the NPRA's accident reports, a hazardous roadside terrain and hazardous objects in the safety zone contributed to the fatal outcome in 22% of all fatal accidents during the period 2005–2017 (Statens vegvesen, 2017). An extraction from the NPRA's accident database performed by the engineering magazine *Teknisk ukeblad* shows that 'roadside terrain – rock' contributed to the scope of injury in 96 fatal accidents during the period 2005–2017 (Teknisk ukeblad, 2017).

1.15 Implemented measures

AMCAR has stated that they are in the process of preparing a motor-hobby manual for the maintenance, use and correct operation of old cars: *Den store bilhobbyboka*. According to AMCAR, the manual will be publicly available on the organisation's website.

LMK states that they have prepared a guide to safe use of historic vehicles ('Veiledning i trygg bruk av historiske kjøretøyer'). The guide sets out basic rules for use and maintenance of such vehicles, conveys knowledge and understanding relating to these vehicles etc. The guide is distributed at all events attended by LMK.

2. ANALYSIS

2.1 Introduction

The AIBN initiated an investigation of the run-off-the-road accident based on the severity of the accident. It was the accident with the greatest number of fatalities in 2018 and involved a vehicle not subject to the requirement for roadworthiness tests.

The accident was investigated and analysed in line with the AIBN's framework and analysis process for systematic safety investigations (Statens havarikommisjon for transport, 2019).

The analysis start with an assessment of the sequence of events. This includes contributory causes of the accident and the scope of injuries/damage. The analysis will also concern the car's safety equipment, maintenance of the car's brakes, lack of requirements for follow-up of the car's technical condition over and above what the owner alone is responsible for, the brake fluid's boiling point, the driver's qualifications and actions, and factors relating to the road and roadside terrain.

According to information the AIBN has obtained, the rescue operation was satisfactory, and it will therefore not be analysed.

2.2 Assessment of the sequence of events

The damage to the car that ran off the Fv 651 road on its way down from Gaustatoppen shows that the speed of the car was reduced to zero in a very short space of time when it crashed into the rockface. The car's occupants were not secured by seatbelts and were all thrown forward and exposed to great acceleration forces at the time of impact. The serious outcome of the accident must therefore be attributed to a combination of those factors.

It has been a challenge in this investigation to ascertain the accurate sequence of events leading up to the crash. Witnesses noticed a smell of hot brakes from the accident car during the descent along Svineroivegen. Witnesses have also described that the accident car, after having travelled at a low speed for some time, accelerated after the penultimate hairpin bend.

Technical examinations of the brakes on the accident car indicate that the car lost parts of its braking power between the two hairpin bends, and, at some point, the driver lost control of the vehicle's speed in the given situation. The investigation suggests that parts of the brake band on the right front wheel came loose during the descent, causing a partial or complete loss of brake force from the service brakes. An analysis of the brakes follows in section 2.4.

The examination of the brakes suggests that the driver may have attempted to use the parking brake to brake the car during the steep descent. The foot-operated parking brake had been applied when the car was examined. The AIBN has been unable to verify whether the parking brake was applied as a result of the damage the car sustained in or after the accident, on the stretch of road between the final two hairpin bends, or whether it had not been disengaged after the last known stop, 4.3 km uphill from the accident site. Based on technical examinations of the car, the sequence of events and witness statements, the AIBN considers it likely that the driver did not attempt to use the gear for braking by setting it to ‘Low’ on the way down Svineroivegen. A more detailed analysis of the driver’s ability to and possibility of controlling the car in this situation is provided in section 2.6.

By compiling information from witnesses, tracks on the roadway and deformation measurements, the AIBN has estimated that the car was moving at a speed of between 55 and 70 km/h at the time of impact. This is greater than the critical speed for this bend, which, according to the AIBN’s estimates, is somewhere around 36–46 km/h.

The configuration of the road leading down to the accident site made it difficult to reduce the speed of the car with the aid of the roadside terrain. The road conditions are analysed in more detail in section 2.7.

2.3 Safety of older vehicles

The car was a 1959 model Cadillac equipped more or less as it had been in the year of production. The safety standard was lower than in modern cars, in terms of both passive safety in the form of crash protection, seat belts and airbags, and active safety in the form of driver support systems.

The requirements for brake systems were also less stringent than for modern cars. The AIBN believes that puts demands on the driver’s know-how and assessments when driving down long, steep roads.

Despite major deformations of the car front, the passenger compartment was relatively intact after the crash, and there was survival space in both the front and the back. The post-mortem reports, in conjunction with deformations and marks inside the car, indicate that the injuries were sustained as the occupants crashed into the car’s interior. The occupants in the back were thrown forward towards the occupants in the front seats. This information, compiled with the AIBN’s estimate of the speed at the time of impact, supports the view that the scope of injuries would have been considerably reduced had seatbelts been installed and used.

The use of seatbelts is one of the most important measures for reducing the scope of injuries in accidents. This and several other investigations[11] have shown that correct use of seatbelts increases both the driver and the passengers’ chances of survival. The AIBN therefore believes that seatbelt should be retrofitted in all vehicles where possible, regardless of how old they are.

2.4 Maintenance of the car’s brakes

The investigation has shown that defects in the car’s brakes were an important factor that contributed to the accident. The front brake bands were worn, and the brake bands on the right front wheel were more worn than those on the left front wheel. The investigation has also shown that the piston on the secondary side of the right front wheel was stuck, and there was a clearly visible difference in colour between the brake drum on the right front wheel and the other brake drums. The AIBN believes that this indicates that the brake problems on the right front wheel had persisted for some time before the accident and did not arise on this particular trip.

[11] See, for example, the AIBN’s special report on vehicle safety (ROAD report 2012/01).

The AIBN's assessment is that the build-up of heat while driving downhill and the degree of wear on the brake bands on the right front wheel contributed to loosening the brake band on the trailing shoe. As the brake band came loose, there was steel-to-steel contact between the drum and the shoe. It also created too wide a clearance between the shoe and drum, which may have caused a lowering of the brake pedal. This may have further reduced the car's braking power.

Witnesses have described a smell of hot brakes from the accident car during the descent. The AIBN's investigation has shown that the rear brake bands have been exposed to high temperatures, evidenced by a blue/brownish colour on the rear drums' contact surfaces. The AIBN believes that the heat build-up may have been a result of prolonged braking in conjunction with the weight of the car, the gradient of the road and poor alignment between the rear brake bands and drums. Depending on when it was applied, use of the parking brake may also have contributed to the build-up of heat.

The investigation has shown a high water content in the brake fluid, resulting in a low boiling point. The sequence of events indicates that the brake fluid may have reached boiling point during the descent, which may have further reduced the car's braking power.

The condition of the brakes and brake fluid is evidence of inadequate maintenance of the car's brakes.

2.5 Lack of requirements for follow-up of technical condition

Because the car was registered for the first time in 1959, there were no requirements for follow-up of the car's technical condition in the form of periodic roadworthiness tests (PKK) or other technical inspection. The owner did not ensure necessary maintenance of the vehicle, and no other bodies identified or repaired the defects in the car's brakes.

The AIBN is aware of there being few accidents with cars older than 30 years, and that these vehicles are usually only used for a short period of the year. The number of vehicles currently exempt from the requirement for roadworthiness tests is also relatively low. At the same time, AMCAR and LMK have stated that the group owning such vehicles is changing, with an increasing proportion having little technical competence when it comes to cars. Seen in conjunction with older cars having a lower safety standard than newer cars, in terms of both active and passive safety, the AIBN considers it unfortunate that the owner's duty to maintain the vehicle represents the only barrier against safety-critical technical defects.

The brakes of the car involved in this accident did not meet the test requirements described in the inspection instructions for periodic roadworthiness tests. The AIBN's assessment is that the poor technical condition of the brakes would most probably have been identified in a technical inspection had such an inspection been required.

The AIBN therefore proposes a safety recommendation for follow-up of the technical condition of older cars.

2.5.1 <u>Testing of brake fluid boiling point</u>

At present, periodic roadworthiness tests do not include testing of the brake fluid's boiling point. A visual inspection of the brake fluid is included, however, and any serious contamination or sedimentation in the brake fluid shall be remarked on. In the present case, the AIBN believes that discolouration and sediments in the brake fluid reservoir would have given cause for remarks.

The low boiling point of the brake fluid would not have been detected, however, even if a roadworthiness test had been carried out. The quality of brake fluid deteriorates over time without necessarily resulting in visual signs of contamination. The AIBN therefore believes that the brake fluid’s boiling point should be tested in connection with the inspection of brakes.

The AIBN submits one safety recommendation on this point.

2.6 The driver’s qualifications and conduct

Witnesses have described the driver as cautious, which is also evidenced by the driver’s behaviour prior to the accident. Based on the time of the final stop and the time the accident occurred, the AIBN has calculated an average speed of between 28 and 37 km/h over a distance of approximately 4.3 km down to the accident site. Seen in conjunction with the AIBN’s estimated speed at the time of impact, this means that the driver covered parts of the distance down towards Rjukan at a considerably lower speed. Witnesses have also stated that the car was going slowly and cautiously down the steep descent, before accelerating after the penultimate hairpin bend.

Based on information received by the AIBN, the driver was probably aware of there being a technical problem with the brakes. Whether the driver was aware of the scope and possible consequences of this problem is uncertain, however. Findings made in the investigation suggest that the driver may have attempted to brake the vehicle by using the parking brake, which was placed as a foot pedal on the driver’s side, without achieving the desired effect. Technical examinations of the car also suggest that the driver did not use the possibility of gear braking to slow down the car. This is supported by the fact that the gear handle was found to be in the ‘drive’ position closest to ‘neutral’ after the accident as well as by the estimated speed at the time of impact.

According to the car manufacturer, ‘Low’ is the recommended gear for driving down long, steep descents. Information that the AIBN has received from AMCAR documents that engine braking was possible by setting the gear handle manually to ‘Low’.

Based on the report from the Department of Forensic Medicine and other information obtained by the AIBN, there is no basis for claiming that the use of medication affected the driver’s conduct or skills.

2.6.1 Safe use of older vehicles

The investigation has shown how important it is that the driver is aware of the car’s functions and limitations under different road conditions. Long, steep downhill drives are challenging for all vehicles. Knowledge about correct use is particularly important in older cars, as they lack the safety standard and road performance of newer cars. The AIBN considers it important that both owners and users of older vehicles make a point of obtaining information about the possible modes of control and capacities of their respective vehicles and adjust the use of such vehicles accordingly.

The AIBN is aware that AMCAR and LMK prepare guidelines for the safe use of old vehicles. The AIBN takes a positive view of this work and emphasises the importance of making this material easily accessible to drivers and owners of such vehicles.

2.7 Consequences of road and the roadside terrain configurations

The average gradient of Svineroivegen is approximately 9.6%. The gradient contributed to the car accelerating in step with the loss of braking power. In this situation, the roadside terrain, consisting of a hillside cutting with protruding rocks on the right-hand side and a concrete crash barrier verging on the steeply sloping terrain on the left-hand side, became a factor that made it difficult to implement alternative measures to reduce the speed of the car when the brakes failed.

Svineroivegen is a road constructed in the late 1930s, and no major upgrades have been carried out since the year of construction. None of the NPRA’s requirements relating to the roadside terrain, as defined in Manual N101 *Rekkverk og vegens sideområder* (‘Crash barriers and roadside terrain’) (2014), are applicable. The AIBN finds that the requirements in the manual are nonetheless an illustration of the discrepancy between the safety standard that applies to new roads and the requirements that apply to the roadside terrain along Svineroivegen.

For example, the manual sets a maximum limit of 30 cm for protruding rocks. No measures have been to taken to even out the hillside cutting along Svineroivegen. Nor are any alternative measures in place to protect vehicles from hitting the rockface if they run off the road, and the rockface is located well inside what would be the safety zone on a newer road, given the same overall conditions. Crash barriers have been installed along parts of the road section, but these are barriers against the steep slope and not against the hillside cutting.

The AIBN understands that it is difficult to upgrade Svineroivegen to meet the roadside terrain requirements for newer roads. The AIBN is nonetheless of the view that Telemark County Authority should inspect the stretch of road concerned and consider the options available for improving road safety, for example by filling ditches with gravel to give drivers a refuge area in the event of unforeseen incidents. The current configuration of the roadside terrain, with a short distance from the roadway to the hillside cutting with protruding rocks and no emergency lay-bys, increases the risk of any traffic accidents on the descent towards Rjukan having a serious outcome for those involved.

3. CONCLUSION

3.1 Operational and technical factors

a) The final seven kilometres of road the accident car travelled along down to the accident site had an average gradient of 9.6%.

b) The actual weight of the car was just below the maximum authorised weight.

c) The driver did not make sufficient use of the gear to slow down the car on the descent towards Rjukan.

d) The brakes were used over a long distance during the descent, generating a great deal of heat in the brake system.

e) The build-up of heat during braking may have caused the brake fluid to boil, thereby reducing the braking effect.

f) The car had no seat belts, which contributed to the scope of injuries.

3.2 Underlying factors

a) The car was not adequately maintained.

b) The wear of the brake bands on the right front wheel contributed to building up heat and caused the brake band on the trailing shoe to come loose.

c) The brake fluid had a high water content and a low boiling point.

d) No requirements are specified for follow-up of the technical condition of vehicles registered before 1960, over and above what the owner alone is responsible for.

e) Requirements for safety equipment in cars have no retroactive effect, which, among other things, means that the car was not required to be fitted with seatbelts.

3.3 Other investigation results

Traces of medication were found in the post mortem examination of the driver. Based on the expert assessment carried out by Oslo University Hospital seen in conjunction with the sequence of events and other information obtained, the AIBN considers it unlikely that the driver’s use of medication was a factor that contributed to the accident.

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.[12]

Safety recommendation ROAD No 2019/17T

The investigation into the run-off-the-road accident at Rjukan on 2 September 2018 found that the car's brakes were not adequately maintained. Brake defects was one of several factors that contributed to the accident. No requirements apply for follow-up of the vehicle's technical condition other than the owner's own responsibility. The investigation has identified a need for a barrier to identify safety-critical technical defects in older vehicles.

The Accident Investigation Board Norway recommends that the Ministry of Transport, in cooperation with special interest organisations for older vehicles, review the regulatory framework governing the follow-up of such vehicles' technical condition.

Safety recommendation ROAD No 2019/18T

The investigation into the run-off-the-road accident at Rjukan on 2 September 2018 found that the quality of the car's brake fluid had deteriorated. At present, periodic roadworthiness tests do not include testing the brake fluid's boiling point. The quality of brake fluid deteriorates over time and is crucial for the car's brakes to function in all situations. In the Accident Investigation Board Norway's assessment, boiling point testing should be included in the inspection of brakes.

The Accident Investigation Board Norway recommends that the Norwegian Public Roads Administration consider including control of the brake fluid's boiling point in the inspection instructions for periodic roadworthiness tests.

Accident Investigation Board Norway

Lillestrøm, 21 August 2019

[12] The investigation report is submitted to the Ministry of Transport, which will take the necessary steps 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.

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