Bundesstelle für
Flugunfalluntersuchung

German Federal Bureau of
Aircraft Accident Investigation

Investigation Report

Identification

Type of Occurrence:	Serious incident
Date:	26 June 2014
Location:	Mannheim City Airport
Aircraft:	Helicopter
Manufacturer / Model:	Agusta S.p.A. / AB 412
Injuries to Persons:	None
Damage:	Minor damage to aircraft
Other Damage:	None
Information Source:	Investigation by BFU
State File Number:	BFU 7X002-14

Factual Information

History of the Flight

The pilot stated that the helicopter had been parked on the apron in front of the terminal after the landing at Mannheim City at 1137 hrs[1]. It was then re-fuelled with 600 litres kerosene. Afterwards the helicopter was to be flown to the Universitätsklinikum Mannheim (University Medical Centre Mannheim) for patient pick-up. The pilot, one flight mechanic, and two physicians were on board.

1 All times local, unless otherwise stated.

The pilot stated that he had started the first engine after the re-fuelling process. He lowered the pitch at an rpm of 60 - 65% N2 and the helicopter sacked. This behaviour of the helicopter after re-fuelling was not unusual. On this day, however, the movement was more intense than he had expected from past experience. Then he started the second engine. He completed the Before Hover Check and asked for hover clearance from the tower. During this phase, the helicopter sank back and to the left. The pilot stated he suspected immediately that something had happened with the landing skid. He informed the tower and requested the fire brigade. Then he stabilised the helicopter using the collective pitch to prevent dynamic rollover. After he had stabilised the helicopter, he instructed the crew members to exit the cabin using the right front door.

Once the fire brigade arrived, he slowly pulled back the thrust levers and shut off the engines. The helicopter remained in its position resting on the fractured part of the aft cross tube and the tread (see Appendix Images 1 and 2).

Personnel Information

The 38-year-old Pilot in Command (PIC) held a European Union Airline Transport Pilot License (Helicopter) (ATPL (H)) issued in accordance with Part-FCL. The Luftfahrt-Bundesamt (LBA, German civil aviation authority) initially issued his license on 21 January 2014. His class 1 medical certificate was valid until 28 March 2015. The pilot had a total flying experience of 2,344 hours and seven minutes with 4,541 landings; of which 1,135 hours and 49 minutes with 1,470 landings were on the type in question. The type rating was valid until 31 December 2014.

Aircraft Information

The Augusta S.p.A. AB 412 is of all-metal construction, and was equipped with rigid skids. It was powered by two Pratt & Whitney PT6T-3BE engines. The aircraft with the manufacturer's serial number 25802 was manufactured in 1994 and had a German certificate of registration.

The helicopter was operated by a German air rescue services operator. It was equipped for ambulance flights and had a full intensive care unit on board. The maximum take-off mass was 5,400 kg (11,905 lbs).

At the time of the accident the helicopter's total operating time was 8,262 hours and 26 minutes.

The skids - part number 412-050-001-107 and serial number 133 - had been fitted as new parts on 11 April 1995. At that time, the helicopter's total operating time was 295 hours and 54 minutes. At the time of the serious incident, the skid had a total operating time of 7,966 hours and 32 minutes and 26,157 cycles. The helicopter's landing gear consisted of two skids mounted parallel left and right below the fuselage. The two skids were connected by two bent cross tubes fitted to the front and aft below the fuselage. The cross tubes were fixed to the fuselage with clamps.

The aft cross tube had the part number 412-050-002-107, and the serial number 175142. It was a bent pipe drawn out to the ends. The bending started in the middle and increased toward the ends. The outer diameter of the tube was largest in the middle and decreased towards the ends. The two ends were reinforced where they met the skids. The bending created the ground clearance between the bottom surface of the fuselage and the skids.

In the middle of the cross tube a support clamp connected it with the fuselage.

The operator stated that the manufacturer of the cross tube had delivered it varnished white. The former operator of the helicopter had varnished the cross tube green. In May 2006 the current operator had it varnished black. Due to insufficient varnish adhesive in February 2008 some parts, e.g. the aft cross tube, were touched up. The paintwork was done by a commissioned paint shop.

Meteorological Information

The pilot stated visibility had been more than 10 km, the wind came from north-west with 5 - 10 kt, and the outside air temperature was 18°C.

Aerodrome Information

Mannheim City Airfield has two runways. They are oriented 09/27. The asphalt runway is located in the south and has a length of 1,066 m and a width of 25 m. The grass runway is located north of it and is 795 m long and 30 m wide. The apron is located in front of the terminal in the northern area of the airfield.

Wreckage and Impact Information

The serious accident occurred on the apron in front of the terminal (see Appendix Image 1). The helicopter sacked back to the left and rested on the fractured part of the aft cross tube.

The middle of the aft cross tube of the skid was fixed to the fuselage with a clamping device. It was slightly bent downward. The bent increased in the outer area of the fuselage's lower side. The two ends were reinforced where they met the skids.

The fracture occurred on the left side in the area of the cross tube with the increased bent. The larger part of the fractured cross tube remained attached to the fuselage. The right fracture face (viewed in the direction of the flight) hit the apron's concrete. The left stub of the cross tube had been pushed into the fuselage and the outer panel in the left area of the cross tube tunnel had been damaged (see Appendix Image 3).

The fractured aft cross tube was removed, and taken to the BFU in Braunschweig for further examination.

Examination of the Fracture Surfaces

The aft cross tube fractured in the area where it is bent more strongly toward the skid. The fracture occurred in the inside radius of the bent on the outer bottom surface of the tube (six o'clock position). Beginning at approximately the neutral bevel the fracture ran towards the lesser bent area of the outer radius.

The bottom surface of the larger fragment, which was still connected with the fuselage by way of the brackets, had crashed to the concrete surface of the apron. This had flattened approximately half of the fracture surface of the outer wall. The traces for fracture analysis had been destroyed in that area. The fracture surface of the smaller fragment, which was still connected with the left skid, was undamaged. The fracture analysis was performed on this part (Image 4).

The image shows an overview of the fracture surfaces of the cross tube (aluminium alloy). On the outer tube underside, i.e. in the area of the largest tensile stress, three extended thumbnail initial cracks had formed (Image 4). The cracks were in different levels; the left crack ran into a gap behind the crack in the middle. Unequivocally, the cracks were fatigue cracks. They had progressed to about half of the wall thickness before the forced rupture occurred.

From a constructional point of view the fracture occurred in the area of the largest bent with the largest tensile stress (large bending moment). It was caused by the bending up behaviour as normal reaction of the cross tube to the helicopter's mass.

The Fraunhofer Institut für Schicht- und Oberflächentechnik (IST) in Braunschweig provided the scanning electron microscope and technical assistance for the microscopic examination. The characteristic striation micro-topography (Image 5) confirmed the fatigue crack. The image shows the origin of the right fatigue crack. The residual fracture occurred as micro ductile forced rupture.

Image 6 shows an overview of the surface topography in the area of the left fatigue fracture. The surface was covered in chrome (EDX Analysis) and its striation ran in longitudinal direction to the component dimension. The surface was covered with irregular, almost concentric, scratches. It seemed they might have originated from some kind of process, such as a rotating steel brush. These scratches were kerfs which served as starting points for fatigue cracks. The gap initially ran crosswise to the longitudinal axis of the component, i.e. crosswise to the stress. Then it spiked 90° toward the fracture surface. Image 7 shows that the fatigue crack originated from one of the scratches. The crack started where the scratch ran in the area of the largest stress, i.e. crosswise to the load direction.

Examination of the Surface of the Fractured Cross Tube

Based on the results of the laboratory examination the entire cross tube was again subjected to macroscopic examination.

The crack began on the inside radius of the cross tube approximately 390 mm from the left end (see Appendix, Drawing 1). The fracture then formed a “tongue” and ran upward. In this area the cross tube had an oval section. At the fracture site the height of the outer diameter was 66.4 mm and the inner diameter 54.3 mm. The width of the outer diameter was 70.3 mm and the inner diameter 58.7 mm.

The paintwork and the paint surface, respectively, of the cross tube had different properties. The area which used to be in the fuselage tunnel was white. The mounting for the fuselage (clamp), and the immediate vicinity had a green colouring. The neck through which the connecting bolt to the fuselage was guided was white. The far larger part of the cross tube was black. The optical appearance of the black varnish ranged from shinny to dull. At closer inspection it became clear that some

areas had been repainted. In some of these areas the surface of the varnish had burst open and could be raised up with a finger nail. This was also true for the fracture surface.

Six places on the cross tube were selected; three on each side of the centre. At these areas the varnish was removed.

Image 8 shows an overview in flight direction. Numeration occurred from the centre outwards. The white numbers indicate the examined places on the left side; the black ones those of the right side. The underside was the tensile side of the cross tube and therefore mostly places on this side were chosen.

Left side: Area 1 showed a metallic surface; it is highly likely that it had been shot peened. No scratches were found. During the stripping the varnish showed good adhesive force. Area 2 was chosen due to the varnish touch up. Spray was visible on the surface; its appearance was dull. After varnish removal the metallic surface showed scratches. Area 3 (Image 9) shows the area next to the fracture origin. Scratches on the metal surface were found after varnish removal; as was the case during the microscopic examination. The silver-coloured coating visible in this area was not subject to further examination.

Right side: In Area 1 the clamp for the fuselage catch was removed. It was assumed that the clamp was part of the original equipment and therefore depicted the original condition. Between clamp and cross tube insulation material was found. In this area, the primer had a slightly different colouring than the left side; the green was slightly darker. The metal surface had been shot peened and did not show any scratches. Area 2 on the right side was once again a place where apparently touch-up had occurred. The metal surface showed scratches and areas with silver coating, similar to area 3 on the left side. And there were small areas where dark-green primer still remained. Area 3 approximately corresponded with the fracture area of the left side. The metal surface also showed scratches.

The clamp of the right skid showed two different primers; green on the outer side and yellow on the inner.

Fire

There was no fire.

Organisations and their Procedures

The helicopter operator also operated a maintenance organisation, which had commissioned a paint shop for the varnish work on the helicopter.

Additional Information

After the BFU had finished the examinations of the fractured cross tube it was sent to the manufacturer. In their laboratory further examinations were conducted in the presence of the Italian safety investigation authority (ANSV). These showed the same results.

The Manufacturer's Maintenance Manual Chapter 32-11-06 Landing Gear Assembly included the precautionary warning that the surface of the cross tube shall not be damaged. The Standard Practices Manual (BHT-ALL-SPM) Chapter 4 described chemicals and pickling agents and their method of application which should be used for paint removal.

Analysis

Macroscopic examination of the cross tube surface showed that some paint areas of the cross tube had been repainted and touched-up during its life span. The surface had been treated by some mechanical abrading material. The use of this abrading material left scratches on the metal surface. These scratches formed a kerf.

The microscopic examination showed that several cracks had formed in the cross tube area with high tensile stress. Subsequently, the cracks resulted in fatigue fracture and then the remaining section destroyed the cross tube by way of forced rapture.

In summary, it can be concluded that during paint work varnish residue was not removed using chemicals, as was recommended by the manufacturer, but with mechanical means, e.g. rotating steel brush or grinding disks. The subsequent scratches facilitated the development of a fatigue fracture in a high tensile stress area of the cross tube.

Conclusions

The cross tube of the helicopter landing gear was destroyed by several extended fatigue fractures. They developed at a highly stressed part of the component, i.e. where the bent is stronger (high bending moment, tensile side). The start of the fatigue cracks was made possible by the scratches on the surface which served as kerfs.

Safety Recommendations

Safety Recommendation No. SE 02/2016

When commissioning work on aircraft, the operator's maintenance organisation should inform any contractor about the stipulated and approved procedures of the manufacturer and supervise the work.

Investigator in charge:	Nehmsch
Assistance:	Marzi (ANSV)

Braunschweig 31/08/2016

Appendix

Image 1: Overall view Photo: Operator

Image 2: Fracture viewed from left rear Photo: Operator

Image 3: Damage on the left side of the fuselage Photo: Operator

Image 4: Fracture surface of the smaller fracture piece including cracks Photo: BFU

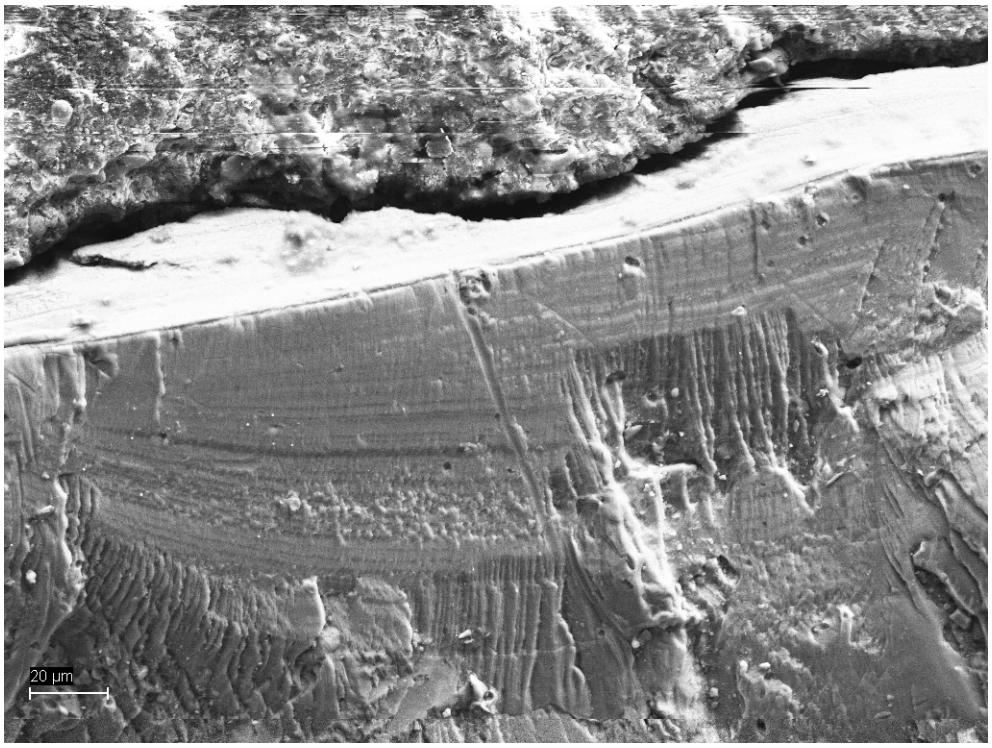


Image 5: Right fatigue fracture (Image 4) in detail Photo: IST

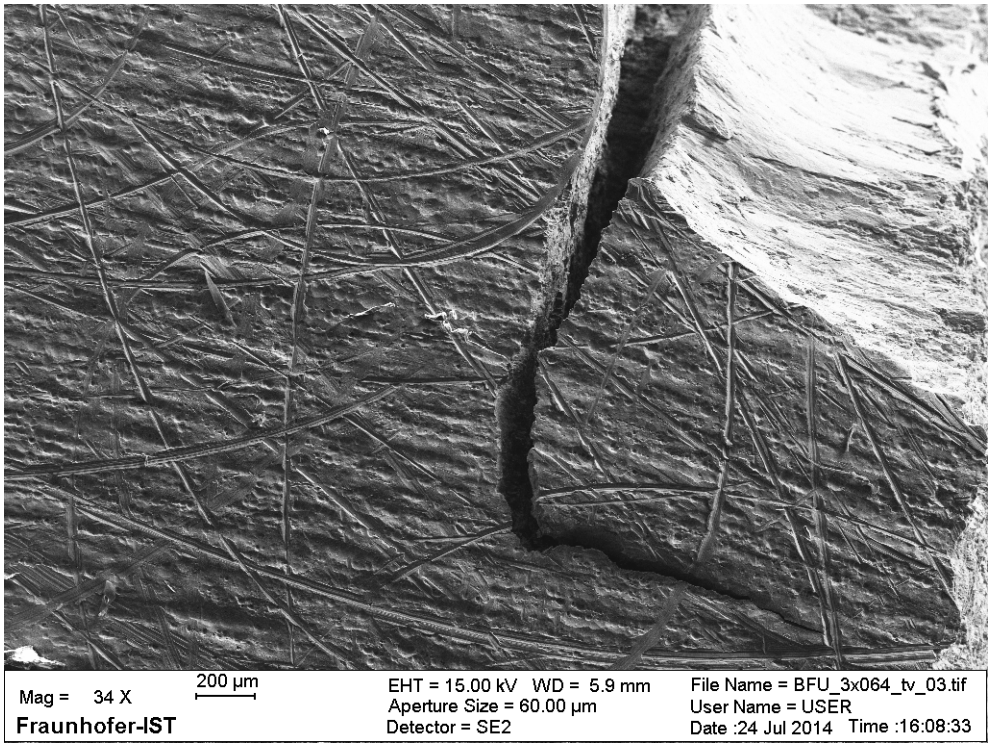


Image 6: Overview crack Photo: IST

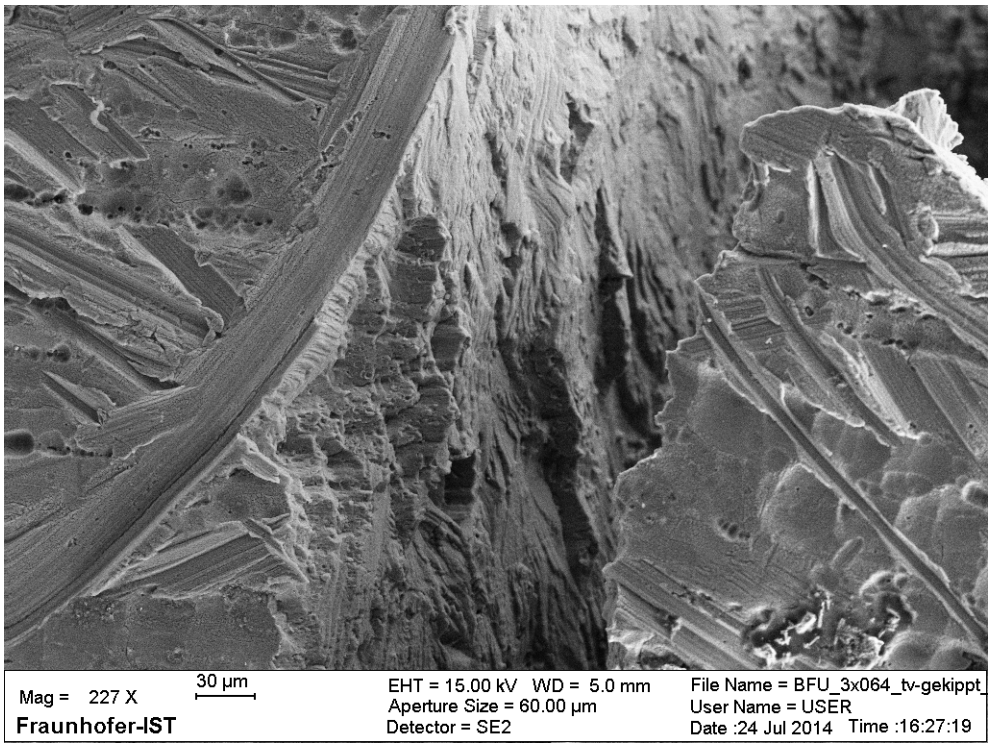
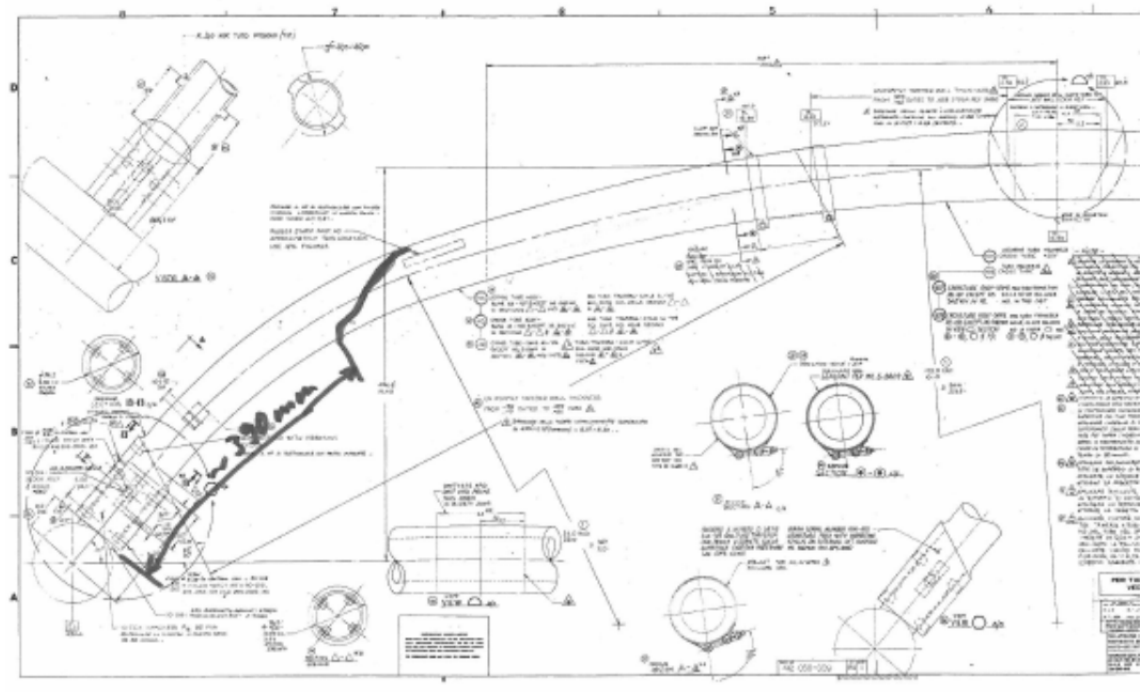


Image 7: Beginning of the crack at a scratch Photo: IST



Drawing 1 Cross tube with drawn-in fracture propagation Source: Agusta S.p.A.

Image 8: Cross tube overview with the six examination areas Photo: BFU

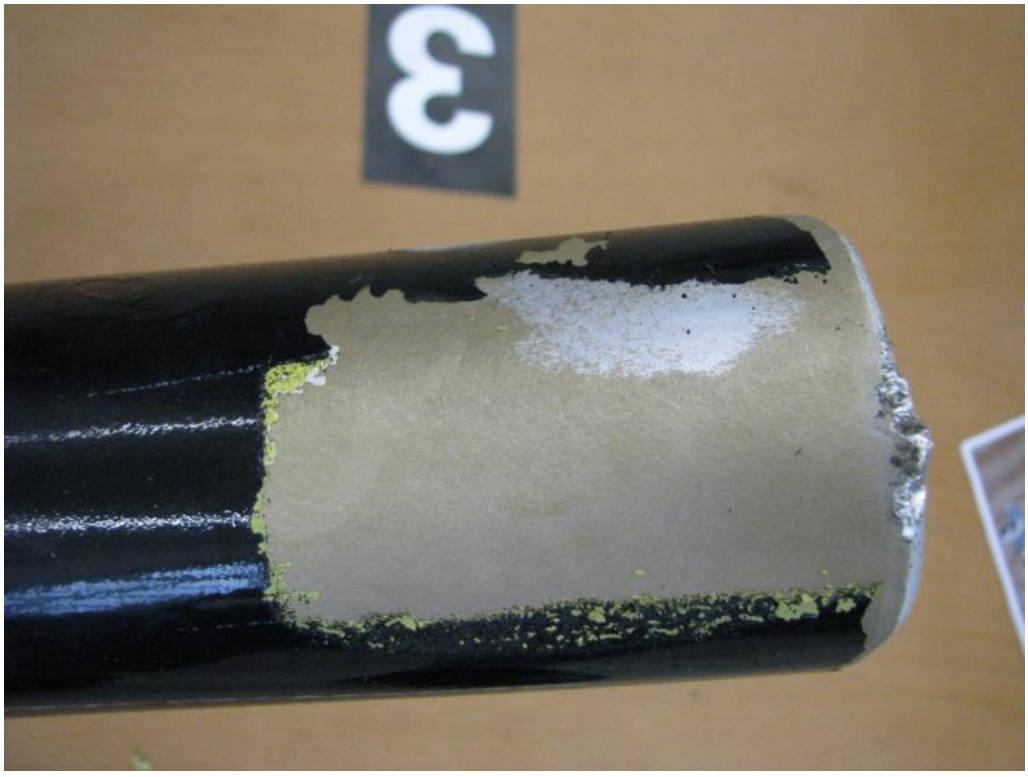


Image 9: Detail left cross tube area 3 Photo: BFU

This investigation was conducted in accordance with the regulation (EU) No. 996/2010 of the European Parliament and of the Council of 20 October 2010 on the investigation and prevention of accidents and incidents in civil aviation and the Federal German Law relating to the investigation of accidents and incidents associated with the operation of civil aircraft (*Flugunfall-Untersuchungs-Gesetz - FlUUG*) of 26 August 1998.

The sole objective of the investigation is to prevent future accidents and incidents. The investigation does not seek to ascertain blame or apportion legal liability for any claims that may arise.

This document is a translation of the German Investigation Report. Although every effort was made for the translation to be accurate, in the event of any discrepancies the original German document is the authentic version.

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