

# Investigation Report

## Identification

Type of Occurrence:	Serious incident
Date:	28 August 2009
Location:	Münster-Osnabrück Airport
Aircraft:	Cargo airplane
Manufacturer / Model:	Antonov / AN-12 BK
Injuries to Persons:	None
Damage:	Minor damage to aircraft
Other Damage:	None
Information Source:	Investigation by BFU
State File Number:	BFU EX007-09

## Factual Information

### History of the Flight

The cargo airplane had been loaded with cargo and prepared for the flight from Münster-Osnabrück to Tripoli (Libya). Seven crew members were aboard. At 2045 hrs<sup>1</sup> at engine start-up the right main landing gear bogie beam broke during the start-up of engine No. 3. The engines were shut down and the aircraft remained in the parking position.

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<sup>1</sup> All times local, unless otherwise stated

## Personnel Information

The 58 year-old Pilot in Command (PIC) held an Air Transport Pilot's License (ATPL) issued by the Ukrainian aeronautical authority in accordance with ICAO with the commensurate class and type ratings. He had a class 1 medical certificate. He had a total flying experience of 22,000 hours; 10,000 of which on Antonov AN-12.

The 28 year-old co-pilot held an Air Transport Pilot's License (ATPL) issued by the Ukrainian aeronautical authority in accordance with ICAO with the commensurate class and type ratings. He had a class 1 medical certificate. His total flying experience was 4,000 hours; 1,500 of which on the Antonov AN-12.

The 48 year-old flight engineer held a Flight Engineer's License (FEL) issued by the Ukrainian aeronautical authority in accordance with ICAO with the commensurate class and type ratings. He had a class 1 medical certificate.

Also aboard the airplane: One navigator, one radio operator and two technicians.

## Aircraft Information

The Antonov AN-12 BK is a high-wing cargo aircraft in all-metal construction with a retractable landing gear in nose wheel configuration. The aircraft was fitted with four Iwtschenko Ai-20M turbo prop engines. The engines were equipped with AV-68 propellers. Maximum take-off weight was 61,000 kg. Maximum landing weight was 58,000 kg. The aircraft with the Manufacturer's Serial Number 7345203 was built in 1967.

The aircraft was registered in Ukraine and operated by a Ukrainian operator.

The landing gear with the Serial Number 150, which later broke was mounted to the aircraft in 1983. Indications as to maintenance occurrences were not found.

## Meteorological Information

At the time of the occurrence it was twilight.

## Communication

There were radio communications with Münster roll control.

## Aerodrome information

Münster-Osnabrück International Airport has one asphalt runway. The runway is 2,170 m long, 45 m wide and oriented 07/25. The three aprons and the taxiways have concrete pavements.

## Flight Recorders

The magnetic tape of the Flight Data Recorder (FDR), model MSRP-12-96-S2, and the wire spool of the Cockpit Voice Recorder (CVR), model MS 61, were available to the BFU for read-out. The film of the mechanical FDR, model K-3-63, was seized.

Read-out and analysis of the data recordings did not yield any usable results.

## Wreckage and Impact Information

The aircraft had been parked at the northern edge of Apron East. It tilted to the right (Appendix 1). The right main landing gear had collapsed (Appendix 2); for comparison purposes, the intact left main landing gear is depicted in Appendix 3. The right main landing gear bogie beam was broken in flight direction right behind the pivot pin lug for the landing gear leg and the tow rod was bent (Appendix 4). The right landing gear had descended through the torque link onto the tyres. Parts of the broken landing gear bogie beam (Appendix 5) were taken to the BFU in Braunschweig for further investigation.

## Determinations on the Landing Gear

The landing gear bogie beam is built as a pipe on whose ends the adapters for the axles are welded to. In the middle the pivot pin lug for the landing gear leg is moulded on (Appendix 6). In the area of the fracture it has an external diameter of 119 mm and a wall thickness of about 17.5 mm. The ends of the pipe are sealed with caps.

The entire inside wall of the bogie beam was heavily corroded (Appendix 7); especially in the six o'clock position (Appendix 8). The individual fracture pieces were consequently significantly damaged by the collapse of the aircraft and covered by oil absorbents. However, at the beginning of the fracture an extensive corrosion pit was

visible. For further investigation the aft part of the landing gear bogie beam was chosen because its fracture surfaces were better preserved. After the fracture surface had been cleaned a thumbnail shaped crack could be clearly distinguished from the final rupture (Appendix 9). The corrosion pit which initiated the crack is depicted in Appendix 10.

The fracture pieces were examined at the Technische Universität Braunschweig, Institut für Werkstoffe (IfW). From different places on the fracture surface energy dispersive allocation charts were made using a scanning electron microscope. This confirmed that the material consisted of low alloyed heat-treatable steel. The notch groove and the corrosion particles firmly attached to the fracture surface showed reproducible Chlorine peaks.

After this analysis the fracture area was sputtered with Gold and looked into the scanning electron microscope once again. It was found that the whole fracture area showed the typical topography of hydrogen induced breakup: Bare grain boundaries with ductile flashes („crow's feet“), wide open cracks between grains, scattered transgranular, strongly fragmented cleavage plains plus sporadic “pores” (seats of dissolved spherical chromium carbide) (Appendices 11 – 13). No indications were found anywhere that vibrations supported crack expansion.

The border between initial crack and final rupture is clearly defined. There the typical mixed fracture of dimple and cleavage planes of high-strength steel was found (Appendix 14). Along a circular, approximately one millimetre wide edge zone, the final rupture has developed 45° ductile shear lips on the inner and outer side. The same applies to the outer edge at the area of the initial corrosion crack (Appendix 15). The crack had not penetrated the outer surface prior to the final rupture.

## Fire

There was no fire.

## Analysis

The landing gear bogie beam is designed so that all support pipes are mounted to it from the outside. The pipe itself is sealed off from outside influences by caps. However, moisture or liquid found its way inside the support pipe. The Chlorine peaks in the energy dispersive allocation chart indicate splash water possibly mixed with de-icing salt. Significant corrosion protection could not be determined on the

inside wall of the pipe. This also confirms the significant corrosion on the inside of the pipe especially in the 6 o'clock position.

The landing gear bogie beam was, without doubt, destroyed by hydrogen induced stress corrosion cracking. Thereby, hydrogen was atomically produced directly at the "Crime Scene" by partly cathodic reaction and penetrated the steel. The underside of the bogie beam was subject to intense tensile stress, which is required for crack propagation, any time the aircraft was parked. The fracture occurred at the force transmission point; the pivot pin lug for the landing gear leg. The required time span was sufficiently given since the landing gear was mounted to the aircraft (1983). Furthermore, the steel used exceeds the minimum tensile strength required for this kind of damage. Obviously, the initial corrosion crack propagated far enough during the last parking phase on 28 August 2009 that the additional load induced at the start of engine number 3 directly above the right landing gear was sufficient to initiate a critical situation for unstable crack propagation (final rupture). The ratio of crack cross section parts and the final rupture parts is reasonable, given the limited fracture toughness of high-strength steel.

## Conclusions

The landing gear bogie beam was, without doubt, destroyed by hydrogen induced stress corrosion cracking. It was caused by moisture entry (water in connection with de-icing salt) into the inside of the bogie beam and the expanded time period in which the corrosion was not detected.

## Safety Recommendation

Safety Recommendation No. 03/2011

The State Aviation Administration of Ukraine should ensure that on all Antonov AN 12 main landing gears the inside of the landing gear bogie beams are inspected for traces of corrosions and the caps on the ends are inspected for liquid tightness.

Safety Recommendation No. 04/2011

The State Aviation Administration of Ukraine should ensure that the manufacturer establishes suitable test procedures and cycles for the Antonov AN 12 landing gears.

Furthermore, the manufacturer should determine actions which remedy corrosion or defects in liquid tightness.

Investigator in charge: Dietmar Nehmsch  
Assistance: Dieter Ritschel  
Hans-Werner Hempelmann  
Field Investigation: Dietmar Nehmsch  
Braunschweig: 2 November 2011

## Appendices



Appendix 1: Aircraft



Appendix 2: Damaged right main landing gear

Photos (2): BFU



Appendix 3: Undamaged left main landing gear



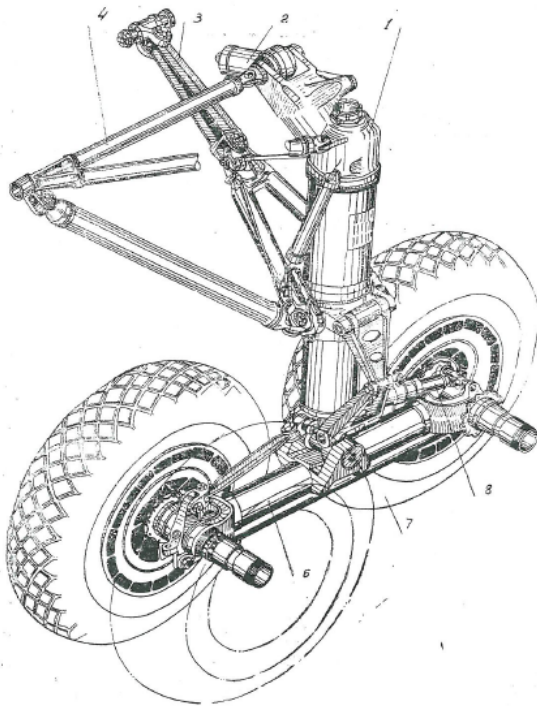
Appendix 4: Broken landing gear bogie beam and bent tow rod

Photo: BFU



Appendix 5: Parts of the fractured landing gear bogie beam

Photo: BFU



Appendix 6: Schematic plan of the main landing gear

Source: Antonov



Appendix 7: Corroded inside wall

Photo: BFU



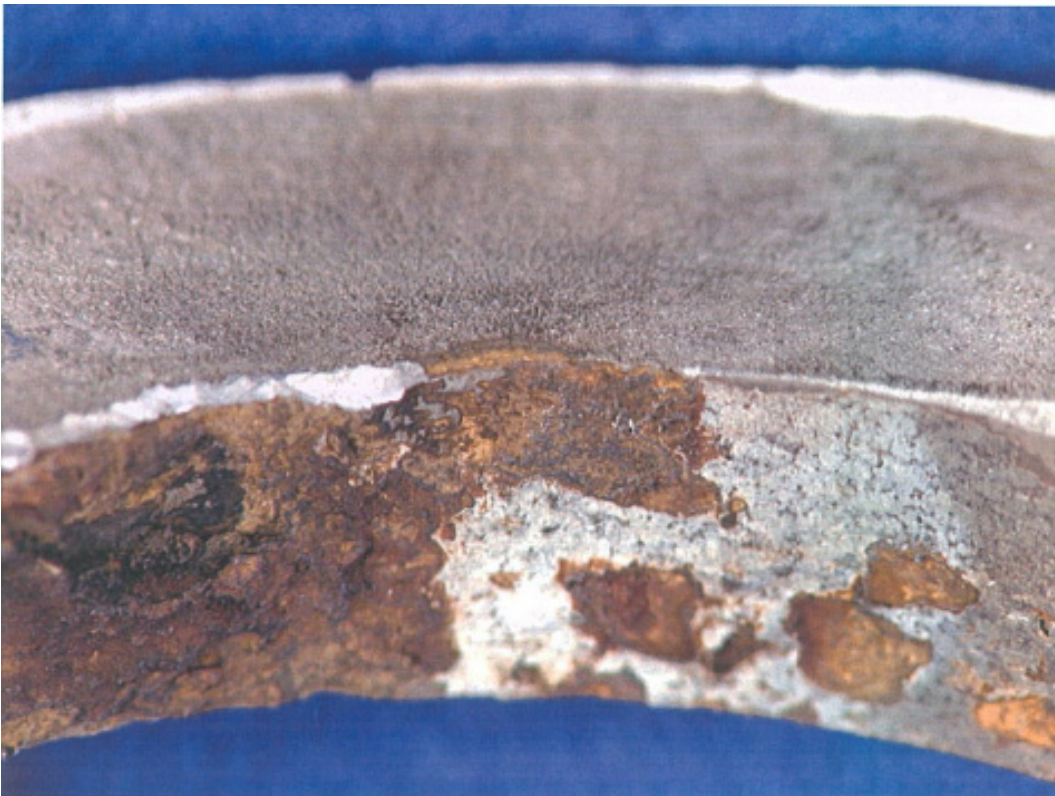
Appendix 8: Corrosion in the 6 o'clock position (top view)

Photo: IfW



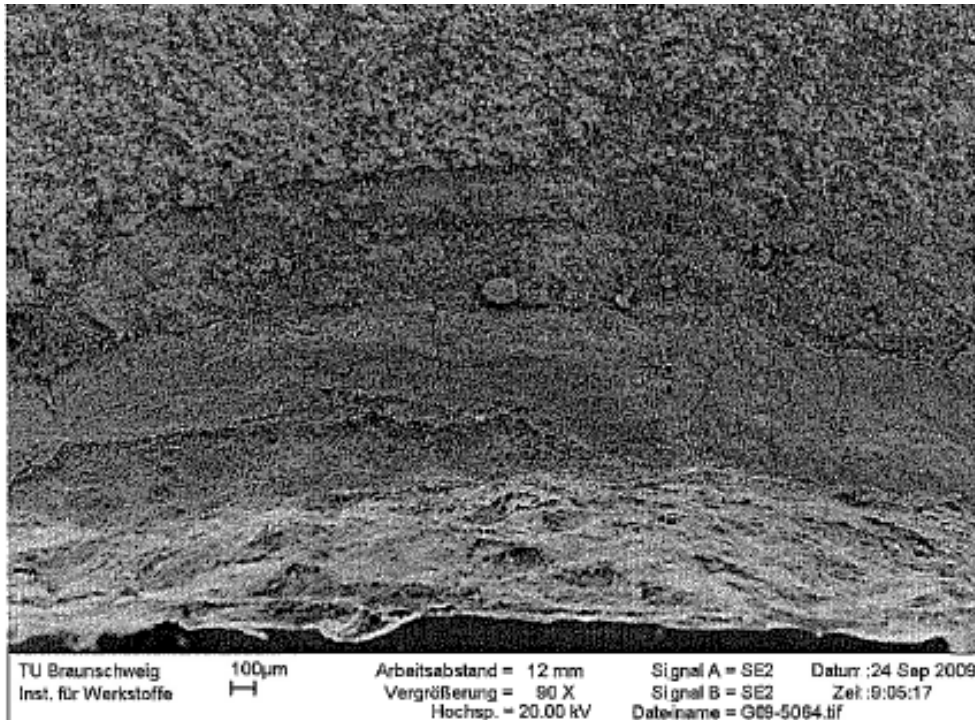
Appendix 9: Thumbnail initial crack (arrows)

Photo: IfW

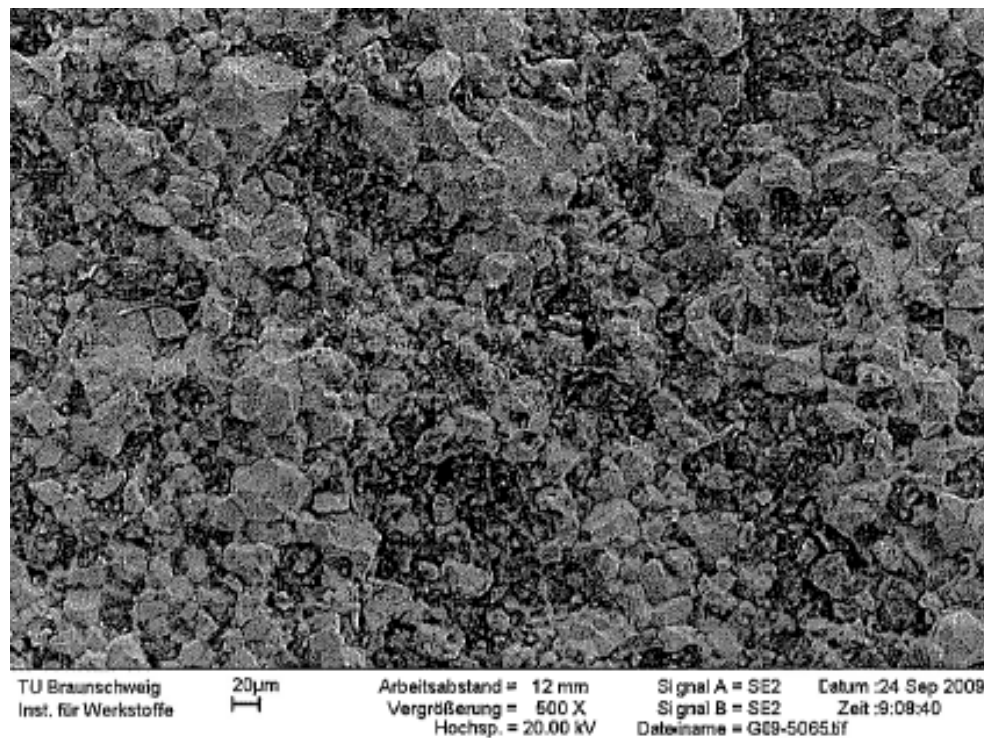


Appendix 10: Corrosion pit (tilted)

Photos (2): IfW



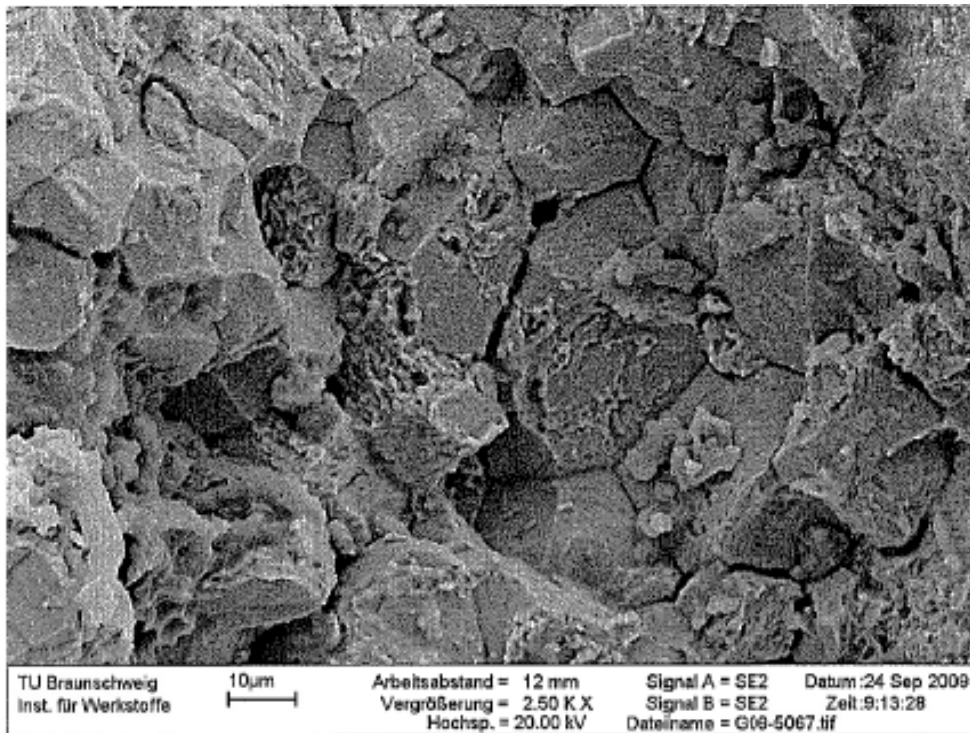
Appendix 11: Corrosion pit filled with corrosion products Scanning electron microscope



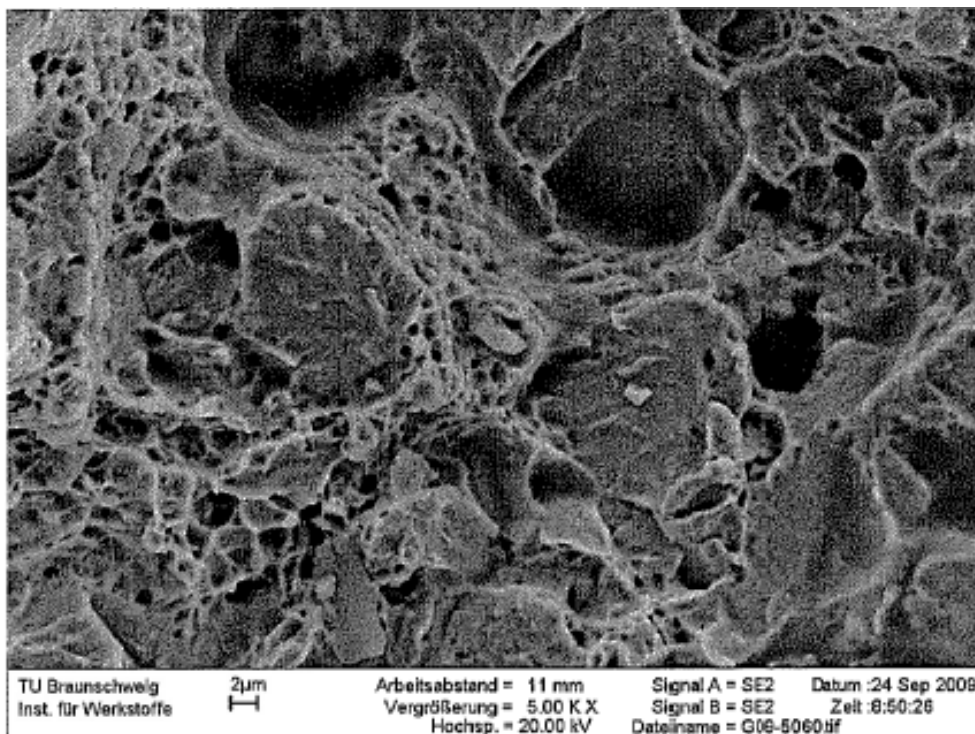
Appendix 12: Intercrystalline separation in the whole area of the fracture

Photos (2): IfW

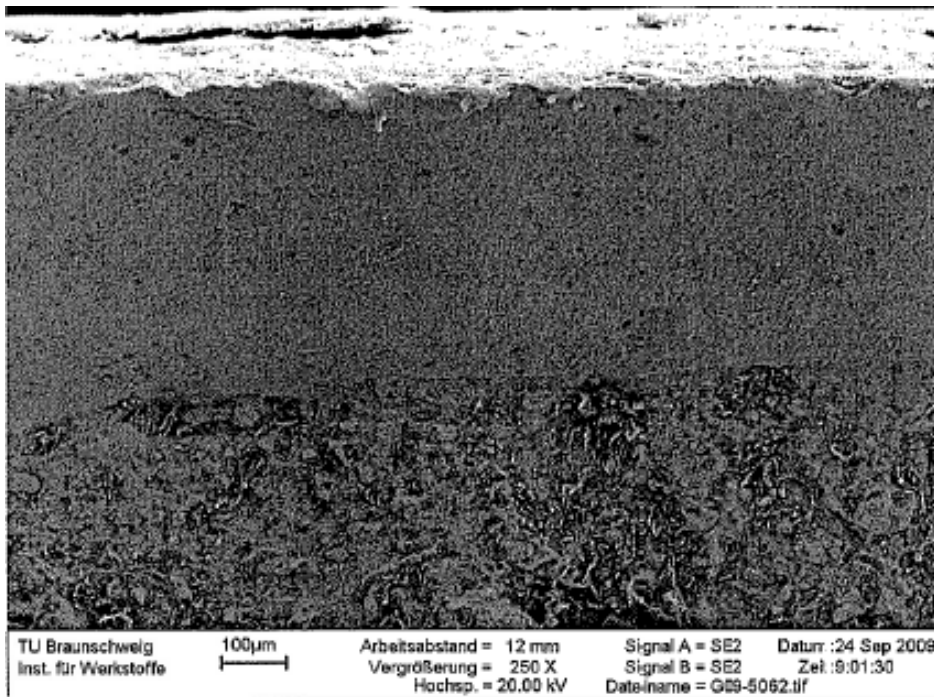
Scanning electron microscope



Appendix 13: Topography of the hydrogen induced crack with a higher resolution - scanning electron microscope



Appendix 14: Final rupture; dimple and cleavage planes - scanning electron microscope Photos (2): IfW



Appendix 15: Ductile shear lips on the outer wall bordering the hydrogen crack (lower part)

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 - FIUUG*) 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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