



National Transportation Safety Board

Pipeline Accident Brief

Magellan Pipeline Anhydrous Ammonia Release

Near Tekamah, Nebraska

October 17, 2016

The Accident

On October 17, 2016, shortly after 9:00 p.m. local time, an 8-inch-diameter underground transmission pipeline ruptured and released 2,587 barrels (108,654 gallons) of liquid anhydrous ammonia on private property adjacent to milepost (MP) 263.32 on County Road P in Burt County, near Tekamah, Nebraska.¹ The pipeline was owned and operated by Magellan Midstream Partners, LP, (Magellan). Upon release and exposure to the atmosphere, the ammonia vaporized and produced a toxic plume. (See figure 1.) A local resident who had left his home to investigate the accident scene died of respiratory failure due to exposure to the ammonia vapor; additionally, two people sustained minor injuries. A total of 29 households, involving 49 people, were evacuated. U.S. Highway 75, a main roadway in the area, was closed for several days.²

The ammonia pipeline was operated and monitored from a control center located in Tulsa, Oklahoma. Low pressure alerts were received in the control center at 9:03 p.m., and a rupture alarm first occurred at 9:14 p.m. At 9:21 p.m., control center personnel received a third-party report of strong ammonia odor and a vapor cloud located 8.5 miles north of Tekamah, Nebraska.

¹ Tekamah, Nebraska, is located about 8 miles directly south of the accident site, and Decatur, Nebraska, is about 6.5 miles directly north.

² For more detailed information about this accident investigation, see the the public docket at www.nts.gov/investigations/dms.html and search for accident number DCA17FP001.

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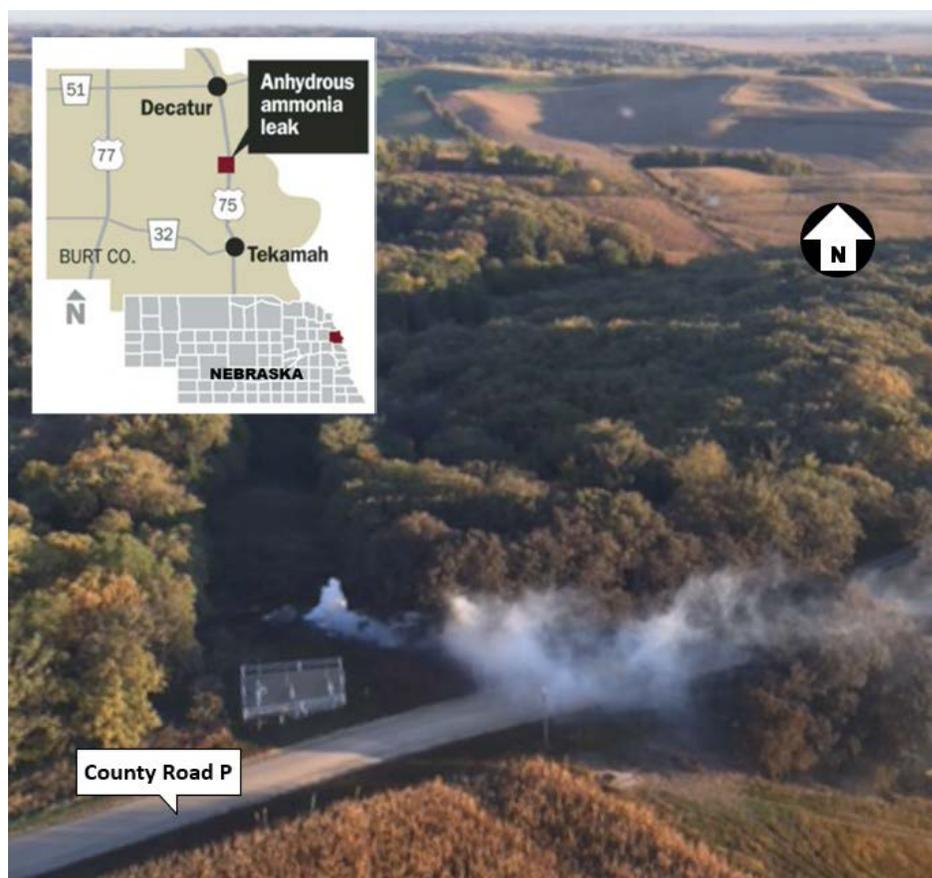


Figure 1. Aerial photograph of active anhydrous ammonia release with map insert showing release location. (Source: Magellan.)

Activities at Time of Accident

During the early evening of October 17, 2016, no operational issues were reported by the on-duty controller at shift change, and operational records did not indicate any operating irregularities. About 9:00 p.m., the controller was pumping ammonia north on the pipeline system for a customer delivery. At 9:03:45 p.m., the ammonia pipeline pressure dropped 42 psi on the suction side of the Herman pump, which was located south of the Burt County line and near where the release occurred. Then, at 9:03:49 p.m., a 68-psi pressure decrease occurred on the discharge side of the Herman pump. These events triggered an alert in the control center and led to an automatic shutdown of the Herman pump.

At 9:11:38 p.m., the on-duty controller contacted the leak detection analyst (LDA) after receiving additional alerts and notices from the control system. The on-duty controller told National Transportation Safety Board (NTSB) investigators that he did not initially think he had a rupture. Rather, he stated that he contacted the LDA to seek an opinion on why the system appeared to be losing pressure. The controller wanted to determine if the alerts were caused by an irregularity in the Magellan software.

At 9:14:40 p.m., the on-duty controller received an alarm indicating that a rupture had occurred. The SCADA controller immediately began to shut down the ammonia pipeline. At

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9:17:15 p.m., another leak alert was received after the controller had initiated a pipeline system shutdown.

Post Release Actions

Following the 9:14:40 p.m. alert, Magellan's on-duty controller began isolating the pipeline rupture by shutting down pumps and closing valves. The sequence of valves closed to stop the discharge of ammonia is shown in figure 2.

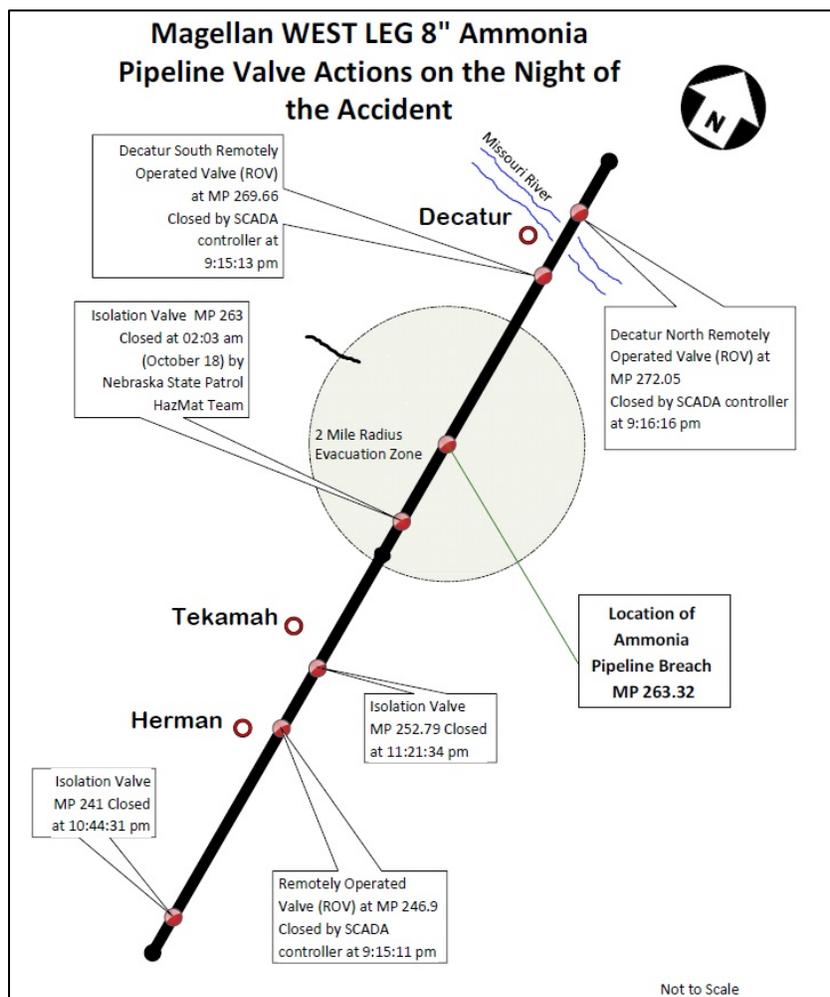


Figure 2. Magellan ammonia pipeline showing valves located at mileposts surrounding the release site.

Emergency Response

At 9:26:23 p.m., Magellan's on-duty controller issued a Code Red, which initiated emergency response actions by Magellan staff, and established a phone bridge at 9:35:10 p.m. for

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communications among responders.³ A Magellan operations control relief controller notified the Burt County Sheriff's office at 9:35:50 p.m. and advised that 500 barrels of ammonia had been released and to avoid gas clouds.

The community emergency response involved the Tekamah Fire and Rescue Association (TFRA) and the Burt County Sheriff's Department. About 10:33 p.m., the TFRA fire chief assumed the role of incident commander and developed a tactical response plan, which involved isolating an area on County Road P between County Road 32 and U.S. Route 75. They planned to evacuate anyone found in that area. The TFRA dispatched fire and rescue resources to the scene. The sheriff's 911/dispatch center made phone calls to residents within an initial 1/2-mile evacuation zone downwind of the release.

A Magellan employee was designated to provide technical support to emergency responders. The Magellan employee recommended a 2-mile evacuation distance and took over the incident command. The TFRA fire chief requested mutual aid from the Decatur Rural Volunteer Fire Department. Personnel from both agencies conducted the evacuation by door-to-door canvassing of residences. Afterward, the Nebraska Hazardous Incident Team (hazardous materials release response unit of the Nebraska State Patrol) arrived to assist with the emergency response.

Pipeline Operation

Magellan is an interstate pipeline operator that primarily transports, stores, and distributes crude oil and refined petroleum products. In 2016, Magellan had more than 1,700 employees in 23 states, with about 9,700 miles of oil and petroleum refined product pipelines and 56 storage terminals, throughout 15 states, extending from the Gulf Coast throughout the middle of the United States to Minnesota. Among these assets, Magellan operated an 1,100-mile common carrier ammonia pipeline⁴

Magellan's ammonia pipeline system has three branches that originate in Borger, Texas, Verdigris, Oklahoma, and Enid, Oklahoma, and terminate in Mankato, Minnesota. Liquid ammonia is injected into the pipeline from third-party production facilities and is transported to agricultural centers in Iowa, Kansas, Minnesota, Nebraska, Oklahoma, and South Dakota. The ammonia is used to produce nitrogen compounds such as urea, ammonium nitrate, ammonium phosphate, and ammonium sulfate.

Magellan's ammonia pipeline was installed in 1968. The pipeline has an outside diameter of 8.625 inches and, in the area of the release, was buried 48 inches below grade. The pipe wall

³ The Code Red procedure provides a play-by-play set of actions for Magellan staff, on-scene Magellan parties, and subcontract support staff. The Code Red procedure includes the roles and responsibilities of each participant from the onset of a release to the point the release has been neutralized. Code Red Event Procedure 9.02-ADM-011 covers a standardized method for event response, focusing on a safe and prompt responses for the public and employees, environmental protection, minimization of release volume, containment of release volume, and containment in primary vessel (pipeline, tank, etc.). The procedure addresses SCADA-indicated pipeline ruptures and notifications reporting pipeline fire, explosion, or vapor cloud that leads to suspicion or confirmation of a pipeline rupture or high-rate release.

⁴ *Common carrier pipelines* provide transportation services for any person or company, and the carriers are responsible for the loss of goods during transport as authorized by a regulatory body such as the Federal Energy Regulatory Commission or by state agencies. *Private carrier pipelines* are not authorized to provide services to the public.

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thickness was 0.156 inch. The maximum operating pressure (MOP) at the release location was 1,198 psig.⁵ The pipeline was manufactured by Lone Star Steel in accordance with American Petroleum Institute (API) Specification 5L using Grade X46 steel and a low frequency electric resistance longitudinal seam welding process. The pipeline had an impressed current cathodic protection system as well as a field-applied polyethylene tape wrap to mitigate external corrosion.

The release occurred on a segment of the ammonia pipeline known as the West Leg. Magellan records indicated that the West Leg in Burt County has had multiple leaks and repairs since it was installed. In April 1984, 168 gallons of ammonia were released due to a defective pipe. Between 1988 and 1990, five minor ammonia leaks occurred that required pipeline repairs. From May 1993 to October 1994, there were three pinhole leaks that released 221 gallons of ammonia.

Inspection of Damaged Pipeline

On October 20, 2016, the ruptured section of ammonia pipeline was unearthed. The pipe had fracture on its underside (6 o'clock position) and exhibited downward bending proximal to the fracture location. (See figure 3.) The fracture followed the spiral seam pattern of the field-applied polyethylene tape wrap (See figure 4.) The fracture ran roughly 45° from the longitudinal axis of the pipe in a spiral path. The fracture had sawtooth-like features, with numerous short cracks merging into the main fracture. The total length of the fracture was 11 7/8 inches, and the widest opening of the fracture was 0.19 inch. About a 60-inch section of the pipeline containing the fracture was removed and was shipped to the NTSB Materials Laboratory in Washington, DC for further examination.

Portions of the protective polyethylene tape coating adjacent to the fracture were displaced from the pipe but recovered during the investigation. When loose pieces of tape were positioned on the pipe surface, the fracture aligned with the edges of successive windings of the tape, where the tape overlapped. Also, there were areas on the pipe segment where the tape wrap had visibly shifted. One area of the tape had its edges folded over, exposing the pipe surface. Brown-colored corrosion was visible on the exposed pipe surface. Tenting of the tape wrap was observed longitudinally along the 6 o'clock position of the pipe, roughly in line with the fracture.⁶

Numerous thumbnail-shaped cracks consistent with fatigue cracks were visible on the fracture surfaces. The patterns were oriented such that the thumbnail-shaped cracks emanated from the outside diameter of the pipe. The presence of numerous thumbnail-shaped cracks was consistent with multiple initiation fatigue cracking. The deepest thumbnail-shaped fatigue crack extended through approximately 75 percent of the pipe wall thickness. The areas between the thumbnails and adjacent to the inside diameter of the pipe exhibited microvoid coalescence consistent with overstress fracture. Overall, the fracture features were consistent with corrosion fatigue.

⁵ *Maximum operating pressure* (MOP), as defined in Title 49 *Code of Federal Regulations* (CFR) §195.406, is the maximum pressure permitted for normal line or vessel operation; MOP is related to pipe strength and the ability of a pipe to withstand internal pressure. MOP ratings are based on three factors: design pressure, hydrostatic test pressure, or flange rating. Internal design pressure for a pipeline is determined according to an established formula.

⁶ *Tenting* is a form of disbondment of a pipeline coating. *Disbondment* refers to the loss of the bond (adhesion) between a pipeline and its protective coating, which has been known to allow moisture to become trapped between the surface of the pipe and the tape wrap, creating an environment that may be corrosive.

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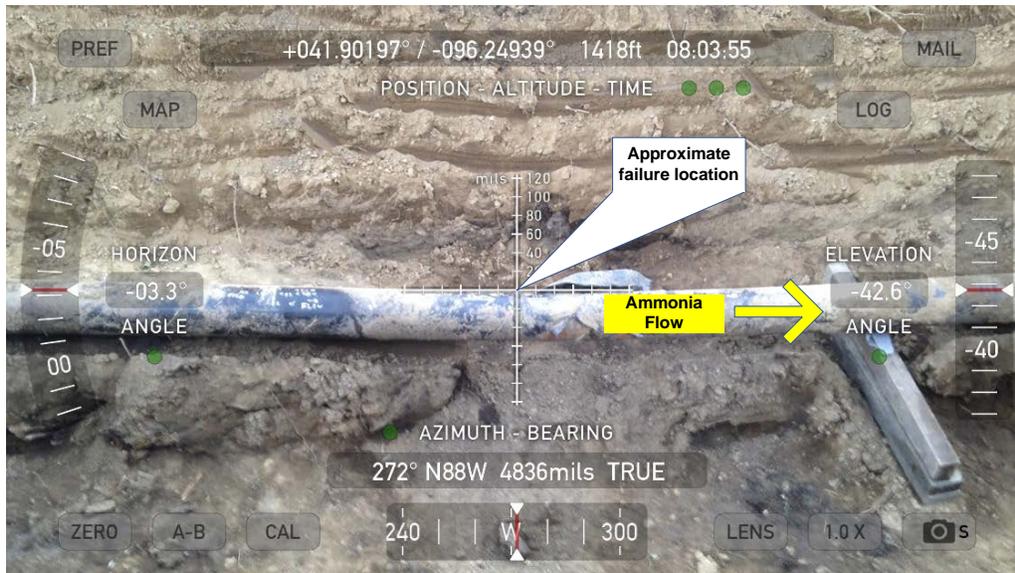


Figure 3. Photograph of failed section of ammonia pipeline.

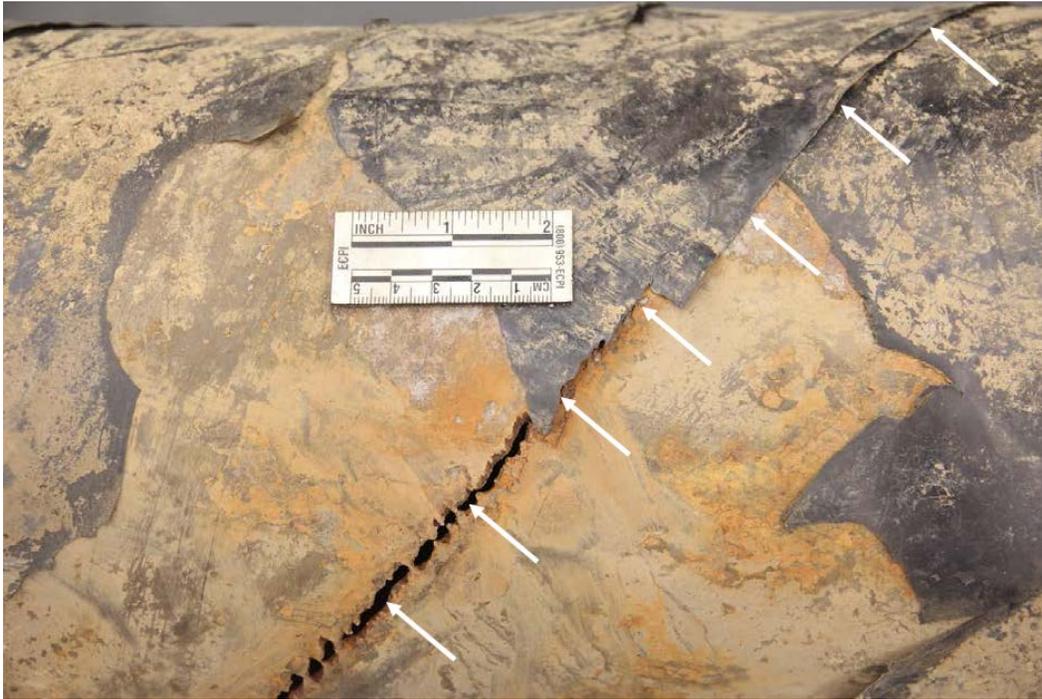


Figure 4. Photograph of ammonia pipeline crack showing alignment with seam in protective tape and sawtooth crack features.

The residual curvature of the pipe section after removal from the pipeline indicated that the stress from the bending loads had exceeded the yield stress of the steel. The tensile stress from bending would have been the greatest on the bottom of the pipe, at the external surface, in the area where cracking initiated. The hoop stress from the MOP at the rupture location is about 70 percent of the specified yield stress of the steel.

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Samples were taken from the pipeline to test the chemical composition and material properties (yield stress, tensile strength, and elongation at failure) of the steel. The test results were consistent with the API 5L X46 specification.

Magellan records indicate that the West Leg had been in-line inspected periodically from 2004 to 2015 using NACE International standard practices.⁷ The last in-line inspection (ILI) run through the section of pipe where the rupture occurred was in September 2015, using magnetic flux leakage (MFL) measurements and smart pigging tools for detection of wall-loss corrosion and other indications of pipeline integrity issues.⁸ The MFL assessment used contractor-supplied specifications for defect sizing for metal loss, pitting, axial grooving, circumferential grooving, and circumferential slotting in the pipe body and girth weld heat-affected zones.⁹ Technicians reviewed the 2015 ILI data and did not find any anomalies or indications of pipeline failures at that time.

Magellan records indicate that hydrostatic testing of the ammonia pipeline occurred from September 2008 to January 2012. The hydrostatic tests were not required by federal regulations, but Magellan nevertheless performed the conventional 8-hour test methodology recommended by the Pipeline and Hazardous Materials Safety Administration (PHMSA) as well as spike tests.¹⁰ The hydrostatic tests revealed five leaks, two of which were attributed to stress corrosion cracking. Magellan repaired these leaks prior to the accident.

Postaccident Actions

On October 21, 2016, PHMSA issued Corrective Action Order (CPF No. 3-2016-5009H), which required Magellan to shut down a 49-mile section of the anhydrous ammonia pipeline extending from Valley, Nebraska, (MP 223.61) to the Missouri River (MP 272.05). After repairs were made, Magellan was ordered by PHMSA to operate the pipeline at a 20 percent reduction from the actual operating pressure prior to the October 17, 2016, accident.

Magellan trains its pipeline operators annually using SCADA simulations representing various operating conditions. Following the accident, Magellan recognized that the simulation training did not fully prepare their controllers to quickly recognize and handle an ammonia release. Magellan developed new simulator training using the SCADA logs from the accident to train operators to recognize pipe breach conditions; this new training is required for the annual certification of SCADA controllers.

Following the accident, Magellan told the NTSB that they had re-examined the 2015 MFL ILI data for characteristics obtained from the ruptured pipeline. Magellan technicians were able to define a new signature from the ILI data to forecast the pipeline failure. Magellan then used the new ILI signature to screen the pipeline from Valley, Nebraska, to Decatur, Nebraska, where they

⁷ *In-Line Inspection (ILI)* is an inspection of a pipeline from the interior of the pipe using an in-line inspection tool. It is also called intelligent or smart pigging. (NACE International Practice SP0102-2010 In-Line Inspection of Pipelines).

⁸ *Magnetic Flux Leakage (MFL)* testing is a nondestructive procedure for detection of corrosion and pitting in steel structures. MFL is used for integrity assessment of pipelines and storage tanks.

⁹ TDW Magpie Systems, Inc. MFL Sizing Accuracy Specification. Rev. B of December 2, 2005.

¹⁰ A *Spike Hydrostatic Test* uses a test-pressure-to-operating-pressure ratio that significantly exceeds the minimum value of 1.25 required by federal regulation 49 *CFR* 195, Subpart E and the duration considerably shorter (1/2 to 1 hour) than a minimum time of 8 hours required by this federal regulation.

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found additional indications of pending failures. Magellan completed direct assessments and repairs for these locations.

In January 2019, Magellan announced that they would decommission the 1,100-mile Texas to upper Midwest ammonia pipeline system later in the year. They initiated the shutdown and product displacement of the anhydrous ammonia pipeline system in September 2019. According to Magellan, as of the end of December 2019, they have decommissioned approximately 588 miles of pipeline. Magellan indicated that they anticipate completion of the anhydrous ammonia displacement activities in the summer of 2020.

Probable Cause

The National Transportation Safety Board determines that the probable cause of the pipeline rupture was corrosion fatigue cracks that grew and coalesced under disbanded polyethylene tape coating. Contributing to the location of the cracking was external loading that caused bending stress in the pipe in addition to the cyclic stresses in the pipe from the internal pressure of the ammonia transported.

For more details about this accident, visit www.nts.gov/investigations/dms.html and search for NTSB accident identification number DCA17FP001.

Report Date: January 29, 2020

The NTSB has authority to investigate and establish the facts, circumstances, and cause or probable cause of a pipeline accident in which there is a fatality or substantial property damage, or that involves a passenger train. (49 U.S. Code § 1131 – *General authority*)

The NTSB does not assign fault or blame for an accident or incident; rather, as specified by NTSB regulation, “accident/incident investigations are fact-finding proceedings with no formal issues and no adverse parties . . . and are not conducted for the purpose of determining the rights or liabilities of any person.” (49 *Code of Federal Regulations*, Section 831 Assignment of fault or legal liability is not relevant to the NTSB’s statutory mission to improve transportation safety by investigating accidents and incidents and issuing safety recommendations. In addition, statutory language prohibits the admission into evidence or use of any part of an NTSB report related to an accident in a civil action for damages resulting from a matter mentioned in the report. 49 *United States Code*, Section 1154(b).
