INDIANA UNIVERSITY

TRANSPORTATION RESEARCH CENTER

ON-SITE COMPRESSED NATURAL GAS VEHICLE EXPLOSION INVESTIGATION

FOR THE OFFICE OF DEFECTS INVESTIGATION (ODI)
CASE NUMBER - IN14016
LOCATION - WISCONSIN
VEHICLE - 2014 FREIGHTLINER M2 112
INCIDENT DATE - April 2014

Contract Number: DTNH22-12-C-00270

Prepared for:

U.S. Department of Transportation
National Highway Traffic Safety Administration
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Washington, D.C. 20590-0003

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The crash investigation process is an inexact science which requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points be coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

Because each crash is a unique sequence of events, generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicle(s) or their safety systems.

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16. *Abstract*

This on-site investigation focused on the Compressed Natural Gas (CNG) fuel system of a 2014 Freightliner M2 112. One of the vehicle's five CNG fuel cylinders was punctured by the left fork of an unsecured Yale Type E forklift located in the cargo box of the Freightliner, resulting in an explosion of the fuel cylinder. There was no fire. This incident occurred on a two-lane roadway in an industrial park. The Freightliner was a two-door straight truck equipped with a CNG fuel system, consisting of five CNG fuel cylinders stacked vertically and secured within an aluminum cabinet located between the truck cab and cargo box. The cylinders had been filled the previous evening and the truck was used in the morning on the day of the incident. While the specific fill level of the CNG tanks is not known, it was reported by an investigator from the Clean Vehicle Education Foundation that the CNG cylinders were nearly full at the time of the incident. A restrained 59-year-old male driver and a restrained 29-year-old male front right passenger occupied the vehicle. The Freightliner was traveling east and was transporting an unsecured Yale Type E forklift. The Freightliner's driver was braking to initiate a right turn into a driveway when the forklift was displaced forward as a result of the deceleration and the forks impacted and pierced the front panel of the cargo box. The left fork then impacted and ruptured the lowest of the five CNG fuel cylinders resulting in a explosion. The driver sustained fatal injuries and expired at the scene. The front right passenger sustained police reported "A" (incapacitating) injuries and was transported by ambulance to a hospital where he was admitted for one day.

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BACKGROUND

This on-site investigation focused on the Compressed Natural Gas (CNG) fuel system of a 2014 Freightliner M2 112 (**Figure 1**). One of the five CNG fuel cylinders was punctured by the left fork of an unsecured Yale Type E forklift located in the cargo box of the Freightliner resulting in a explosion of the fuel cylinder. There was no fire. This investigation was initiated by the National Highway Traffic Safety Administration (NHTSA) on April 15, 2014 through the Office of Defects Investigation (ODI), which was responding to an on-line news article. This investigation was assigned on April 17, 2014 when cooperation to inspect the Freightliner was finalized with the vehicle's owner. The incident involved the Freightliner and the Yale Type E forklift located within the cargo box of the vehicle. This incident occurred in April 2014 at 1335 hours, in Wisconsin and was investigated by a local police agency. The Freightliner and incident scene were inspected on April 22, 2014. Interviews with the front right passenger of the Freightliner, the owner of the Freightliner, and the city public safety director were also conducted on April 22, 2014.

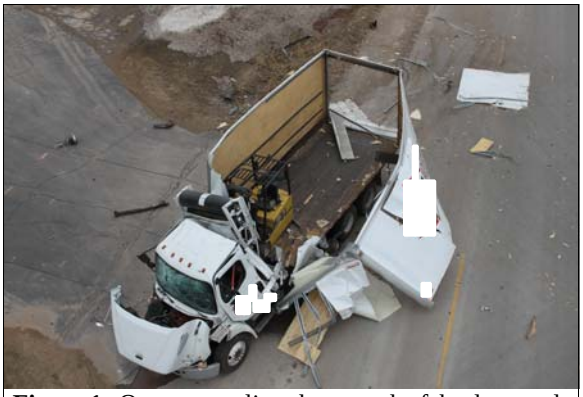


Figure 1: On-scene police photograph of the damaged 2014 Freightliner M2 112

This incident occurred on a two-lane roadway in an industrial park. The Freightliner was a two-door straight truck equipped with a CNG fuel system, consisting of five CNG fuel cylinders oriented horizontally and stacked vertically within an aluminum cabinet located between the truck cab and cargo box. The cylinders had been filled the previous evening and the truck was used in the morning on the day of the incident. The fill level of the CNG tanks could not be determined. A restrained 59-year-old male driver and a restrained 29-year-old male front right passenger occupied the vehicle. The Freightliner was traveling east and was transporting an unsecured Yale Type E forklift. The Freightliner's driver was braking to initiate a right turn into a driveway when the forklift was displaced forward as a result of the deceleration and the forks impacted and pierced the front panel of the cargo box. The left fork then impacted and ruptured the lowest of the five CNG fuel cylinders resulting in a explosion. There was no fire. The driver sustained fatal injuries and expired at the scene. The front right passenger sustained police reported "A" (incapacitating) injuries and was transported by ambulance to a hospital where he was admitted for one day.

Incident Site: This incident occurred during daytime hours on a two-lane roadway in an industrial park. The weather conditions were clear with 10 mile visibility, northeasterly winds at 27 km/h (17 mph), a temperature of 0.6° C (33° F), and dew point of -2° C (28° F), according to local weather reports. The bituminous roadway traversed in an east-west direction and had one through lane in each direction that were bordered by gravel shoulders approximately 2 m (6.5 ft) in width. The eastbound lane was 3.5 m (11.5 ft) wide and the westbound lane was 4 m (13.1 ft) wide. The roadway pavement markings consisted of a broken yellow center line. The roadway was level and the speed limit was 56 km/h (35 mph). The Incident Diagram is included on page 13 of this report.

Pre-Incident: The forklift was driven into the Freightliner's cargo box at a factory loading dock by the driver of the Freightliner, and the forks were lowered to the floor of the cargo box. It was reported in the police reconstruction report that the forklift's shift lever was placed in neutral and the parking brake was set. The forklift was not secured with straps nor were the wheels blocked. It was also reported in the police reconstruction report that, based on information from representatives of a local Yale forklift dealer, the parking brake was designed only to hold the forklift in place on a ≤15% grade. It was not designed to prevent the forklift from rolling during transport. The forklift's specific location within the cargo box is unknown, since only the driver of the Freightliner was involved in loading it onto the truck and he sustained fatal injuries during the incident. The driver of the Freightliner intended to travel from the loading dock to the street, turn right, and travel to a second building located approximately 500 m (1,640 ft) from the loading dock where the driver and right passenger would deliver the forklift and pick up a table. The Freightliner was traveling east in the right lane approaching the driveway to the second building (**Figure 2**) at a travel speed, estimated by the right passenger, of 40 km/h (25 mph). The passenger stated during the SCI interview that he and the driver were conversing, and it was necessary for him to alert the driver that they were approaching the driveway to their destination. He further stated the driver then pumped the brakes to reduce the Freightliner's speed.

Figure 2: Freightliner's eastbound approach to the driveway (on right) and area of explosion

Incident: The unsecured forklift traveled forward in the cargo box as the driver braked. The front forks pierced the front panel of the cargo box and the left fork impacted the lowest of five CNG fuel cylinders that were oriented horizontally and stacked vertically within an aluminum cabinet located between the truck cab and cargo box. The impact site on the CNG cylinder was located 65 cm (25.6 in) left of the right cylinder end. This impact resulted in a rupture and explosion of the cylinder. There was no fire. The Freightliner's air lines were severed and the wheels locked, leaving police-reported skid marks that ranged from 4.3 - 7.44 m (14.1 - 24.4 ft) in length as the vehicle skidded to final rest, heading southeast. A speed to skid to a stop calculation based on the longest skid mark length and a deceleration value range[1] of 0.41 - 0.56 g yielded a speed range at the onset of the skid

[1] Traffic Accident Reconstruction, Volume 2 of The Traffic Accident Investigation Manual by Lynn B. Fricke, Northwestern University Traffic Institute, 1990

of 27.8 km/h (17.3 mph) - 32.5 km/h (20.2 mph). The force of the explosion resulted in severe damage to the frame, undercarriage, cargo box, fuel cabinet, CNG cylinders, and cab of the Freightliner.

Post-Incident: The police were notified of the incident at 1336 hours and arrived on scene at 1342 hours. Fire, rescue, and medical personnel responded to the incident. The front right passenger of the Freightliner stated during the interview that he checked on the driver and attempted to awake him from unconsciousness but was unsuccessful. He noticed the smell of natural gas and climbed out of the right front window which had disintegrated from the explosion. The driver of the Freightliner sustained fatal injuries and expired at the scene. The front right passenger sustained police reported "A" (incapacitating) injuries and was transported by ambulance to a hospital where he was admitted for two days. The Freightliner was towed from the incident scene due to damage.

2014 FREIGHTLINER M2 112

DESCRIPTION

The Freightliner was a rear wheel drive, 6 x 4, two-passenger, straight truck (VIN: 1FVHC5DX9EHxxxxxx) that was manufactured in August 2013 and was equipped with an 8.9-liter I-6 engine powered by compressed natural gas, a ten-speed automatic transmission, four-wheel anti-lock brakes, and a 6.1 m (20 ft) long cargo box. The windshield glazing was AS1 laminated and the left, right, and backlight glazings were AS2 tempered. The glazing for all non-fixed windows were closed at the time of the incident. The specified wheelbase was 472 cm (186 in).

The vehicle manufacturer's recommended tire size was 295/75R22.5 The vehicle was equipped with tires sized 295/75R22.5 and 275/80R22.5 on the front and rear wheels, respectively. The manufacturer's recommended cold tire pressure for the front and rear tires was 758 kPa (110 psi).

The vehicle was equipped with driver and right passenger cloth-covered, box-mount bucket seats with integral head restraints.

EXTERIOR DAMAGE

Frame and Undercarriage: The explosion deformed the truck frame directly below the fuel cylinder cabinet (**Figure 3**). Both frame rails were bent, as were the frame cross members fore and aft of the cylinder cabinet. The center section of the drive shaft was fractured and separated from the transmission. The air brake lines were severed and the air brake tank was also slightly displaced. The rear engine mounts were undamaged.

Figure 3: Freightliner's undercarriage damage directly under fuel cabinet

Passenger Cab: The cab of the truck was heavily damaged from the explosion (**Figure 4**). The most

severe damage occurred below and behind the driver's seat . The entire cab was displaced upward and forward approximately 40 cm (15.7 in) and the back panel of the cab was torn vertically, intruding into the passenger area. Shards of carbon fiber wrap and fiberglass from the ruptured cylinder were found throughout the inside of the cab and the windshield was holed from the force of the explosion.

Figure 4: Police on-scene photograph of damage to cab of the Freightliner

Cargo Box: The truck's cargo box (**Figure 5**) was also heavily damaged from the explosion. The front panel was largely displaced from the main structure. The roof and rear door panels completely detached and the left side panel was partially detached. There was slight damage to the floor and right side panel.

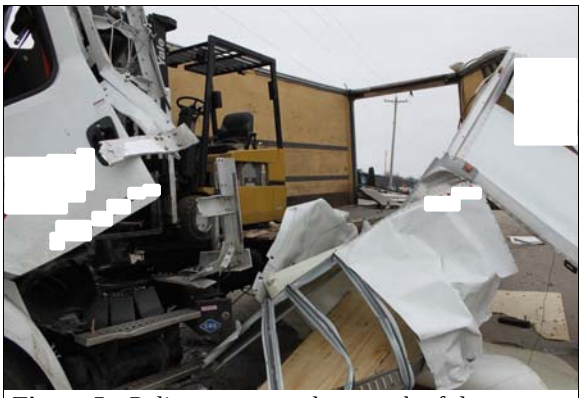


Figure 5: Police on-scene photograph of damage to the Freightliner's cargo box

Cargo: The only cargo was a Yale Type E battery powered forklift, Model ERP040TFN03739W. The forklift (**Figure 6**) measured 306 cm (120.5 in) from back to fork tips and weighed 4,035 kg (8,896 lb). Each fork was 106 cm (41.7 in) in length and 10 cm (3.9 in) in width. The forks were 1.5 cm (0.5 in) thick at the tips and 4 cm (1.6 in) at the base and were set 49 cm (19.3 in) apart from each other. A parking brake was located on the left side of the instrument panel and was engaged at the time of the incident.

Figure 6: Yale Type E forklift (in cargo box at time of incident)

CNG CYLINDER CABINET DAMAGE

The cabinet for the CNG cylinders was manufactured by Agility Fuel Systems and was located between the cab and cargo box. The cabinet included an aluminum support structure that measured 217 cm (85.4 in) in height and 53 cm (20.9 in) in width, which was encased by aluminum sheeting. There was no protective barrier between the CNG cabinet and the cargo box. The rack allowed for five CNG cylinders to be mounted by the neck, horizontally onto cross members. The cylinders were stacked vertically in the cabinet. The cabinet sustained severe damage as a result of the explosion (**Figure 7**). The sheet metal encasing the cabinet was mostly displaced from the vehicle, with only the forward panel remaining attached. The left rear vertical frame member fractured and separated 88 cm (34.6 in) from the bottom support and the front vertical frame member

was rotated 90 degrees to the left. All cross members, on both sides, were either fractured, displaced, or bent (**Figure 8**).

Figure 7: Left side damage to fuel cabinet

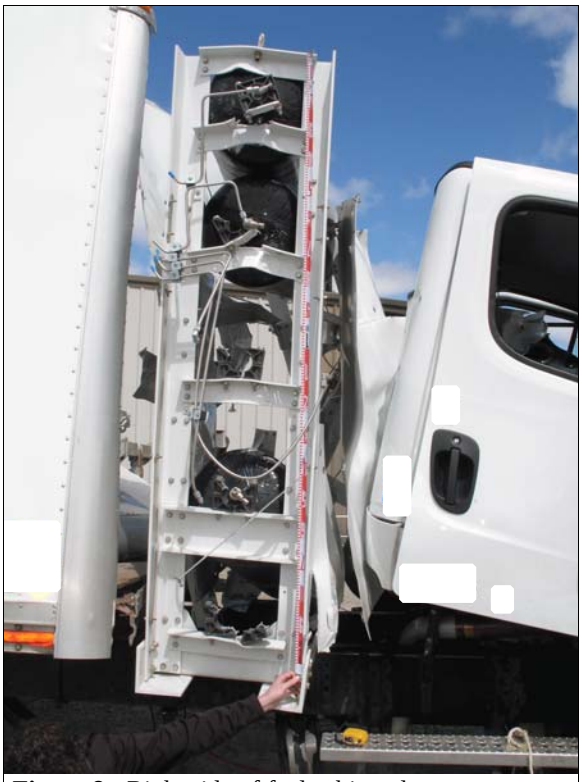


Figure 8: Right side of fuel cabinet damage to cross members

CNG CYLINDERS AND DAMAGE

The five CNG cylinders were Type 4 design (polymer liner with carbon fiber and fiberglass overwrap), manufactured by Hexagon Lincoln, Model number RH36A16-07601. Each cylinder measured 205 cm (80.6 in) in length, 41 cm (16 in) in diameter, and were certified with ANSI NGV2 and FMVSS 304. Each cylinder was equipped with a Pressure Relief Device (PRD) at each end, which was designed to pipe discharge away to the top of the cabinet in the event of a breach of the system. Each cylinder had a manual valve without an excess flow device that was manufactured by OMB. The bottom cylinder (cylinder 1) was impacted by the left fork of the forklift and ruptured (**Figure 9**), with the damage starting 65 cm (25.6 in) left of the right end of the cylinder. A 66 cm (26 in) section of the left end of the cylinder (**Figure 10**) separated and was displaced into the street (**Figure 11**). Both valves separated from the bottom cylinder. Cylinder 2 remained intact, but the left side dropped from its mount. The left side valve was detached and part of the right side valve remained in place. Cylinder 3 was propelled out of the cabinet and landed in the street, according

Figure 9: Ruptured CNG cylinder

to incident documents. At least one valve remained attached to the cylinder. Cylinders 4 and 5, at the top of the cabinet, remained in their positions and all valves remained attached.

Figure 10: Displaced section of ruptured CNG cylinder

Figure 11: Police on-scene photograph showing location of displaced section of bottom CNG cylinder (arrow)

Figure 12: Exterior view of intrusion of back wall of Freightliner's cab

INTERIOR DAMAGE

The interior of the Freightliner sustained severe damage from the CNG cylinder explosion. There were a total of twelve intrusions to the passenger compartment. The most severe intrusions occurred in the driver's space and were to the back wall of the cab and the backlight header (**Figures 12** and **13**), which intruded longitudinally approximately 80 cm (31 in), and 30 cm (12 in), respectively, and the floor, which intruded vertically approximately 40 cm (16 in). The driver was projected forward by the explosion and he loaded the steering assembly (**Figure 13**), displacing it forward approximately 25 cm (10 in). Scuff marks were noted on the roof above the driver's seat, possibly from contact by the driver's head. The rearview mirror was also displaced from possible contact by the driver's right hand. Fragments of fiber glass from the ruptured CNG tank were also deposited throughout the cab. Some of the fragments cut the ceiling upholstery in the front right passenger's space, and fragments were embedded in the roof and damaged a plastic storage compartment in this area. Both doors were jammed shut and the left door was mechanically pried open by rescue personnel. The windshield was in place and holed due to explosion forces. The right and left glazings as well as the backlight all disintegrated due to the explosion. The only undamaged glazings were the small windows on each door.

MANUAL RESTRAINT SYSTEMS

The front seating positions were equipped with lap and shoulder safety belts with fixed upper anchors.

The driver was restrained by the lap and shoulder safety belt based on the police-reported statement of a witness who was one of the first to arrive at the vehicle immediately following the

incident. The front right passenger stated during the interview that he was restrained by the lap and shoulder safety belt. He sustained a contusion across his chest consistent with safety belt usage. Inspection of both safety belt assemblies revealed evidence of historical usage, but no discernable evidence of loading was found.

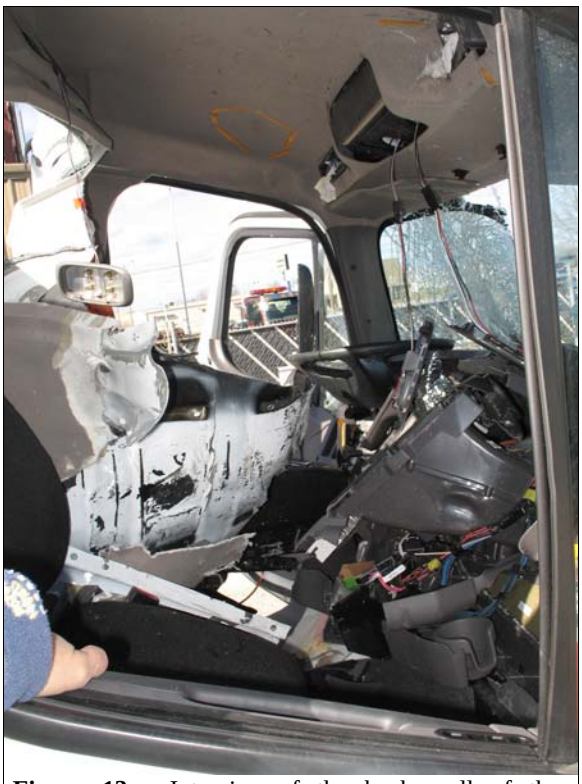


Figure 13: Intrusion of the back wall of the Freightliner's cab and displacement of the steering column from driver contact

CNG Fuel System Inspection by Other Party

The Freightliner and its fuel system were inspected by the Director of Technology for the Clean Vehicle Education Foundation. A summary of findings from his preliminary report[2] relative to the CNG fuel system are as follows:

1. The neck mounts on all five cylinders were broken by the pressure wave and there were many fractures of the aluminum supporting structure.

2. The right front vertical member of the supporting structure was bent into a radius, apparently by the rupturing cylinder when it was propelled forward and to the right by the escaping gas.

3. All of the high-pressure CNG from the system escaped through the broken cylinder connections in about ten minutes following the arrival of the first responders. There was no ignition and no fire.

4. The composite fracture apparently progressed approximately in a longitudinal direction and then turned and ran circumferentially, separating one of the cylinder ends and ejecting it from the driver's side of the truck.

5. No existing reports of such low velocity, high momentum and concentrated impacts against fiber reinforced composite pressure vessels have been identified. This impact scenario is unlike either the blunt impacts imposed during the NGV2 drop tests or the high-velocity impact of the NGV2 penetration test (gunfire). The sharpness of the fork tip and its point of impact directly into the cylinder sidewall are also unlike the previous oblique severe impacts of roof-mounted cylinders against overhead obstruction. This is the first rupture incident apparently resulting from impact on a NGV2 cylinder made since the drop impact tests were strengthened in 1998.

6. The pressurized cylinder had enhanced sidewall rigidity because it was nearly full. This rigidity probably prevented general deflection in the sidewall (to an oval shape). This deflection is

[2] The report was obtained from the investigating police agency. There was no prohibition specified in the report regarding the dissemination of the preliminary findings.

considered favorable in reducing impact damage to an empty cylinder. A more compliant, less pressurized cylinder could have deflected and reduced damage at the point of impact.

7. The cylinder was possibly more rigidly attached to the massive truck chassis because it was the bottom cylinder in a framework rigid enough to carry a five-high stack of cylinders. The cylinder thus could not move away from the impact to reduce the damage at the point of impact.

8. The shape of the fork tip probably produced a cut perpendicular to the critical hoop direction reinforcing fibers. These fibers carry the greatest load in a pressure vessel and the orientation of the fork tip was such to maximize the number of hoop fibers that were damaged.

9. If the fork tip penetrated the sidewall of the cylinder it would have wedged the break open because the long taper of the fork. This could have inflicted greater damage than a simple penetration by a 2 mm x 60 mm point.

10. A low impact speed with high momentum may be more damaging to composites than a high velocity impact.

11. Information from tests and other accidents indicate that CNG cylinders resist rupture as a result of more blunt impacts. This may be a more likely damage scenario from general loose cargo. The occupant space in the cab could receive considerable protection from the cylinders and mounting structure.

2014 FREIGHTLINER M2 112 OCCUPANTS

DRIVER DEMOGRAPHICS

Age/Sex:	59 years/Male
Height:	178 cm (70 in)
Weight:	79 kg (175 lbs)
Eyewear:	Corrective lenses
Seat Type:	Pedestal
Seat Track Position:	Unknown
Manual Restraint Usage:	Lap and shoulder safety belt
Usage Source:	Witness statement
Air Bags	None
Alcohol/Drug Involvement:	None
Egress from Vehicle:	Removed by emergency responders
Transport from Scene:	Transported from scene for autopsy
Medical Treatment:	None, deceased at scene

Injury Number	Injury	AIS 2005/08	Injury Source	Confidence Level
1 2	Hemorrhage, subarachnoid over both cerebral hemispheres, not further specified	140693.2,1 140693.2,2	Steering wheel rim	Probable
3	Fracture right orbital plate, not further specified	251200.2,1	Steering wheel rim	Probable
4	Fracture nose with displacement (deformity), not further specified	251002.2,4	Steering wheel rim	Probable
5	Laceration pericardium with residual blood in sac	441602.2,4	Steering wheel hub and/or spokes	Certain
6	Laceration (tear) right and left atria, not further specified	441016.6,4	Steering wheel hub and/or spokes	Certain
7	Laceration (tear), multiple, thoracic aorta, not further specified	420206.4,4	Steering wheel hub and/or spokes	Certain
8	Laceration (rupture) left diaphragm with protrusion of stomach into left chest cavity	440610.4,2	Steering wheel hub and/or spokes	Certain
9	Fractured ribs, multiple, bilaterally, right greater than left	450203.3,3	Steering wheel hub and/or spokes and rim	Certain
10	Contusions bilateral pleural surfaces of lungs, not further specified	441420.3,3	Steering wheel hub and/or spokes	Probable
11	Lacerations bilateral pleural surfaces of lungs with extensive parenchymal hemorrhage	441450.4,3	Steering wheel hub and/or spokes	Certain
12	Hemothoraces, bilaterally, with residual blood in each pleural cavity, not further specified	442200.3,3	Steering wheel hub and/or spokes and rim	Certain
13	Laceration left kidney, not further specified	541620.2,2	Steering wheel rim	Certain
14	Lacerations, multiple, capsule of liver, with internal crush injury of parenchyma, not further specified	541826.4,1	Steering wheel hub and/or spokes and rim	Certain
15	Laceration capsule of spleen with fragmentation of spleen, not further specified	544226.4,2	Steering wheel hub and/or spokes and rim	Certain
16	Fracture, palpable, right shoulder, not further specified	751800.2,1	Seat back, driver's	Probable
17 18	Lacerations (cuts) right side of face from right periorbital area to right chin, not further specified	210602.1,1 210602.1,8	Noncontact injury: flying glass, back light	Probable
19	Lacerations (cuts) right side of neck, not further specified	310602.1,1	Noncontact injury: flying glass, back light	Probable

Injury Number	Injury	AIS 2005/08	Injury Source	Confidence Level
20	Laceration, stellate tear, open wound, right lower quadrant of abdomen, not further specified	510602.1,1	Steering column and/or tilt adjustment lever	Probable
21	Abrasions, multiple, posterior right upper arm from shoulder to elbow	710202.1,1	Noncontact injury: flying glass, back light	Probable
22	Laceration (cut) posterior right arm near elbow	710602.1,1	Noncontact injury: flying glass, back light	Probable
23	Abrasions, multiple, dorsal (posterior) left wrist, not further specified	710202.1,2	Noncontact injury: flying glass, back light	Probable
24	Lacerations, multiple, dorsal (posterior) right hand	710602.1,1	Noncontact injury: flying glass, back light	Probable
25	Abrasions, multiple, on bilateral thighs, not further specified	810202.1,3	Steering wheel rim	Probable
26	Abrasions, multiple, on lower legs, not further specified	810202.1,3	Left lower instrument panel	Certain
27	Contusions, multiple, on proximal bilateral thighs, not further specified	810402.1,3	Steering wheel rim	Probable
28	Contusions, multiple, on lower legs, not further specified	810402.1,3	Left lower instrument panel	Certain
29	Laceration, open, just below and lateral to left knee with foreign material embedded	810602.1,2	Left lower instrument panel	Certain

Source: Autopsy Records.

DRIVER KINEMATICS

The driver was restrained by the lap and shoulder safety belt. He was displaced forward and upward as a result of explosion forces and intrusion of the back wall of the cab. His face and chest loaded the steering assembly causing a subarachnoid hemorrhage, fracture of the right orbital plate and nose, lacerations of the pericardium, right and left atria, thoracic aorta, and diaphragm. He also sustained bilateral fractures of multiple ribs, contusions and lacerations of the lungs, and lacerations of the left kidney, liver, and spleen from contacting the steering assembly. Contact with the seat back caused a fracture of the right shoulder, and he sustained multiple lacerations and abrasions from flying glass from the disintegrated backlight. He also sustained multiple abrasions and contusions to the lower extremities from contacting the lower left instrument panel and steering wheel rim, and an open laceration of the left lower leg, also from contacting the lower left instrument panel. The driver injuries were fatal and he was officially pronounced deceased at 1640 hours.

FRONT RIGHT OCCUPANT DEMOGRAPHICS IN14016

Age/Sex:	29 years/Male
Height:	175 cm (69 in)
Weight:	87 kg (191 lbs)
Eyewear:	None
Seat Type:	Pedestal
Seat Track Position:	Unknown
Manual Restraint Usage:	Lap and shoulder safety belt
Usage Source:	Passenger interview and injury data
Air Bags	None
Alcohol/Drug Involvement:	None
Egress from Vehicle:	Exited without assistance through disintegrated right front window
Transport from Scene:	Ambulance
Medical Treatment:	Hospitalized one day

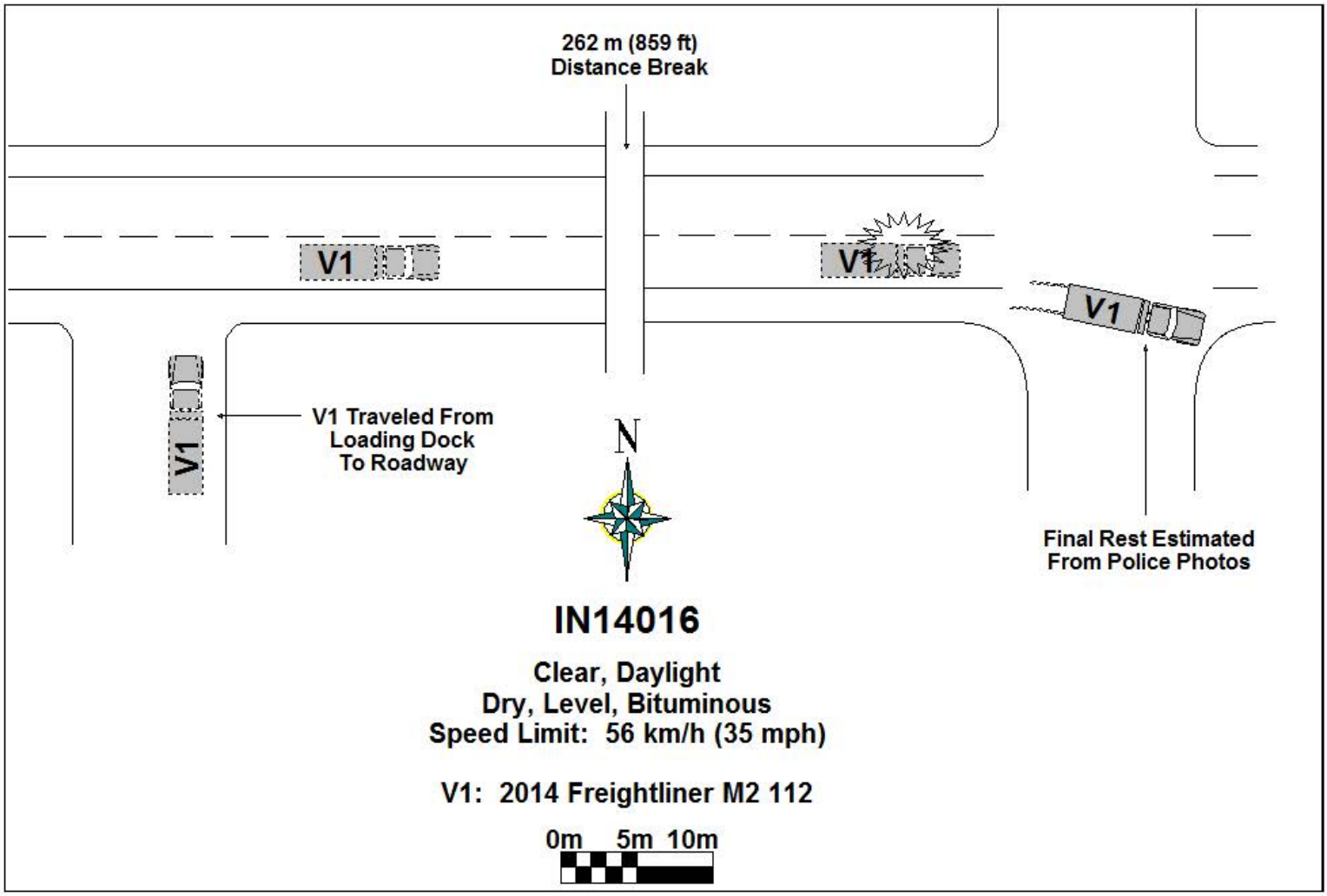
FRONT RIGHT OCCUPANT INJURIES

Injury Number	Injury	AIS 2005/08	Injury Source	Confidence Level
1	Traumatic (closed) head injury, not further specified, with mild headache	110009.1,0	Noncontact injury: impact (blast) forces	Probable
2	Contusion, acute left lung, left upper lobe, secondary to explosion/blast	441420.3,2	Noncontact injury: impact (blast) forces	Certain
3	Contusion posterior scalp, not further specified	110402.1,6	Seat back, front right passenger's	Probable
4	Laceration, 1.3 cm (0.5 in) in length on right posterior scalp	110602.1,6	Other interior loose object: fiber glass debris	Probable
5	Avulsed (missing) gum tissue from upper right incisor area	243206.1,8	Right instrument panel	Probable
6 7	Abrasions, superficial, to right side of nose and lower lip	210202.1,4 210202.1,8	Right instrument panel	Probable
8	Abrasion across mid chest with bilateral tenderness, not further specified	410202.1,4	Torso portion of safety belt system	Certain
9	Penetrating (puncture) injury back of left shoulder, one near arm pit, one over scapula	716011.1,2	Other interior loose object: fiber glass debris	Certain
10	Laceration, 2.5 cm (1 in), vertically oriented, above right knee	810602.1,1	Right lower instrument panel	Probable
11	Laceration, 2.5 cm (1 in), horizontally oriented, below right knee	810602.1,1	Right lower instrument panel	Probable
12	Abrasion left lower leg, probably left knee, not further specified	810202.1,2	Right lower instrument panel	Probable

Sources: Emergency Room Records, Hospitalization Records, and Interviewee Data–Same Person. Injury Numbers 4 and 9 through 11 came only from ***Interviewee Data****. Injury Numbers 3, 5, and 12 came only from* ***Emergency Room Records****. Injury Number 8 came only from* ***Hospitalization Records****. Injury Numbers 1 and 2 came from a combination of* ***Emergency Room*** *and* ***Hospitalization Records****. Injury Numbers 6 and 7 came from all three sources.*

FRONT RIGHT OCCUPANT KINEMATICS

The front right passenger was restrained by the lap and shoulder safety belt and was displaced forward as a result of explosion. The blast forces caused a closed head injury and left lung contusion. He loaded the safety belt causing an abrasion across his chest, and contacted his face on the right instrument panel causing an abrasion on the nose and lower lip, and an avulsion of the gum. His lower extremities contacted the right lower instrument panel causing a laceration above and below the right knee and an abrasion on the left knee. He rebounded back into his seat and contacted the back of his head on the seat causing a contusion to the posterior scalp. Flying fiber glass fragments from the exploded CNG cylinder caused two puncture injuries to the back of the left shoulder and a laceration to the back of the head. The front right passenger exited the vehicle without assistance through the disintegrated right side window glazing. He was transported by ambulance to a hospital where he was admitted for one day.


262 m (859 ft)
Distance Break
V1
V1
V1
V1
V1 Traveled From
Loading Dock
To Roadway
N
Final Rest Estimated
From Police Photos
IN14016
Clear, Daylight
Dry, Level, Bituminous
Speed Limit: 56 km/h (35 mph)
V1: 2014 Freightliner M2 112
0m 5m 10m