RAILROAD SIGNAL &
TRAIN CONTROL GROUP

Fatal Grade Crossing Accident
Midland, TX; 11/15/2012

HWY-13-MH-003
(10 Pages)

NATIONAL TRANSPORTATION SAFETY BOARD
OFFICE OF HIGHWAY SAFETY
WASHINGTON, D.C. 20594

A. ACCIDENT

LOCATION:	At the intersection of South Garfield Street and the Union Pacific Railroad (UPRR), Mile Post 554.65, DOT grade crossing inventory #796-331L, Midland, Midland County, Texas
VEHICLE 1:	2006 Peterbilt truck-tractor in combination with a 2005 Transcraft Eagle Drop Deck (Flatbed) Semitrailer
OPERATOR:	Smith Industries of Midland, Texas
VEHICLE 2:	Union Pacific Freight Train ZLCAI-14, consisting of 4 locomotives and 84 loaded cars
OPERATOR:	Union Pacific Railroad (UPRR)
VEHICLE 3:	2008 Ford Crown Victoria Police Interceptor
OPERATOR:	Midland County Sheriff's Office
DATE:	November 15, 2012
TIME:	Approximately 4:35 p.m. CST

NTSB #: **HWY-13-MH-003**

B. SIGNAL & TRAIN CONTROL GROUP

R. Payan
Electrical Engineer
NTSB, Office of Railroad, Pipeline & Hazardous Materials Investigations

D. Walsh, P.E.
Highway Accident Investigator
NTSB, Office of Highway Safety

T.J. Yetmar
Director Signal Maintenance
Southern Region South
Union Pacific Railroad

S. Pyle
Traffic Signal Supervisor - Transportation
City of Midland, Texas

M. Ciurej
Vice President – West
Brotherhood of Railroad Signalmen

G. Rasco
Signal & Train Control Inspector
U.S. Department of Transportation
Federal Railroad Administration

C. DETAILS OF THE SIGNAL & TRAIN CONTROL INVESTIGATION

1. Railroad Traffic Control Signal System

The UPRR, Ft Worth Service Unit, Toyah Subdivision runs between Sweetwater, Texas (MP T447.8) and Sierra Blanca, Texas (MP T768.7). Railroad tracks were oriented by timetable in an east-west direction with milepost numbers increasing westward. UPRR tracks in the vicinity of the accident consisted of single main track territory with passing siding tracks. The maximum timetable[1] speed for freight trains operating in the vicinity of the accident was 70 mph.

Train movements on the Toyah Subdivision were governed by General Code of Operating Rules[2], timetable instructions, bulletins and the signal indications of a traffic control signal (TCS) system. The train dispatcher (dispatcher position number 26) located at the UPRR Dispatch Center in Omaha, Nebraska coordinated train movements with the signal system on the Toyah Subdivision. The UPRR TCS system utilized dc coded track circuits and four-aspect colorlight type signals.

1.1 Railroad Dispatch Center Data

Postaccident data was downloaded from the Union Switch & Signal computer aided dispatching system at the UPRR, Harriman Dispatch Center located in Omaha, Nebraska. Table 1 summarizes signal and train control events recorded for control points (CP) Bounce (T558) and Chub (T550) on the date of the accident. The table covers the events for the last two train movements routed through the accident area. The eastbound signal at CP Chub was lined for the accident train but the collision occurred between the two control points.

Table 1 *Recorded events from Harriman Dispatch Center CAD log.*

Time[3]	Control Point	Event
3:44:53 pm	Bounce (T558)	Westbound signal 20 indicated clear for train ZMQLC-15

[1] UP Railroad Sunset Area Timetable No. 3, effective Monday, November 22, 2010
[2] GCOR, sixth edition, effective April 7, 2010
[3] Time based on UPRR Dispatch Center system clock (central standard time) which was synchronized to UTC.

3:58:51 pm	Chub (T550)	Track circuit 01 indicated occupied for train ZMQLC-15
4:00:37 pm	Chub (T550)	OS track circuit indicated unoccupied for train ZMQLC-15
4:02:35 pm	Bounce (T558)	Track circuit 01 indicated occupied for train ZMQLC-15
4:04:17 pm	Chub (T550)	Track circuit 01 indicated unoccupied for train ZMQLC-15
4:07:14 pm	Bounce (T558)	Westbound signal 20 indicated at stop OS track circuit indicated occupied for train ZMQLC-15 Track circuit 11 indicated occupied for train ZMQLC-15
4:09:43 pm	Bounce (T558)	Track circuit 01 indicated unoccupied for train ZMQLC-15
4:09:45 pm	Bounce (T558)	OS track circuit indicated unoccupied for train ZMQLC-15
4:16:54 pm	Bounce (T558)	Track circuit 11 indicated unoccupied for train ZMQLC-15
4:23:31 pm	Bounce (T558)	Eastbound signal 18 requested clear for train ZLCAI-14
4:23:52 pm	Bounce (T558)	Eastbound signal 18 indicated clear for train ZLCAI-14
4:29:01 pm	Bounce (T558)	Track circuit 11 indicated occupied for train ZLCAI-14
4:30:17 pm	Chub (T550)	Eastbound signal 02 requested clear for train ZLCAI-14
4:30:53 pm	Chub (T550)	Eastbound signal 02 indicated clear for train ZLCAI-14
4:32:53 pm	Bounce (T558)	Eastbound signal 18 indicated at stop OS track circuit indicated occupied for train ZLCAI-14 Track circuit 01 indicated occupied for train ZLCAI-14
4:34:22 pm	Bounce (T558)	Track circuit 11 indicates unoccupied for train ZLCAI-14
4:34:24 pm	Bounce (T558)	OS track circuit indicated unoccupied for train ZLCAI-14
4:39:40 pm	Chub (T550)	Eastbound signal 02 requested at stop by Dispatcher

1.2 Railroad Wayside Defect Detector Logs

Approaching eastbound to the vicinity of the collision, the UPRR had hot bearing detectors located at MP T560.7 and T582.0. The defect detectors recorded data for train movements traveling past those locations[4].

The defect detector at MP T582.0 recorded eastbound train ZLCAI-14 at 4:02 pm. The data recorded the eastbound train with 3 locomotive engines, 63 rail cars 308 axles. Train length was recorded as 7,246 feet. The train was traveling at 61 mph and the temperature was recorded as 71º Fahrenheit. The data log indicated no defects were noted for eastbound train ZLCAI-14.

The defect detector at MP T560.7 recorded eastbound train ZLCAI-14 at 4:30 pm. The data recorded the eastbound train with 3 locomotive engines, 63 rail cars and 308 axles. Train length was recorded as 7,210 feet. The train was traveling at 49 mph and the temperature was recorded as 71º Fahrenheit. The data log indicated no defects were noted for eastbound train ZLCAI-14.

1.3 Railroad Traffic Control Signal System Damages

The UPRR traffic control signal system did not sustain any damage as a result of the collision.

[4] The defect detectors only recognize locomotives at the front of the consist and do not recognize the distributed power locomotive on the trailing end of the train. In addition, the defect detectors count axles and then calculate the number of cars based on the number of axles detected. The axle configuration on intermodal cars is different from the axle configuration of standard rail cars. Thus the detectors recorded 63 rail cars instead of the actual 84 cars.

2. Highway-Rail Grade Crossing Warning System

The UPRR single main track through the City of Midland, Texas was paralleled by five-lane West Front Avenue to the North and three-lane West Industrial Avenue to the South. At MP T554.74, the UPRR main track and five-lane South Garfield Street crossed at grade[5]. The grade crossing inventory number was DOT #796-331L. The highway-rail grade crossing was equipped with an active grade crossing warning system. The grade crossing warning system consisted of eight, 12-inch flashing LED light units, two warning bells and two fiberglass gate arms mounted on two signal masts and arranged to provide warning for all directions of highway traffic[6]. The gate arms extended across all lanes of South Garfield Street to a concrete median for each direction of traffic. Three, 4-inch lights were mounted on each gate arm. When the warning system was activated, the tip light was configured to be continuously lit while the other two lights flashed alternately.

The grade crossing warning system operated on commercial electric power and was equipped with a standby battery backup system. In addition, the South Garfield Street grade crossing warning system had an interconnection to initiate a ten second advance preemption of the highway traffic signals adjacent to the highway-rail grade crossing.

Train detection and warning system activation was configured through a Safetran Grade Crossing Predictor (GCP), model 3000D2, microprocessor unit. The crossing was equipped with a primary and standby GCP unit. Each GCP unit was configured in a bi-directional mode. The GCP unit was a constant warning device and could calculate the speed of an approaching train by measuring the rate of change in track circuit voltage, receiver signal level and signal phase relationships. The GCP unit provided a relatively uniform warning time, but the time could fluctuate slightly due to changing ballast and track conditions or variances in the speed of an approaching train. The warning devices were configured to provide a minimum warning time of 20 seconds required by the Federal Railroad Administration (FRA) and recommended by the Manual on Uniform Traffic Control Devices (MUTCD) for all train speeds up to 79 mph[7]. The UPRR standard design for crossings with automatic warning devices was 20 seconds of warning time plus five seconds of buffer time for a signal design time of 25 seconds. The five seconds of buffer time was included to provide a margin of safety to ensure that a minimum of 20 seconds of warning time is provided.

The signal prints designated the design times as 25-5-10. The number 25 represented the mandated 20 seconds warning time plus the five seconds of buffer time. The number five represented the equipment response time during which the system first detected the approach of a train and made the necessary calculations to determine the speed and timing of the train. The number ten represented the advanced preemption time during which the railroad equipment alerted the highway traffic signals to activate a preemption sequence to manage traffic flow at the crossing prior to the railroad warning system activating.

---

[5] West Front Avenue had a posted speed limit of 45 mph. South Garfield Street and West Industrial Avenue had a posted speed limit of 35 mph.

[6] Reference the Highway Factors Group Factual Report for a description of highway signage and pavement markings.

[7] Maximum train speed was limited to 70 mph as listed in the timetable.

In 1987, as part of the proposed signal upgrade project at the South Garfield Street crossing, the initial design plans from the UPRR contained a design time of 30-5-10. In 1989, the revised design plans from the UPRR contained modifications that included a change in the design time to 25-5-10.

The upgraded grade crossing warning system was installed by the UPRR in 1991. The Texas Department of Transportation inspected and approved the installed system which had the specified signal design time of 25-5-10. In 2003, the grade crossing warning system at South Garfield Street and several adjacent grade crossings were modified by the UPRR to accommodate an increase in track speed. The modifications were completed in 2005, the design times for the five crossings adjacent to and including South Garfield Street remained as designated in the signal design plans at 25-5-10. In 2010, the FRA issued a nationwide safety advisory regarding highway traffic signal preemption connections to grade crossing warning systems. The UPRR hired a contractor to review numerous crossings and which also included South Garfield Street. In March 2012, the contractor found that the South Garfield Street crossing warning system had been changed to 35 seconds instead of the designated 25 seconds. In consultation with the City of Midland, the crossing warning system was again set as specified in the signal design plans.

2.1 Highway-Rail Grade Crossing Warning System Data Logs

The GCP unit at the South Garfield Street crossing was equipped with a data logger. The data logger provided the capability to record information associated with the previous train movements through that location. The data log contained the date and time of train movements, the detected train speed[8], the average train speed[9], pre-emption initiation signal[10], and island speed[11]. The log could also retain any error alarms detected by the microprocessor.

The data logs recorded westbound UPRR train ZMQLC-15 activating the interconnection circuit to preempt the highway traffic signals at 4:01:06 pm, and activating the South Garfield Street grade crossing warning system at 4:01:23 pm. The logs recorded the average train speed approaching the grade crossing at 47 mph and the warning devices activating for 28 seconds before the train occupied the island circuit.

The data logs recorded eastbound UPRR train ZLCAI-14 activating the interconnection circuit to preempt the highway traffic signals at 4:34:08 pm, and activating the South Garfield Street grade crossing warning system at 4:34:17 pm. The logs recorded the average train speed approaching the grade crossing at 64 mph and the warning devices activating for 21 seconds before the train occupied the island circuit.

The data log for the South Garfield Street crossing contained over 600 data log entries. A postaccident review of the data found all warning times to be in accordance with the minimum

[8] Train speed calculated by microprocessor to determine warning device activation time.
[9] Average speed of train as it traversed approach circuit.
[10] Signal from railroad equipment to highway equipment to initiate the preemption sequence.
[11] Train speed calculated by microprocessor as it enters the island circuit, typically in close proximity to edge of paved roadway.

requirements except a train movement that occurred at 2:05:08 am on October 29, 2012. The data indicates the grade crossing warning system was activated for 19 seconds before the train occupied the island circuit.

2.2 Inspection & Testing of Grade Crossing Warning System

Following the accident, NTSB investigators requested the signal bungalow for the grade crossing warning equipment to be sealed. UPRR secured the signal bungalow with seal #1430190. On November 16, 2012, representatives from the UPRR, the FRA, Brotherhood of Railroad Signalmen, City of Midland, Texas and NTSB began conducting a field inspection and investigation of the highway-rail grade crossing warning system and highway traffic light pre-emption system at the South Garfield Street. The postaccident inspection of the grade crossing warning equipment, found the signal bungalow and all flashing light units locked and secured. The UPRR seal on the signal bungalow was confirmed and no evidence of vandalism or tampering was found.

2.2.1 Track Circuits

Track components and connections were inspected and the approach track circuits were verified. Approach track circuits extended from the South Garfield Street crossing in both track directions. The eastbound and westbound approach track circuit lengths were configured in the GCP unit at 4,636 feet for train speeds up to 79 mph, and in accordance with the signal circuit plans for that location.

The eastbound approach track circuit length from the connection point of the track wires on the rails to the 156 Hertz (Hz) narrow band shunt at the termination point was measured at 4,571 feet. A train moving at a constant 79 mph would travel 4,571 feet in 39.5 seconds.

$$\left(\frac{1\text{ hour}}{79\text{ miles}}\right)\left(\frac{1\text{ mile}}{5280\text{ feet}}\right)\left(\frac{3600\text{ seconds}}{1\text{ hour}}\right)\left(4571\text{ feet}\right) = 39.5\text{ seconds}$$

The westbound approach track circuit length from the connection point of the track wires on the rails to the 156 Hz narrow band shunt at the termination point was measured at 4,595 feet. A train moving at a constant 79 mph would travel 4,595 feet in 38.8 seconds.

$$\left(\frac{1\text{ hour}}{79\text{ miles}}\right)\left(\frac{1\text{ mile}}{5280\text{ feet}}\right)\left(\frac{3600\text{ seconds}}{1\text{ hour}}\right)\left(4595\text{ feet}\right) = 39.7\text{ seconds}$$

Trains moving at less than 79 mph would take additional time to travel the distances of the approach track circuits.

2.2.2 GCP Microprocessor Unit

The signal circuit plans for the South Garfield Street grade determined the GCP unit was configured to provide a minimum 20 seconds of warning time activation. The UPRR also added five seconds of buffer time and ten seconds of advance preemption time.

The postaccident inspection found the South Garfield Street grade crossing warning system to be operating on the standby GCP unit. The primary GCP unit was locked out and was not used either before or after the accident. The clock time of the GCP unit was verified with the

UPRR Dispatch Center clock. The GCP unit clock was ahead of the Dispatch Center time by 59 minutes and 7 seconds. The program configuration of the GCP microprocessor was recorded and verified against the programming parameters on file. Operating values were recorded for the vital relays used in the grade crossing signal bungalow. No discrepancies were identified in the programming parameters of the GCP unit. The operating values of the vital relays were within operating requirements.

Postaccident testing determined the 156 Hz frequency used on the approach track circuits for the South Garfield Street crossing was sufficiently close to the 114 Hz frequency used on the approach track circuits for the G Street crossing. The 114 Hz narrow band shunt was located approximately 600 feet off the crossing and under certain conditions would load the 156 Hz frequency. The frequency loading would result in a slight increase in the train detection time.

2.2.3 Gate Arms

The southeast gate arm was damaged as a result of the accident. Postaccident testing measured the start of the descent time for the northwest gate arm to be about 6.8 seconds after the flashing light units were activated. The gate arms assumed a horizontal position less than 15 seconds after the flashing light units were activated.

2.2.4 Flashing Light Units

Postaccident insulation resistance tests were completed for the lighting cables from the signal bungalow to the signal masts. Testing determined the flashing light units were operating at 42 flashes per minute. Lamp voltage measurements were taken with the warning devices operating on primary commercial power (AC voltage reading) and on the standby battery backup system (DC voltage reading). Lighting circuit voltages on the southeast signal mast measured 10.8 volts AC and 14 volts DC. Lighting circuit voltages on the northwest signal mast measured 10.2 volts AC and 14.5 volts DC.

2.3 Railroad Traffic Control Signal System Damages

The UPRR, highway-rail grade crossing warning system sustained damage to the southeast gate arm as a result of the accident. Repair damages were estimated at $500.

3. Highway Traffic Signal System

The South Garfield Street-West Front Avenue intersection and the South Garfield Street-West Industrial Avenue intersection were equipped with 12-inch LED indications and a TS1 cabinet which housed a Naztec microprocessor controller. The traffic signal lights used a combination of color lenses and clear lenses with color LEDs to direct traffic in all directions through both intersections. The highway traffic controller and lights operated on commercial power and were equipped with a standby battery backup system. According to City of Midland officials, the intersections had been in operation for over 15 years. The last major change at these intersections was done on October 30, 2008 when the Naztec controller was changed.

The highway traffic signal system had an interconnection for preemption operation with the highway-rail grade crossing warning system. The preemption operation was programmed and referenced as "Preempt 1". The railroad equipment provided a normally energized relay contact that opened a traffic signal circuit to initiate the preemption sequence of the highway

traffic lights. The railroad equipment was configured to open the traffic light preemption circuit when a train was detected on either one of the approach track circuits and 10 seconds before the grade crossing warning system was activated. Neither intersection had crosswalks nor pedestrian equipment so the highway traffic preemption phase or track clearance phase, sequenced the traffic lights to provide a green light to traffic on South Garfield Street waiting between West Front Avenue and West Industrial Avenue in both directions. The traffic lights were configured to remain green for 25 seconds and then sequenced to red. The highway lights for traffic approaching the grade crossing were sequenced to red and remained at red while the grade crossing warning system was activated. Following the completion of the track clearance phase, the traffic signals were permitted to cycle highway traffic movements that did not conflict with railroad train operations through both intersections.

3.1 Highway Traffic Signal System Data Logs

Postaccident data was downloaded regarding preemption operation at the South Garfield Street intersections. The data indicated that on November 16, 2012, the railroad preemption was activated 4:02:02 pm and terminated at 4:04:46 pm. The data indicated the next railroad preemption activation was at 4:35:05 pm. This activation did not terminate until the next day at 2:29:33 pm. This railroad preemption activation was correlated to the accident train.

3.2 Inspection & Testing of Highway Traffic Signal System

A complete description of the highway traffic signal preemption operation is included in the Highway Factors Group Factual Report. Postaccident testing by the Signal & Train Control Group included testing of the track clearance phases to verify programming of the highway traffic signals with the timing plan specifications on file at the time of the accident.

Testing determined the highway traffic signals were programmed to provide about 25 seconds of Green light indication during the track clearance phase. The track clearance phase provided solid Green light indications and a Green left turn arrow to northbound traffic on South Garfield Street that was queued on the railroad tracks.

Testing further determined the track clearance phase also provided solid Green light indications to southbound traffic on South Garfield Street that was queued on the railroad tracks. The track clearance phase however did not provide a Green left turn arrow to southbound traffic on South Garfield Street as specified in the timing plan. The Green left turn arrow for southbound traffic was added to the track clearance phase following the postaccident testing.

4. Grade Crossing Regulations and Industry Standards

FRA regulations specified a minimum warning time in Title 49, Code of Federal Regulations, Part 234.225, Activation of Warning Systems, which stated:

> *A highway-rail grade crossing warning system shall be maintained to activate in accordance with the design of the warning system, but in no event shall it provide less than 20 seconds warning time before the grade crossing is occupied by rail traffic.*

The 2009 edition of the MUTCD recommended national uniformity in traffic control devices. In order to provide for uniformity, MUTCD was the adopted national standard for traffic control devices. The MUTCD provided guidance through its recommended standards regarding flashing light units, gates and traffic control signals.

The AREMA, Communication and Signal Manual of Recommended Practices recommends the addition of buffer times and equipment response times to the warning time to accommodate assurance of providing the minimum required warning time.

5. Quiet Zone Corridor through City of Midland

The City of Midland established a 24-hour quiet zone corridor that encompassed eleven highway-rail grade crossings in the vicinity of the accident. The South Garfield Street grade crossing is located within this quiet zone. The quiet zone restricts trains from sounding their locomotives horns through this area.

The quiet zone was a Public Authority designated quiet zone and was established in accordance with Federal Railroad Administration regulations by the City of Midland. The quiet zone went into effect in May 2007 when a Notice of Establishment was issued to the UP railroad by the City of Midland. A file copy is provided to FRA.

6. Additional Information

Oncor Electric Delivery was the electric power utility supplier in the vicinity of the accident area. Both the highway traffic signals and the grade crossing warning system used Oncor as their electric power utility supplier. Oncor's outage management system indicated that on November 15, 2012 at 3:01 pm[12], Oncor experienced a service interruption[13] to part of its distribution grid at feeder MDDTN4321. The electric power service interruption affected both the highway traffic signals and the grade crossing warning system. The outage management system records indicate that electric power was restored at 4:23 pm.

End of Signal & Train Control Factual Report

[12] Clock time was for system which was synchronized to UTC
[13] Recorded as event number T98677 in outage management system log report