December 5, 2017

In-Service Tank Car Net Braking Ratio Test

I. ACCIDENT

NTSB Number:	DCA17MR007
Location:	Graettinger, Iowa
Date:	March 10, 2017
Time:	0054 central standard time (CST)
Train:	UEGKOT-09 (Unit Tank Car Ethanol Train)
Railroad Owner:	Union Pacific Railroad Company
Train Operator:	Union Pacific Railroad Company
Fatalities:	0
Injuries:	0

II. CAR BRAKE SYSTEM TEST PARTICIPANTS

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1.0 INTRODUCTION

The official summary of the accident circumstances is provided in the Accident Synopsis Report, located in the NTSB docket for this investigation under NTSB number DCA17MR007.[1]

On June 19, 2017, two NTSB investigators traveled to the Trinity Rail tank car maintenance facility in Saginaw, TX to witness in-service tank car net braking ratio (NBR) tests on three (3) exemplar undamaged tank cars from accident train UEGKOT-09. The brake system tests were conducted in response to an NTSB request to quantify tank car NBR values for representative in-service cars.

2.0 METHOD

Single car brake test equipment and procedures consistent with Standard S-401 of the Association of American Railroads (AAR) Manual of Standards and Recommended Practices for Brakes and Brake

[1] Unverified accident context provided for reader convenience: On Friday, March 10, 2017, about 12:50 a.m. central standard time, eastbound Union Pacific Railroad (UP) unit ethanol train, UEGKOT-09, with 3 locomotives, 98 loaded tank cars and 2 buffer cars filled with sand derailed near milepost (MP) 56.8 at a timber railroad bridge near Graettinger, Iowa. Twenty (20) loaded tank cars in positions 21 through 40 derailed. Fourteen of the derailed tank cars released an estimated 322,000 gallons of undenatured ethanol, fueling a post-accident fire. The train consist was traveling at about 30 mph when the accident occurred near Jack Creek, a tributary of the Des Moines River. There were no injuries and no mandatory evacuations. About 400 feet of railroad track and a 152-foot railroad bridge were destroyed in the accident. Weather at the time of the accident was winds from the northwest at 17 mph gusting to 30 mph, visibility 10 miles, and temperature 10° F.

Equipment (Adopted: 1964; Last Revised: 2011) were used to measure and document the applicable handbrake, loaded, empty, or combined empty/loaded car NBR value for each car tested. In addition, emergency brake application loaded and empty car NBR values were calculated for the two cars equipped with empty/loaded devices. Trinity Rail arranged for tank car access and supplied the test facilities, equipment, and technical resources required to conduct and document the test. The car NBR tests were performed in Saginaw, TX on June 20, 2017.

2.1 Exemplar Tank Cars

The NTSB preferenced four exemplar tank cars for the car NBR test based on a strategy to uniformly sample cars from the accident train trailing consist of cars that were able to safely stop short of the derailment site. Three of the four requested tank cars from the accident train consist were delivered and tested, as summarized in Table 1. For comparison purposes, Trinity Rail also provided as-built car NBR data for car TILX 194965 (see Table 2), which shares the same brake system design/build as cars 1 and 3 in Table 1. The as-built loaded car NBR for the sister tank car in Table 2 was 11.4 percent.

Table 1: Exemplar Legacy DOT-111 Tank Cars Tested

Car	Position in Train UEGKOT-09 (from trailing end)	Build Date	Car Number	Gross Rail Load, lb	Light Weight, lb	Equipped with Empty/Loaded Device	Acceptable Loaded Car NBR Range	Acceptable Empty Car NBR Range
1	41	04-2008	TILX 198364	263,000	64,400	Yes	11 – 14%	15 – 32%
2	26	05-2002	TILX 320122	263,000	66,700	No	8.5 – 13%	15 – 38%
3	11	04-2008	TILX 199545	263,000	64,600	Yes	11 – 14%	15 – 32%

Table 2: As-Built "Sister" Car from Same Brake System Design/Build Lot as Legacy DOT-111 Tank Cars 1 and 3

Sister Car	Loaded Car NBR	Build Date	Car Number	Gross Rail Load, lb	Light Weight, lb	Equipped with Empty/Loaded Device	Acceptable Loaded Car NBR Range	Acceptable Empty Car NBR Range
A	11.4%	04-2007	TILX 194965	263,000	66,200	Yes	11 – 14%	15 – 32%

2.2 Single Car Brake Test Procedure

A summary of the steps accomplished to complete the single car brake test for each car follows:

1. Clean the car tank, move the car to the brake test site, and secure the car.
2. Install a digital air pressure gage in the existing brake cylinder pressure port and wire the digital air pressure gage to a digital multiplexer display device (channel 9 for this test).
3. Pneumatically plumb the tank car brake pipe to the single car test device, close the brake pipe on the car opposite end, pressurize the single car test device, and wait for the air pressure to stabilize at 90 psi in the brake pipe, auxiliary reservoir, and emergency reservoir. Check for and correct any air leaks in the car brake system.
4. Sequentially measure and record the brake cylinder pressure in psi and piston travel in inches for each of the following brake pipe pressure (BPP) reductions:
    a. 20-pound reduction
    b. Full service reduction (BPP set at or below 64 psi)

c. Emergency brake application (BPP set to 0 psi)

These measurements were taken before tapping.

5. Release the brake cylinder pressure to release the brake shoes from the wheel treads.
6. For each car wheel position, remove the brake shoe key and the brake shoe and then install a calibrated brake force transducer in the brake head using the same brake shoe key to position and contain the brake force transducer in the brake head. Wire each brake force transducer to a digital multiplexer display device (channels 1 through 8 for this test).
7. Remove the existing brake pin and install a calibrated brake pin force transducer (a “smart” pin) in the handbrake lever control input position on the brake lever that also connects to the brake cylinder piston. Wire the brake pin force transducer to a digital multiplexer display device (channel 10 for this test).
8. Perform the handbrake force test; apply an input force of 4,000 pounds by cranking the hand wheel in the direction that tightens the chain; record the applied, untapped brake shoe force for each wheel; then release the handbrake.
9. If the car is equipped with an empty load device, set it up in the loaded configuration. Otherwise proceed to step 10.
10. Recharge the brake pipe, auxiliary reservoir, and emergency reservoir to 90 psi.
11. Perform a minimum service brake pipe pressure reduction force test; decrease the BPP by 6 to 7 psi; allow the pressure to stabilize, and record the applied, untapped brake shoe force for each wheel.
12. Perform a full service reduction for the loaded (or nominal) car condition by reducing the BPP by at least 26 psi and allowing the pressure to stabilize. Then:
    a. Record the applied, untapped brake shoe force for each wheel.
    b. Tap the brake pins in the required sequence.
    c. Record the brake cylinder pressure, the brake cylinder piston length, and the applied, tapped brake shoe force for each wheel.
13. Optionally perform an experimental emergency BPP reduction for the loaded (or nominal) car condition. First recharge the system. Then rapidly reduce the BPP to 0 psi, allow the pressure to stabilize, and:
    a. Record the applied, untapped brake shoe force for each wheel.
    b. Tap the brake pins in the required sequence.
    c. Record the brake cylinder pressure, the brake cylinder piston length, and the applied, tapped brake shoe force for each wheel.
14. Recharge the brake pipe, auxiliary reservoir, and emergency reservoir to 90 psi.
15. If the car is equipped with an empty load device, set it up in the empty configuration and complete steps 16 and 17. Otherwise skip steps 16 and 17.
16. Perform a full service reduction for the empty car condition by reducing the BPP by at least 26 psi and allowing the pressure to stabilize. Then:
    a. Record the applied, untapped brake shoe force for each wheel.
    b. Tap the brake pins in the required sequence.
    c. Record the brake cylinder pressure, the brake cylinder piston length, and the applied, tapped brake shoe force for each wheel.
17. Optionally perform an experimental emergency BPP reduction for the empty car condition. First recharge the system. Then rapidly reduce the BPP to 0 psi, allow the pressure to stabilize, and:
    a. Record the applied, untapped brake shoe force for each wheel.
    b. Tap the brake pins in the required sequence.

c. Record the brake cylinder pressure, the brake cylinder piston length, and the applied, tapped brake shoe force for each wheel.

18. Close off the compressed air supply to the car from the single car test device and disconnect the car brake pipe from the single car test device.
19. Release the brake cylinder pressure to release the brake shoes from the wheel treads.
20. Remove the calibrated brake pin force transducer in the handbrake lever control input position on the brake lever that also connects to the brake cylinder piston and reinstall the original brake pin.
21. For each car wheel position, remove the brake shoe key and calibrated force transducer and then properly reinstall the brake shoe and brake shoe key.
22. Remove the air pressure gage in the existing brake cylinder pressure port.
23. Gather and stow test instrumentation, equipment, and tools.
24. Process the test data to calculate the car NBR and other results of interest.

3.0 RESULTS

The results of the single car brake test are presented in this section.

3.1 Measured Brake Cylinder Pressures and Brake Shoe Forces

Trinity Rail provided an electronic log of the brake cylinder pressures, brake piston extensions, and brake shoe forces measured for each car. The raw test data in Attachment 1 were used to calculate the required and optional (emergency braking) loaded and empty car NBR values and the handbrake NBR values that are documented in Table 3. The full service, loaded car NBR values ranged from 9.4 percent for the oldest car tested to 11.3 percent for the newest car tested. The full service, empty car NBR values ranged from 22.7 percent for the newest car tested to 37.2 percent for the oldest car tested. These car NBR results are consistent with the applicable AAR car NBR standards for new, rebuilt, and in-service cars. The experimental emergency, loaded car NBR values ranged from 13.4 to 13.8 percent whereas the corresponding empty car NBR values ranged from 27.6 to 28.3 percent. The in-service car NBR test results indicate that each car brake system provided acceptable brake shoe forces in response to handbrake, minimum service, and full service brake applications.

3.2 Test Photo Logs

A summary of the photographs taken during the exemplar car NBR tests to document the brake system instrumentation and measurements is provided in Table 4. The photographs provide a general overview of each car including tank capacity, car light and loaded weight, a view of the specific brake system equipment installed on each car, examples of the installed force transducers and pressure tap(s), and the measured brake piston extensions, brake cylinder pressures, and brake shoe forces. Backup photographs of measured lengths and digital force and/or pressure values were included to provide an alternate information source if content in one (or more) photograph(s) is blurred or obscured.

4.0 CONCLUSION

The exemplar in-service car NBR test results indicate that each car brake system provided acceptable brake shoe forces in response to handbrake, minimum service, and full service brake applications.

Table 3: Calculated Car NBR Values for Handbrake and Full Service Brake Applications, Empty and Loaded Car Configurations

Car	Position in Train UEGKOT-09 (from trailing end)	Build Date	Car Number	Car Mileage	Gross Rail Load, lb	Light Weight, lb	Equipped with Empty/Loaded Device	Handbrake Car NBR	Calculated Loaded Car NBR	Acceptable Loaded Car NBR Range	Calculated Empty Car NBR	Acceptable Empty Car NBR Range
1	41	04-2008	TILX 198364	259,885	263,000	64,400	Yes	10.8%	11.3%	11 – 14%	24.8%	15 – 32%
2	26	05-2002	TILX 320122	408,357	263,000	66,700	No	10.5%	9.4%	8.5 – 13%	37.2%	15 – 38%
3	11	04-2008	TILX 199545	252,585	263,000	64,600	Yes	10.0%	11.2%	11 – 14%	22.7%	15 – 32%

Table 4: Summary of Photographs

Attachment	Car Number	Comments
2	TILX 198364, TILX 320122, TILX 199545	General overview of each car and its standard brake system equipment
3	TILX 198364	Photographs documenting instrumented brake test instrumentation and measurements for car 198364
4	TILX 320122	Photographs documenting instrumented brake test instrumentation and measurements for car 320122
5	TILX 199545	Photographs documenting instrumented brake test instrumentation and measurements for car 199545

Attachment 1: Measured Brake System Pressures and Brake Shoe Forces

TRINITYRAIL™

BRAKE SYSTEM EQUALIZATION AND BRAKE SHOE FORCE TEST S-401-2005

JOB NO.: | TANK NO.: ▲ (Tank Cars Only) | DATE: 20-Jun-17

CAR NO.: TILX 199545 | CUSTOMER: Trinity Leasing

CAR TYPE: 31459 WG Tank Car

LIGHT WEIGHT: 64,600 | G.R.L.: 263,000 LBS

BRAKE TYPE: Bottom Rod Through

PISTON TRAVEL READINGS

Brake Pipe Reduction	Brake Cylinder Pressure		Piston Travel	
	Empty (psi)	Loaded (psi)	Empty (In.)	Loaded (In.)
20#(set-up)	27.2	49.2	7-5/8	8-1/8
30#	33.3	64.5	7-5/8	8-3/8
Emergency	N/A	75.7	N/A	8-5/8

◀(Freight Car Only)

▲(data used for % B.C. Pressure Calculation)

EMPTY LOAD SYSTEM: NYABCO 50%

HANDBRAKE FORCE: 4120

HANDBRAKE TYPE: Group N with 66 Bell Crank

BRAKE DRAWING NO: D58499

LOCATION TESTED: Plant 25 Sagiaw, TX

SHOE FORCE

SHOE LOCATION	RUN # 1			RUN #2			EMPTY LOAD		6 TO 7 PSI REDUCTION
	UNTAPPED	TAPPED	HANDBRAKE	UNTAPPED	TAPPED	HANDBRAKE	UNTAPPED	TAPPED	
L1	3150	3770	3680				1540	1840	260
L2	2880	3660	3410				1400	1840	260
R1	3030	3680	3160				1450	1810	110
R2	2930	3620	2960				1380	1810	220
L3	2940	3710	3230				1470	1840	290
L4	3050	3650	3590				1470	1790	180
R3	3100	3740	3190				1560	1920	300
R4	2960	3710	3210				1420	1830	190
TOTALS	24040	29540	26430	0	0	0	11690	14680	1810

AIR BRAKE SHOE FORCE = 29540 LBS

HANDBRAKE SHOE FORCE = 26430 LBS

GROSS RAIL LOAD = 263000 LBS

LIGHT WEIGHT= 64600 LBS

(AIR BRAKE SHOE FORCE / LIGHT WEIGHT) * 100 = 22.7% % Ltwt. (<= 32.0%)(22%-30% preferred w/empty ld brk)

(AIR BRAKE SHOE FORCE /GROSS RAIL LOAD) * 100 = 11.2% % G.R.L. (>=11%) (<= 14.0%)

(HANDBRAKE SHOE FORCE/ GROSS RAIL LOAD)*100 = 10.0% % G.R.L. (>=10.0%) {>=11.0% for lever-type handbrakes}

((EMERG B.C.PRESS -LOADED B.C.PRESS) / LOADED B.C. PRESS) * 100 = 17.4% % B.C. PRESS (+15% TO +20%)

AVERAGE BRAKE SHOE FORCE AT 30 PSI REDUCTION = 3692.5 +12.5 % = 4154 -12.5 % = 3231

AVERAGE BRAKE SHOE FORCE AT 6 TO 7 PSI REDUCTION = 226.25 (>=100 lbs.)

Test Conducted by:	DWGoodrich	Dir Engineering-Air Brakes	NTSB as Witness
Job Title:	Daniel Thommason	Liasion Engineer	

HANDBRAKE	AAR SHEAVE	NO. 66 BELL CRANK
CONV. GROUP N	3015	4000
INTER. GROUP O	4027	5400

Comments: Forces under Run #2 are emergency forces .Columns 5 and 6 are TAPPED readings

Full Service, Handbrake, and Minimum Service Brake Test

FULL SERVICE

TRINITYRAIL™

BRAKE SYSTEM EQUALIZATION AND BRAKE SHOE FORCE TEST S-401-2005

JOB NO.: | TANK NO.: ▲ (Tank Cars Only) | DATE: 20-Jun-17

CAR NO.: TILX 199545 | CUSTOMER: Trinity Leasing

CAR TYPE: 31459 WG Tank Car

LIGHT WEIGHT: 64,600 | G.R.L. 263,000 LBS | BRAKE TYPE: Bottom Rod Through

PISTION TRAVEL READINGS

Brake Pipe Reduction	Brake Cylinder Pressure		Piston Travel	
	Empty (psi)	Loaded (psi)	Empty (In.)	Loaded (In.)
20#(set-up)	27.2	49.2	7-5/8	8-1/8
30#	33.3	64.5	7-5/8	8-3/8
Emergency	N/A	75.7	N/A	8-5/8

◄(Freight Car Only)

▲(data used for % B.C. Pressure Calculation)

EMPTY LOAD SYSTEM: NYABCO 50%

HANDBRAKE FORCE: 4120

HANDBRAKE TYPE: Group N with 66 Bell Crank

BRAKE DRAWING NO: D58499

LOCATION TESTED: Plant 25 Sagiaw, TX

SHOE FORCE

SHOE LOCATION	RUN # 1			RUN #2			EMPTY LOAD		6 TO 7 PSI REDUCTION
	UNTAPPED	TAPPED	HANDBRAKE	UNTAPPED	TAPPED	HANDBRAKE	UNTAPPED	TAPPED	
L1	4160	4480						2250	
L2	3860	4360						2220	
R1	4050	4430						2170	
R2	3980	4250						2200	
L3	4010	4390						2230	
L4	4020	4420						2210	
R3	4070	4520						2300	
R4	4160	4430						2230	
TOTALS	32310	35280	0	0	0	0	0	17810	0

AIR BRAKE SHOE FORCE = 35280 LBS

HANDBRAKE SHOE FORCE = 0 LBS

GROSS RAIL LOAD = 263000 LBS

LIGHT WEIGHT= 64600 LBS

(AIR BRAKE SHOE FORCE / LIGHT WEIGHT) * 100 = 27.6% % Ltwt. (<= 32.0%)(22%-30% preferred w/empty ld brk)

(AIR BRAKE SHOE FORCE /GROSS RAIL LOAD) * 100 = 13.4% % G.R.L. (>=11%) (<= 14.0%)

(HANDBRAKE SHOE FORCE/ GROSS RAIL LOAD)*100 = 0.0% % G.R.L. (>=10.0%) {>=11.0% for lever-type handbrakes}

((EMERG B.C.PRESS -LOADED B.C.PRESS) / LOADED B.C. PRESS) * 100 = 17.4% % B.C. PRESS (+15% TO +20%)

AVERAGE BRAKE SHOE FORCE AT 30 PSI REDUCTION = 4410 +12.5 % = 4961 -12.5 % = 3859

AVERAGE BRAKE SHOE FORCE AT 6 TO 7 PSI REDUCTION = data incomplete (>=100 lbs.)

Test Conducted by:	DWGoodrich	Dir Engineering-Air Brakes	NTSB as Witness
Job Title:	Daniel Thommason	Liasion Engineer	

HANDBRAKE	AAR SHEAVE	NO. 66 BELL CRANK
CONV. GROUP N	3015	4000
INTER. GROUP O	4027	5400

Comments: Forces are EMERGENCY forces .

Experimental Emergency Brake Application Data
(Not Defined Among AAR Car Brake Test Standards)

QS-1025-1
Issued 7-31-2007

EMERGENCY

TRINITYRAIL™

BRAKE SYSTEM EQUALIZATION AND BRAKE SHOE FORCE TEST S-401-2005

JOB NO.: | TANK NO.: ▲ (Tank Cars Only) | DATE: 20-Jun-17

CAR NO.: TILX 320122 | CUSTOMER: Trinity Leasing

CAR TYPE: 31459 WG Tank Car

LIGHT WEIGHT: 66,700 | G.R.L. 263,000 LBS

BRAKE TYPE: Bottom Rod Through

EMPTY LOAD SYSTEM: None

HANDBRAKE FORCE: 4120

BRAKE DRAWING NO.:

HANDBRAKE TYPE: Group N with 66 Bell Crank

LOCATION TESTED: Plant 25 Sagiaw, TX

PISTON TRAVEL READINGS

Brake Pipe Reduction	Brake Cylinder Pressure		Piston Travel	
	Empty (psi)	Loaded (psi)	Empty (In.)	Loaded (In.)
20#(set-up)	N/A	50	N/A	8-1/2 ◀(Freight Car Only)
30#		65	N/A	8-1/2
Emergency	N/A	77	N/A	8-3/4

▲(data used for % B.C. Pressure Calculation)

SHOE FORCE

SHOE LOCATION	RUN # 1			RUN #2			EMPTY LOAD		6 TO 7 PSI REDUCTION
	UNTAPPED	TAPPED	HANDBRAKE	UNTAPPED	TAPPED	HANDBRAKE	UNTAPPED	TAPPED	
L1	2630	3130	3570						330
L2	2460	2940	3380						330
R1	2560	3190	3530						140
R2	2370	3000	3230						260
L3	2490	3060	3360						310
L4	2560	2990	3450						240
R3	2660	3290	3630						340
R4	2560	3180	3480						230
TOTALS	20290	24780	27630	0	0	0	0	0	2180

AIR BRAKE SHOE FORCE = 24780 LBS

HANDBRAKE SHOE FORCE = 27630 LBS

GROSS RAIL LOAD = 263000 LBS

LIGHT WEIGHT= 66700 LBS

(AIR BRAKE SHOE FORCE / LIGHT WEIGHT) * 100 = 37.2% % Ltwt. (<= 32.0%)(22%-30% preferred w/empty ld brk)

(AIR BRAKE SHOE FORCE /GROSS RAIL LOAD) * 100 = 9.4% % G.R.L. (>=11%) (<= 14.0%)

(HANDBRAKE SHOE FORCE/ GROSS RAIL LOAD)*100 = 10.5% % G.R.L. (>=10.0%) {>=11.0% for lever-type handbrakes}

((EMERG B.C.PRESS -LOADED B.C.PRESS) / LOADED B.C. PRESS) * 100 = 18.5% % B.C. PRESS (+15% TO +20%)

AVERAGE BRAKE SHOE FORCE AT 30 PSI REDUCTION = 3097.5 +12.5 % = 3485 -12.5 % = 2710

AVERAGE BRAKE SHOE FORCE AT 6 TO 7 PSI REDUCTION = 272.5 (>=100 lbs.)

Test Conducted by:	DWGoodrich	Dir Engineering-Air Brakes	NTSB as Witness
Job Title:	Daniel Thommason	Liasion Engineer	

HANDBRAKE	AAR SHEAVE	NO. 66 BELL CRANK	Comments
CONV. GROUP N	3015	4000	
INTER. GROUP O	4027	5400	

Full Service, Handbrake, and Minimum Service Brake Test

FULL SERVICE

TRINITYRAIL™

BRAKE SYSTEM EQUALIZATION AND BRAKE SHOE FORCE TEST S-401-2005

JOB NO.: | TANK NO.: ▲ (Tank Cars Only) | DATE: 20-Jun-17

CAR NO.: TILX 198364 | CUSTOMER: Trinity Leasing

CAR TYPE: 31459 WG Tank Car

LIGHT WEIGHT: 64,400 | G.R.L. 263,000 LBS

BRAKE TYPE: Bottom Rod Through

PISTION TRAVEL READINGS

Brake Pipe Reduction	Brake Cylinder Pressure		Piston Travel	
	Empty (psi)	Loaded (psi)	Empty (In.)	Loaded (In.)
20#(set-up)	29.8	49.6	7-3/4	7-7/8 ◄(Freight Car Only)
30#	34	64.3	7-3/4	8-1/4
Emergency	N/A	76.8	N/A	8-1/2

▲(data used for % B.C. Pressure Calculation)

EMPTY LOAD SYSTEM: NYABCO 50%

HANDBRAKE FORCE: 4020

HANDBRAKE TYPE: Group N with 66 Bell Crank

BRAKE DRAWING NO: D58499

LOCATION TESTED: Plant 25 Sagiaw, TX

SHOE FORCE

SHOE LOCATION	RUN # 1			RUN #2			EMPTY LOAD		6 TO 7 PSI REDUCTION
	UNTAPPED	TAPPED	HANDBRAKE	UNTAPPED	TAPPED	HANDBRAKE	UNTAPPED	TAPPED	
L1	3260	3780	3890				1750	2000	360
L2	3110	3650	3660				1650	1990	390
R1	3070	3700	3330				1670	2000	210
R2	2990	3690	3290				1670	1950	300
L3	3250	3870	3950				1750	2040	390
L4	3100	3560	3560				1640	1950	300
R3	2880	3610	3050				1750	2050	340
R4	3220	3830	3560				1730	2010	290
TOTALS	24880	29690	28290	0	0	0	13610	15990	2580

AIR BRAKE SHOE FORCE = 29690 LBS

HANDBRAKE SHOE FORCE = 28290 LBS

GROSS RAIL LOAD = 263000 LBS

LIGHT WEIGHT= 64400 LBS

(AIR BRAKE SHOE FORCE / LIGHT WEIGHT) * 100 = 24.8% % Ltwt. (<= 32.0%)(22%-30% preferred w/empty ld brk)

(AIR BRAKE SHOE FORCE /GROSS RAIL LOAD) * 100 = 11.3% % G.R.L. (>=11%) (<= 14.0%)

(HANDBRAKE SHOE FORCE/ GROSS RAIL LOAD)*100 = 10.8% % G.R.L. (>=10.0%) {>=11.0% for lever-type handbrakes}

((EMERG B.C.PRESS -LOADED B.C.PRESS) / LOADED B.C. PRESS) * 100 = 19.4% % B.C. PRESS (+15% TO +20%)

AVERAGE BRAKE SHOE FORCE AT 30 PSI REDUCTION = 3711.25 +12.5 % = 4175 -12.5 % = 3247

AVERAGE BRAKE SHOE FORCE AT 6 TO 7 PSI REDUCTION = 322.5 (>=100 lbs.)

Test Conducted by:	DWGoodrich	Dir Engineering-Air Brakes	NTSB as Witness
Job Title:	Daniel Thommason	Liasion Engineer	

HANDBRAKE	AAR SHEAVE	NO. 66 BELL CRANK
CONV. GROUP N	3015	4000
INTER. GROUP O	4027	5400

Comments: Forces under Run #2 are emergency forces .Columns 5 and 6 are TAPPED readings

Full Service, Handbrake, and Minimum Service Brake Test

FULL SERVICE

TRINITYRAIL™

BRAKE SYSTEM EQUALIZATION AND BRAKE SHOE FORCE TEST S-401-2005

JOB NO. | TANK NO: ▲ (Tank Cars Only) | DATE: 20-Jun-17

CAR NO: TILX 198364 | CUSTOMER: Trinity Leasing

CAR TYPE: 31459 WG Tank Car

LIGHT WEIGHT: 64,400 | G.R.L. 263,000 LBS | BRAKE TYPE: Bottom Rod Through

PISTION TRAVEL READINGS

Brake Pipe Reduction	Brake Cylinder Pressure		Piston Travel	
	Empty (psi)	Loaded (psi)	Empty (In.)	Loaded (In.)
20#(set-up)	29.8	49.6	7-3/4	7-7/8
30#	34	64.3	7-3/4	8-1/4
Emergency	N/A	76.8	N/A	8-1/2

◄(Freight Car Only)

▲(data used for % B.C. Pressure Calculation)

EMPTY LOAD SYSTEM: NYABCO 50%

HANDBRAKE FORCE: 4020

HANDBRAKE TYPE: Group N with 66 Bell Crank

BRAKE DRAWING NO: D58499

LOCATION TESTED: Plant 25 Sagiaw, TX

SHOE FORCE

SHOE LOCATION	RUN # 1			RUN #2			EMPTY LOAD		6 TO 7 PSI REDUCTION
	UNTAPPED	TAPPED	HANDBRAKE	UNTAPPED	TAPPED	HANDBRAKE	UNTAPPED	TAPPED	
L1	4140	4640					1750	2300	
L2	3840	4320					1650	2250	
R1	4050	4580					1670	2290	
R2	3920	4510					1670	2230	
L3	4110	4650					1750	2340	
L4	3810	4280					1640	2210	
R3	3960	4550					1750	2320	
R4	4170	4670					1730	2310	
TOTALS	32000	36200	0	0	0	0	13610	18250	0

AIR BRAKE SHOE FORCE = 36200 LBS

HANDBRAKE SHOE FORCE = 0 LBS

GROSS RAIL LOAD = 263000 LBS

LIGHT WEIGHT= 64400 LBS

(AIR BRAKE SHOE FORCE / LIGHT WEIGHT) * 100 = 28.3% % Ltwt. (<= 32.0%)(22%-30% preferred w/empty ld brk)

(AIR BRAKE SHOE FORCE /GROSS RAIL LOAD) * 100 = 13.8% % G.R.L. (>=11%) (<= 14.0%)

(HANDBRAKE SHOE FORCE/ GROSS RAIL LOAD)*100 = 0.0% % G.R.L. (>=10.0%) {>=11.0% for lever-type handbrakes}

((EMERG B.C.PRESS -LOADED B.C.PRESS) / LOADED B.C. PRESS) * 100 = 19.4% % B.C. PRESS (+15% TO +20%)

AVERAGE BRAKE SHOE FORCE AT 30 PSI REDUCTION = 4525 +12.5 % = 5091 -12.5 % = 3959

AVERAGE BRAKE SHOE FORCE AT 6 TO 7 PSI REDUCTION = data incomplete (>=100 lbs.)

Test Conducted by:	DWGoodrich	Dir Engineering-Air Brakes	NTSB as Witness
Job Title:	Daniel Thommason	Liasion Engineer	

HANDBRAKE	AAR SHEAVE	NO. 66 BELL CRANK	Comments
CONV. GROUP N	3015	4000	Forces are EMERGENCY Forces
INTER. GROUP O	4027	5400	

QS-1025-1
Issued 7-31-2007

Experimental Emergency Brake Application Data
(Not Defined Among AAR Car Brake Test Standards)

EMERGENCY

DWG GOODRICH
TRINITY
6-21-2017

CAR NO (TILX)	BUILD DATE	LT. WEIGHT	GRL	BCP. PISTON TRAVEL / TOTAL SHOE FORCE LOADED	EMPTY	EMERGENCY LOADED	EMERGENCY (EMPTY)	HANDBRAKE	%ONSE NBR
199545 252585 MILES	04-08	64600	263K	64.5PSI 8-3/8" 29540# 11.2%	33.3PSI 7-5/8" 14680# 22.7%	75.7PSI 8-5/8" 35280 13.4%	39.4PSI 7-5/8" 17810 27.6%	26430 10.0%	11-14% 32 ~~10-0~~
198364 259,885 MILES	04-08	64400	263K	64.3PSI 8-1/4" 29690# 11.3%	34PSI 7-3/4" 15990 24.8%	76.8PSI 8-1/4" 36200 13.8%	38.4PSI 7-3/4" 18250 28.3%	28290 10.7%	11-14% 32
320122 408,357 MILES	05-02	66700	263K	65PSI 8-1/2" 24780 9.4%	24780 37.1%	77PSI 8-3/4" X	X	~~26~~ 27630 10.5%	8 1/2-13% 38%

Initial Summary of Car NBR Brake Test Results,
Includes Standard and Experimental (Emergency) Test Data

SISTER CAR

TRINITYRAIL™

BRAKE SHOE FORCE TEST S-401-2003 (Cars ordered after 1-1-2004)

JOB NO: T06021 TANK NO: 341 ▲ (Tank Cars Only) DATE: 4/24/2007

CAR NO: TILX 194965 CUSTOMER: TILC/CARGILL

CAR TYPE: TANK CAR CLASS: DOT 111A100W1

LIGHT WEIGHT: 66,200 G.R.L. 263,000 LBS

BRAKE TYPE: Bottom Rod Through

PISTON TRAVEL READINGS

Brake Pipe Reduction	Brake Cylinder Pressure		Piston Travel	
	Empty (psi)	Loaded (psi)	Empty (In.)	Loaded (In.)
20#(set-up)				
30#	32	65	7 1/2	8
Emergency	N/A	77	N/A	8 1/5

◀(Freight Car Only)

▲(data used for % B.C. Pressure Calculation)

EMPTY LOAD SYSTEM: NYABCO 50%

HANDBRAKE FORCE: 4000

HANDBRAKE TYPE: VERTICAL

BRAKE DRAWING NO: D-58499

PLANT TESTED: 19

SHOE FORCE

SHOE LOCATION	RUN # 1			RUN #2			EMPTY LOAD		6 TO 7 PSI REDUCTION
	UNTAPPED	TAPPED	HANDBRAKE	UNTAPPED	TAPPED	HANDBRAKE	UNTAPPED	TAPPED	
L1	3676	3897	4501				1636	1723	660
L2	3529	3735	4326				1536	1640	602
R1	3610	3664	3877				1615	1691	697
R2	3495	3834	3769				1550	1622	631
L3	3611	3793	4311				1549	1632	644
L4	3652	3684	4408				1638	1721	717
R3	3656	3701	3749				1499	1569	574
R4	3557	3746	3704				1388	1655	530
TOTALS	28786	30054	32645	0	0	0	12411	13253	5055

AIR BRAKE SHOE FORCE = 30054 LBS

HANDBRAKE SHOE FORCE = 32645 LBS

GROSS RAIL LOAD = 263000 LBS

LIGHT WEIGHT= 66200 LBS

(AIR BRAKE SHOE FORCE / LIGHT WEIGHT) * 100 = 20.0% % Ltwt. (<= 32.0%)(22%-30% preferred w/empty ld brk)

(AIR BRAKE SHOE FORCE /GROSS RAIL LOAD) * 100 = 11.4% % G.R.L. (>=11%) (<= 14.0%)

(HANDBRAKE SHOE FORCE/ GROSS RAIL LOAD)*100 = 12.4% % G.R.L. (>=10.0%)

((EMERG B.C.PRESS -LOADED B.C.PRESS) / LOADED B.C. PRESS) * 100 = 18.5% % B.C. PRESS (+15% TO +20%) updated 2/18/05

AVERAGE BRAKE SHOE FORCE AT 30 PSI REDUCTION = 3756.75 +12.5 % = 4226 -12.5 % = 3287

AVERAGE BRAKE SHOE FORCE AT 6 TO 7 PSI REDUCTION = 631.875 (>=100 lbs.)

HANDBRAKE	AAR SHEAVE	NO. 66 BELL CRANK
CONV. GROUP N	3015	4000
INTER. GROUP O	4027	5400

TESTED BY:

TITLE:

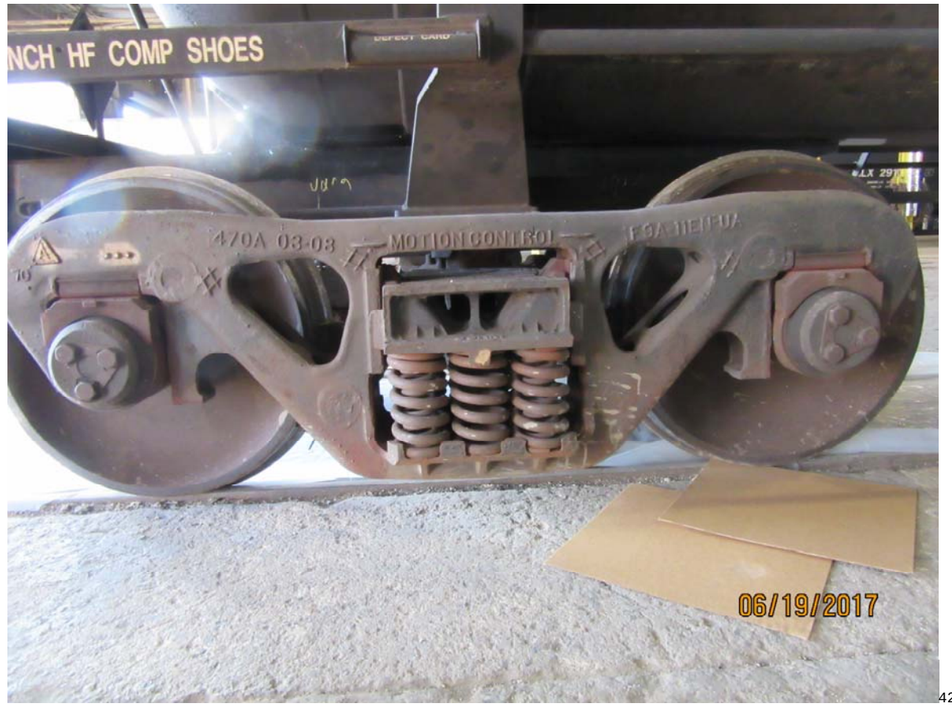
QS-1025-2
Revised: 7-26-2004

Car Build Record for "Sister" Car to Cars 198364 and 199545
Full Service, Handbrake, and Minimum Service Brake Test

Attachment 2: Photograph Log, General Overview of Brake System Equipment, Load Capability, and Schedules for Each Car

4226

Figure 4226: TILX 199545, car overview



4227

Figure 4227: TILX 199545, truck arrangement

4228

Figure 4228: TILX 199545, tank support structure and truck mount

4229

Figure 4229: TILX 199545, tank qualification and inspection schedules

4230

Figure 4230: TILX 199545, brake cylinder and handbrake pin connection

4231

Figure 4231: TILX 199545, brake system mechanical linkage diagram

4232

Figure 4232: TILX 199545, car air reservoir (auxiliary and emergency)

4233

Figure 4233: TILX 199545, handbrake control wheel and chain

4234
Figure 4234: TILX 199545, hand brake chain connection to input linkage

4235
Figure 4235: TILX 199545, brake control valve

4236
Figure 4236: TILX 199545, brake control valve

4237
Figure 4237: TILX 199545, retainer valve

4238
Figure 4238: TILX 199545, slack adjuster and mechanical linkages

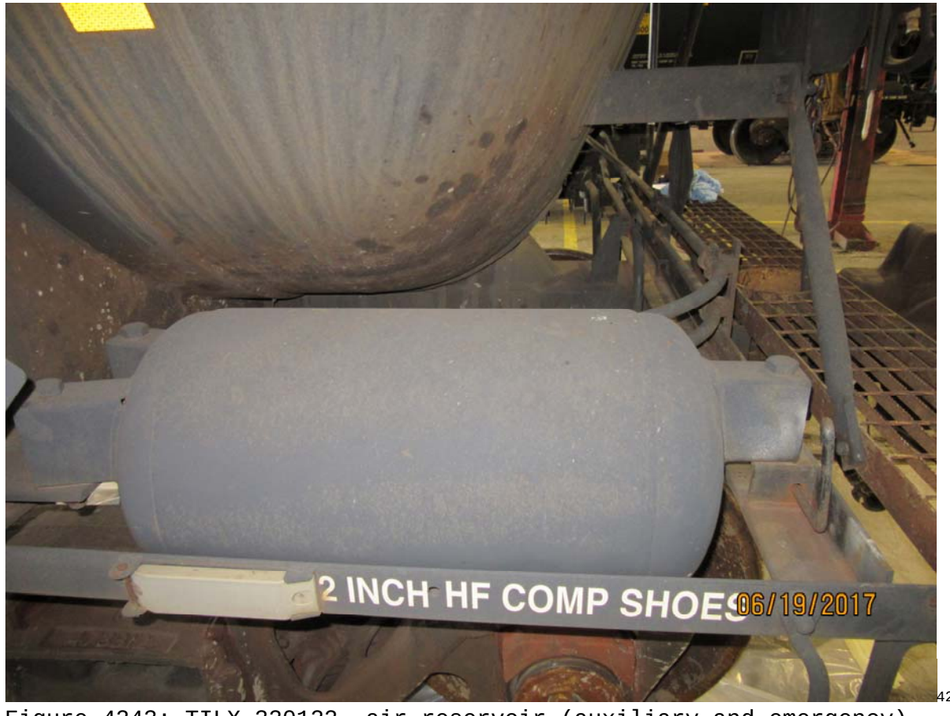
4239
Figure 4239: TILX 199545, empty load device

4240
Figure 4240: TILX 320122, car overview

4241
Figure 4241: TILX 320122, handbrake arrangement

4242

Figure 4242: TILX 320122, handbrake control input connections



4243

Figure 4243: TILX 320122, air reservoir (auxiliary and emergency)

4244

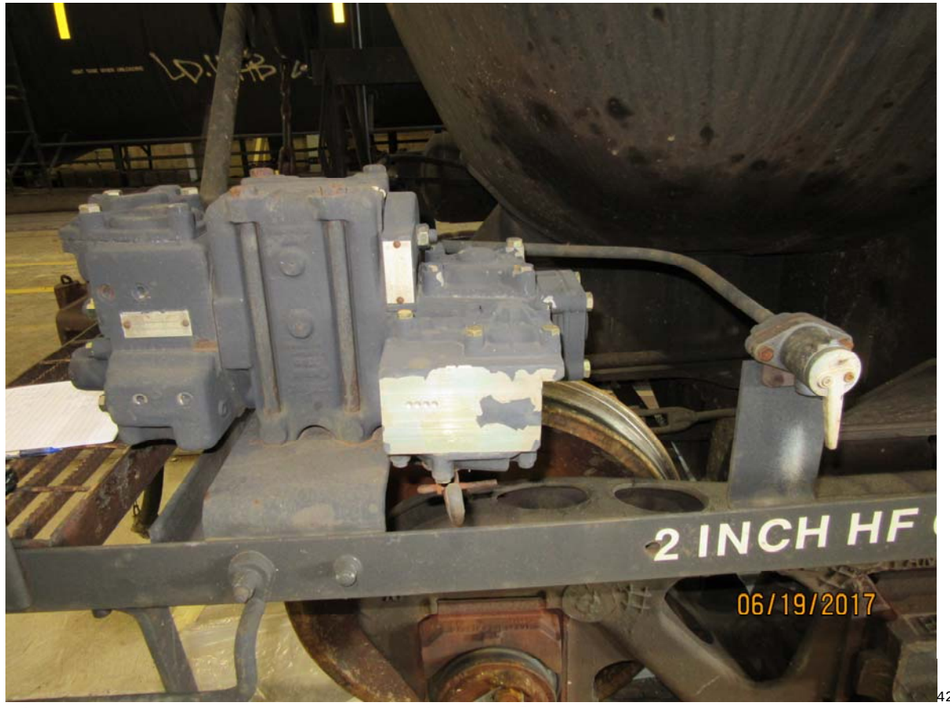
Figure 4244: TILX 320122, not equipped with an empty load device

4245

Figure 4245: TILX 320122, brake control valve

4246

Figure 4246: TILX 320122, brake control valve



4247

Figure 4247: TILX 320122, retainer valve

4248

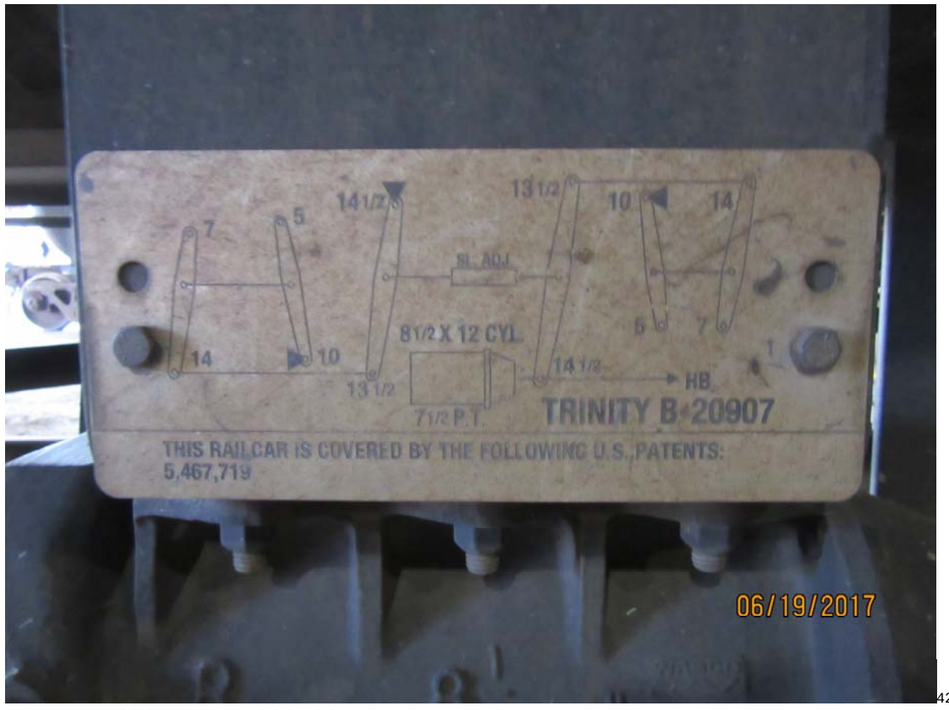
Figure 4248: TILX 320122, brake shoe and wheel tread

4249

Figure 4249: TILX 320122, brake beam, brake pin, and mechanical linkages

4250
Figure 4250: TILX 320122, slack adjuster and mechanical linkages

4251
Figure 4251: TILX 320122, brake cylinder



4252
Figure 4252: TILX 320122, brake system mechanical linkage diagram

4253
Figure 4253: TILX 320122, brake cylinder and mechanical linkages

4254

Figure 4254: TILX 320122, mechanical linkages and brake pins

4255

Figure 4255: TILX 198364, handbrake arrangement and chain

4256

Figure 4256: TILX 198364, handbrake control input connections

4257

Figure 4257: TILX 198364, empty load device air reservoir

4258
Figure 4258: TILX 198364, empty load device

4259
Figure 4259: TILX 198364, brake cylinder with brake cylinder pressure tap

4260
Figure 4260: TILX 198364, brake system mechanical linkage diagram

4261
Figure 4261: TILX 198364, mechanical linkages to brake cylinder, handbrake, and slack adjuster with brake pin connections

4262
Figure 4262: TILX 198364, slack adjuster

4263
Figure 4263: TILX 198364, slack adjuster and mechanical linkages

4264
Figure 4264: TILX 198364, brake control valve

4265
Figure 4265: TILX 198364, brake control valve

4266

Figure 4266: TILX 198364, brake control valve and brake pipe cut-out valve

4267

Figure 4267: TILX 198364, brake beam, pins, and mechanical linkages

4268

Figure 4268: TILX 198364, brake beam, pins, and mechanical linkages

4269

Figure 4269: TILX 198364, slack adjuster and mechanical linkages

4270
Figure 4270: TILX 198364, slack adjuster and mechanical linkages

4271
Figure 4271: TILX 198364, car light weight and load capability

4272
Figure 4272: TILX 198364, car overview

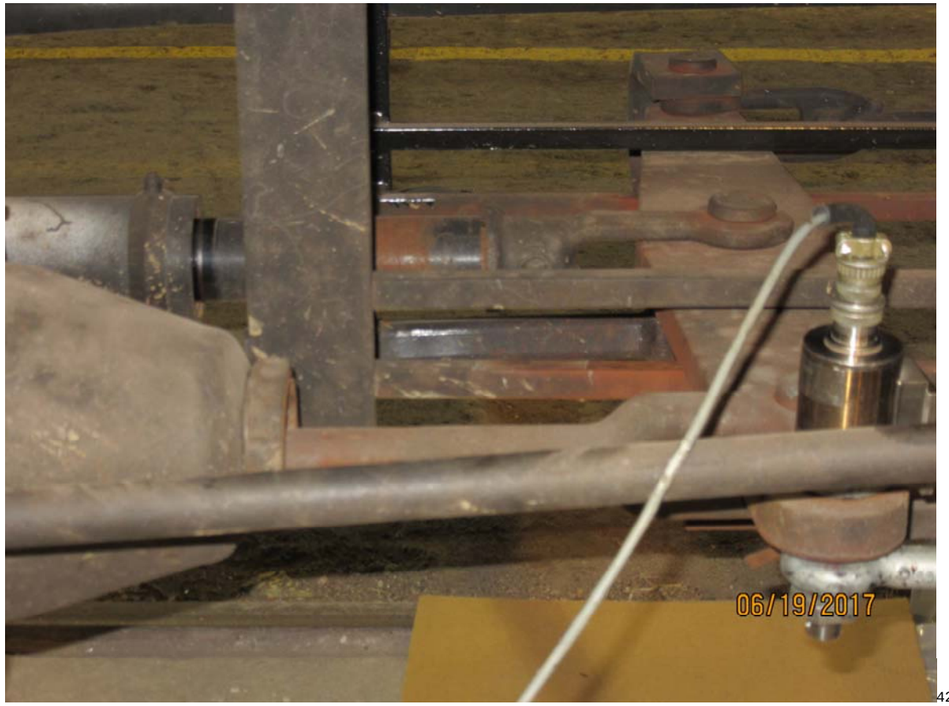
4273
Figure 4273: TILX 198364, tank qualification and inspection schedules

4274

Figure 4274: TILX 198364, handbrake arrangement

4275

Figure 4275: TILX 198364, brake cylinder with test instrumentation to measure brake cylinder pressure and/or handbrake input force



4276

Figure 4276: TILX 198364, force transducer “smart” pin mounted to measure handbrake control input force

Attachment 3: Photograph Log, Instrumentation and Measurements for TILX 198364

4277

Figure 4277: TILX 198364, 20 pound brake pipe pressure (BPP) reduction, loaded car, brake cylinder (BC) piston length

4278

Figure 4278: TILX 198364, 20 pound BPP reduction, loaded car, BC piston length (Figure 4277 backup)

4279

Figure 4279: TILX 198364, full service BPP reduction, loaded car, BC piston length

4280

Figure 4280: TILX 198364, full service BPP reduction, loaded car, BC piston length (Figure 4279 backup)

4281

Figure 4281: TILX 198364, emergency BPP reduction, loaded car, BC piston length

4282

Figure 4282: TILX 198364, emergency BPP reduction, loaded car, BC piston length (Figure 4281 backup)

4283

Figure 4283: TILX 198364, single car brake test stand

4284

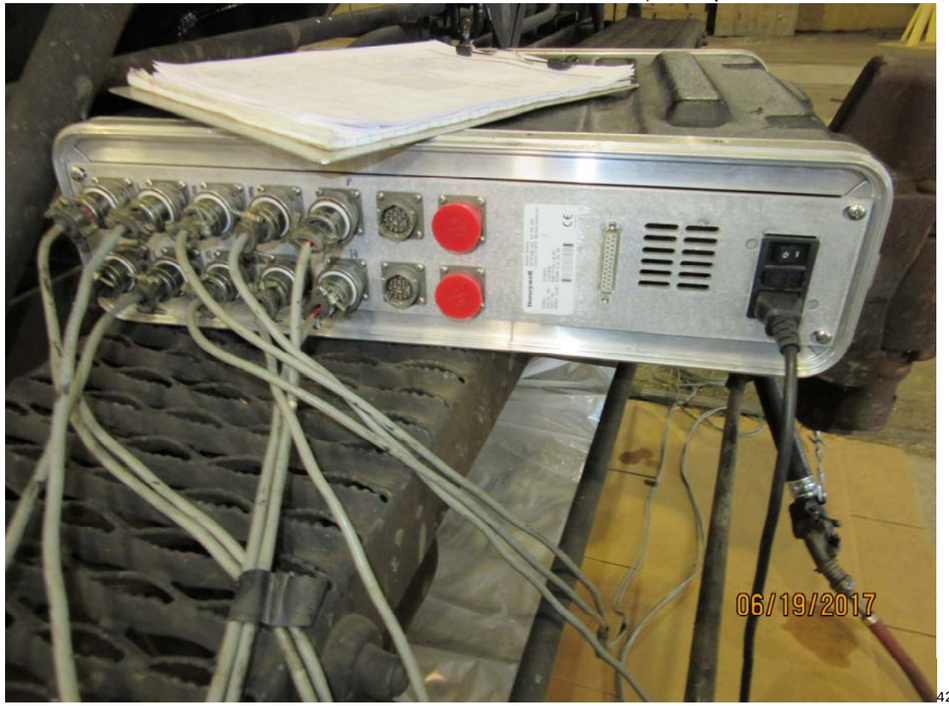
Figure 4284: TILX 198364, single car brake test stand, pressure gauge calibration data

4285

Figure 4285: TILX 198364, force and pressure data acquisition unit, brake shoe forces on channels 1-8, BC pressure on channel 9

4286

Figure 4286: TILX 198364, force and pressure data acquisition unit, model identification plate



4287

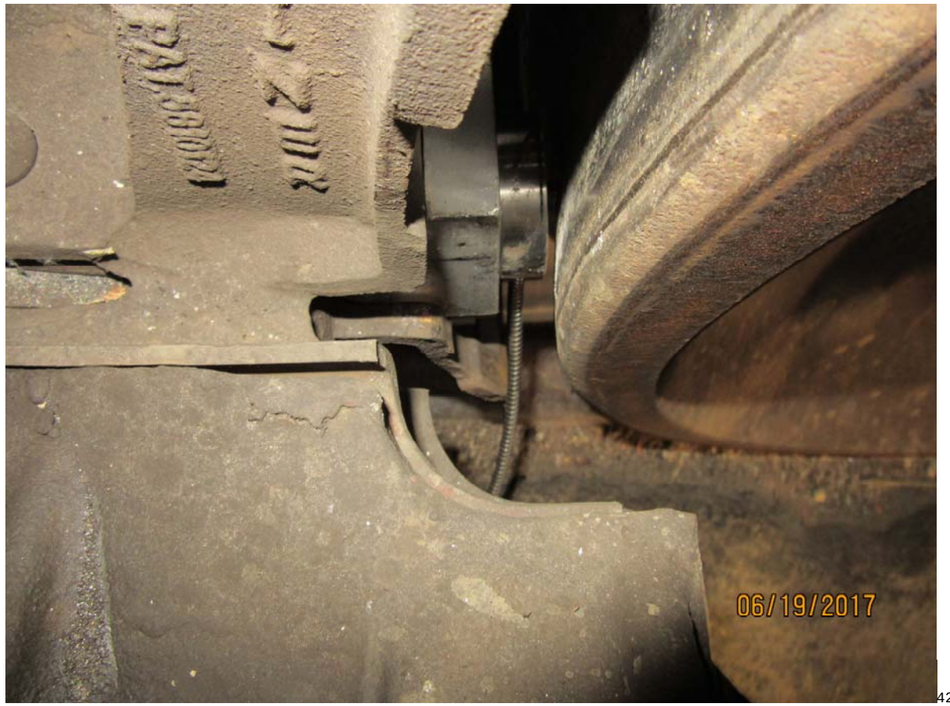
Figure 4287: TILX 198364, force and pressure data acquisition unit, transducer input arrangement, channels 1-10

4288

Figure 4288: TILX 198364, force transducer designed to measure equivalent brake shoe force (view 1 of 2)

4289

Figure 4289: TILX 198364, force transducer designed to measure equivalent brake shoe force (view 2 of 2)



4290

Figure 4290: TILX 198364, force transducer installed in nominal brake shoe position (view 1 of 2)

4291

Figure 4291: TILX 198364, force transducer installed in nominal brake shoe position (view 2 of 2)

4293

Figure 4293: TILX 198364, handbrake application, brake shoe forces, (channels 1-8 of 12 are L1, L2, L3, L4, R1, R2, R3, R4)

4294

Figure 4294: TILX 198364, handbrake application, brake shoe forces (Figure 4293 backup)

4295

Figure 4295: TILX 198364, minimum service BPP reduction, loaded car, brake pipe pressure

4297

Figure 4297: TILX 198364, minimum service BPP reduction, loaded car, brake pipe pressure (Figure 4295 backup)

4299

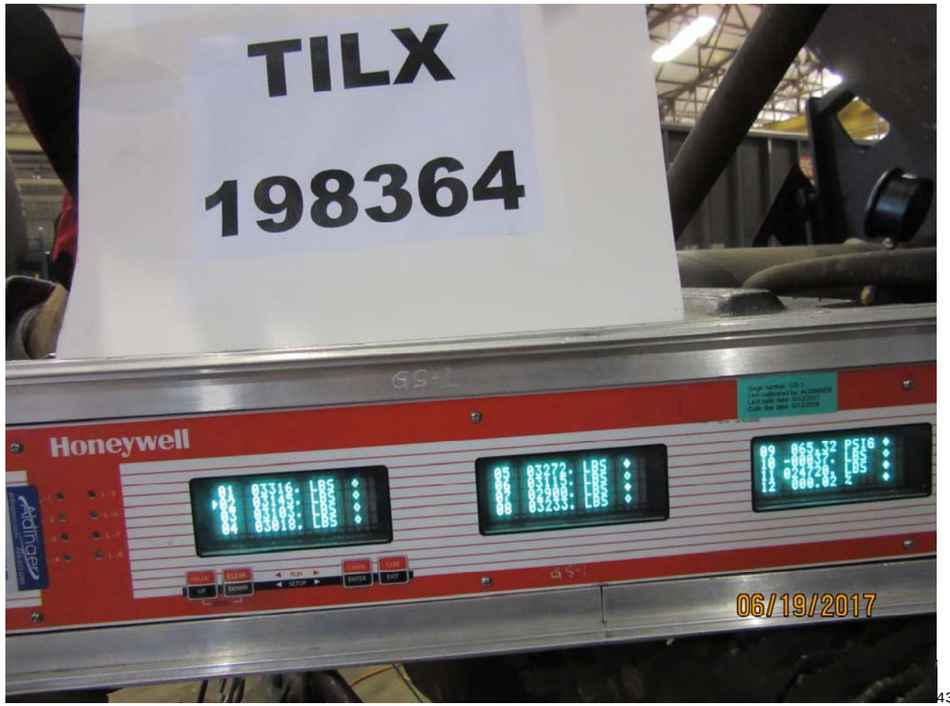
Figure 4299: TILX 198364, minimum service BPP reduction, loaded car, brake shoe forces, brake pins untapped

4300

Figure 4300: TILX 198364, minimum service BPP reduction, loaded car, brake shoe forces, brake pins untapped (Figure 4299 backup)

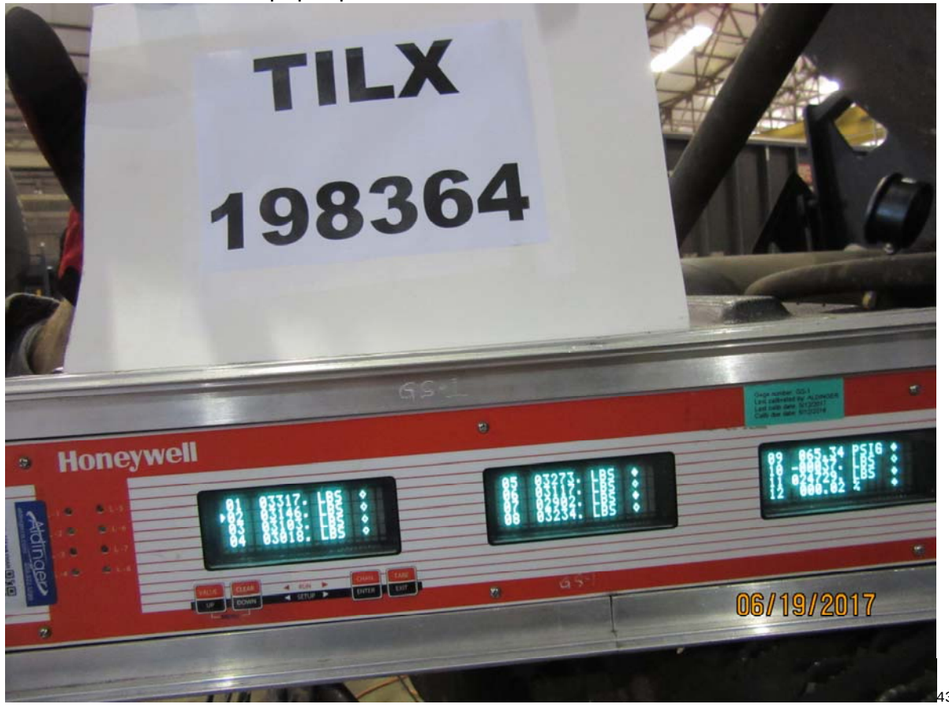
4301

Figure 4301: TILX 198364, full service BPP reduction, loaded car, brake pipe pressure



4302

Figure 4302: TILX 198364, full service BPP reduction, loaded car, brake shoe forces, brake pins untapped



4303

Figure 4303: TILX 198364, full service BPP reduction, loaded car, brake shoe forces, brake pins untapped (Figure 4302 backup)

4304

Figure 4304: TILX 198364, full service BPP reduction, loaded car, brake shoe forces, brake pins tapped

4305

Figure 4305: TILX 198364, full service BPP reduction, loaded car, brake shoe forces, brake pins tapped (Figure 4304 backup)

4306

Figure 4306: TILX 198364, emergency BPP reduction, loaded car, brake pipe pressure

4307

Figure 4307: TILX 198364, emergency BPP reduction, loaded car, brake shoe forces, brake pins untapped

4308

Figure 4308: TILX 198364, emergency BPP reduction, loaded car, brake shoe forces, brake pins untapped (Figure 4307 backup)

4309

Figure 4309: TILX 198364, emergency BPP reduction, loaded car, brake shoe forces, brake pins tapped

4310

Figure 4310: TILX 198364, emergency BPP reduction, loaded car, brake shoe forces, brake pins tapped (Figure 4309 backup)

4311

Figure 4311: TILX 198364, 20 pound BPP reduction, empty car, brake pipe pressure

4312

Figure 4312: TILX 198364, 20 pound BPP reduction, empty car, brake shoe forces, brake pins untapped

4313

Figure 4313: TILX 198364, 20 pound BPP reduction, empty car, brake shoe forces, brake pins untapped (Figure 4312 backup)

4314

Figure 4314: TILX 198364, full service BPP reduction, empty car, brake pipe pressure

4315

Figure 4315: TILX 198364, full service BPP reduction, empty car, brake shoe forces, brake pins untapped

4316

Figure 4316: TILX 198364, full service BPP reduction, empty car, brake shoe forces, brake pins untapped (Figure 4315 backup)

4318

Figure 4318: TILX 198364, full service BPP reduction, empty car, brake shoe forces, brake pins tapped

4319

Figure 4319: TILX 198364, full service BPP reduction, empty car, brake shoe forces, brake pins tapped (Figure 4319 backup)

4320

Figure 4320: TILX 198364, full service BPP reduction, empty car, brake pipe pressure, brake pins tapped

4321

Figure 4321: TILX 198364, emergency BPP reduction, empty car, brake shoe forces, brake pins untapped

4322

Figure 4322: TILX 198364, emergency BPP reduction, empty car, brake shoe forces, brake pins untapped (Figure 4321 backup)

Attachment 4: Photograph Log, Instrumentation and Measurements for TILX 320122

4323

Figure 4323: TILX 320122, 20 pound brake pipe pressure (BPP) reduction, brake cylinder (BC) piston length

4324

Figure 4324: TILX 320122, full service BPP reduction, brake cylinder piston length

4325

Figure 4325: TILX 320122, force transducer installed in nominal brake shoe position (view 1 of 4)

4326

Figure 4326: TILX 320122, force transducer installed in nominal brake shoe position (view 2 of 4)

4327

Figure 4327: TILX 320122, force transducer installed in nominal brake shoe position (view 3 of 4)

4328

Figure 4328: TILX 320122, force transducer installed in nominal brake shoe position (view 4 of 4)

4329

Figure 4329: TILX 320122, handbrake application, brake shoe forces, (channels 1-8 of 12 are L1, L2, L3, L4, R1, R2, R3, R4)

4330

Figure 4330: TILX 320122, minimum service BPP reduction, car not equipped with empty load valve, brake pipe pressure

4331

Figure 4331: TILX 320122, minimum service BPP reduction, car empty/ loaded, brake shoe forces, brake pins untapped

4332

Figure 4332: TILX 320122, full service BPP reduction, car empty/ loaded, brake pipe pressure, brake pins untapped

4333

Figure 4333: TILX 320122, full service BPP reduction, car empty/ loaded, BC pressure, brake pins untapped

4334

Figure 4334: TILX 320122, full service BPP reduction, car empty/loaded brake shoe forces, brake pins untapped

4335

Figure 4335: TILX 320122, full service BPP reduction, car empty/ loaded, brake shoe forces, brake pins untapped (Figure 4334 backup)

4336

Figure 4336: TILX 320122, full service BPP reduction, car empty/ loaded, brake shoe forces, brake pins tapped

4337

Figure 4337: TILX 320122, full service BPP reduction, car empty/ loaded, brake shoe forces, brake pins tapped (Figure 4336 backup)

Attachment 5: Photograph Log, Instrumentation and Measurements for TILX 199545

4338

Figure 4338: TILX 199545, 20 pound brake pipe pressure (BPP) reduction, loaded car, brake pipe pressure

4339

Figure 4339: TILX 199545, 20 pound BPP reduction, loaded car, brake cylinder (BC) pressure (channel 9 of 12)

4341

Figure 4341: TILX 199545, 20 pound BPP reduction, loaded car, BC piston length

4342

Figure 4342: TILX 199545, full service BPP reduction, loaded car, brake pipe pressure

4343

Figure 4343: TILX 199545, full service BPP reduction, loaded car, BC piston length

4344

Figure 4344: TILX 199545, full service BPP reduction, loaded car, BC piston length (Figure 4343 backup)

4345

Figure 4345: TILX 199545, emergency BPP reduction, loaded car, BC piston length

4346

Figure 4346: TILX 199545, handbrake application, brake shoe forces, (channels 1-8 of 12 are L1, L2, L3, L4, R1, R2, R3, R4)

4347

Figure 4347: TILX 199545, handbrake application, brake shoe forces (Figure 4346 backup)

4348

Figure 4348: TILX 199545, minimum service BPP reduction, loaded car, brake pipe pressure

4349

Figure 4349: TILX 199545, minimum service BPP reduction, loaded car, brake shoe forces, brake pins untapped

4350

Figure 4350: TILX 199545, minimum service BPP reduction, loaded car, brake shoe forces, brake pins untapped (Figure 4349 backup)

4352

Figure 4352: TILX 199545, full service BPP reduction, loaded car, brake pipe pressure, brake pins untapped

4353

Figure 4353: TILX 199545, full service BPP reduction, loaded car, brake shoe forces, brake pins untapped

4354

Figure 4354: TILX 199545, full service BPP reduction, loaded car, brake shoe forces, brake pins untapped (Figure 4353 backup)

4355

Figure 4355: TILX 199545, full service BPP reduction, loaded car, brake shoe forces, brake pins tapped

4356

Figure 4356: TILX 199545, full service BPP reduction, loaded car, brake shoe forces, brake pins tapped (Figure 4355 backup)

4357

Figure 4357: TILX 199545, emergency BPP reduction, loaded car, brake shoe forces, brake pins untapped

4358

Figure 4358: TILX 199545, emergency BPP reduction, loaded car, brake shoe forces, brake pins untapped (Figure 4357 backup)

4359

Figure 4359: TILX 199545, emergency BPP reduction, loaded car, brake shoe forces, brake pins tapped

4360

Figure 4360: TILX 199545, emergency BPP reduction, loaded car, brake shoe forces, brake pins tapped (Figure 4359 backup)

4361

Figure 4361: TILX 199545, full service BPP reduction, empty car, BC piston length, brake pins untapped

4362

Figure 4362: TILX 199545, full service BPP reduction, empty car, BC piston length, brake pins untapped (Figure 4361 backup)

4363

Figure 4363: TILX 199545, full service BPP reduction, empty car, brake shoe forces, brake pins untapped

4364

Figure 4364: TILX 199545, full service BPP reduction, empty car, brake shoe forces, brake pins untapped (Figure 4363 backup)

4365

Figure 4365: TILX 199545, full service BPP reduction, empty car, BC piston length, brake pins untapped

4366

Figure 4366: TILX 199545, full service BPP reduction, empty car, BC piston length, brake pins untapped (Figure 4365 backup)

4367

Figure 4367: TILX 199545, full service BPP reduction, empty car, brake pipe pressure, brake pins untapped

4368

Figure 4368: TILX 199545, full service BPP reduction, empty car, brake shoe forces, brake pins untapped

4369

Figure 4369: TILX 199545, full service BPP reduction, empty car, brake shoe forces, brake pins untapped (Figure 4368 backup)

4370

Figure 4370: TILX 199545, full service BPP reduction, empty car, brake pipe pressure, brake pins tapped

4371

Figure 4371: TILX 199545, full service BPP reduction, empty car, brake shoe forces, brake pins tapped

4372

Figure 4372: TILX 199545, full service BPP reduction, empty car, brake shoe forces, brake pins tapped (Figure 4371 backup)

4373

Figure 4373: TILX 199545, emergency BPP reduction, empty car, brake pipe pressure, brake pins untapped

4374

Figure 4374: TILX 199545, emergency BPP reduction, empty car, brake shoe forces, brake pins untapped

4375

Figure 4375: TILX 199545, emergency BPP reduction, empty car, brake shoe forces, brake pins untapped (Figure 4374 backup)

4376

Figure 4376: TILX 199545, emergency BPP reduction, empty car, brake shoe forces, brake pins tapped

4377

Figure 4377: TILX 199545, emergency BPP reduction, empty car, brake shoe forces, brake pins tapped (Figure 4376 backup)