

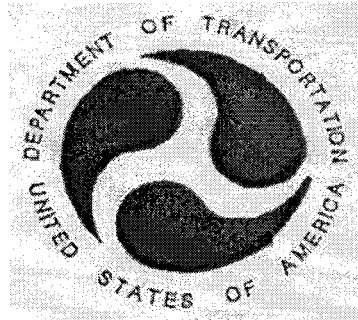
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REPORT NO. 121D-LTL- 06-002

SAFETY COMPLIANCE TESTING FOR FMVSS 121D
Air Brakes Systems - Dynamometer

FREIGHTLINER
2005 Columbia Tractor
Meritor RR-20-145
NHTSA No.: C50700

LINK TESTING LABORATORIES, INC.
13840 Elmira Avenue
Detroit, MI 48227-3017



January 4, 2007

FINAL REPORT

U.S. DEPARTMENT OF TRANSPORTATION
National Highway Traffic Safety Administration
Safety Assurance
Office of Vehicle Safety Compliance
400 Seventh Street, SW
Room 6115 (NVS-220)
Washington, DC 20590

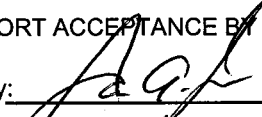
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Prepared By: 

Approved By: 

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16. ABSTRACT A compliance test was conducted on the 2005 Freightliner Columbia Tractor Rear Axle in accordance with the specifications of the Office of Vehicle Safety Compliance Test Procedure No TP-121D-01 for the determination of FMVSS 121D compliance. Test Failures identified were as follows: None				
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SECTION I

PURPOSE OF COMPLIANCE TEST

A test was conducted on the braking performance of a 2005 FREIGHTLINER COLUMBIA TRACTOR REAR VIN# 1FUJA6CK25LV14982, to determine compliance with the dynamometer portion of FMVSS 121, "Air Brake Systems."

The compliance test was conducted in accordance with the National Highway Traffic Safety Administration (NHTSA), Office of Vehicle Safety Compliance (OVSC) Laboratory Test Procedure TP-121D-01 Dated May 9, 1990 and the corresponding Link Testing Laboratories, Inc. test procedure Link \ D98071A0 dated October 2, 1998.

There were no test failures.

SECTION II
TEST DATA SUMMARY

DYNAMOMETER TEST SUMMARY

S5.4.1.1 - BRAKE RETARDATION FORCE RATIO

REQUIRED		ACTUAL		PASS / FAIL
AIR PRESSURE	RETARDATION FORCE RATIO (Min)	AVERAGE AIR PRESSURE (psi)	RETARDATION FORCE RATIO	
20 psi	0.05	20	0.10	PASS
30 psi	0.12	30	0.17	PASS
40 psi	0.18	40	0.24	PASS
50 psi	0.25	50	0.30	PASS
60 psi	0.31	60	0.37	PASS
70 psi	0.37	70	0.44	PASS
80 psi	0.41	80	0.51	PASS

S5.4.2.1 - BRAKE POWER PHASE - Requirement: Max Pressure During Stops: 100 psi

SNUB	MAXIMUM AIR PRESSURE (psi)	PASS/FAIL	REMARKS
1	52	PASS	-
2	51	PASS	-
3	50	PASS	-
4	52	PASS	-
5	52	PASS	-
6	53	PASS	-
7	53	PASS	-
8	55	PASS	-
9	56	PASS	-
10	58	PASS	-

S5.4.2.1 - 20 MPH STOP

STOP	MAXIMUM AIR PRESSURE (psi)	PASS/FAIL	REMARKS
11	87	PASS	-

S5.4.3 - BRAKE RECOVERY - Requirement: Air Pressure (psi)

	MIN	MAX
w/o antilock	20	85
w/ antilock	12	85

STOP	AIR PRESSURE (psi)		PASS / FAIL	REMARKS
	MINIMUM	MAXIMUM		
1	59	67	PASS	-
2	58	67	PASS	-
3	55	62	PASS	-
4	56	63	PASS	-
5	55	63	PASS	-
6	56	63	PASS	-
7	57	64	PASS	-
8	56	63	PASS	-
9	55	63	PASS	-
10	55	62	PASS	-
11	56	63	PASS	-
12	55	62	PASS	-
13	55	59	PASS	-
14	54	59	PASS	-
15	55	60	PASS	-
16	56	62	PASS	-
17	56	63	PASS	-
18	56	63	PASS	-
19	56	63	PASS	-
20	55	63	PASS	-

SECTION III

TEST DATA

SPECIFICATIONS

TEST NO.: 121D-LTL-06-002 DATE: 1/4/2007

VEHICLE:

MODEL YEAR/MAKE/MODEL: 2005 Freightliner Columbia Tractor
NHTSA NO.: C50700 VIN: 1FUJA6CK25LV14982
AXLE: Meritor RR-20-145

BRAKE ASSEMBLY:

BRAKE TYPE: Meritor Q+
MANUFACTURER: Meritor Assy P/N: A3211P3448
DRUM SIZE: 16.5" X 7"
MANUFACTURER: Conmet P/N: 10009830B
FRICTION MATERIAL: Meritor MA212
MANUFACTURER: Meritor Assy P/N: MA212 FF 4707D
SLACK ADJUSTER: Auto 5.5"
MANUFACTURER: Meritor Assy P/N: R801073
AIR CHAMBER: MGM Type 30/30 Long Stroke
MANUFACTURER: MGM P/N: 3230951

TEST PARAMETERS:

TEST START: 11/13/06 DYNAMOMETER: 68
TEST COMPLETE: 11/14/06 FIXTURE: 064353
REQUIRED WHEEL LOAD (lb): 10,000 ROLLING RADIUS (in): 19.2
ACTUAL WHEEL LOAD (lb): 9999 ROTATION: Left
REQUIRED INERTIA (slug ft²): 796 COOLING AIR TEMP: 84°F
ACTUAL INERTIA (slug ft²): 796 COOLING AIR VELOCITY (ft/min): 2,200

REMARKS:

Cooling air velocity was manually adjusted to ensure the flow over the brake was 2,200 feet/min.

BRAKE ADJUSTMENT S6.2.6

VEHICLE MY/MAKE/MODEL: _____ 2005 Freightliner Columbia Tractor _____

VEHICLE NHTSA NO.: _____ C50700 _____ DATE OF TEST: _____ 11/14/06 _____

SCHEDULE:

PERFORMANCE REQUIREMENT:

Brakes may be adjusted up to 3 times during the burnish procedure at intervals specified by vehicle manufactures, and may be adjusted at the conclusion of the burnishing in accordance with the vehicle manufacturer's recommendation

1st Brake Adjustment = Initial Before Burnish

2nd Brake Adjustment = Before Brake Performance

*Refer to manual for brake adjustment section 33.3 on the following pages.

RECORDED BY: _____ DATE: _____

APPROVED BY: _____

BRAKE MANUAL FOR INSTRUCTIONS

Pretrip Inspection and Daily Maintenance

brake operation is dependant on periodic maintenance and inspection of the brake linings.

- 32.1 Apply the parking brakes and chock the tires to prevent vehicle movement.
- 32.2 If the axle assembly is not equipped with a dust shield or backing plate, measure the axle brake lining thickness. If any of the brake linings are worn to less than 1/4 inch (6.5 mm) at the thinnest point, replace the linings on all brake assemblies on that axle. See Group 42 of the *Columbia® Workshop Manual* for lining replacement instructions and camshaft endplay inspection.
- 32.3 If the axle assembly is equipped with a dust shield or backing plate, remove the inspection plugs to inspect the brake lining thickness. If any of the brake linings are worn to less than approximately 1/4 inch (6.4 mm) at the thinnest point, replace the linings on all brake assemblies on that axle. See Group 42 of the *Columbia® Workshop Manual* for lining replacement instructions and camshaft endplay inspection.
- 32.4 Install the inspection plugs in the dust shields or backing plates if equipped.
- 32.5 Remove the chocks from the tires.

IMPORTANT: Brake checking and adjusting is necessary for all vehicles, including trucks equipped with automatic slack adjusters.

33. Inspect the slack adjusters as follows:

33.1 For Gunite Automatic Slack Adjusters:

Inspect the slack adjuster for any signs of damage. If damaged, replace the slack adjuster.

Inspect the slack adjuster boot for cuts or tears. If the boot is damaged, replace it. See Fig. 11.13.

Check for correct brake chamber stroke:

- With the brakes fully released, use a ruler to measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See Fig. 11.14, Ref. A.
- Build air pressure to at least 85 psi (585 kPa). Apply the brakes, then measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See Fig. 11.14, Ref. B. The difference between the measurements is the brake chamber stroke.

Pretrip Inspection and Daily Maintenance

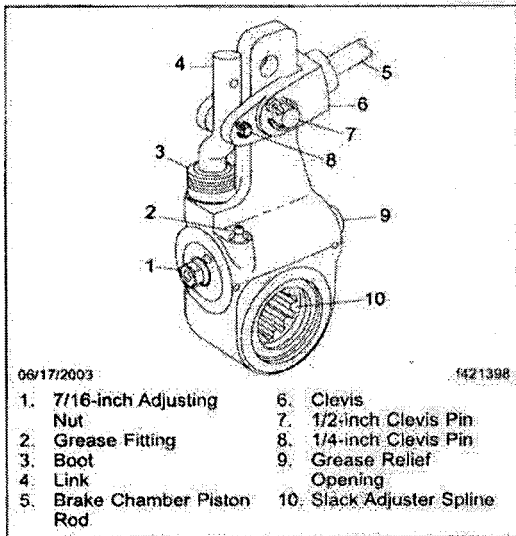


Fig. 11.13, Gunite Automatic Slack Adjuster

Compare the brake chamber stroke with the measurements shown in

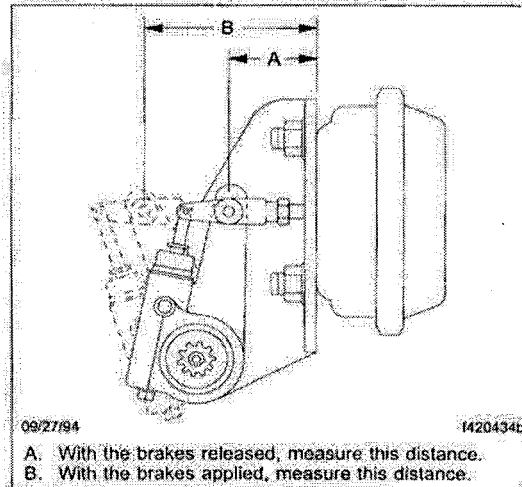


Fig. 11.14, Brake Stroke Check, Gunite Automatic Slack Adjuster

Table 11.1. Long stroke design is indicated by a tag or embossing on the brake chamber. If the brake chamber stroke exceeds the measurements

Pretrip Inspection and Daily Maintenance

shown in Table 11.1, check the foundation brakes for problems such as worn cams, bushings, pins and rollers, or broken springs. Repair or replace as needed. For instructions, see the applicable section in Group 42 of the *Columbia® Workshop Manual*.

If there are no problems with the foundation brakes, manually adjust the slack adjuster. See Group 42 of the *Columbia® Workshop Manual* for instructions to adjust the Gunite slack adjuster.

Maximum Allowable Brake Chamber Stroke	
Chamber Size	Maximum Allowable Stroke: inches (mm)
16	1-3/4 (44)
16 (long stroke)*	2 (51)
20	1-3/4 (44)
20 (long stroke)	2 (51)
24	2 (51)
24 (long stroke)	2-1/2 (64)
30	2 (51)
30 (long stroke)	2-1/2 (64)

Maximum Allowable Brake Chamber Stroke	
Chamber Size	Maximum Allowable Stroke: inches (mm)
36	2-1/2 (64)

*Long stroke design is indicated by a tag, or embossing, on the brake chamber.

Table 11.1. Maximum Allowable Brake Chamber Stroke

33.2 For Haldex Slack Adjusters:

Inspect each slack adjuster and anchor strap for damage. See Fig. 11.15. Replace any damaged components.

Check that the control-arm nut is tightened 10 to 15 lbf-ft (14 to 20 N-m).

If the control arm is in the wrong position, the brakes will drag. Verify that the control arm is in its full-release position as follows:

Check the rear tires, then release the parking brakes.

Remove the clevis pin.

With your finger, lightly push the slack adjuster into the clevis, then release it. The adjuster may move slightly due to springing of the anchor strap, but will return to its

Pretrip Inspection and Daily Maintenance

original position (holes in the adjuster and the clevis will remain in alignment). This shows that the control arm is fully released.

If the control arm is fully released, install the clevis pin. If the holes in the adjuster and the clevis do not remain aligned, it means the control arm is not against the internal body stop. This indicates an incorrect installation. Move the adjuster into alignment with the clevis hole and install the clevis pin. Loosen the control-arm nut and rotate the control arm toward the brake chamber until you can feel it contacting the internal stop. See Fig. 11.16, Ref. A. Be sure the control-arm stud moves freely in the slot of the anchor strap.

Tighten the control-arm nut 10 to 15 lbf-ft (14 to 20 N-m).

Repeat this step to be certain that the control arm is fully released. Final operating travel is obtained after the vehicle has been driven and the brakes are heated.

Check for correct brake chamber stroke:

- With the brakes released, measure the distance from the face of the air chamber to the far side of the clevis-pin hole. See Fig. 11.16, Ref. A.

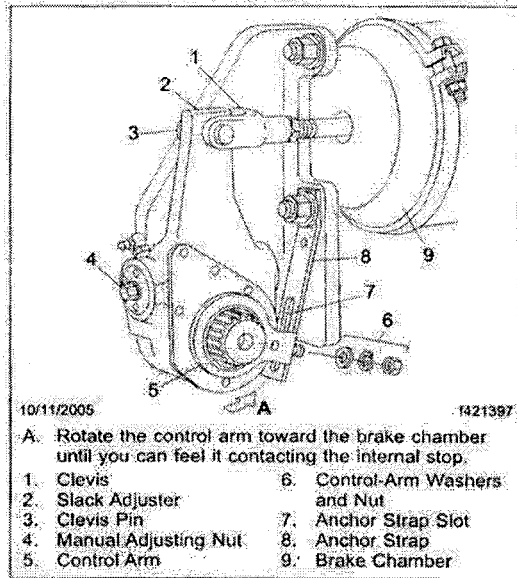


Fig. 11.15, Haldex Automatic Slack Adjuster

Pretrip Inspection and Daily Maintenance

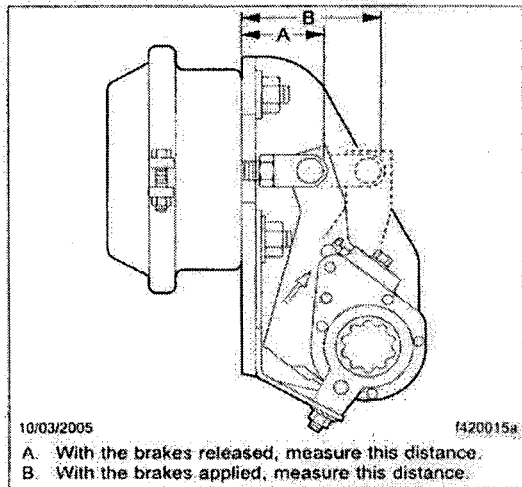


Fig. 11.16, Brake Stroke Check, Haldex Automatic Slack Adjuster

Record the exact distance as measurement A.

- Apply the service brakes and hold them on full line pressure of at least 80 psi (550 kPa). Measure the distance from the face of the brake chamber to the far side of the clevis pin hole. See Fig. 11.16, Ref. B. Record the exact distance as measurement B.
- Subtract measurement A from measurement B to determine the applied stroke. Compare this value to the allowable stroke value in Table 11.1. Long stroke design is indicated by a tag or embossing on the brake chamber.
- If the stroke varies or is greater than the specified range, check the brake components and, if necessary, replace the slack adjuster.

If the stroke is less than the specified range, see Group 42 of the *Columbia® Workshop Manual* for adjustment and troubleshooting information.

Apply the parking brakes and remove the chocks from the tires.

Pretrip Inspection and Daily Maintenance

CAUTION

Do not hammer on the control arm. This may cause internal damage.

IMPORTANT: Haldex automatic slack adjusters should never need to be adjusted during normal use. The only time they need adjustment is during installation, removal, or to back off the brake shoes during repair work. Constant manual adjustment will shorten internal clutch life.

33.3 For Meritor Slack Adjusters:

Check the boot for cuts, tears, or other damage. Replace it if necessary.

If the vehicle has new brakes or brakes with new linings, you must check the free-stroke. If the brakes or linings are not new, go to the next step.

With the brakes fully released, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See Fig. 11.17, Ref. A.

Use a pry bar to move the slack adjuster, applying the brakes. Again, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See Fig. 11.17, Ref. B.

The difference between the two measurements is the initial free-stroke, and sets the clearance between the linings and the drum. The free-stroke must be 5/8 to 3/4 inch (16 to 19 mm) for drum brakes, or 7/8 to 1-1/8 inch (22 to 29 mm) for disc brakes.

If the free-stroke is incorrect, remove the pressure-relief capscrew, spring, and pawl assembly (Fig. 11.18) from the slack adjuster housing. If equipped with a pull-pawl assembly (Fig. 11.19), carefully insert a screwdriver and raise the relief cap about 1/8 inch (3.2 mm).

Turn the adjusting nut one-eighth turn, as shown in Fig. 11.20. Measure the stroke again and adjust until correct.

If removed, install the pawl assembly, spring, and the pressure-relief capscrew. Tighten the capscrew 15 to 20 lbf-ft (20 to 27 N-m) or, remove the screwdriver from the pull-pawl assembly (if equipped).

Check for correct brake chamber stroke.

11.30

Pretrip Inspection and Daily Maintenance

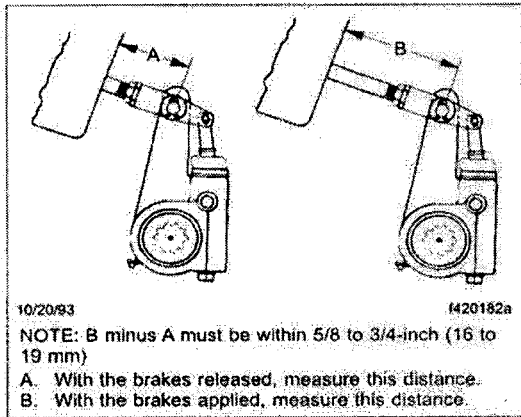


Fig. 11.17, Brake Stroke Check, Meritor Automatic Slack Adjuster

- With the brakes fully released, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See Fig. 11.17, Ref. A.
- Build air pressure to 100 psi (690 kPa), then shut down the engine. With

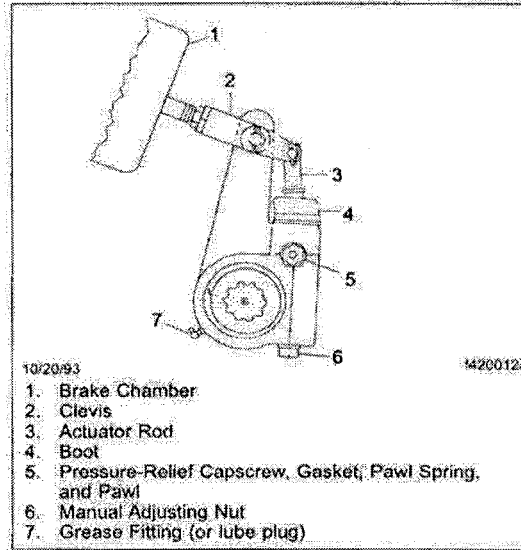


Fig. 11.18, Meritor Automatic Slack Adjuster

the brakes fully applied, measure the distance from the bottom of the brake

Pretrip Inspection and Daily Maintenance

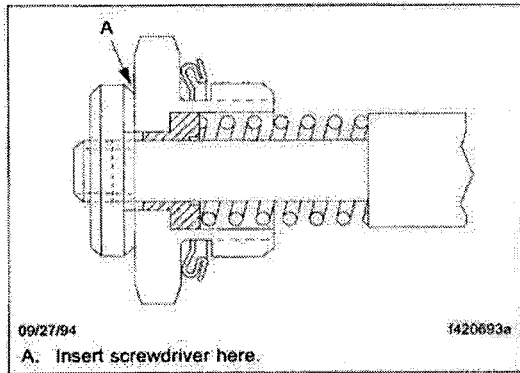


Fig. 11.19, Pull-Pawl Assembly (sectional view)

chamber to the center of the large clevis pin. See Fig. 11.17, Ref. B.

The difference between measurement A and measurement B is the brake chamber stroke.

The brake chamber stroke must be less than the measurements shown in Table 11.1. Long stroke design is indi-

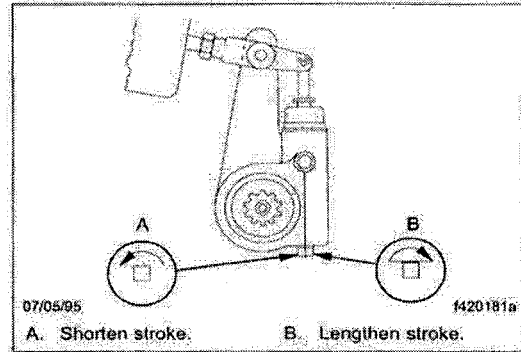


Fig. 11.20, Brake Stroke Adjusting

cated by a tag or embossing on the brake chamber.

- If the brake chamber stroke is incorrect, remove the pressure-relief cap-screw, spring, and pawl assembly (Fig. 11.18) from the slack adjuster housing. If equipped with a pull-pawl assembly (Fig. 11.19), carefully insert a screwdriver and raise the relief cap about 1/8-inch (3.2 mm).

11.32

Pretrip Inspection and Daily Maintenance

- Turn the adjusting nut one-eighth turn (Fig. 11.20). Measure the stroke again and adjust until correct.

If the stroke varies or remains greater than the specified range, check brake components, including camshafts, camshaft bushings, anchor pins, rollers, chamber brackets, the clevis, and clevis pins. For instructions, see **Group 42** of the *Columbia® Workshop Manual*.

- If removed, install the pawl assembly, spring, and the pressure-relief capscrew. Tighten the capscrew 15 to 20 lbf-ft (20 to 27 N·m) or remove the screwdriver from the pull-pawl assembly (if equipped).

CAUTION

Before turning the adjusting nut, remove the pressure-relief capscrew, spring, and pawl assembly. If equipped with a pull-pawl assembly, raise the relief cap as instructed. Failure to do so could strip the teeth on the pawl.

Do not make the adjusted chamber stroke too short. The free-stroke must not be less than the measurements given previously. If the chamber stroke is too

short, the linings can drag, which could damage the brake.

IMPORTANT: Do not use installation templates to check the slack adjuster angles. Installation templates are used only when installing a new slack adjuster or reinstalling the existing slack adjuster.

34. Check the inflation pressures of the tires before each trip using an accurate tire pressure gauge. Tires should be checked when cool. Be sure the valve stem caps are on every tire and that they are screwed on finger-tight. Inflate the tires to the applicable pressures if needed.

If a tire has been run flat or underinflated, check the wheel for proper locking and side-ring seating, and possible wheel, rim, or tire damage before adding air.

Moisture inside a tire can result in body ply separation or a sidewall rupture. During tire inflation, compressed air reservoirs and lines must be kept dry. Use well-maintained inline moisture traps and service them regularly.

WARNING

Do not operate the vehicle with underinflated or overinflated tires. Incorrect inflation can stress the

BURNISH TEST DATA S6.2.6

VEHICLE NHTSA NO.: C50700 DATE OF TEST: 11/14/06

SCHEDULE:

200 stops from 40 MPH (350 rpm) @ 10 ft/s/s, IBT
 315-385°F each stop
 200 stops from 40 mph (350 rpm) @ 10 ft/s/s, IBT
 450-550°F each stop
 Stop time: 5.78-5.96 seconds

PERFORMANCE REQUIREMENT:

None

STOP	RPM	F/M TEMP. (315-385°F)	TORQUE (lb-ft)	STOP TIME (5.78 - 5.96 sec)	AVERAGE AIR PRESSURE	REMARKS
1	351	350	4919	5.82	70	-
20	351	350	4967	5.80	59	-
40	350	348	4933	5.83	54	-
60	351	348	4969	5.78	51	-
80	351	349	4960	5.83	51	-
100	352	349	4960	5.84	50	-
101	351	349	4944	5.83	50	-
120	350	348	4939	5.82	49	-
140	352	349	4963	5.82	49	-
160	350	349	4928	5.84	48	-
180	351	349	4933	5.81	49	-
200	350	350	4929	5.85	48	-
		(450-550°F)				
201	350	380	4924	5.84	51	-
220	351	501	4918	5.87	55	-
240	352	500	4537	6.38	49	-
260	352	500	4527	6.39	49	-
280	350	500	4513	6.37	48	-
300	351	500	4974	5.79	53	-
301	350	500	4957	5.78	52	-
320	350	500	4952	5.82	53	-
340	349	500	4937	5.82	52	-
360	350	500	4960	5.82	52	-
380	351	500	4967	5.81	52	-
400	351	500	4959	5.78	52	-

Percent Shoe Contact	LEADING SHOE	85%
	TRAILING SHOE	85%

BRAKE RETARDATION FORCE S5.4.1, S5.4.1.1

VEHICLE NHTSA NO.: C50700

DATE OF TEST: 11/14/06

SCHEDULE:

PERFORMANCE REQUIREMENT:

Decelerate from 50 MPH at pressures of
20,30,40,50,60,70,80 psi

Retardation ratio as in table below

IBT 125-200 °F each stop

Measure torque starting coincident with
required pressure

AIR PRESSURE APPLIED (psi)	RPM	F/M TEMPERATURE (°F)	TORQUE (lb-ft)	STOP TIME (seconds)
20	437	170	1532	23.6
30	438	169	2595	13.9
40	438	169	3621	9.9
50	437	169	4570	7.9
60	438	169	5523	6.5
70	437	169	6475	5.6
80	438	170	7415	4.9

AIR PRESSURE APPLIED (psi)	TORQUE DIVIDED BY STATIC RAD 1.60 feet	FORCE DIVIDED BY LOAD 9999.3 lbs	REQUIRED RETARDATION FORCE QUOTIENT	Pass/ Fail	Remarks
20	957	0.10	0.05	PASS	-
30	1622	0.16	0.12	PASS	-
40	2263	0.23	0.18	PASS	-
50	2856	0.29	0.25	PASS	-
60	3452	0.35	0.31	PASS	-
70	4047	0.40	0.37	PASS	-
80	4634	0.46	0.41	PASS	-

DATA INDICATES: XXXXX PASS

 FAIL

BRAKE POWER S5.4.2, S5.4.2.1, S5.4.2.2

VEHICLE MY/MAKE/MODEL: 2005 Freightliner Columbia Tractor

VEHICLE NHTSA NO.: C50700 DATE OF TEST: 11/14/06

SCHEDULE:

Initial Brake Temperature 150 - 200°F
Speed 50-15 MPH (438 RPM) - (131RPM)
Deceleration 9 ft/s/s for 72 sec intervals
Speed from 20 MPH (175 RPM) Stop No. 11
Deceleration at 14 ft/s/s
Snub times stops 1-10, 5.70 - 6.42 seconds
Snub times stop 11, 2.09-2.26 seconds

PERFORMANCE REQUIREMENT:

Maximum pressure during Snubs
100 psi

SNUB OR STOP	RPM	F/M TEMP. (°F)	TORQUE (lb-ft)	MAXIMUM AIR PRESSURE (psi)	STOP TIME (sec)	PASS/ FAIL
1	436	149	4436	52	5.68	PASS
2	439	204	4466	51	5.75	PASS
3	437	251	4429	50	5.75	PASS
4	437	284	4430	52	5.71	PASS
5	438	309	4433	52	5.76	PASS
6	437	331	4412	53	5.72	PASS
7	438	350	4443	53	5.75	PASS
8	439	369	4452	55	5.70	PASS
9	439	388	4455	56	5.70	PASS
10	439	407	4426	58	5.79	PASS
	RPM (1 Minute After Snub 10)					
11	176	428	6665	87	2.14	PASS

DATA INDICATES: XXXXXXXX PASS _____ FAIL

BRAKE RECOVERY S5.4.3

VEHICLE NHTSA NO.: C50700 DATE OF TEST: 11/14/06

SCHEDULE:

Speed 30 mph (263 RPM)
 Deceleration at 12 ft/s/s
 @ 1 minute intervals
 Stop time = 3.52 - 3.83 seconds

PERFORMANCE REQUIREMENT:

	Min.	Max.
w/o Antilock	20 psi	85 psi
w/ Antilock	12 psi	85 psi

STOP No.	RPM	F/M TEMP. (°F)	TORQUE (lb-ft)	AIR PRESSURE (psi)		STOP TIME (sec)	PASS/ FAIL
				MINIMUM	MAXIMUM		
1	263	407	5936	59	67	3.61	PASS
2	264	413	5948	58	67	3.61	PASS
3	264	417	5969	55	62	3.61	PASS
4	263	417	5910	56	63	3.62	PASS
5	263	420	5936	55	63	3.62	PASS
6	264	420	5975	56	63	3.62	PASS
7	263	420	5943	57	64	3.57	PASS
8	263	420	5949	56	63	3.59	PASS
9	262	420	5933	55	63	3.61	PASS
10	263	420	5959	55	62	3.62	PASS
11	262	420	5947	56	63	3.61	PASS
12	264	420	5975	55	62	3.59	PASS
13	263	420	5959	55	59	3.61	PASS
14	264	421	6015	54	59	3.60	PASS
15	263	420	5949	55	60	3.62	PASS
16	264	419	5964	56	62	3.61	PASS
17	263	419	5931	56	63	3.57	PASS
18	264	417	5977	56	63	3.62	PASS
19	263	417	5951	56	63	3.63	PASS
20	262	415	5949	55	63	3.56	PASS

DATA INDICATES: XXXXXXX PASS FAIL

TEST DATA PLOTS: S5.4.1, S5.4.2 AND S5.4.3

REPORT NUMBER:

LTL-DOT-066919-001

MODEL YEAR/MAKE/MODEL:

2005 Freightliner Columbia Tractor

AXLE:

Meritor RR-20-145

BRAKE TYPE:

Meritor Q+

DRUM SIZE AND TYPE:

16.5" X 7" Conmet 10009830B

FRICTION MATERIAL:

Meritor MA212

AIR CHAMBER:

MGM Type 30/30 Long Stroke

SLACK ADJUSTER:

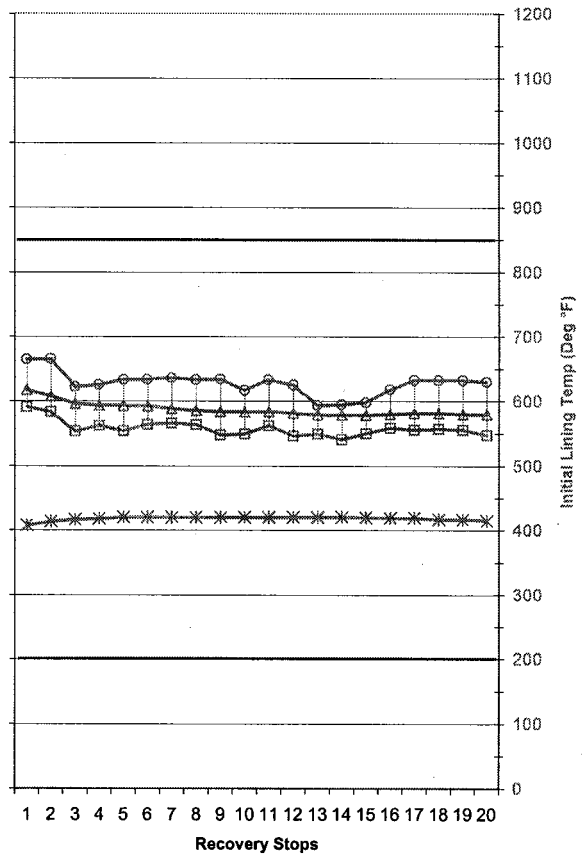
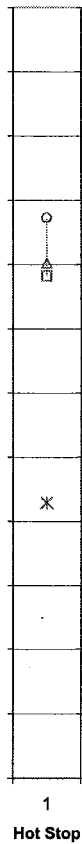
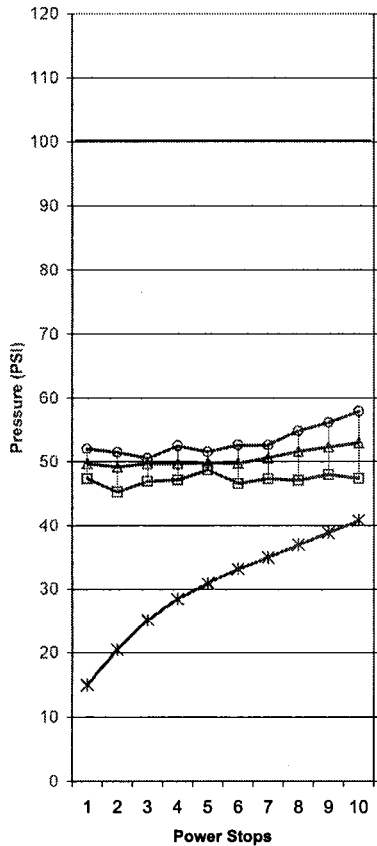
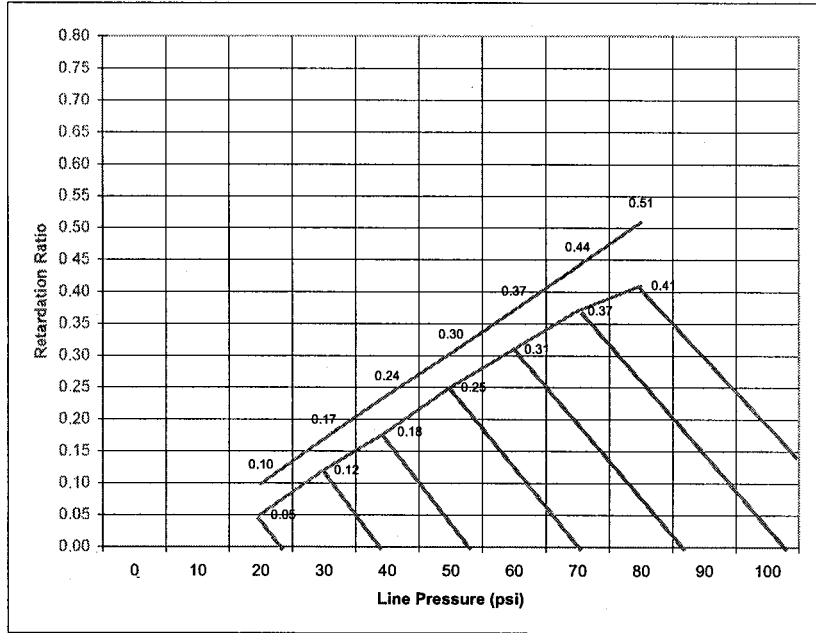
Meritor 5.5" Automatic

GAWR (lbs):

20000

ROLLING RADIUS (in):

19.2



SECTION IV
TEST EQUIPMENT AND
CALIBRATION RECORDS

Section IV - INSTRUMENTATION

Testing Equipment

Link Dynamometer No. 68

Description	Serial Number	*Calibration Date	Next Calibration Date
Torque	3852	6/16/2006	6/16/2007
Brake Temperature	T-135385	6/16/2006	6/16/2007
Air Pressure	76898	6/16/2006	6/16/2007
Stroke	29030148	6/16/2006	6/16/2007
Shaft Speed	96200686	6/16/2006	6/16/2007
Air Velocity	0068AS	6/16/2006	6/16/2007

*Calibration By Matthew J. Curtis



Certificate of Calibration

Calibration Performed By
 Link Testing Laboratories
 13840 Elmira Ave.
 Detroit, Mi 48227
 (313) 933-4900

Calibration Performed For
 Link Testing Laboratories
 13840 Elmira Ave
 Detroit, Michigan 48227

Machine Description: Dynamometer 68
 Report Number: D0068-6-2006
 Certificate Number: 3852(F)2006
 Calibration Date: 6/16/2006
 Next Calibration Date: 6/16/2007
 Procedure Used: 1 Torque Calibration
 Procedure Date: 6/16/2006
 Technician: M. Curtis

Description: Torque Fwd
 Manufacturer: Lebow
 Condition: Good
 Serial Number: 3852(F)
 Model Number: 312A
 Instrument Range: 15000 lb
 Rated Full-Scale: 200 Klb-in
 Temperature: 72 F
 Relative Humidity: 40 %

Signature: M. Curtis

Calibration Standard Value (lb-ft)	Initial "As Found" Value (lb-ft)	Calibration Standard Value (lb-ft)	Final Calibrated Value (lb-ft)	Initial Percent (%) of Full Scale Range (FSR) Error	Final Percent (%) of Full Scale Range (FSR) Error
0.2	0.8	0.2	0.8	.004%	.004%
2483.9	2491.3	2483.9	2491.3	.044%	.044%
4906.1	4911.4	4906.1	4911.4	.032%	.032%
9990.1	9994.6	9990.1	9994.6	.027%	.027%
14305.9	14315.2	14305.9	14315.2	.056%	.056%

	PRE-CAL	POST-CAL
Maximum % of full-scale error observed:	0.0580%	0.0560%
Maximum % of FSR error allowable (+/-):	1.0000%	1.0000%
Pre-Calibration Status:	Instrument met required accuracy	
Post-Calibration Status:	Instrument meets required accuracy	

The reported expanded uncertainty of measurement is stated as the standard uncertainty multiplied by the coverage factor (k=2), which for a normal distribution corresponds to a coverage probability of 95%. The data contained in this document is applicable only to the above listed equipment and is not valid unless signed by the technician. Measurement standards used for this test are traceable to the National Institute of Standards and Technology. This document shall not be reproduced without the written approval of Link Testing Laboratories.

Ref #	Description	Serial Number	Range	Accuracy	Uncertainty	Last Cal	Cal Due
REF:3	DISPLAY MODULE	13344-1	9999 COUNTS	+/- .05%	% +/- .05	11/7/2005	12 MO
REF:10	LOAD CELL 3000 LB	97781	3000 LB	+/- .05%FS	%FS +/- .05	11/7/2005	12 MO



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Calibration Performed For
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 Detroit, Michigan 48227

Machine Description: Dynamometer 68
 Report Number: D0068-6-2006
 Certificate Number: 0068TEMP12006
 Calibration Date: 6/16/2006
 Next Calibration Date: 6/16/2007
 Procedure Used: 4 Temperature Calibration (thermocouple cond.)
 Procedure Date: 6/16/2006
 Technician: M.Curtis

Description: Temperature1
 Manufacturer: Link Engineering
 Condition: Good
 Serial Number: 0068TEMP1
 Model Number: 1484-CAQ-CAV
 Instrument Range: 1400 °F
 Rated Full-Scale: 1400 °F
 Temperature: 72 F
 Relative Humidity: 40 %

Signature: M. Curtis

Calibration Standard Value (°F)	Initial "As Found" Value (°F)	Calibration Standard Value (°F)	Final Calibrated Value (°F)	Initial Percent (%) of Full Scale Range (FSR) Error	Final Percent (%) of Full Scale Range (FSR) Error
0.0	-0.8	0.0	0.0	-.057%	.000%
350.0	350.8	350.0	350.7	.057%	.050%
700.0	700.9	700.0	699.9	-.064%	-.007%
1050.0	1051.5	1050.0	1050.1	.107%	.007%
1390.0	1392.0	1390.0	1389.7	-.143%	-.021%

	PRE-CAL	POST-CAL
Maximum % of full-scale error observed:	0.1430%	0.0500%
Maximum % of FSR error allowable (+/-):	1.0000%	1.0000%
Pre-Calibration Status:	Instrument met required accuracy	
Post-Calibration Status:	Instrument meets required accuracy	

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Ref #	Description	Serial Number	Range	Accuracy	Uncertainty	Last Cal	Cal Due
REF-4	TEMP	T-135385	-210-760 C	+/- 1 F	F +/- 1	11/7/2005	12 MO.



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Calibration Performed For
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 Detroit, Michigan 48227

Machine Description: Dynamometer 68
 Report Number: D0068-6-2006
 Certificate Number: 768982006
 Calibration Date: 6/16/2006
 Next Calibration Date: 6/16/2007
 Procedure Used: 2 Pressure Calibration
 Procedure Date: 6/16/2006
 Technician: M. Curtis

Description: Air Pressure
 Manufacturer: BLH
 Condition: Good
 Serial Number: 76898
 Model Number: D-HF
 Instrument Range: 200 PSI
 Rated Full-Scale: 200 PSI
 Temperature: 72 F
 Relative Humidity: 40 %

Signature: M. Curtis

Calibration Standard Value (PSI)	Initial "As Found" Value (PSI)	Calibration Standard Value (PSI)	Final Calibrated Value (PSI)	Initial Percent (%) of Full Scale Range (FSR) Error	Final Percent (%) of Full Scale Range (FSR) Error
0.0	0.0	0.0	0.0	.000%	.000%
24.2	24.1	24.8	24.9	-.050%	.050%
50.0	49.9	49.7	49.7	-.050%	.000%
75.1	74.8	74.8	74.8	-.150%	.000%
117.5	116.7	117.5	117.2	-.400%	-.150%

	PRE-CAL	POST-CAL
Maximum % of full-scale error observed:	-0.4000%	-0.1500%
Maximum % of FSR error allowable (+/-):	1.0000%	1.0000%
Pre-Calibration Status:	Instrument met required accuracy	
Post-Calibration Status:	Instrument meets required accuracy	

The reported expanded uncertainty of measurement is stated as the standard uncertainty multiplied by the coverage factor (k=2), which for a normal distribution corresponds to a coverage probability of 95%. The data contained in this document is applicable only to the above listed equipment and is not valid unless signed by the technician. Measurement standards used for this test are traceable to the National Institute of Standards and Technology. This document shall not be reproduced without the written approval of Link Testing Laboratories.

Ref #	Description	Serial Number	Range	Accuracy	Uncertainty	Last Cal	Cal Due
REF.3	DISPLAY MODULE	13344-1	9999 COUNTS	+/- .05%	% +/- .05	11/7/2005	12 MO.
REF.6	PRESSURE CELL 200 PSI	852283	200 PSI	+/- .25%FSR	% FSR +/- .25	11/7/2005	12 MO.



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Calibration Performed For
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 Detroit, Michigan 48227

Machine Description: Dynamometer 68
 Report Number: D0068-6-2006
 Certificate Number: 290301482006
 Calibration Date: 6/16/2006
 Next Calibration Date: 6/16/2007
 Procedure Used: 6 Distance Calibration
 Procedure Date: 6/16/2006
 Technician: M. Curtis

Description: Drum Brake Stroke
 Manufacturer: Unimeasure
 Condition: Good
 Serial Number: 29030148
 Model Number: P5A-004-NJC
 Instrument Range: 10 in
 Rated Full-Scale: 10 in
 Temperature: 72 F
 Relative Humidity: 40 %

Signature: M. Curtis

Calibration Standard Value (in)	Initial "As Found" Value (in)	Calibration Standard Value (in)	Final Calibrated Value (in)	Initial Percent (%) of Full Scale Range (FSR) Error	Final Percent (%) of Full Scale Range (FSR) Error
0.000	0.000	0.000	0.000	.000%	.000%
1.000	0.997	1.000	0.995	-.030%	-.050%
2.000	2.005	2.000	2.000	.050%	.000%
3.000	3.017	3.000	3.008	.170%	.080%

	PRE-CAL	POST-CAL
Maximum % of full-scale error observed:	0.1700%	0.0800%
Maximum % of FSR error allowable (+/-):	1.0000%	1.0000%

Pre-Calibration Status: Instrument met required accuracy
 Post-Calibration Status: Instrument meets required accuracy

The reported expanded uncertainty of measurement is stated as the standard uncertainty multiplied by the coverage factor (k=2), which for a normal distribution corresponds to a coverage probability of 95%. The data contained in this document is applicable only to the above listed equipment and is not valid unless signed by the technician. Measurement standards used for this test are traceable to the National Institute of Standards and Technology. This document shall not be reproduced without the written approval of Link Testing Laboratories.

Ref #	Description	Serial Number	Range	Accuracy	Uncertainty	Last Cal	Cal Due
REF.5	6 IN CALIPER	33333	0-6 IN	+/- .001 IN	IN +/- .001	11/7/2005	12 MO.



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Calibration Performed For
 Link Testing Laboratories
 13840 Elmira Ave
 Detroit, Michigan 48227

Machine Description: Dynamometer 68
 Report Number: D0068-6-2006
 Certificate Number: 962006862006
 Calibration Date: 6/16/2006
 Next Calibration Date: 6/16/2007
 Procedure Used: 3 Rotational Speed Calibration
 Procedure Date: 6/16/2006
 Technician: M. Curtis

Description: Shaft Speed
 Manufacturer: Lucas Ledex
 Condition: Good
 Serial Number: 96200686
 Model Number: HD-20-DN-600-5LD-7LBS
 Instrument Range: 2000 RPM
 Rated Full-Scale: 1200 RPM
 Temperature: 72 F
 Relative Humidity: 40 %

Signature: M. Curtis

Calibration Standard Value (RPM)	Initial "As Found" Value (RPM)	Calibration Standard Value (RPM)	Final Calibrated Value (RPM)	Initial Percent (%) of Full Scale Range (FSR) Error	Final Percent (%) of Full Scale Range (FSR) Error
0.0	0.0	0.0	0.0	.000%	.000%
50.0	50.0	50.0	50.0	.000%	.000%
250.0	250.5	250.0	250.5	.042%	.042%
500.0	500.0	500.0	500.0	.000%	.000%
750.0	749.0	750.0	749.0	-.083%	-.083%

	PRE-CAL	POST-CAL
Maximum % of full-scale error observed:	-0.0830%	-0.0830%
Maximum % of FSR error allowable (+/-):	1.0000%	1.0000%

Pre-Calibration Status: Instrument met required accuracy
 Post-Calibration Status: Instrument meets required accuracy

The reported expanded uncertainty of measurement is stated as the standard uncertainty multiplied by the coverage factor (k=2), which for a normal distribution corresponds to a coverage probability of 95%. The data contained in this document is applicable only to the above listed equipment and is not valid unless signed by the technician. Measurement standards used for this test are traceable to the National Institute of Standards and Technology. This document shall not be reproduced without the written approval of Link Testing Laboratories.

Ref #	Description	Serial Number	Range	Accuracy	Uncertainty	Last Cal	Cal Due
REF-24	NON-CONTACT DIGITAL TACHOMETER	TACHOMETER 1390447	100000 RPM	+/- .01%	% +/- .01	4/22/2006	12 MO.



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 (313) 933-4900

Calibration Performed For
 Link Testing Laboratories
 13840 Elmira Ave
 Detroit, Michigan 48227

Machine Description: Dynamometer 68
 Report Number: D0068-6-2006
 Certificate Number: 0068AS2006
 Calibration Date: 6/16/2006
 Next Calibration Date: 6/16/2007
 Procedure Used: 9 Air Velocity Calibration
 Procedure Date: 6/16/2006
 Technician: M.Curtis

Description: Air Velocity
 Manufacturer: R M Young
 Condition: Good
 Serial Number: 0068AS
 Model Number: 27105R
 Instrument Range: 50 MPH
 Rated Full-Scale: 185 MPH
 Temperature: 72 F
 Relative Humidity: 40 %

Signature: M. Curtis

Calibration Standard Value (MPH)	Initial "As Found" Value (MPH)	Calibration Standard Value (MPH)	Final Calibrated Value (MPH)	Initial Percent (%) of Full Scale Range (FSR) Error	Final Percent (%) of Full Scale Range (FSR) Error
0.0	0.0	0.0	0.0	.000%	.000%
5.0	4.5	5.0	5.2	-.270%	.108%
10.0	9.4	10.0	10.0	-.324%	.000%
20.0	19.0	20.0	19.9	-.541%	-.054%
25.0	24.1	25.0	25.0	-.486%	.000%

	PRE-CAL	POST-CAL
Maximum % of full-scale error observed:	-0.5410%	0.1080%
Maximum % of FSR error allowable (+/-):	5.0000%	5.0000%
Pre-Calibration Status:	Instrument met required accuracy	
Post-Calibration Status:	Instrument meets required accuracy	

The reported expanded uncertainty of measurement is stated as the standard uncertainty multiplied by the coverage factor (k=2), which for a normal distribution corresponds to a coverage probability of 95%. The data contained in this document is applicable only to the above listed equipment and is not valid unless signed by the technician. Measurement standards used for this test are traceable to the National Institute of Standards and Technology. This document shall not be reproduced without the written approval of Link Testing Laboratories.

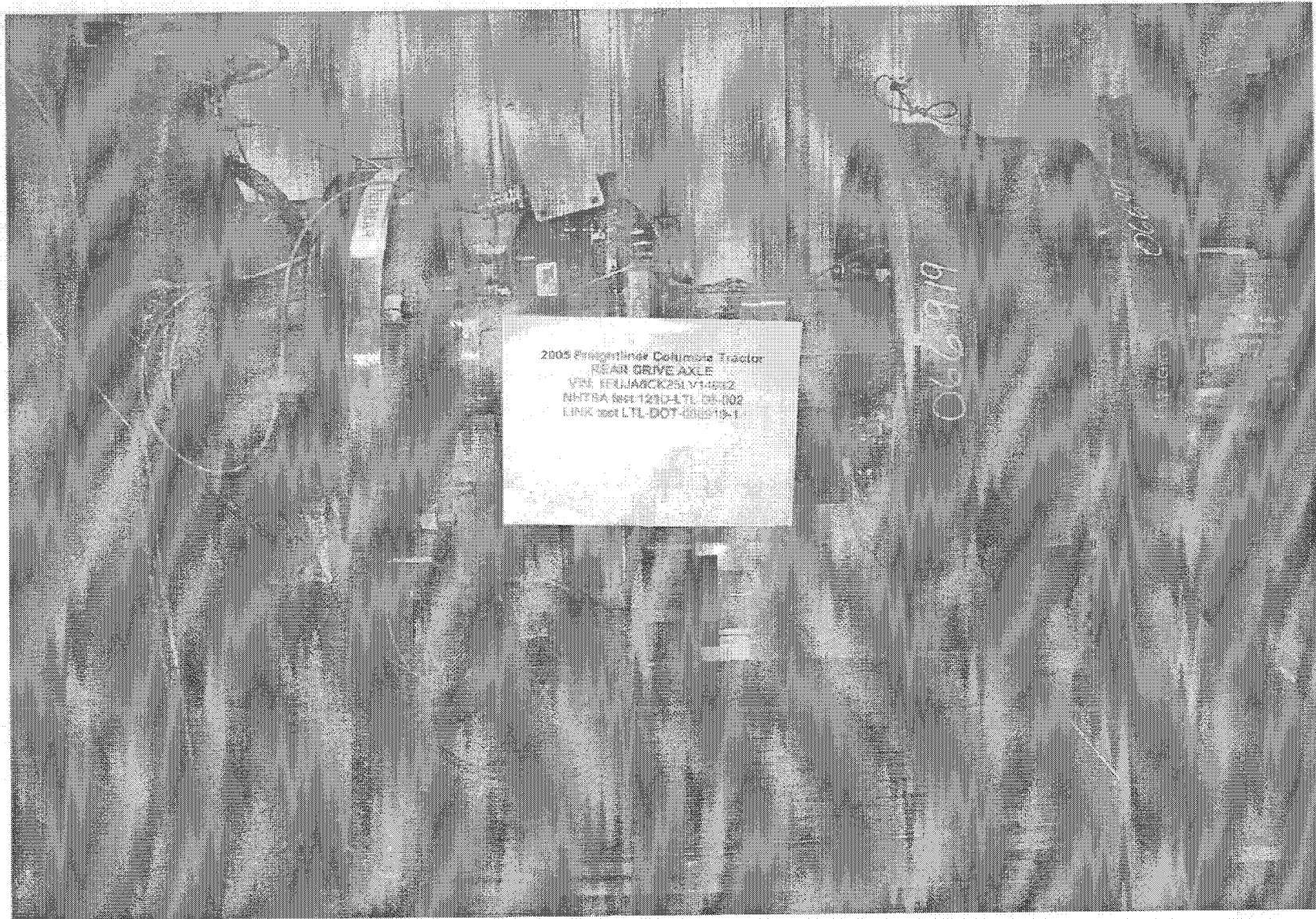
Ref #	Description	Serial Number	Range	Accuracy	Uncertainty	Last Cal	Cal Due
REF:11	AIR VELOCITY	40-96-05425	40-7800 FPM	+/- .25%FSR	% FSR +/- .25	6/30/2005	12 MO.

SECTION V
DYNAMOMETER
BRAKE ASSEMBLY
SET UP
PHOTOGRAPHS

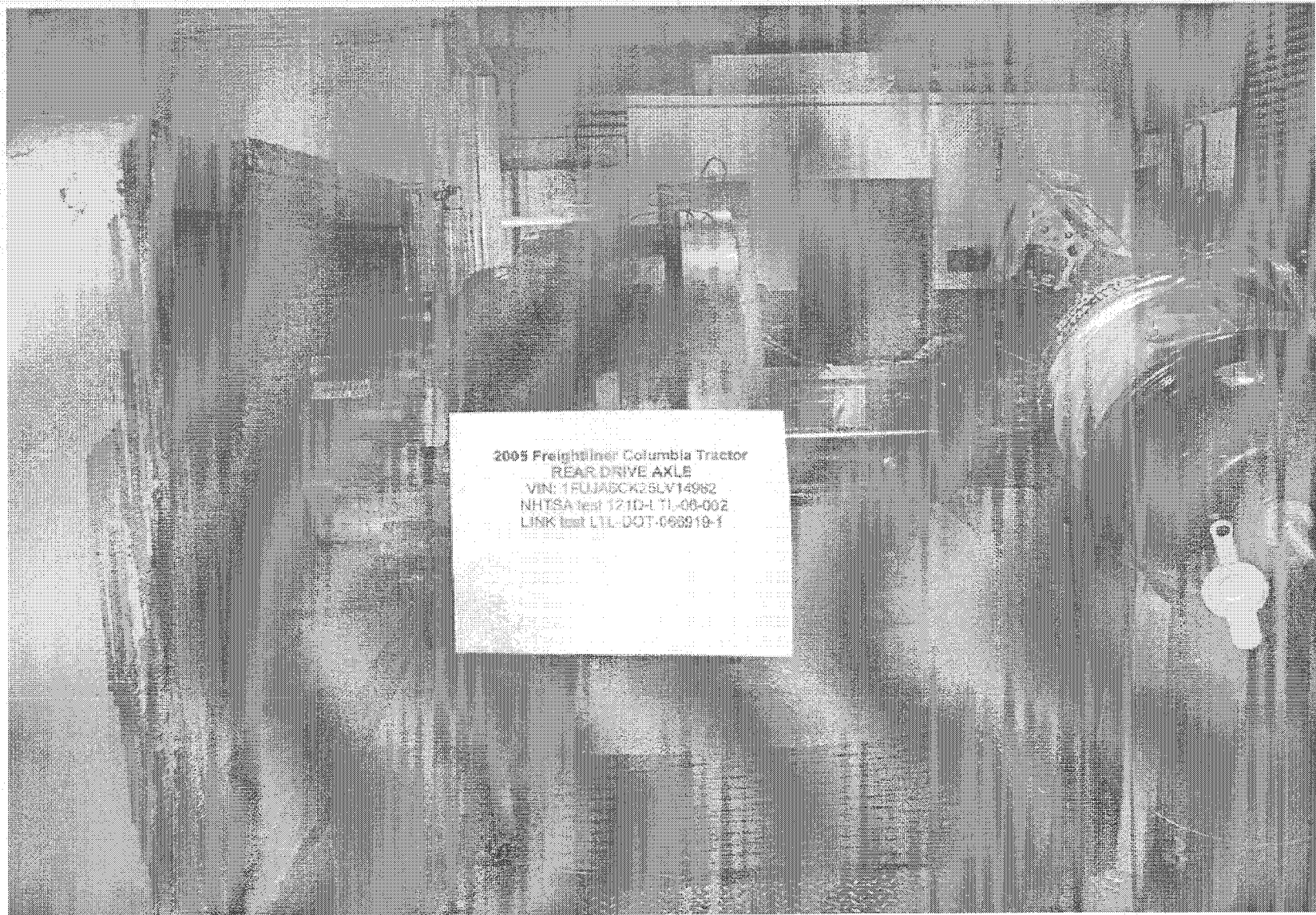
Thermocouple Installation



Dynamometer Setup



Dynamometer Setup



2005 Freightliner Columbia Tractor
REAR DRIVE AXLE
VIN: 1FUJASCK2SLV14962
NHTSA test 121D-L TL-00-002
LINK test LTL-DOT-066919-1