

639046

REPORT NO. 121D-LTL- 07-003

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

VOLVO
2008 Tractor VNM64T
Meritor FF961 20435232
NHTSA No.: C80700

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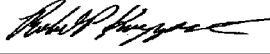


September 17, 2007

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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16. ABSTRACT A compliance test was conducted on the 2008 Volvo Tractor VNM64T Front 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 2008 VOLVO TRACTOR VNM64T FRONT VIN# 4V4MC9GF58N488369, 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	0.12	PASS
30 psi	0.12	30	0.21	PASS
40 psi	0.18	40	0.30	PASS
50 psi	0.25	50	0.39	PASS
60 psi	0.31	60	0.48	PASS
70 psi	0.37	70	0.58	PASS
80 psi	0.41	80	0.69	PASS

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

SNUB	MAXIMUM AIR PRESSURE (psi)	PASS/FAIL	REMARKS
1	46	PASS	-
2	45	PASS	-
3	47	PASS	-
4	50	PASS	-
5	51	PASS	-
6	52	PASS	-
7	51	PASS	-
8	49	PASS	-
9	47	PASS	-
10	46	PASS	-

S5.4.2.1 - 20 MPH STOP

STOP	MAXIMUM AIR PRESSURE (psi)	PASS/FAIL	REMARKS
11	63	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	45	57	PASS	-
2	42	57	PASS	-
3	40	58	PASS	-
4	39	56	PASS	-
5	38	57	PASS	-
6	37	56	PASS	-
7	37	55	PASS	-
8	36	54	PASS	-
9	37	52	PASS	-
10	37	53	PASS	-
11	37	53	PASS	-
12	37	52	PASS	-
13	37	51	PASS	-
14	38	51	PASS	-
15	38	51	PASS	-
16	38	50	PASS	-
17	38	50	PASS	-
18	40	50	PASS	-
19	40	50	PASS	-
20	40	49	PASS	-

SECTION III

TEST DATA

SPECIFICATIONS

TEST NO.: N/A DATE: 9/17/2007

VEHICLE:

MODEL YEAR/MAKE/MODEL: 2008 Volvo Tractor VNM64T

NHTSA NO.: C80700 VIN: 4V4MC9GF58N488369

AXLE: Meritor FF961 20435;

BRAKE ASSEMBLY:

BRAKE TYPE: Meritor Q+

MANUFACTURER: Meritor Assy P/N: 20525042

DRUM SIZE: 15"x4"

MANUFACTURER: Gunite 3800 P/N: 3949229

FRICTION MATERIAL: MG1 4702 CAM FF 05343

MANUFACTURER: Meritor Assy P/N: MG1 4702 QP

SLACK ADJUSTER: Auto 5.5"

MANUFACTURER: GUNITE 2000 Assy P/N: AS1172

AIR CHAMBER: TYPE 20

MANUFACTURER: Meritor P/N: 3946582

TEST PARAMETERS:

TEST START: 09/10/07 DYNAMOMETER: 84

TEST COMPLETE: 09/11/07 FIXTURE: 074476-1

REQUIRED WHEEL LOAD (lb): 6,000 ROLLING RADIUS (in): 19.5

ACTUAL WHEEL LOAD (lb): 5848 ROTATION: Left

REQUIRED INERTIA (slug ft²): 492 COOLING AIR TEMP: 84°F

ACTUAL INERTIA (slug ft²): 492 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: 2008 Volvo Tractor VNM64T

VEHICLE NHTSA NO.: C80700 DATE OF TEST: 09/11/07

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 on 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

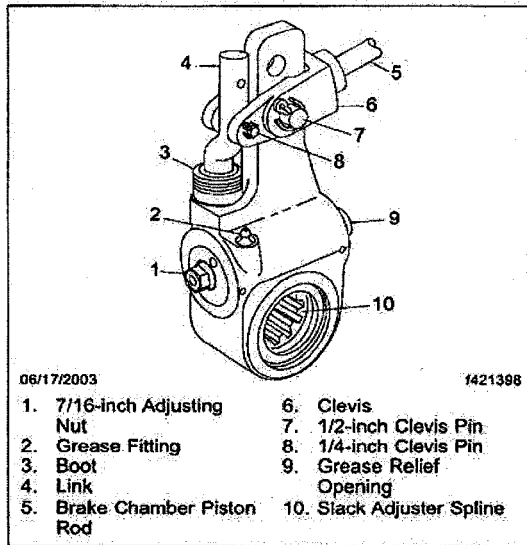


Fig. 11.13, Gunite Automatic Slack Adjuster

Compare the brake chamber stroke with the measurements shown in

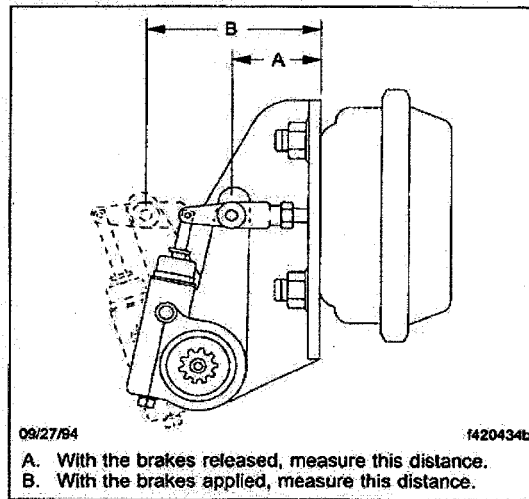


Fig. 11.14, Brake Stroke Check, Gunite Automatic Slack Adjuster

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.

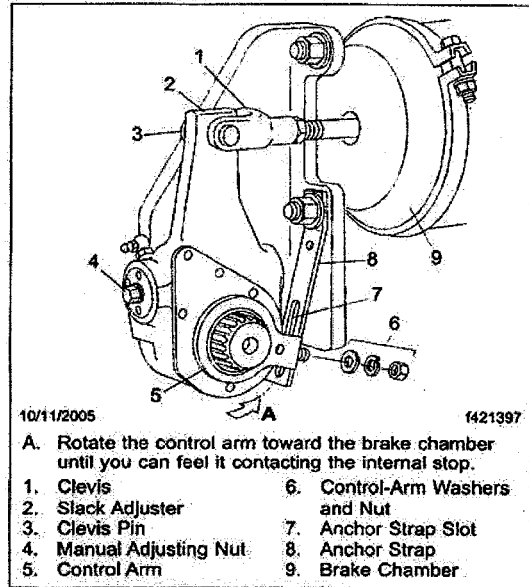


Fig. 11.15, Haldex Automatic Slack Adjuster

Pretrip Inspection and Daily Maintenance

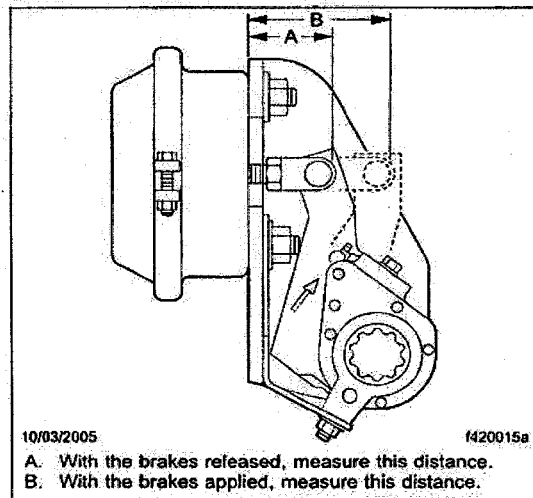


Fig. 11.16, Brake Stroke Check, Haldex Automatic Slack Adjuster

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

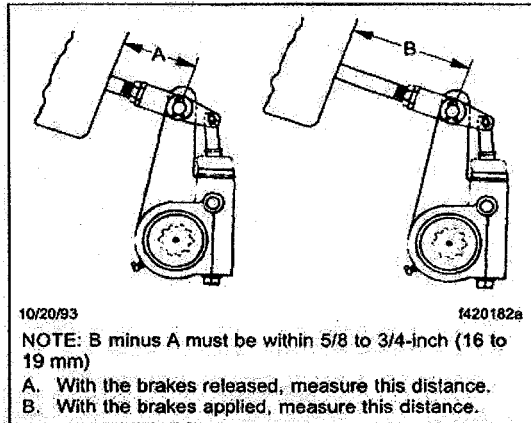


Fig. 11.17, Brake Stroke Check, Meritor Automatic Slack Adjuster

- 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

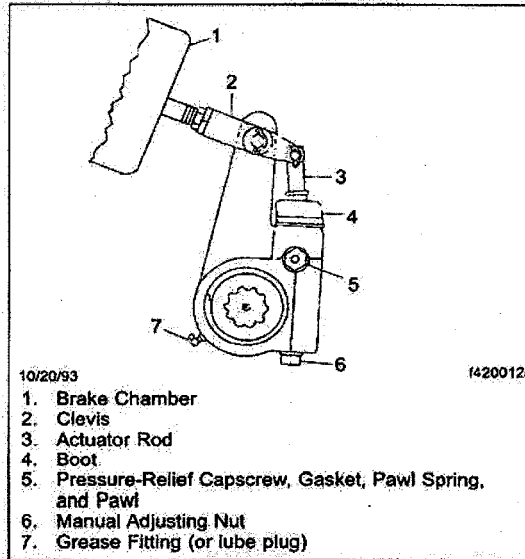


Fig. 11.18, Meritor Automatic Slack Adjuster

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

Pretrip Inspection and Daily Maintenance

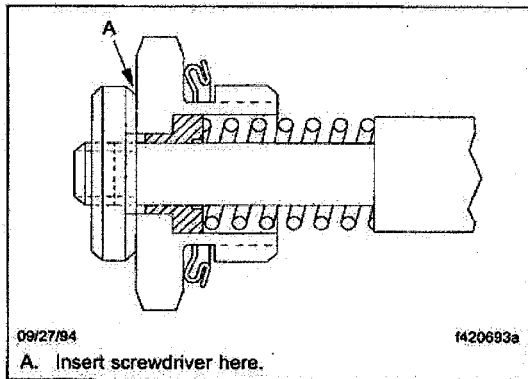


Fig. 11.19, Pull-Pawl Assembly (sectional view)

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-

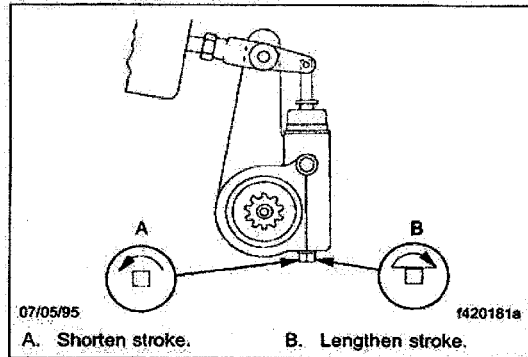


Fig. 11.20, Brake Stroke Adjusting

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.: C80700 DATE OF TEST: 09/11/07

SCHEDULE:

200 stops from 40 MPH (344.8 rpm) @ 10 ft/s/s, IBT
 315-385°F each stop
 200 stops from 40 mph (344.8 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	344	351	2949	5.79	57	-
20	344	350	2965	5.78	62	-
40	344	350	2963	5.76	52	-
60	344	350	2954	5.79	46	-
80	345	351	2960	5.79	44	-
100	345	350	2957	5.80	42	-
101	345	351	2951	5.79	42	-
120	345	351	2952	5.79	41	-
140	345	350	2963	5.78	40	-
160	345	352	2964	5.79	40	-
180	345	351	2963	5.79	39	-
200	345	352	2966	5.79	39	-
		(450-550°F)				
201	344	380	2966	5.77	41	-
220	345	501	2965	5.78	44	-
240	345	501	2952	5.81	42	-
260	345	500	2962	5.80	41	-
280	345	501	2967	5.79	40	-
300	345	501	2961	5.78	39	-
301	345	500	2960	5.79	39	-
320	345	501	2961	5.79	39	-
340	345	501	2965	5.79	38	-
360	345	501	2967	5.75	38	-
380	345	501	2967	5.78	38	-
400	345	501	2967	5.77	38	-

Percent Shoe Contact	LEADING SHOE	80%
	TRAILING SHOE	75%

BRAKE RETARDATION FORCE S5.4.1, S5.4.1.1

VEHICLE NHTSA NO.: C80700

DATE OF TEST: 09/11/07

SCHEDULE:

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

IBT 125-200 °F each stop

Measure torque starting coincident with
required pressure

PERFORMANCE REQUIREMENT:

Retardation ratio as in table below

AIR PRESSURE APPLIED (psi)	RPM	F/M TEMPERATURE (°F)	TORQUE (lb-ft)	STOP TIME (seconds)
20	431	171	1121	19.5
30	431	170	1927	11.1
40	432	171	2745	7.8
50	432	170	3518	6.1
60	432	171	4292	5.0
70	432	171	5155	4.2
80	432	171	6010	3.6

AIR PRESSURE APPLIED (psi)	TORQUE DIVIDED BY STATIC RAD 1.63 feet	FORCE DIVIDED BY LOAD 5847.8 lbs	REQUIRED RETARDATION FORCE QUOTIENT	Pass/Fail	Remarks
20	690	0.12	0.05	PASS	-
30	1186	0.20	0.12	PASS	-
40	1690	0.29	0.18	PASS	-
50	2165	0.37	0.25	PASS	-
60	2641	0.45	0.31	PASS	-
70	3172	0.54	0.37	PASS	-
80	3699	0.63	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: 2008 Volvo Tractor VNM64T

VEHICLE NHTSA NO.: C80700 DATE OF TEST: 09/11/07

SCHEDULE:

Initial Brake Temperature 150 - 200°F
 Speed 50-15 MPH (431 RPM) - (129.3RPM)
 Deceleration 9 ft/s/s for 72 sec intervals
 Speed from 20 MPH (172.4 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	432	151	2572	46	5.92	PASS
2	431	197	2592	45	5.86	PASS
3	431	231	2606	47	5.83	PASS
4	431	258	2607	50	5.83	PASS
5	431	283	2747	51	5.53	PASS
6	431	327	2720	52	5.58	PASS
7	431	355	2687	51	5.65	PASS
8	431	372	2693	49	5.64	PASS
9	432	382	2681	47	5.68	PASS
10	431	398	2677	46	5.67	PASS
	RPM (1 Minute After Snub 10)					
11	173	420	4162	63	0.00	PASS

DATA INDICATES: XXXXXX PASS _____ FAIL

BRAKE RECOVERY S5.4.3

VEHICLE NHTSA NO.: C80700 DATE OF TEST: 09/11/07

SCHEDULE:

Speed 30 mph (258.6 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

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in

STOP No.	RPM	F/M TEMP. (°F)	TORQUE (lb-ft)	AIR PRESSURE (psi)		STOP TIME (sec)	PASS/ FAIL
				MINIMUM	MAXIMUM		
1	259	384	3592	44.6	56.7	3.57	
2	259	386	3589	41.6	57.3	3.57	
3	259	381	3616	39.8	57.8	3.53	
4	259	376	3634	39.4	56.4	3.54	
5	259	371	3603	37.7	56.9	3.55	
6	259	366	3584	36.9	56.1	3.57	
7	259	361	3579	36.8	54.8	3.57	
8	259	358	3549	36.3	54.3	3.61	
9	259	354	3556	36.6	52.1	3.60	
10	259	350	3545	36.6	52.8	3.61	
11	259	347	3565	36.9	53.2	3.58	
12	259	343	3554	36.9	51.9	3.61	
13	259	341	3558	37.4	51.2	3.59	
14	259	338	3571	37.8	51.4	3.60	
15	259	337	3542	38.0	50.6	3.62	
16	259	334	3551	38.2	50.2	3.60	
17	259	333	3539	38.0	50.1	3.63	
18	259	330	3543	39.7	49.7	3.62	
19	259	330	3558	40.0	49.8	3.62	
20	259	328	3527	39.9	48.8	3.62	

DATA INDICATES: N/A PASS N/A FAIL

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

REPORT NUMBER:

N/A

MODEL YEAR/MAKE/MODEL:

2008 Volvo Tractor VNM64T

AXLE:

Meritor FF961 20435232

BRAKE TYPE:

Meritor Q+

DRUM SIZE AND TYPE:

15"x4" Gunitite 3800 3949229

FRICTION MATERIAL:

MG1 4702 CAM FF 05343

AIR CHAMBER:

TYPE 20

SLACK ADJUSTER:

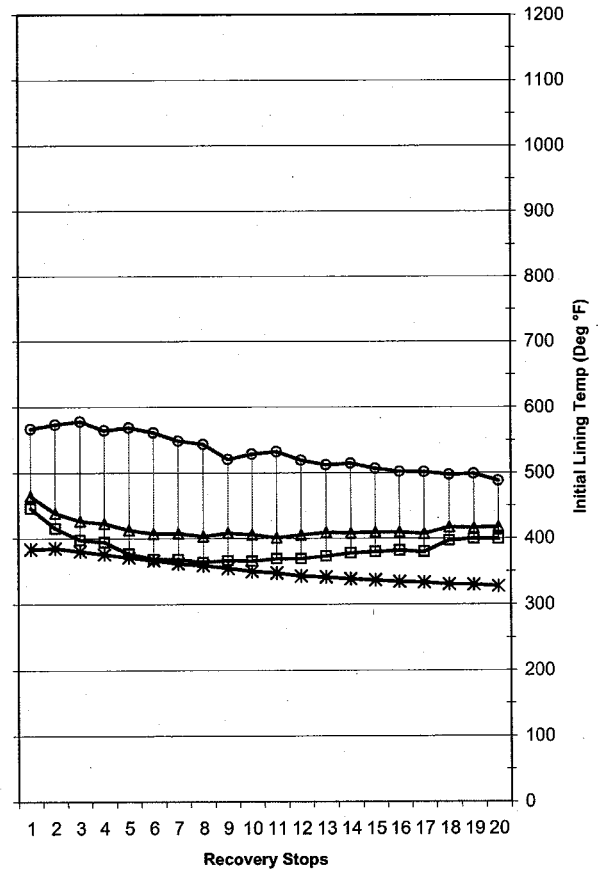
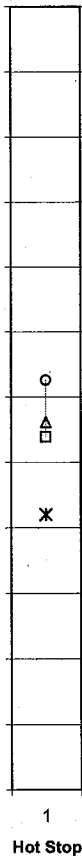
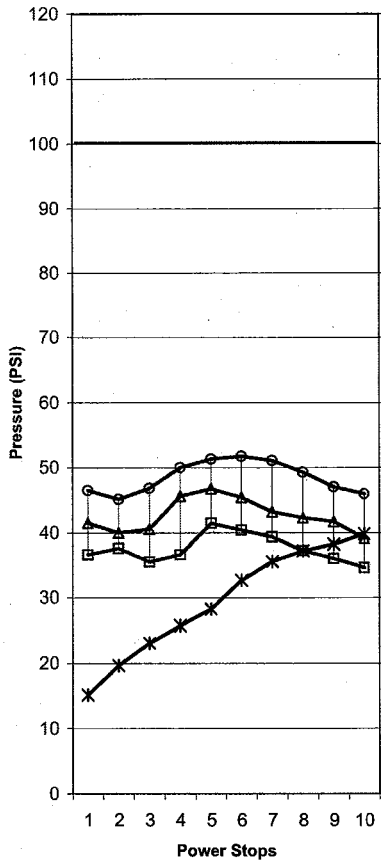
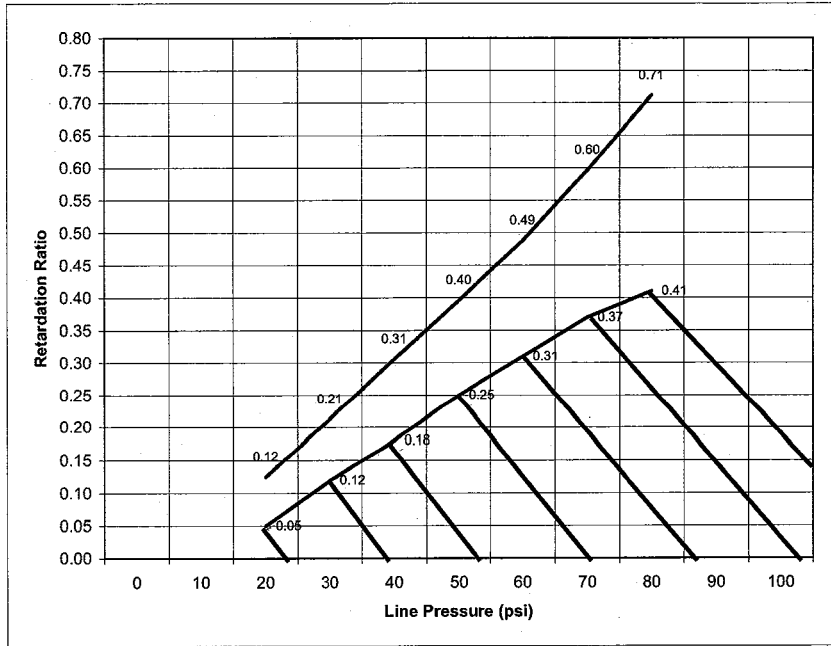
Gunitite 2000 #As1172 5.5" Automatic

GAWR (lbs):

12000

ROLLING RADIUS (in):

19.5



SECTION IV

**TEST EQUIPMENT AND
CALIBRATION RECORDS**

Section IV - INSTRUMENTATION

Testing Equipment

Link Dynamometer No. 84

Description	Serial Number	*Calibration Date	Next Calibration Date
Torque	390	6/4/2007	6/4/2008
Brake Temperature	231748-4	6/4/2007	6/4/2008
Air Pressure	6801439	6/4/2007	6/4/2008
Stroke	34030749	6/4/2007	6/4/2008
Shaft Speed	4020249	6/4/2007	6/4/2008
Air Velocity	0084AS	6/4/2007	6/4/2008

*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

Project Description: Dynamometer 84
 Link Work Order Number: 6-07D084
 Report Number: 904070-6-2007
 Certificate Number: 040202492007
 Calibration File Name: 6-07D084 - 04020249.cal
 Calibration Date: 6/4/2007
 Next Calibration Date: 6/4/2008
 Procedure Used: 3 Rotational Speed Calibration
 Technician: H.FLYNN
 Technician's Initials: H.D.F.

Item Description: Rotational Speed
 Manufacturer: Stegmann
 Condition: Good
 Serial Number: 04020249
 Model Number: CI25
 Instrument Range: 1000 RPM
 Rated Full-Scale: 1000 RPM
 Temperature: 73 °F
 Relative Humidity: 47 %RH
 Calibration Site: Link Facility

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%
300.0	300.0	300.0	300.0	.000%	.000%
600.0	600.0	600.0	600.0	.000%	.000%
800.0	800.0	800.0	800.0	.000%	.000%

	<u>PRE-CAL</u>	<u>POST-CAL</u>
Maximum % of full-scale error observed:	0.000%	0.000%
Maximum % of FSR error allowable (+/-):	1.000%	1.000%

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

Technical Comments:

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.

Calibration Equipment Utilized:

Ref #	Description	Serial Number	Range	Accuracy	Uncertainty	Last Cal	Cal Due
REF.16	DIGITAL TACHOMETER	65409509-2	.1-25000 RPM	+/- 2RPM MAX	+/- 2 RPM	11/17/06	12 MO.

Total Measurement Uncertainty: (+/-) 0.0 RPM

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 Detroit, Mi 48227
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Calibration Performed For:
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 13840 Elmira Ave
 Detroit, Michigan 48227

Project Description: Dynamometer 84
 Link Work Order Number: 6-07D084
 Report Number: 904070-6-2007
 Certificate Number: 0084AS2007
 Calibration File Name: 6-07D084 - 0084AS.cal
 Calibration Date: 6/4/2007
 Next Calibration Date: 6/4/2008
 Procedure Used: 9 Air Velocity Calibration
 Technician: H.FLYNN
 Technician's Initials: H.F.

Item Description: Air Velocity A
 Manufacturer: R.M Young
 Condition: Good
 Serial Number: 0084AS
 Model Number: 27105R
 Instrument Range: 100 MPH
 Rated Full-Scale: 100 MPH
 Temperature: 73 °F
 Relative Humidity: 47 %RH
 Calibration Site: Link Facility

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	5.2	5.0	5.2	.200%	.200%
10.0	9.9	10.0	9.9	-.100%	-.100%
20.0	20.7	20.0	20.7	.700%	.700%
25.0	25.2	25.0	25.2	.200%	.200%

	PRE-CAL	POST-CAL
Maximum % of full-scale error observed:	0.700%	0.700%
Maximum % of FSR error allowable (+/-):	5.000%	5.000%

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

Technical Comments:

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.

Calibration Equipment Utilized:

Ref #	Description	Serial Number	Range	Accuracy	Uncertainty	Last Cal	Cal Due
REF.11	AIR VELOCITY	40-96-05428	40-7800 FPM	+/- .25%FSR	+/- .25 %FS	10/6/06	12 MO

Total Measurement Uncertainty: (+/-) 0.0 MPH

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 Detroit, MI 48227
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Calibration Performed For:
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 13840 Elmira Ave
 Detroit, Michigan 48227

Project Description: Dynamometer 84
 Link Work Order Number: 6-07D084
 Report Number: 904070-6-2007
 Certificate Number: 340307492007
 Calibration File Name: 6-07D084 - 34030749.cal
 Calibration Date: 6/4/2007
 Next Calibration Date: 6/4/2008
 Procedure Used: 6 Distance Calibration
 Technician: H.FLYNN
 Technician's Initials: H.F.

Item Description: Stroke A
 Manufacturer: UniMeasure
 Condition: Good
 Serial Number: 34030749
 Model Number: PA-5-004-NJC
 Instrument Range: 5 in
 Rated Full-Scale: 5 in
 Temperature: 73 °F
 Relative Humidity: 47 %RH
 Calibration Site: Link Facility

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	0.998	1.000	0.999	-.040%	-.020%
2.000	1.998	2.000	2.000	-.040%	.000%
3.000	3.001	3.000	3.000	.020%	.000%
4.000	4.001	4.000	4.000	.020%	.000%

Maximum % of full-scale error observed:	<u>PRE-CAL</u>	<u>POST-CAL</u>
Maximum % of FSR error allowable (+/-):	-0.040%	-0.020%
	1.000%	1.000%

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

Technical Comments:

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.

Calibration Equipment Utilized:

Ref #	Description	Serial Number	Range	Accuracy	Uncertainty	Last Cal	Cal Due
REF:5	6 IN. CALIPER	0033933	0-6 IN.	±.001 IN	±.001 IN	11/21/06	12 MO.
REF:12	GAUGE BLOCK SET	999/99	.0025-2 IN.	GRADE 3	GRADE 3	11/16/06	12 MO.

Total Measurement Uncertainty: (+/-) ERROR: Invalid units of 'in.' for 'range'; the conversion returns zero. 1

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Calibration Performed By:

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 Detroit, MI 48227
 (313) 933-4900

Calibration Performed For:

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 13840 Elmira Ave.
 Detroit, Michigan 48227

Project Description: Dynamometer 84
 Link Work Order Number: 6-07D084
 Report Number: 904070-6-2007
 Certificate Number: 6814392007
 Calibration File Name: 6-07D084 - 681439.cal
 Calibration Date: 6/4/2007
 Next Calibration Date: 6/4/2008
 Procedure Used: 2 Pressure Calibration
 Technician: H.FLYNN
 Technician's Initials: H.F.F.

Item Description: Pressure Air A-End
 Manufacturer: Sensotec
 Condition: Good
 Serial Number: 681439
 Model Number: TJE-3897-05TJG
 Instrument Range: 200 PSI
 Rated Full Scale: 200 PSI
 Temperature: 73 °F
 Relative Humidity: 47 %RH
 Calibration Site: Link Facility

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%
25.1	25.1	25.1	25.1	.000%	.000%
50.0	50.0	50.0	50.0	.000%	.000%
75.0	75.0	75.0	75.0	.000%	.000%
100.1	100.1	100.1	100.1	.000%	.000%

	PRE-CAL	POST-CAL
Maximum % of full-scale error observed:	0.000%	0.000%
Maximum % of FSR error allowable (+/-):	1.000%	1.000%

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

Technical Comments:

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.

Calibration Equipment Utilized:

Ref.#	Description	Serial Number	Range	Accuracy	Uncertainty	Last Cal	Cal Due
REF-3	DISPLAY MODULE	11166-3	9999 COUNTS	1% .05%	INCLUDED COUNTS	11/15/06	12 MO.
REF-6	PRESSURE CELL 200 PSI	852263	200 PSI	1% .25% FSR	1% .25 %FS	11/15/06	12 MO.

Total Measurement Uncertainty: (+/-) 0.0 PSI

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 Detroit, MI 48227
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Calibration Performed For:
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 13840 Elmira Ave
 Detroit, Michigan 48227

Project Description: Dynamometer 84
 Link Work Order Number: 6-070084
 Report Number: 904070-6-2007
 Certificate Number: 231748-42007
 Calibration File Name: 6-070084-231748-4.cal
 Calibration Date: 6/4/2007
 Next Calibration Date: 6/4/2008
 Procedure Used: 4. Temperature Calibration (thermocouple cond.)
 Technician: H. ELYNN
 Technician's Initials: H. D. E.

Item Description: Temperature 1
 Manufacturer: M-Systems
 Condition: Good
 Serial Number: 231748-4
 Model Number: M5TS-24-R/K
 Instrument Range: 2400 °F
 Rated Full-Scale: 2400 °F
 Temperature: 73 °F
 Relative Humidity: 47 %RH
 Calibration Site: Link Facility

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	-1.5	0.0	-1.5	-0.62%	-0.62%
600.0	600.1	600.0	600.1	0.04%	0.04%
1200.0	1200.1	1200.0	1200.1	0.04%	0.04%
1800.0	1800.4	1800.0	1800.4	0.17%	0.17%
2390.0	2389.0	2390.0	2389.0	-0.42%	-0.42%

	PRE-CAL	POST-CAL
Maximum % of full-scale error observed:	-0.062%	-0.062%
Maximum % of FSR error allowable (+/-):	1.000%	1.000%
Pre-Calibration Status:	Instrument met required accuracy	
Post-Calibration Status:	Instrument meets required accuracy	

Technical Comments:

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.

Calibration Equipment Utilized:

Ref #	Description	Serial Number	Range	Accuracy	Uncertainty	Last Cal	Cal Due
REF 4	TEMP	T-135985	210-760.C	±.1 F	±.1 F	11/16/06	12 MO.
REF 14	TEMP/HUMIDITY	H0098286	2-98%	±.3%RH	±.3 %FS	7/25/06	12 MO.

Total Measurement Uncertainty: (+/-) ERROR: Invalid units of '2.98%' for 'range'; the conversion returns ze

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Date: 9/17/2007
 Page: 33 of 39



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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

Project Description: Dynamometer 84
 Link Work Order Number: 6-07D084
 Report Number: 904070-6-2007
 Certificate Number: 390(REV)2007
 Calibration File Name: 6-07D084 - 390(REV).cal
 Calibration Date: 6/4/2007
 Next Calibration Date: 6/4/2008
 Procedure Used: 1 Torque Calibration
 Technician: H. FLYNN
 Technician's Initials: H.F.

Item Description: Torque A-End Reverse
 Manufacturer: Lebow
 Condition: Good
 Serial Number: 390(REV)
 Model Number: 3157
 Instrument Range: 10000 lb
 Rated Full-Scale: 20000 lb-ft
 Temperature: 73 °F
 Relative Humidity: 47 %RH
 Calibration Site: Link Facility

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
0.0	0.0	0.0	0.0	.000%	.000%
3061.1	3039.5	3061.1	3039.5	-1.08%	-1.08%
7065.2	7013.2	7065.2	7013.2	-2.60%	-2.60%
10126.8	10054.5	10126.8	10054.5	-3.61%	-3.61%
15458.8	15365.4	15458.8	15365.4	-4.67%	-4.67%

	PRE-CAL	POST-CAL
Maximum % of full-scale error observed:	-0.467%	-0.467%
Maximum % of FSR error allowable (+/-):	1.000%	1.000%
Pre-Calibration Status:	Instrument met required accuracy	
Post-Calibration Status:	Instrument meets required accuracy	

Technical Comments:

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.

Calibration Equipment Utilized:

Ref #	Description	Serial Number	Range	Accuracy	Uncertainty	Last Cal	Cal Due
REF-3	DISPLAY MODULE	11165-3	9999 COUNTS	+/- .05%	INCLUDED COUNTS	11/15/06	12 MO.
REF-10	LOAD CELL 3000 LB	87781	3000 LB	+/- .05%FS	+/- .05%FS	11/15/06	12 MO.

Total Measurement Uncertainty: (+/-) ERROR: Missing Length and/or Force

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Calibration Performed By:

Certificate of Calibration

Date: 9/17/2007

Calibration Performed For:

Page: 34 of 39

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

Project Description: Dynamometer 84
 Link Work Order Number: 6-07D084
 Report Number: 904070-6-2007
 Certificate Number: 390(FWD)2007
 Calibration File Name: 6-07D084-390(FWD).cal
 Calibration Date: 6/4/2007
 Next Calibration Date: 6/4/2008
 Procedure Used: 1 Torque Calibration
 Technician: H.FLYNN
 Technician's Initials: H.F.

Item Description: Torque A-End Forward
 Manufacturer: Lebow
 Condition: Good
 Serial Number: 390(FWD)
 Model Number: 3157
 Instrument Range: 10000 lb
 Rated Full Scale: 20000 lb-ft
 Temperature: 73 °F
 Relative Humidity: 47 %RH
 Calibration Site: Link Facility

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
0.0	0.0	0.0	0.0	.000%	.000%
3059.5	3055.4	3146.0	3151.6	-.021%	.028%
7070.2	7070.8	7093.0	7094.0	.003%	.005%
10187.3	10197.2	10204.7	10203.4	.050%	-.006%
15151.1	15192.0	15109.9	15111.8	.205%	.009%

	PRE-CAL	POST-CAL
Maximum % of full-scale error observed:	0.205%	0.028%
Maximum % of FSR error allowable (+/-):	1.000%	1.000%
Pre-Calibration Status:	Instrument met required accuracy	
Post-Calibration Status:	Instrument meets required accuracy	

Technical Comments:

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.

Calibration Equipment Utilized:

Ref #	Description	Serial Number	Range	Accuracy	Uncertainty	Last Cal	Cal Due
REF-3	DISPLAY MODULE	11166 3	9999 COUNTS	+/- .05%	INCLUDED COUNTS	11/15/06	12 MO.
REF-10	LOAD CELL 3000 LB	97781	3000 LB	+/- .05%FS	+/- .06%FS	11/18/06	12 MO.

Total Measurement Uncertainty: (+/-) ERROR: Missing Length and/or Force

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SECTION V
DYNAMOMETER
BRAKE ASSEMBLY
SET UP
PHOTOGRAPHS

Thermocouple Installation

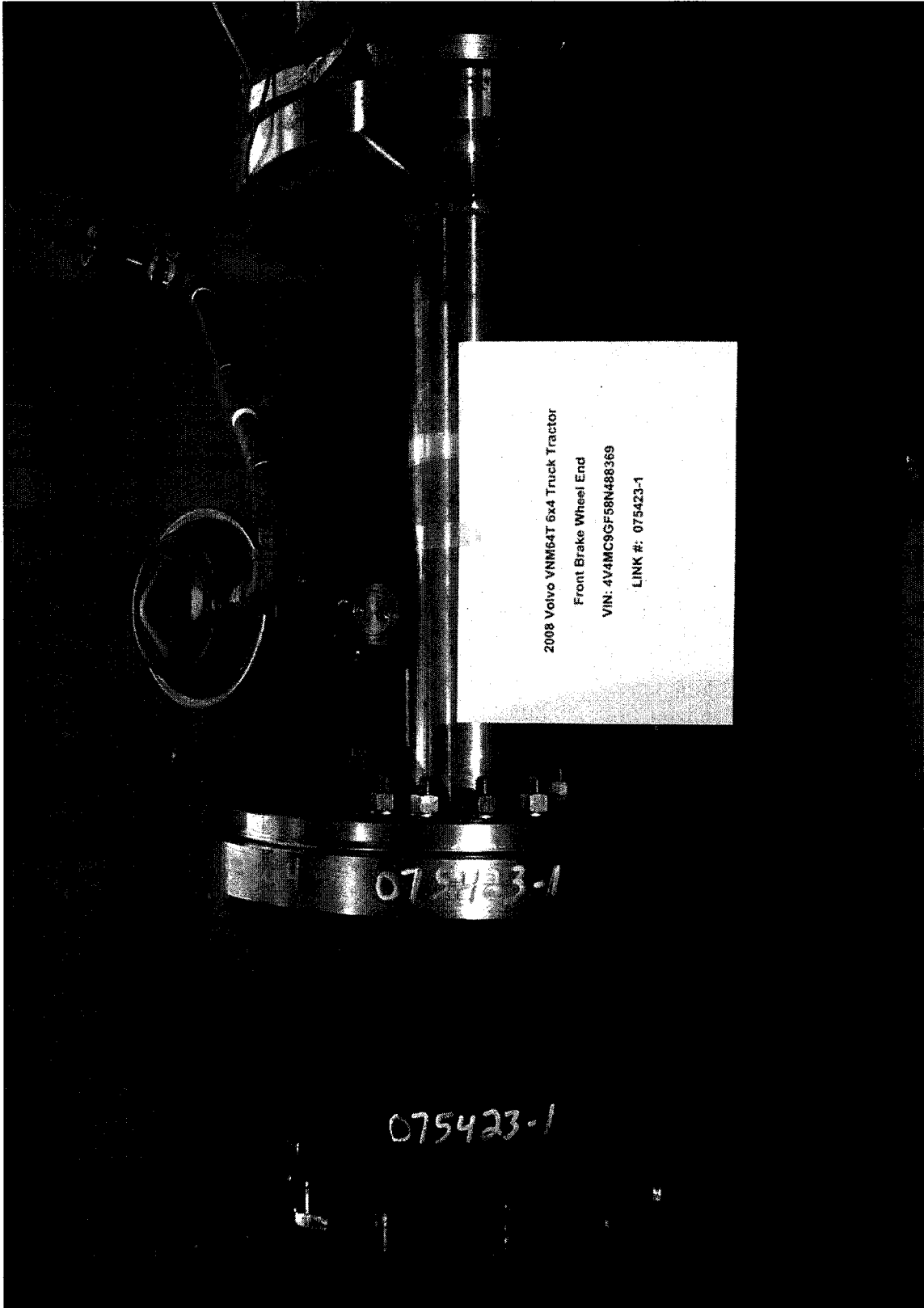
2008 Volvo VNM64T 6x4 Truck Tractor

Front Brake Wheel End

VIN: 4V4MC9GF58N488369

LINK #: 075423-1

Dynamometer Setup



Dynamometer Setup



Thermocouple Installation



2008 Volvo VNM64T 6x4 Truck Tractor

Front Brake Wheel End

VIN: 4V4MC9GF58N488369

LINK #: 075423-1

Dynamometer Setup



2008 Volvo VNM64T 6x4 Truck Tractor
Front Brake Wheel End
VIN: 4V4MC9GF58N488369
LINK #: 075423-1

Dynamometer Setup

