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: [Signature]

Approved By: [Signature]

Approval Date: January 4, 2007

FINAL REPORT ACCEPTANCE BY OVSC:

Accepted By: [Signature]

Acceptance Date: 1/9/2007
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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NHTSA Technical Reference Division
Mail Code: NAD-52, Room 5108
400 Seventh Street, SW
Washington, DC 20590
Telephone No.: 202-366-4946
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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

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

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<td>55</td>
<td>63</td>
<td>PASS</td>
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SECTION III

TEST DATA
SPECIFICATIONS


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
FRICITION 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: ___________________________
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 check 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.
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Fig. 11.13, Gunite Automatic Slack Adjuster

Compare the brake chamber stroke with the measurements shown in

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.
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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 stack adjuster. See Group 42 of the Columbia® Workshop Manual for instructions to adjust the Gunite stack adjuster.

<table>
<thead>
<tr>
<th>Chamber Size</th>
<th>Maximum Allowable Stroke</th>
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</thead>
<tbody>
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<td>Chamber Size</td>
<td>Maximum Allowable Stroke:</td>
</tr>
<tr>
<td>inches (mm)</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>1-3/4 (44)</td>
</tr>
<tr>
<td>16 (long stroke)*</td>
<td>2 (51)</td>
</tr>
<tr>
<td>20</td>
<td>1-3/4 (44)</td>
</tr>
<tr>
<td>20 (long stroke)</td>
<td>2 (51)</td>
</tr>
<tr>
<td>24</td>
<td>2 (51)</td>
</tr>
<tr>
<td>24 (long stroke)</td>
<td>2-1/2 (64)</td>
</tr>
<tr>
<td>30</td>
<td>2 (51)</td>
</tr>
<tr>
<td>30 (long stroke)</td>
<td>2-1/2 (64)</td>
</tr>
</tbody>
</table>

Table 11.1, Maximum Allowable Brake Chamber Stroke

33.2 For Haldex Slack Adjusters:
Inspect each stack 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

* Long stroke design is indicated by a lap, or embossing, on the brake chamber.
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-pinion hole. See Fig. 11.16, Ref. A.

Fig. 11.15, Haldex Automatic Slack Adjuster
• 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.
**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 lb./ft. (20 to 27 N·m) or, remove the screwdriver from the pull-pawl assembly (if equipped).

Check for correct brake chamber stroke:

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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 indicated 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).

Fig. 11.20, Brake Stroke Adjusting

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- 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

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Percent Shoe Contact

LEADING SHOE TRAILING SHOE

85% 85%
BRAKE RETARDATION FORCE S5.4.1, S5.4.1.1

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

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

<table>
<thead>
<tr>
<th>AIR PRESSURE APPLIED (psi)</th>
<th>RPM</th>
<th>F/M TEMPERATURE (°F)</th>
<th>TORQUE (lb-ft)</th>
<th>STOP TIME (seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>437</td>
<td>170</td>
<td>1532</td>
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</table>

<table>
<thead>
<tr>
<th>AIR PRESSURE APPLIED (psi)</th>
<th>TORQUE DIVIDED BY STATIC RAD 1.60 feet</th>
<th>FORCE DIVIDED BY LOAD 9999.3 lbs</th>
<th>REQUIRED RETARDATION FORCE QUOTIENT</th>
<th>Pass/Fail</th>
<th>Remarks</th>
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<tbody>
<tr>
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DATA INDICATES: XXXXX PASS _________ FAIL
# BRAKE POWER S5.4.2, S5.4.2.1, S5.4.2.2

**VEHICLE 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) - (131 RPM)
- 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

<table>
<thead>
<tr>
<th>SNUB OR STOP</th>
<th>RPM</th>
<th>F/M TEMP. (°F)</th>
<th>TORQUE (lb-ft)</th>
<th>MAXIMUM AIR PRESSURE (psi)</th>
<th>STOP TIME (sec)</th>
<th>PASS/FAIL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>436</td>
<td>149</td>
<td>4436</td>
<td>52</td>
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</table>

| RPM (1 Minute After Snub 10) | 176 | 428 | 6665 | 87 | 2.14 | PASS |

**DATA INDICATES:** XXXXXXXX PASS  

**FAIL**

*Date: 1/4/2007  
Page: 24 of 38*
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:

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<th>Min.</th>
<th>Max.</th>
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<td>w/o Antilock</td>
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<td>w/ Antilock</td>
<td>12 psi</td>
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<th>F/M TEMP. (°F)</th>
<th>TORQUE (lb-ft)</th>
<th>AIR PRESSURE (psi) MINIMUM</th>
<th>MAXIMUM</th>
<th>STOP TIME (sec)</th>
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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

FRICITION 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

<table>
<thead>
<tr>
<th>Description</th>
<th>Serial Number</th>
<th>*Calibration Date</th>
<th>Next Calibration Date</th>
</tr>
</thead>
</table>

*Calibration By Matthew J. Curtis
## Certificate of Calibration

### Calibration Performed By
Link Testing Laboratories
13840 Elmira Ave.
Detroit, MI 48227
(313) 833-4900

### 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:

### Technician:
M. Curtis

### Signature:
[Signature]

### Calibration

<table>
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<th>Standard Value (lb-ft)</th>
<th>Initial &quot;As Found&quot; Value (lb-ft)</th>
<th>Calibration Standard Value (lb-ft)</th>
<th>Final Calibrated Value (lb-ft)</th>
<th>Initial Percent (% of Full Scale Range (FSR) Error)</th>
<th>Final Percent (% of Full Scale Range (FSR) Error)</th>
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### Description:
Torque Fwed.

### Manufacturer:
Lebow

### Condition:
Good

### Serial Number:
3852(F)

### Model Number:
312A

### Instrument Range:
15000 lb

### Rated Full Scale:
200 Kib-in

### Temperature:
72 F

### Relative Humidity:
40 %

---

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% %FS +/- .05 11/7/2005 12 MO.

REF.10 LOAD CELL 3000 Lb 97761 3000 Lb +/- .005%FS %FS +/- .05 11/7/2005 12 MO.

---

11-21-2006
Page 28 of 33
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Link Engineering Company Calibration System 3.7.11
service@linkeng.com

Date: 1/4/2007
Page: 29 of 38
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

Description: Temperature1
Manufacturer: Link Engineering
Condition: Good
Serial Number: 0088TEMP1
Model Number: 1484-CAQ-CAV
Instrument Range: 1402 °F
Rated Full-Scale: 1400 °F
Temperature: 72 °F
Relative Humidity: 40 %

Machine Description: Dynamometer 68
Report Number: D0068-6-2006
Certificate Number: 0008TEMP12006
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
Signature: [Signature]

<table>
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<th>Calibration Standard Value (°F)</th>
<th>Initial &quot;As Found&quot; Value (°F)</th>
<th>Calibration Standard Value (°F)</th>
<th>Final Calibrated Value (°F)</th>
<th>Initial Percent (%) of Full Scale Range (FSR) Error</th>
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<td>0.021%</td>
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</table>

Maximum % of Full-scale error observed: PRE-CAL 0.1430%  POST-CAL 0.0600%, Maximum % of FSR error allowable (+/-): PRE-CAL 1.0000%, POST-CAL 1.0000%

Pre-Calibration Status: Instrument not 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:4 TEMP T-135585 -210-760 °C +1 °F +1 °F 11/17/2005 12 NOV.

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Link Engineering Company Calibration System 3.7.11
service@linkeng.com

Date: 1/4/2007
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Certificate of Calibration

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

Machine Description: Dynamometer 68
Report Number: D0068-8-2006
Certificate Number: 786982008
Calibration Date: 6/10/2006
Next Calibration Date: 6/10/2007
Procedure Used: 2 Pressure Calibration
Procedure Date: 6/16/2006
Technician: M. Curtis
Signature: [Signature]

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 0.00% 0.00%
24.2 24.1 24.8 24.9 -.05% .05%
30.0 49.9 49.7 49.7 -.05% .05%
75.1 74.8 74.8 74.8 -.15% .15%
117.5 116.7 117.5 117.2 -.40% .15%

Maximum % of full-scale error observed: PRE-CAL -.40000% POST-CAL -.15000%
Maximum % of FSR error allowable (+/-): 1.00000%
Pre-Calibration Status: Instrument met required accuracy
Post-Calibration Status: Instrument met 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 Cat Due
REF:3 DISPLAY MODULE 13344-1 9999 COUNTS +.28% +.28% FSR 11/7/2005 12 MO.
REF:8 PRESSURE CELL 200 PSI 582203 200 PSI +.05% +.05% FSR 11/7/2005 12 MO.

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<table>
<thead>
<tr>
<th>Calibration Standard Value (in)</th>
<th>Initial &quot;As Found&quot; Value (in)</th>
<th>Calibration Standard Value (in)</th>
<th>Final Calibrated Value (in)</th>
<th>Initial Percent (%) of Full Scale Range (FSR) Error</th>
<th>Final Percent (%) of Full Scale Range (FSR) Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>.000%</td>
<td>.000%</td>
</tr>
<tr>
<td>1.000</td>
<td>0.997</td>
<td>1.000</td>
<td>0.995</td>
<td>-.020%</td>
<td>-.000%</td>
</tr>
<tr>
<td>2.000</td>
<td>2.095</td>
<td>2.000</td>
<td>2.000</td>
<td>.050%</td>
<td>.000%</td>
</tr>
<tr>
<td>3.000</td>
<td>3.017</td>
<td>3.000</td>
<td>3.000</td>
<td>.170%</td>
<td>.000%</td>
</tr>
</tbody>
</table>

Maximum % of full scale error observed:
PRE-CAL: 0.1700%
POST-CAL: 0.0600%

Maximum % of FSR error allowable (+/-):
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.

<table>
<thead>
<tr>
<th>Ref #</th>
<th>Description</th>
<th>Serial Number</th>
<th>Range</th>
<th>Accuracy</th>
<th>Uncertainty</th>
<th>Last Cal</th>
<th>Cal Due</th>
</tr>
</thead>
<tbody>
<tr>
<td>REF.5</td>
<td>6 IN CALIPER</td>
<td>33333</td>
<td>0-6 IN</td>
<td>+/- .001 IN</td>
<td>+/- .001</td>
<td>11/7/2006</td>
<td>12 MO.</td>
</tr>
</tbody>
</table>

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## 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:** 00066-6-2006  
**Certificate Number:** 962006682006  
**Calibration Date:** 6/16/2006  
**Next Calibration Date:** 6/16/2007  
**Procedure Used:** 3 Rotational Speed Calibration  
**Technician:** M. Curtis  
**Signature:** [Signature]

<table>
<thead>
<tr>
<th>Calibration Standard Value (RPM)</th>
<th>Initial &quot;As Found&quot; Value (RPM)</th>
<th>Calibration Standard Value (RPM)</th>
<th>Final Calibrated Value (RPM)</th>
<th>Initial Percent (%) of Full Scale Range (FSR) Error</th>
<th>Final Percent (%) of Full Scale Range (FSR) Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>500.0</td>
<td>50.0</td>
<td>500.0</td>
<td>500.0</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>1250.0</td>
<td>250.5</td>
<td>1250.0</td>
<td>1250.0</td>
<td>0.04%</td>
<td>0.04%</td>
</tr>
<tr>
<td>2500.0</td>
<td>500.0</td>
<td>2500.0</td>
<td>2500.0</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>750.0</td>
<td>749.0</td>
<td>750.0</td>
<td>749.0</td>
<td>-0.83%</td>
<td>-0.83%</td>
</tr>
</tbody>
</table>

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

**POST-CAL**  
- Maximum % of full-scale error observed: 0.0000%  
- Maximum % of FSR error allowed (+/-): 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.

### Reference Table

<table>
<thead>
<tr>
<th>Ref#</th>
<th>Description</th>
<th>Serial Number</th>
<th>Range</th>
<th>Accuracy</th>
<th>Uncertainty</th>
<th>Last Cal</th>
<th>Cal Due</th>
</tr>
</thead>
<tbody>
<tr>
<td>REF.24</td>
<td>Non-Contact Digital Tachometer</td>
<td>1396-147</td>
<td>100000 RPM</td>
<td>+/- .01%</td>
<td>+/- .01%</td>
<td>4/22/2006</td>
<td>12 MO.</td>
</tr>
</tbody>
</table>

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Link Engineering Company Calibration System 3.7.11  
service@linkeng.com

Date: 1/4/2007  
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# 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:** DO68-6-2006  
  - **Certificate Number:** 0068AS2006  
  - **Calibration Date:** 6/16/2006  
  - **Next Calibration Date:** 6/16/2007  
  - **Procedure Used:** Air Velocity Calibration  
  - **Technician:** M. Curtis  
  - **Description:** Air Velocity  
  - **Manufacturer:** R M Young  
  - **Condition:** Good  
  - **Serial Number:** 0068AS  
  - **Model Number:** 270SR  
  - **Instrument Range:** 50 MPH  
  - **Rated Full Scale:** 185 MPH  
  - **Temperature:** 72 F  
  - **Relative Humidity:** 40 %  
  - **Signature:** [Signature]

<table>
<thead>
<tr>
<th>Calibration Standard Value (MPH)</th>
<th>Initial &quot;As Found&quot; Value (MPH)</th>
<th>Calibration Standard Value (MPH)</th>
<th>Final Calibrated Value (MPH)</th>
<th>Initial Percent (%) of Full Scale Range (FSR) Error</th>
<th>Final Percent (%) of Full Scale Range (FSR) Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>-0.000%</td>
<td>-0.000%</td>
</tr>
<tr>
<td>5.0</td>
<td>4.5</td>
<td>5.0</td>
<td>5.2</td>
<td>-0.270%</td>
<td>-0.100%</td>
</tr>
<tr>
<td>10.0</td>
<td>9.4</td>
<td>10.0</td>
<td>10.0</td>
<td>-0.324%</td>
<td>-0.000%</td>
</tr>
<tr>
<td>20.0</td>
<td>19.0</td>
<td>20.0</td>
<td>19.9</td>
<td>-0.543%</td>
<td>-0.054%</td>
</tr>
<tr>
<td>25.0</td>
<td>24.1</td>
<td>25.0</td>
<td>25.0</td>
<td>-0.486%</td>
<td>-0.000%</td>
</tr>
</tbody>
</table>

**Pre-CAL**  
Maximum % of full-scale error observed: -0.5410%  
Maximum % of FSR error allowable (+/-): 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  
REF.11 AIR VELOCITY  

<table>
<thead>
<tr>
<th>Ref#</th>
<th>Description</th>
<th>Serial Number</th>
<th>Range</th>
<th>Accuracy</th>
<th>Uncertainty</th>
<th>Last Cal</th>
<th>Cal Due</th>
</tr>
</thead>
<tbody>
<tr>
<td>REF.11</td>
<td>AIR VELOCITY</td>
<td>40-06-05425</td>
<td>40-7800 FPM</td>
<td>+/- .25%FSR</td>
<td>% FSR +/- .25</td>
<td>6/30/2006</td>
<td>12 MO.</td>
</tr>
</tbody>
</table>

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SECTION V

DYNAMOMETER
BRAKE ASSEMBLY
SET UP
PHOTOGRAPHS
Dynamometer Setup
Dynamometer Setup