



## CONTENTS

Scope of this Manual . . . . .	3
Unpacking and Inspection . . . . .	3
Packing List . . . . .	3
System Description . . . . .	3
System Configuration . . . . .	3
Specifications . . . . .	3
Theory of Operation . . . . .	4
Measuring Body Leakage . . . . .	4
Glossary of Terms . . . . .	4
Preliminary Steps . . . . .	4
Body Leakage Tester Setup . . . . .	4
Leakage Measurement . . . . .	5
Body Leakage Tester Shutdown . . . . .	5
Operation in Vacuum Mode . . . . .	6
System Check Using the Calibration Check Ring . . . . .	6
Calibration Check Ring Values . . . . .	6
Calibration Check Procedure . . . . .	6
Maintenance . . . . .	7
Maintenance Schedule . . . . .	7
Repair Parts for FDD-TMM-400 (400 SCFM, 110V AC) . . . . .	7
System Calibration . . . . .	8
Differential Pressure Gauge Calibration . . . . .	8

## SCOPE OF THIS MANUAL

This manual describes how to install and program the Body Leakage Tester (Tester). The electronic version of this manual is available on our website at [www.badgermeter.com](http://www.badgermeter.com). This manual does not eliminate the need for technician training and management oversight of the process.

### IMPORTANT

*Read this manual carefully before attempting any installation or operation. Keep the manual in an accessible location for future reference.*

## UNPACKING AND INSPECTION

Upon opening the shipping container, visually inspect the product and applicable accessories for any physical damage such as scratches, loose or broken parts, or any other sign of damage that may have occurred during shipment.

**NOTE:** If damage is found, request an inspection by the carrier's agent within 48 hours of delivery and file a claim with the carrier. **A claim for equipment damage in transit is the sole responsibility of the purchaser.**

### Packing List

Item	Qty.	Description
1	1	BLT Flow Stand (Includes Two Filters and Filter Housing)
2	1	Window Adapter
3	1	Stethoscope
4	25 ft	Power Extension Cord
5	1	Pressure Sample Tube
6	1	Exit Duct
7	10 ft	Flexible Duct
8	2	Hose Support (Hanger)
9	1 set	Hole Plug Handle
10	1	Calibration Ring
11	3	4-1/2 in. ~ 7 in. Clamps
12	10 ft	1/4 in. I.D. Tygon R3603 Tube

## SYSTEM DESCRIPTION

The Tester checks automotive bodies for air leakage into or out of the vehicle cabin. The Tester determines the rate of air leakage from the cabin under both pressure and vacuum conditions. The Tester also checks body components, such as doors and windows, with the use of custom adapters.

The Tester uses a *Variable Speed Drive* attached to an *Air Blower* to produce air flow. The rate of flow is measured by a *Mass Air Flow Sensor*. The rate displays in Standard Cubic Feet per Minute (SCFM). The air flow is directed into the vehicle body by a *Flexible Hose* and a *Window Adapter*. A *Differential Pressure Gauge* measures the difference in pressure between the vehicle cabin and the ambient environment. A *Calibration Check Ring* is provided to periodically check the accuracy of the Tester.

### System Configuration

#### Mechanical Components

- Air Blower
- Differential Pressure Gauge
- Flexible Hose
- Calibration Check Ring
- Window Adapter
- Inlet Filter
- Pressure Averaging Wand

#### Electronic Components

- Mass Air Flow Sensor
- Digital Flow Rate Display
- Flow Computer
- Variable Speed Drive
- Electronic Power Supply

## SPECIFICATIONS

<b>Fluid</b>	Air
<b>Range</b>	5...400 SCFM (5...500 SCFM Optional)
<b>Differential Pressure</b>	0.1...1 INWC (0.1...3 INWC Optional)
<b>Uncertainty</b>	2% Full Scale
<b>Ambient Operating Temperature</b>	40...120° F (4...49° C)

**NOTE:** NVLAP accreditation applies only to the Badger Meter Flow Dynamics calibration lab, located in Racine, Wisconsin.



## THEORY OF OPERATION

The air flow from the Body Leakage Tester is produced by a rotating *Air Blower* in the bottom of the Tester. The *Air Blower* is directly connected to an AC motor with a variable speed control. As the motor speed increases, the *Air Blower* speed of rotation increases, resulting in higher air flow.

An *Inlet Filter* on the *Air Blower* removes particles from the air before it is directed through the flow element and into the vehicle.

The air flow is directed from the *Air Blower* to the flow measuring element by the connecting boot. The boot is a molded rubber coupler designed to connect the *Air Blower* and flow element to prevent any air leakage.

The flow measuring element in the Tester is a thermal *Mass Air Flow Sensor*. The flow element operates on the principle of heat transfer. A current is applied to the wire element in the sensor, which heats the wire. As air flows across the sensor, heat is transferred from the sensor to the air, cooling the wire. The cooling changes the resistance of the wire. The resistance is measured with a bridge circuit and converted by the sensor's electronics into a frequency. The frequency is proportional to the mass flow across the sensor. This frequency relationship is non-linear, so it must be linearized with a flow computer.

The *Mass Air Flow Sensor* sends the frequency output to the *Flow Computer*, which is programmed with the non-linear calibration data for the specific flow sensor installed in the Tester. The *Flow Computer* measures the output frequency of the *Mass Air Flow Sensor*, then uses the calibration data for the sensor to calculate the current flow rate. This calculated flow rate is converted to a linear frequency, which is used to drive the *Digital Flow Rate Display*.

The *Digital Flow Rate Display* converts the linear frequency output of the *Flow Computer* into flow rate in Standard Cubic Feet per Minute (SCFM).

The *Differential Pressure Gauge* indicates the difference between the vehicle body and the ambient atmosphere. The *Differential Pressure Gauge* is usually connected to the *Pressure Averaging Wand*. The wand averages the pressure inside the vehicle cabin to provide a better representation of the difference in pressure.

## MEASURING BODY LEAKAGE

The following sections describe how to set up the Tester, initiate flow and take readings from a typical automobile.

### Glossary of Terms

#### SCFM

Standard Cubic Feet per Minute is a measurement of flow rate. A standard cubic foot is the volume the gas (air) occupies at a standard temperature and pressure. In this case, 14.7 PSIA and 70° F.

#### INWC

Inches of water (IN) in a water column (WC) The units are a measurement of small pressure differences.

#### Differential Pressure

The difference in air pressure between the inside of the vehicle and the outside, expressed in inches of water.

#### Inches of Water

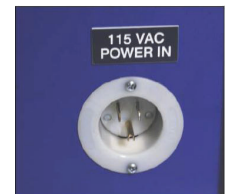
A unit of pressure measurement. One inch of water is the pressure exerted by a column of water one inch high at the reference temperature condition. In this case, 39° F.

### Preliminary Steps

- Read through this procedure completely before beginning.
- Familiarize yourself with the Tester. Identify each of the components called out in this procedure before beginning.
- Be sure to know and follow all safety requirements before beginning.

## BODY LEAKAGE TESTER SETUP

1. Connect the power cable between the Tester and the power outlet.

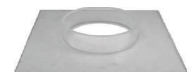


2. Move the Tester *Fan Start* switch, located on the front panel, to the ON position.



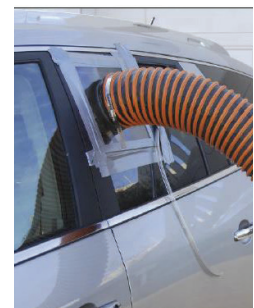
**NOTE:** Allow the Tester to warm up for 15 minutes before taking measurements.

3. Connect the *Window Adapter* to the vehicle window using a vehicle-specific adapter plate.



#### NOTE:

The supplied *Window Adapter* is a generic adapter that provides the necessary connections for operation of the Tester. Each vehicle requires a vehicle-specific adapter plate between the *Window Adapter* and the window frame. These vehicle-specific adapters are user-supplied items and are not provided with the Tester.



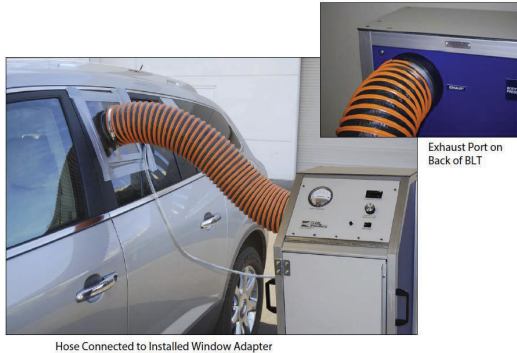
4. Place the *Pressure Averaging Wand* in the vehicle cabin.



- Connect a section of pressure tubing between the *Pressure Averaging Wand* and the *INLET Body Pressure* port on the Tester.



- Connect the 6 in. tester hose between the *Window Adapter* and the Tester *EXHAUST* port.



Hose Connected to Installed Window Adapter

## LEAKAGE MEASUREMENT

- Slowly turn the *Variable Fan Speed Adjust* knob to the right. The *Air Blower* starts turning and air is directed into the vehicle.



- Continue to turn the *Variable Fan Speed Adjust* knob to the right to increase the air flow into the vehicle. As the speed increases, the *Body Pressure* gauge starts to indicate a difference in pressure between the inside and outside of the vehicle.



- Increase the flow until the desired differential pressure displays on the *Differential Pressure Gauge*. The digital display indicates the flow rate in SCFM. The flow rate is the total leakage from the vehicle cabin at the indicated differential pressure.



- Use the stethoscope to help pinpoint areas of leakage.



## BODY LEAKAGE TESTER SHUTDOWN

- Turn the *Variable Fan Speed Adjust* knob to the left to stop the flow of air into the vehicle.



- Remove the 6 in. tester hose from the Tester and the *Window Adapter*. Store the hose on the Tester's hose holder.



- Remove the pressure tubing from the Tester and the *Window Adapter*. Store the tubing in the Tester's storage cabinet.
- Disconnect the *pressure tubing* from the *Window Adapter* and the *Pressure Averaging Wand*. Store the tubing and the wand in the Tester's cabinet.
- Remove the *Window Adapter* from the vehicle. Store the adapter in the Tester's storage cabinet.



- Turn *Fan Start* switch to the OFF position. Disconnect the power cord and store it in the Tester's storage cabinet.





## OPERATION IN VACUUM MODE

Operate the Tester in *Vacuum* mode to produce a negative pressure inside the vehicle. The preliminary setup is the same as described above with the exception of connecting the *pressure tubing* and *6 in. tester hose* to the Tester.

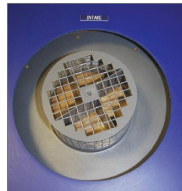
1. Connect a section of *pressure tubing* between the outside of the *Window Adapter* and the *AMBIENT Body Pressure* port on the Tester.



2. Remove the nut from the *Inlet Filter* retainer plate and remove the filter elements from the Tester.



3. Connect the 6 in. tester hose between the *Window Adapter* and the Tester's *INTAKE* port.



4. Perform leakage measurements as described in the pressurized test previously.

5. When measurements are complete, shut down the Tester. See "*Body Leakage Tester Shutdown*" on page 5.

## SYSTEM CHECK USING THE CALIBRATION CHECK RING

The *Calibration Check Ring* provides a quick and easy means of confirming the Tester's accuracy without requiring a flow or pressure measurement standard. **Each Calibration Check Ring is matched by serial number to a particular Tester. They are not interchangeable.** The ring provides a known restriction in air flow that can be used to verify that the flow and differential pressure measurements of the Tester are still performing the same as when they were calibrated at the factory.

### Calibration Check Ring Values

Pressure (H <sub>2</sub> O)	Nominal Volume Flow Rate (SCFM)	Acceptable Range -2% FS (SCFM)	Acceptable Range +2% FS (SCFM)
0.1	114.1	106.1	122.1
0.2	159.6	151.6	167.6
0.3	194.5	186.5	202.5
0.4	223.3	215.3	231.3
0.5	249.6	241.6	257.6
0.6	269.9	261.9	277.9
0.7	292.7	284.7	300.7
0.8	312.3	304.3	320.3
0.9	333.1	325.1	341.1
1.0	353.6	345.6	361.6

Each Tester and *Calibration Check Ring* have unique values for Nominal Flow Rate and Acceptable Range.

## Calibration Check Procedure

1. Connect the power cable between the Tester and the power outlet.



2. Move the Tester *Fan Start* switch, located on the front panel, to the ON position.



**NOTE:** Allow the Tester to warm up for 15 minutes before taking measurements.

3. Install the *Calibration Check Ring* in the Tester's *EXHAUST* port with the inner ring pointing out away from the Tester.



4. Connect a section of pressure tubing from the *Calibration Check Ring* to the *Body Pressure Inlet* port.

5. Slowly turn the *Variable Fan Speed Adjust* knob to the right. The *Air Blower* starts turning and air is directed through the *Calibration Check Ring*.



6. Continue to turn the *Variable Fan Speed Adjust* knob to the right to increase the air flow into the vehicle. As the speed increases, the *Body Pressure* gauge indicates the difference in pressure between the inside and outside of the vehicle.



7. Increase the flow until the *Differential Pressure Gauge* indicates 0.1 inches of water. The digital display indicates the flow rate in SCFM.



8. Apply a barometric pressure correction to the indicated flow value. Correction calculators are available on the Internet.

9. Compare the indicated flow rate to the values listed on the Tester *Calibration Check Ring*, which was provided with the Tester. See "*Calibration Check Ring Values*".

## MAINTENANCE

Perform the system check using the *Calibration Check Ring* at regular intervals to verify Tester performance. Change the *Inlet Filter* periodically and inspect the hoses for cracking or breakage. If the unit fails the system check, return it to the Badger Meter Flow Dynamics lab in Racine, Wisconsin.

### Maintenance Schedule

Maintenance Procedure	Recommended Interval
System check with calibration check ring	Monthly
Inspect hoses for cracking, breakage	Monthly
Replace inlet filters	Annually

### Repair Parts for FDD-TMM-400 (400 SCFM, 110V AC)

**NOTE:** Contact the factory for other models. Most parts for the Tester are stocked at the factory and available for quick delivery.

Component	Description	Usage Qty	Unit
1024T28	Stethoscope	1	Ea.
06 TD-HS	Flex Duct	10	Ea.
5554K14	1/4 in. Tygon R-3603 Tube	15	Ea.
3328	25 ft Extension Cord	1	Ea.
904-7143	Knob, Control, 1.75 in.	1	Ea.
846-4800	Fuse Holder, Littelfuse, 2/3AG, 20 A, 250V AC, PAN	1	Ea.
6231-M2-022	BLT Pressure Wand (FD-TMM-400 PWAND)	1	Ea.
6231-M2-023	Fitting Adapter, Window, BLT	1	Ea.
PLA30067	Filter Element	2	Ea.
2001 (0-1 IN H <sub>2</sub> O)	Magnahelic Gauge	1	Ea.
21-315	For Blue-Sided Machines: Caster, 5 in. Swivel, Locking, M10 Stud Mount	4	Ea.
1.45.31125	For Black-Sided Machines: Caster, 5 in. Swivel, Locking, M10 Stud Mount	4	Ea.
71385K35	Fuse, 3AB, 15 A, 250V AC, Fast Acting	1	Ea.
7085K75	Fuse, 3AG, 1 A, 250V, Fast Acting	1	Ea.

SYSTEM CALIBRATION

The *Mass Air Flow Sensor* and *Differential Pressure Gauge* require periodic calibration to continue providing accurate measurements from the system. The two components are calibrated individually, and then checked as a system with the *Calibration Check Ring*.

Differential Pressure Gauge Calibration

The *Differential Pressure Gauge* is calibrated by comparison to a Pressure Standard. The range of calibration is 0...1 Inch H<sub>2</sub>O. The standard used should have an uncertainty of ± 0.5% of Full Scale or better.

To calibrate the *Differential Pressure Gauge*:

- 1. Connect the Pressure Standard inlet to the Tester *Body Pressure* port. If the standard is a differential type device, connect the High inlet to the *BODY PRESSURE* port and the Low inlet to the *AMBIENT* port.



- 2. With the Pressure Standard set to zero, make sure the *Differential Pressure Gauge* reads zero. If necessary, adjust the mechanical zero adjust on the front of the gauge. Alternately, leave both the *INLET* and *AMBIENT* Pressure Ports open to atmosphere and adjust the mechanical zero.

- 3. Adjust the Pressure Standard until the gauge reads 0.1 inches H<sub>2</sub>O. Record the standard reading. The standard should read 0.1 inches H<sub>2</sub>O ± 0.02 inches H<sub>2</sub>O. Repeat this process at each calibration point. The recommended points are listed in the table below.



Indicated Differential Pressure In H <sub>2</sub> O	Lower Limit	Upper Limit
0.0	Adjust	Adjust
0.1	0.08	0.12
0.2	0.18	0.22
0.3	0.28	0.32
0.4	0.38	0.42
0.5	0.48	0.52
0.6	0.58	0.62
0.7	0.68	0.72
0.8	0.78	0.82
0.9	0.88	0.92
1.0	0.98	1.02

**NOTE:** Replace the gauge if it is out of tolerance.

Control. Manage. Optimize.

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