Bendix® ET-2™ Electronic Treadle

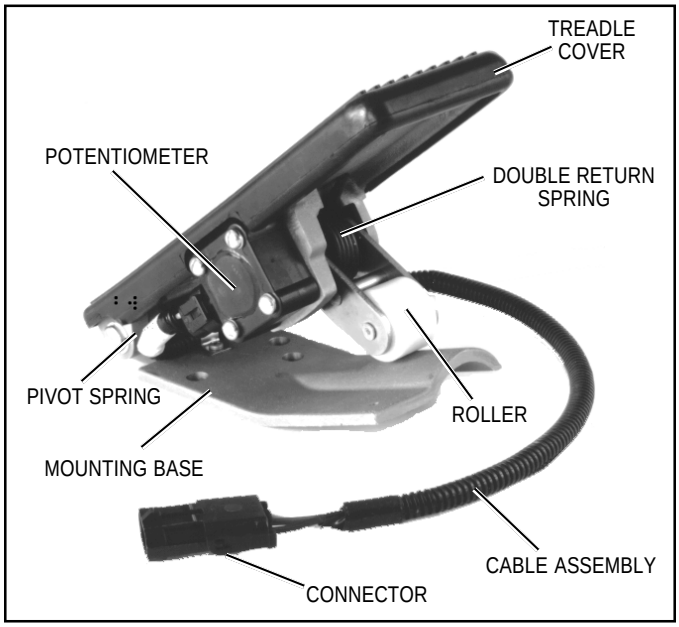

*FIGURE 1 - **ET-2™ ELECTRONIC TREADLE***

DESCRIPTION

The ET-2™ is an electronic throttle. On electronically controlled diesel engines, the ET-2™ treadle fulfills the same function as a conventional mechanical throttle. The ET-2™ treadle controls engine speed by interacting with an electronic fuel management controller on the engine, rather than transmitting a mechanical force from the throttle pedal to the engine governor.

The main components of the ET-2™ throttle are a cast aluminum mounting base and treadle, a rubber treadle cover, a potentiometer (variable resistor), and a roller assembly. The potentiometer is specific to each engine application.

OPERATION

The ET-2™ treadle provides smooth, graduated throttle control through the function of its variable resistor, or potentiometer. The ET-2™ treadle receives its supply voltage from the engine control unit. The lever shaft connects the roller assembly to the potentiometer, so that any movement of the treadle rotates the potentiometer. As the potentiometer rotates, its resistance changes. This way, the potentiometer communicates the throttle position to the fuel control system by changing resistance, returning more or less of the supplied voltage back to the electronic engine controller.

If the driver does not request engine power, the throttle is in the idle (or “closed throttle”) position. In this state, the potentiometer significantly reduces the amount of supply voltage returned to the engine control unit (See Figure 2).

As the driver depresses the ET-2™ treadle, output voltage increases (see Figure 3). The potentiometer allows an increased amount of its supply voltage to return to the engine control unit, which in turn increases the engine’s speed.

In the full (or “open throttle”) position, the driver has fully depressed the ET-2™ treadle. This is the state of least potentiometer resistance. The ET-2™ treadle returns the maximum percentage of supply voltage to the engine control unit (see Figure 2).

Engine Manufacturer	Idle Throttle (Closed)	Full Throttle (Open)
CAT	13 - 21%	79 - 89%
Cummins	8 - 18%	70 - 80%
Detroit Diesel	6 - 14%	86 - 94%
Mack	10 - 20%	70 - 85%

*FIGURE 2 - **ET-2™ TREADLE OUTPUT VOLTAGE, AS A PERCENTAGE OF SUPPLY VOLTAGE***

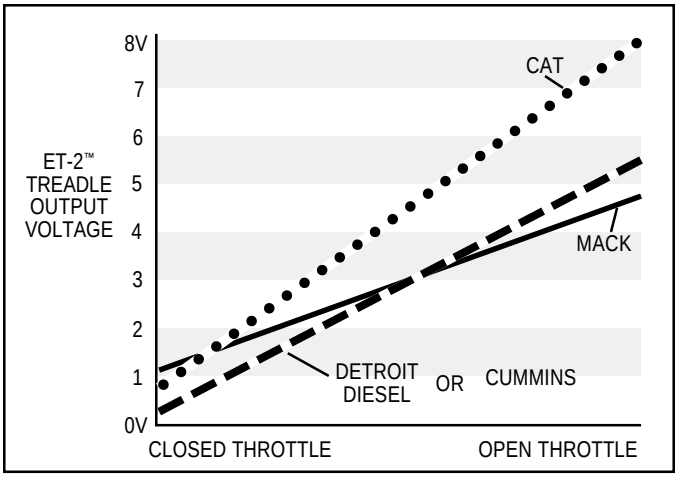

*FIGURE 3 - **ET-2™ TREADLE OUTPUT VOLTAGE***

Figure 3 illustrates the relationship between throttle position and engine RPM. Potentiometer performance will vary for each engine application, therefore potentiometers must not be interchanged.

WARNING! PLEASE READ AND FOLLOW THESE INSTRUCTIONS TO AVOID PERSONAL INJURY OR DEATH:

When working on or around a vehicle, the following general precautions should be observed at all times.

1. **Park the vehicle on a level surface, apply the parking brakes, and always block the wheels. Always wear safety glasses.**
2. **Stop the engine and remove ignition key when working under or around the vehicle. When working in the engine compartment, the engine should be shut off and the ignition key should be removed. Where circumstances require that the engine be in operation, EXTREME CAUTION should be used to prevent personal injury resulting from contact with moving, rotating, leaking, heated or electrically charged components.**
3. **Do not attempt to install, remove, disassemble or assemble a component until you have read and thoroughly understand the recommended procedures. Use only the proper tools and observe all precautions pertaining to use of those tools.**
4. **If the work is being performed on the vehicle's air brake system, or any auxiliary pressurized air systems, make certain to drain the air pressure from all reservoirs before beginning ANY work on the vehicle. If the vehicle is equipped with an AD-IS™ air dryer system or a dryer reservoir module, be sure to drain the purge reservoir.**
5. **Following the vehicle manufacturer's recommended procedures, deactivate the electrical system in a manner that safely removes all electrical power from the vehicle.**
6. **Never exceed manufacturer's recommended pressures.**
7. **Never connect or disconnect a hose or line containing pressure; it may whip. Never remove a component or plug unless you are certain all system pressure has been depleted.**
8. **Use only genuine Bendix® replacement parts, components and kits. Replacement hardware, tubing, hose, fittings, etc. must be of equivalent size, type and strength as original equipment and be designed specifically for such applications and systems.**
9. **Components with stripped threads or damaged parts should be replaced rather than repaired. Do not attempt repairs requiring machining or welding unless specifically stated and approved by the vehicle and component manufacturer.**
10. **Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.**

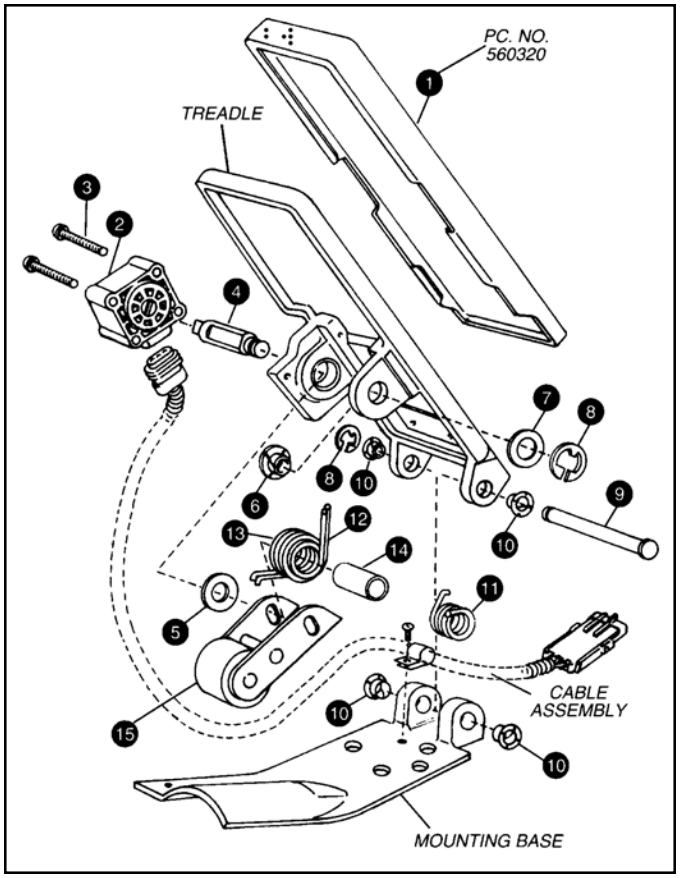

FIGURE 4 - ***EXPLODED VIEW***

PREVENTIVE MAINTENANCE

GENERAL

Perform the following tests and inspections at the prescribed intervals. If the ET-2™ treadle does not function as described, repair it or replace it with a new unit, available at any authorized Bendix parts outlet. EVERY 3 MONTHS, 25,000 MILES, OR 900 OPERATING HOURS:

1. Remove any accumulated contaminants and visually inspect the exterior of the ET-2™ treadle for physical damage or excessive corrosion.
2. Inspect electrical connections and cable assembly for signs of corrosion, wear, or physical damage. Replace as necessary.
3. Inspect springs (11, 12, 13) for signs of corrosion or pitting. Replace as necessary.
4. Inspect bearings (10), washer (7), and snap rings (8) for cracks or deterioration. Replace as necessary.

OPERATIONAL TEST

Perform these tests only if the vehicle's throttle does not appear to operate as expected.

Test 1: For Mack and DDC engines:

1. Unplug the cable assembly from the potentiometer's integral connector by lifting the lock tab and pulling the connectors until they disengage. Inspect cable assembly for loose terminals, frayed wires, corrosion,

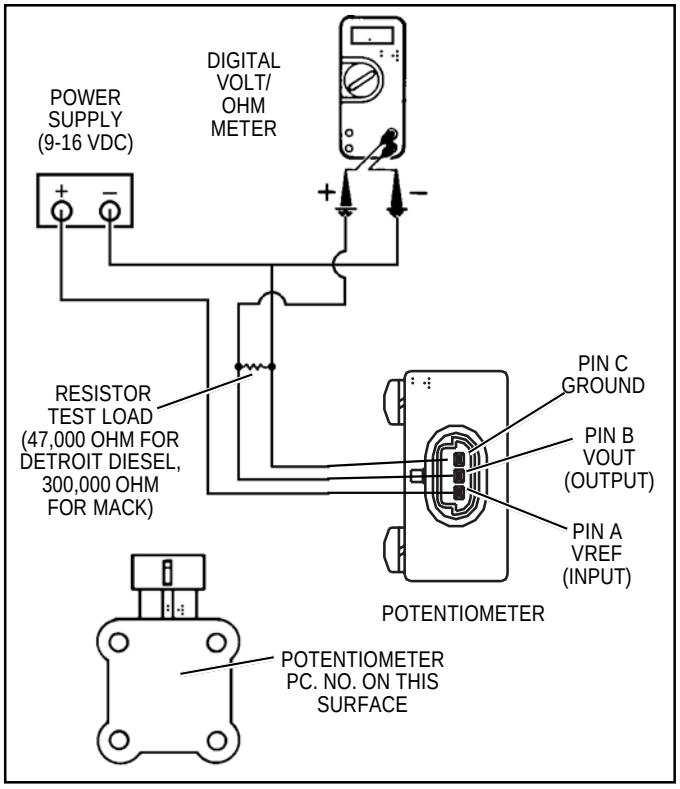

FIGURE 5 - ***ET-2™ TREADLE ELECTRICAL TEST SCHEMATIC FOR THE DETROIT DIESEL CONNECTOR***

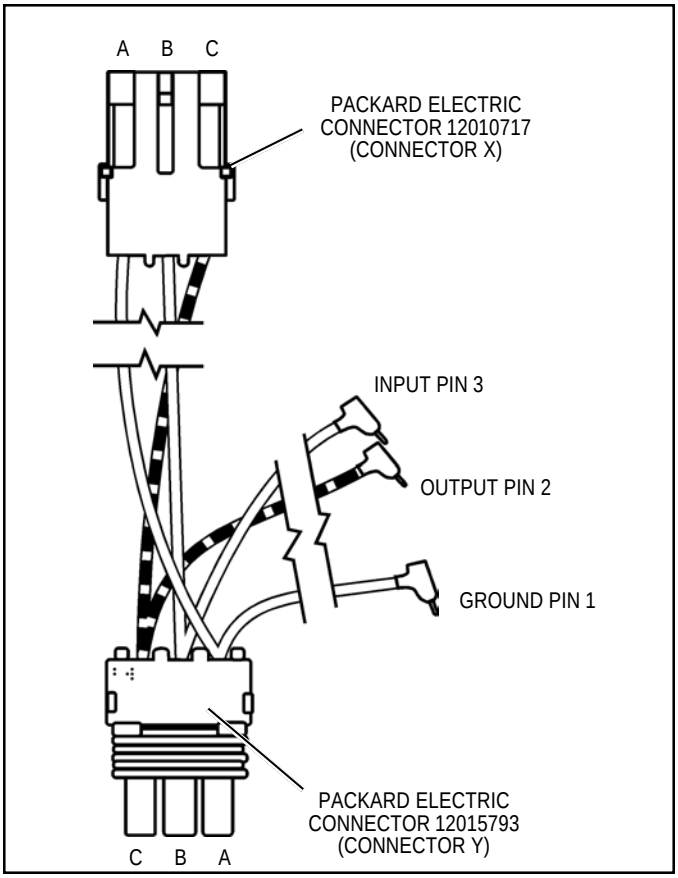

FIGURE 6 - ***ET-2™ TREADLE ELECTRICAL TEST SCHEMATIC FOR THE CUMMINS CONNECTOR***

wear, or physical damage. Check end-to-end electrical continuity at terminals. NOTE: Potentiometer pin locations will remain constant (see Figure 5). However, cable assembly connector pin out may vary from engine to engine.

2. Remove the ET-2™ treadle from the vehicle.
3. Secure the ET-2™ treadle to a smooth, flat surface in such a way that it does not twist the unit.
4. Connect the potentiometer to the volt meter and power supply as shown in Figure 5. NOTE: Power supply can be a 12 VDC vehicle battery in good condition and with known voltage output.
5. Verify that the closed throttle (idle) output voltage, as a percentage of supply voltage, is within the limits listed in Figure 2.
6. Depress the treadle to its full throttle position. The output voltage, as a percentage of supply voltage, should be within the limits listed in Figure 2, e.g. Testing a Detroit Diesel ET-2™ Treadle Potentiometer: Battery = 10 VDC. Full throttle = 9 VDC. 9/10 x 100 = 90%.
7. Make several full applications and record idle position voltage each time. Verify that idle position voltage does not vary by more than .4% (.02 volts). If the ET-2™ treadle does not operate within its specified ranges, service the unit, or replace it with a new ET-2™ treadle, available at your nearest Bendix parts outlet.

<u>Test 2: For Cummins engines (featuring a separate potentiometer and idle validation switch):</u>

To test the potentiometer on the vehicle, use steps 1 through 8. Alternatively, instructions for carrying out a “bench test” is covered in instructions 11 through 16.

1. First construct the “breakout” harness shown in Figure 6.
2. Insert connector X on the breakout harness into the connector leading from the potentiometer. Then insert connector Y on the breakout harness into the connector leading from the dashboard wire harness.
3. Next insert pin 1 into the ground position on a voltmeter. Then insert pin 2 into the positive position on a volt meter.
4. Disconnect the idle validation switch cable from the dashboard wire harness. Connect an ohmmeter to pins A and B on the connector leading from the idle validation switch. The positive lead should be connected to pin A and the negative lead should be connected to pin B.
5. Turn the vehicle’s ignition key to the “battery on” position. This supplies a 5 volt input to the potentiometer. Since the idle validation switch is no longer connected, a fault code may be triggered on some vehicles. This fault code will be reset at the end of this test.

6. Record the output voltage when the pedal is in the idle position (V1). Then slowly depress the pedal. When the ohm meter shows that the resistance has changed from “overload” to about .003 ohms (or from .003 ohms to “overload”), stop depressing the pedal. Record the voltage (Vx) registered with the pedal in this position. Then press the pedal to the full throttle position and record the output voltage (V2).
7. Calculate the “switch point percentage” using the formula below.

   Switch point percentage = ((Vx-V1)/(V2-V1))*100

Vx = Output voltage when the switch changed

V1 = idle voltage

V2 = full throttle voltage

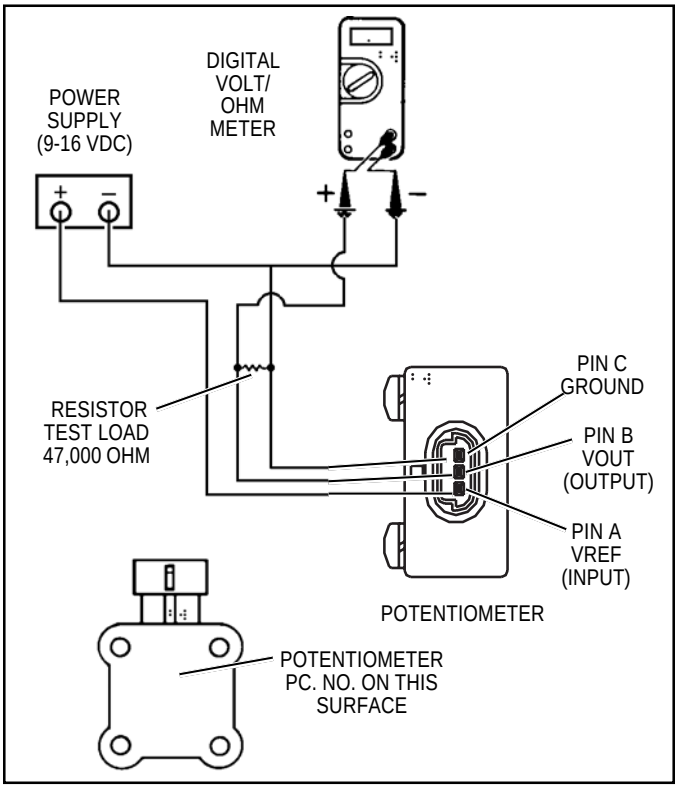

FIGURE 7 - ***ET-2™ TREADLE ELECTRICAL TEST SCHEMATIC FOR THE CUMMINS CONNECTOR***

8. The switch point percentage should be between 3% to 10%. If it is not with in this range adjust the potentiometer by loosening the mounting screws and turning the potentiometer within the range allowed by the mounting holes. Repeat steps 1-7 again. If you can not obtain the proper switch point percentage, replace with a new ET-2™ treadle, available at your nearest Bendix parts outlet.
9. After a successful test the vehicle may be returned to service.

The following instructions are for a bench test for the potentiometer used with Cummins engines.

10. Unplug the cable assembly from the potentiometer’s integral connector by lifting the lock tab and pulling the connectors until they disengage. Inspect cable assembly for loose terminals, frayed wires, corrosion, wear, or physical damage. Check end-to-end electrical continuity at terminals. NOTE: Potentiometer pin locations will remain constant (see Figure 5). However, cable assembly connector pin out may vary from engine to engine.
11. Remove the ET-2™ treadle from the vehicle.
12. Secure the ET-2™ treadle to a smooth, flat surface in such a way that it does not twist the unit.
13. Connect the potentiometer to the volt meter and power supply as shown in Figure 5. NOTE: Power supply can be a 12 VDC vehicle battery in good condition and with known voltage output.
14. Verify that the closed throttle (idle) output voltage, as a percentage of supply voltage, is within the limits listed in Figure 2.
15. Depress the treadle to its full throttle position. The output voltage, as a percentage of supply voltage, should be within the limits listed in Figure 2. e.g. Testing a Detroit Diesel ET-2™ Treadle Potentiometer: Battery = 10 VDC. Full throttle = 9 VDC. 9/10 x 100 = 90%.
16. Make several full applications and record idle position voltage each time. Verify that idle position voltage does not vary by more than .4% (.02 volts). If the ET-2™ treadle does not operate within its specified ranges, service the unit, or replace it with a new ET-2™ treadle, available at your nearest Bendix parts outlet.

<u>Test 3: For Cummins engines (with integrated switch and sensor (ISS):</u> For use only with the Cummins Celet Plus and later editions of the ECU. This sensor can not be used to replace the separate potentiometer & idle validation switch. To do this a new ET-2™ treadle with the ISS must be purchased.

Test 1: Where the set resistance and voltage is shown on a label. The Cummins potentiometer on the ET-2™ treadle has an integral idle validation switch. It also has a set resistance value marked on the cover, which needs to be used to properly install the potentiometer. The drive slot in the potentiometer should engage with the drive tang at the end of the drive shaft. Next rotate the potentiometer until the hole in the metal sleeve matches the mounting holes on the actuator base. Loosely screw the potentiometer in place but do not tighten. Connect an ohmmeter to pins 3 (APS output) and 4 (APS ground) as shown in Figure 8. Now the installer should read the set resistance value marked on the label. Rotate the

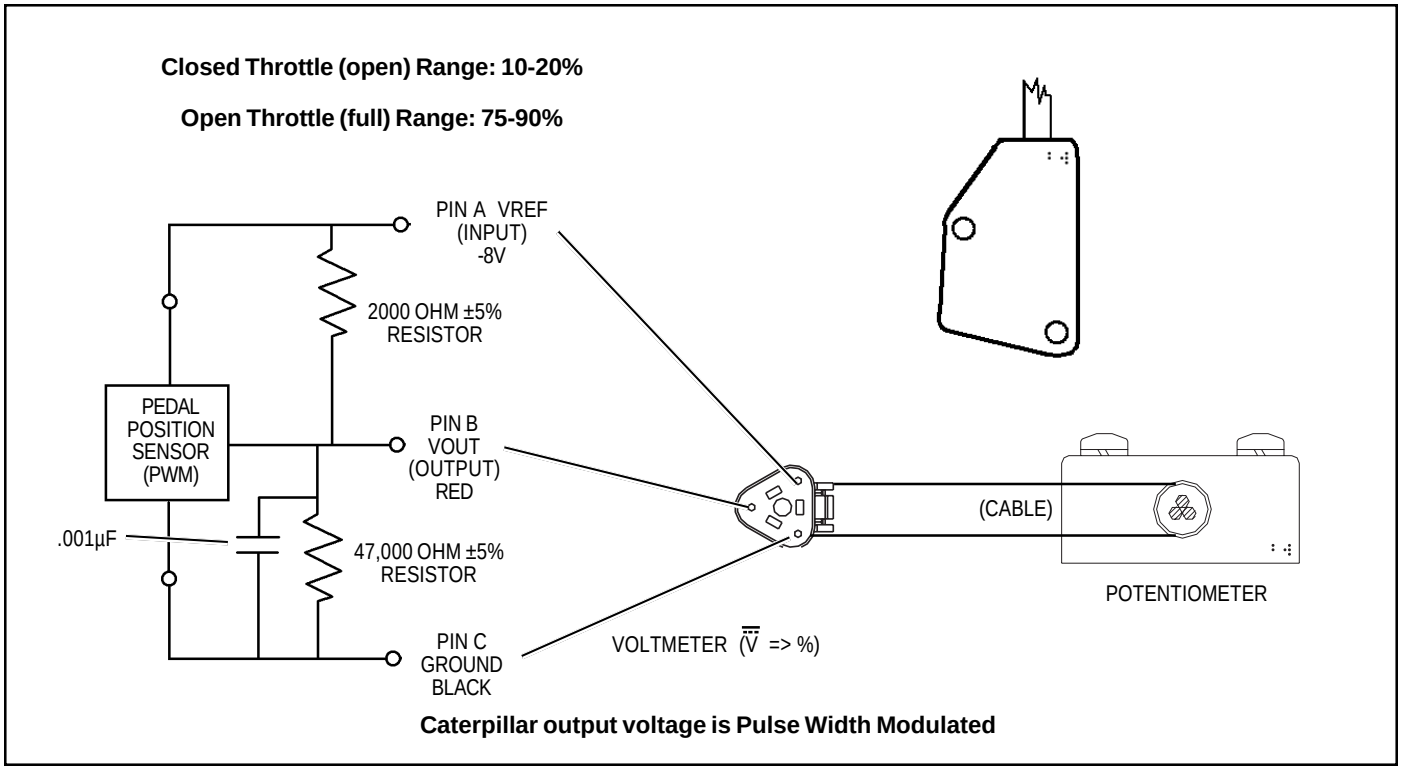

FIGURE 8 - ***ET-S™ TREADLE ELECTRICAL TEST SCHEMATIC FOR THE CATERPILLAR CONNECTOR***

potentiometer until the ohmmeter reads the same resistance as shown on the label within ±10 Ohms. Next, while holding the potentiometer at the set resistance screw and lock the potentiometer in place (torque to 25 inch pounds ±5). The sleeves lock into the body of the potentiometer for easy removal and reassembly.

Test 2: Where the potentiometer has no label, but has engraved set voltage shown. The Cummins potentiometer on the ET-2™ treadle has an integral idle validation switch. It also has a set voltage value marked on the cover, which needs to be used to properly install the potentiometer. The drive slot in the potentiometer should engage with the drive tang at the end of the drive shaft. Next rotate the potentiometer until the hole in the metal sleeve matches the mounting holes on the actuator base. Loosely screw the potentiometer in place but do not tighten. Construct the test circuit following the circuit diagram shown in Figure 8. To make the test circuit connect the test load resistor (47,000 Ohms) and a capacitor (.01 Microfarads) across pins 3 and 4 of the potentiometer. Then connect a voltmeter to the lead ends of the test circuit. Next connect a 5 volt power supply to the potentiometer at pin 4 (APS ground) and pin 5 (supply voltage). Caution: Sensor may be damaged if supply exceeds 5 volts. Now the installer should read the set voltage value marked on the potentiometer. Rotate the potentiometer until the voltmeter reads the same voltage as shown on the potentiometer within ±.02 volts. Next screw and lock the potentiometer in place (torque to 25 inch pounds ±5). The sleeves lock into the body of the potentiometer for easy removal and reassembly.

Test 4: For CAT engines:

1. Securely clamp the treadle Mounting Plate (6).
2. ***For Caterpillar Potentiometers***: Aligning the drive slot, the Potentiometer (1) engages the drive tang at the end of the Cam Follower Drive Shaft (see Figure 4). Rotate the Potentiometer clockwise until the first set of mounting holes align. Secure using two screws (2): torque to 20 (±2) in. lbs.

   To test the Caterpillar sensor construct the test circuit shown in Figure 7. Connect both pin B and pin C into a voltmeter. Set the voltmeter to the settings described in Figure 7. Record the output values in Figure 2. If the unit does not operate within the specified ranges, service the unit or replace it with a new ET-2™ treadle.

REMOVAL

1. Park the vehicle on a level surface and block the wheels and/or hold the vehicle by means other than the air brakes.
2. Drain the air pressure from all vehicle reservoirs.
3. Unplug the cable assembly at the opposite end of the potentiometer. Disconnect by lifting the lock tab and pulling the connectors until they disengage.
4. Remove the ET-2™ treadle from the vehicle.

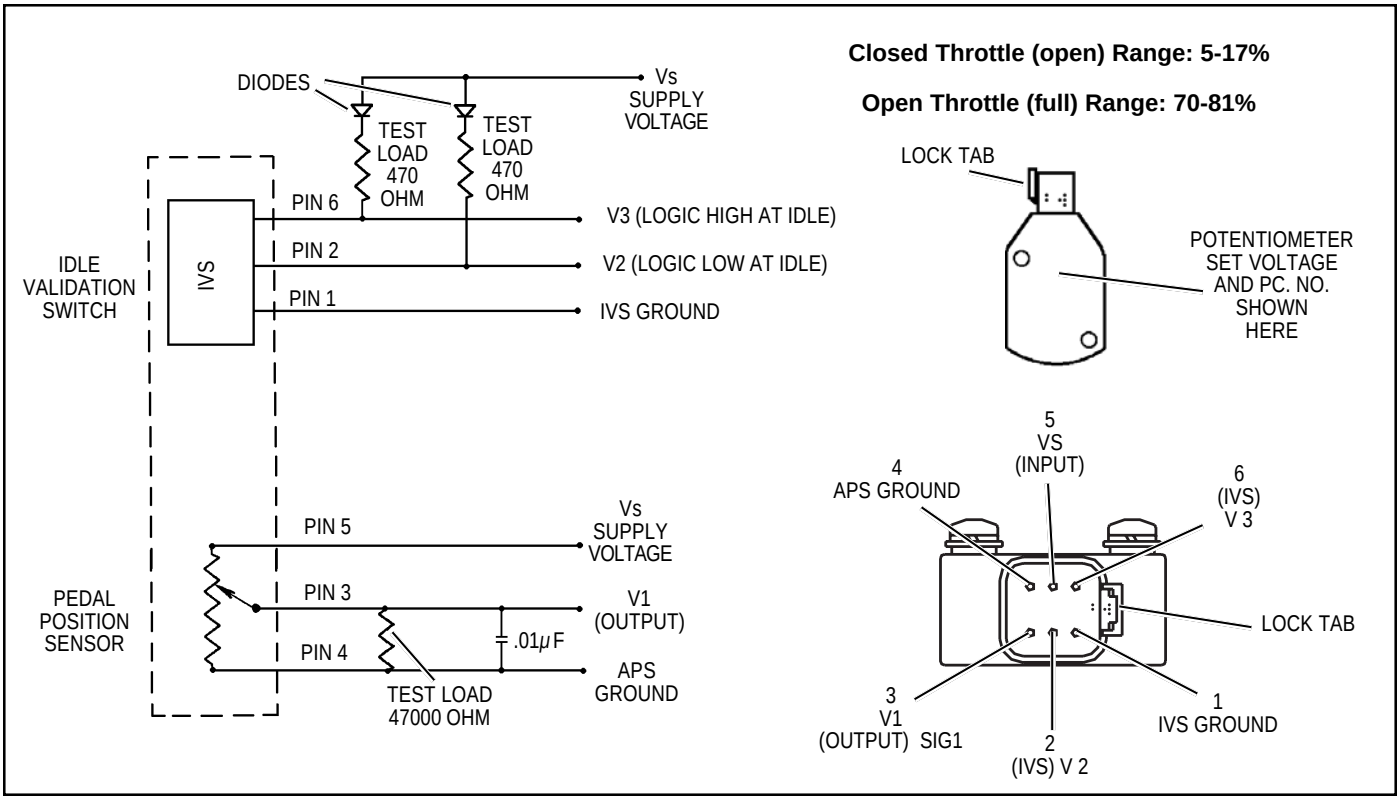

FIGURE 8 - ***ET-2™ TREADLE ELECTRICAL TEST SCHEMATIC FOR THE CUMMINS CONNECTOR***

INSTALLATION

1. Install the assembled ET-2™ treadle on the vehicle.
2. Reconnect the cable connector by plugging it into the potentiometer's integral connector and pushing until the lock tab snaps into place.

DISASSEMBLY

The following instructions present a major disassembly of the ET-2™ treadle. They are included for reference only. Several replacement parts and maintenance kits that do not require full disassembly are available. The instructions provided with those items should be followed in lieu of the steps presented here. Refer to Figure 4 throughout the procedures.

1. Remove the treadle cover (1).
2. Remove the pivot pin's snap ring (8).
3. Remove the pivot pin (9) and the two nyliner bearings (10) from the treadle's exterior. Also remove the two nyliner bearings (10) from the mounting base.
4. Remove the pivot spring (11).
5. Remove the screws (3) that secure the potentiometer (2) to the treadle. Remove the potentiometer.
6. Remove the lever shaft's snap ring (5).
7. Remove the lever shaft (4) and the washer (7). Then remove the roller assembly (15), the inner washer (5), and the nyliner bearing (6) from the treadle. Separate the treadle from the mounting base.
8. The roller assembly consists of the lever, roller, two springs (12 & 13), and a spring support (14). Remove the springs and the spring support from the lever.

CLEANING & INSPECTION

1. Use mineral spirits or an equivalent solvent to clean all metal parts. Be sure to thoroughly dry the parts.
2. Inspect the treadle and mounting base for severe corrosion, pitting, or cracks. Replace as necessary. Superficial corrosion and/or pitting is acceptable.
3. Inspect the cable assembly for loose or frayed wires, physical damage, or any contaminants on the connectors. Check end-tend electrical continuity at terminals. Replace as necessary.

ASSEMBLY

Refer to Figure 4 throughout the assembly procedure.

1. Install the four nyliner bearings (10) on the mounting base and treadle.
2. Place the treadle "ears" outside the mounting base "ears" so that the holes line up.
3. Install the pivot spring (11) into the base and treadle. The curved end of the spring fits into a small hole in the treadle, and the straight end fits into a small hole in the mounting base.
4. The pivot pin (9) should slide through the holes in the "ears" of the treadle and base assembly, then through the center of the spring. Secure the pin with its snap ring (8). Make sure the pivot spring is straight and is seated in its holes.

5. The installation of the remaining components is much easier if the inner and outer springs (12 & 13) are compressed and caged. This can be done with a short piece of wire, or even a paper clip. The springs should be compressed so that their ends are approximately one inch apart.
6. Place the spring support (14) inside the caged spring assembly. Then insert the springs into the roller assembly (15). The curved ends of the springs fit over the small bar directly behind the roller.
7. In order to install the lever shaft (4), the roller assembly, with its springs and spring support, and the washers (5 & 7) must be aligned. This can be done by resting the ET-2™ treadle on its side, with the smaller ear of the treadle facing up. Insert the washers as shown in Figure 4. Washer (5) has the larger diameter (.520"). While holding the roller assembly in place, push the lever shaft through the treadle ears.
8. With the ET-2™ treadle on its side, as mentioned above, the lever shaft should protrude from the treadle with its snap ring groove visible. Secure the lever shaft with its snap ring (8).
9. Turn the ET-2™ treadle upright. Place the potentiometer (2) in the position shown in Figure 4, with its connector facing the rear of ET-2™ treadle. Secure the potentiometer with its screws (3). Torque to 20 inch pounds (+/-5).
10. Install the treadle cover (1) and cable assembly as shown in Figure 4. Clip the wire from the spring assembly so that the straight end of the springs rest against the underside of the treadle.
11. Make sure the ET-2™ treadle has smooth, even treadle movement. Also, perform Operational Test steps 3-7 before installing the ET-2™ treadle.
12. Install the ET-2™ treadle on the vehicle.