WOODWARD

Manual 36746
(Revision B, 10/2017)
Original Instructions

Electronic Throttle Body for Gasoline, CNG, & LPG Fuel-Injected Engines

Product Usage Instructions

General Precautions

Read this entire manual and all other publications pertaining to the work to be performed before installing, operating, or servicing this equipment.

Practice all plant and safety instructions and precautions.

Failure to follow instructions can cause personal injury and/or property damage.

Revisions

This publication may have been revised or updated since this copy was produced. To verify that you have the latest revision, check manual *26455*, *Customer Publication Cross Reference and Revision Status & Distribution Restrictions*, on the *publications page* of the Woodward website:

www.woodward.com/publications

The latest version of most publications is available on the *publications page*. If your publication is not there, please contact your customer service representative to get the latest copy.

Proper Use

Any unauthorized modifications to or use of this equipment outside its specified mechanical, electrical, or other operating limits may cause personal injury and/or property damage, including damage to the equipment. Any such unauthorized modifications: (i) constitute "misuse" and/or "negligence" within the meaning of the product warranty thereby excluding warranty coverage for any resulting damage, and (ii) invalidate product certifications or listings.

Translated Publications

If the cover of this publication states "Translation of the Original Instructions" please note:

The original source of this publication may have been updated since this translation was made. Be sure to check manual *26455*, *Customer Publication Cross Reference and Revision Status & Distribution Restrictions*, to verify whether this translation is up to date. Out-of-date translations are marked with ⚠. Always compare with the original for technical specifications and for proper and safe installation and operation procedures.

Revisions—Changes in this publication since the last revision are indicated by a black line alongside the text.

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Important Definitions

This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

- **DANGER**—Indicates a hazardous situation which, if not avoided, will result in death or serious injury.
- **WARNING**—Indicates a hazardous situation which, if not avoided, could result in death or serious injury.
- **CAUTION**—Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.
- **NOTICE**—Indicates a hazard that could result in property damage only (including damage to the control).
- **IMPORTANT**—Designates an operating tip or maintenance suggestion.

WARNING

Overspeed / Overtemperature / Overpressure

The engine, turbine, or other type of prime mover should be equipped with an overspeed shutdown device to protect against runaway or damage to the prime mover with possible personal injury, loss of life, or property damage.

The overspeed shutdown device must be totally independent of the prime mover control system. An overtemperature or overpressure shutdown device may also be needed for safety, as appropriate.

WARNING

Personal Protective Equipment

The products described in this publication may present risks that could lead to personal injury, loss of life, or property damage. Always wear the appropriate personal protective equipment (PPE) for the job at hand. Equipment that should be considered includes but is not limited to:

- **Eye Protection**
- **Hearing Protection**
- **Hard Hat**
- **Gloves**
- **Safety Boots**
- **Respirator**

Always read the proper Material Safety Data Sheet (MSDS) for any working fluid(s) and comply with recommended safety equipment.

WARNING

Start-up

Be prepared to make an emergency shutdown when starting the engine, turbine, or other type of prime mover, to protect against runaway or overspeed with possible personal injury, loss of life, or property damage.

WARNING

Automotive Applications

On- and off-highway Mobile Applications: Unless Woodward's control functions as the supervisory control, customer should install a system totally independent of the prime mover control system that monitors for supervisory control of engine (and takes appropriate action if supervisory control is lost) to protect against loss of engine control with possible personal injury, loss of life, or property damage.

NOTICE

Battery Charging Device

To prevent damage to a control system that uses an alternator or battery-charging device, make sure the charging device is turned off before disconnecting the battery from the system.

Electrostatic Discharge Awareness

NOTICE

Electrostatic Precautions

Electronic controls contain static-sensitive parts. Observe the following precautions to prevent damage to these parts:

- **Discharge body static before handling the control (with power to the control turned off, contact a grounded surface and maintain contact while handling the control).**
- **Avoid all plastic, vinyl, and Styrofoam (except antistatic versions) around printed circuit boards.**
- **Do not touch the components or conductors on a printed circuit board with your hands or with conductive devices.**

To prevent damage to electronic components caused by improper handling, read and observe the precautions in Woodward manual *82715*, *Guide for Handling and Protection of Electronic Controls, Printed Circuit Boards, and Modules*.

Follow these precautions when working with or near the control.

1. Avoid the build-up of static electricity on your body by not wearing clothing made of synthetic materials. Wear cotton or cotton-blend materials as much as possible because these do not store static electric charges as much as synthetics.
2. Do not remove the printed circuit board (PCB) from the control cabinet unless absolutely necessary. If you must remove the PCB from the control cabinet, follow these precautions:
   - Do not touch any part of the PCB except the edges.
   - Do not touch the electrical conductors, the connectors, or the components with conductive devices or with your hands.
   - When replacing a PCB, keep the new PCB in the plastic antistatic protective bag it comes in until you are ready to install it. Immediately after removing the old PCB from the control cabinet, place it in the antistatic protective bag.

Chapter 1.
General Information

Introduction

This electronic throttle body is designed for use on gasoline fuel injected engines. Approved platforms include MI-2012, OH-5 and OH-6 systems.

Two throttle position sensors are used to provide feedback to a Power-train / Engine Control Module (PCM/ECM). The PCM/ECM affects the performance of the throttle body by the speed of response, damping and overshoot parameters. The PCM/ECM must also not allow the throttle plate to hit the mechanical end stops under normal operating conditions. The other is for the PCM/ECM to control the level of current through the motor where it will not be damaged through excess heat dissipation in the unlikely event that the plate should encounter an obstruction.

The data in this document reflects these requirements and shows performance using a corresponding PCM/ECM.

Some general guidelines for selecting an optimal throttle size for a particular application are as follows.

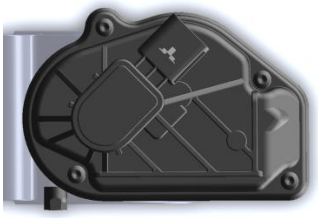
- Generally speaking, the smaller the throttle size, the longer the throttle life.
- The throttle size should not be too large for the needs of the application, as this will cause the throttle to position at 2% during engine idle, which is the minimum position allowed for operation.
- The throttle size should not be too small for the needs of the application, as this will cause a pressure drop across the throttle to be larger than is allowed for proper performance.
- On the application, the throttle shall not operate normally at a position of 9.5% to 11% (with a new or clean throttle). This is the default position of the throttle to which the throttle will move when power is removed allowing for limited engine operation in case of throttle control shut-down. At this default position, throttle control is less responsive and idle control will be degraded.

Available throttle body sizes are given in the chart below.

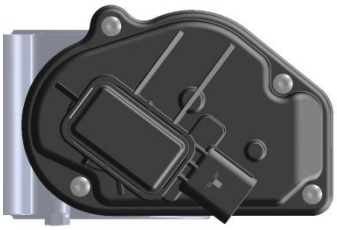
Figure 1-1 shows the available throttle body sensor types.

Available Throttle Body Sizes, Parallel Configuration

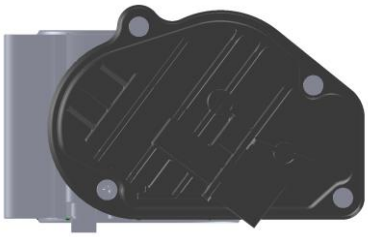
Item Number (Contacting TPS)	Item Number (Non Contacting TPS)	Description (Flange)	Bolt Pattern	Throttle Plate Diameter	Weight (Contacting TPS)	Weight (Non Contacting TPS)
6945-5026	6945-5035	Single	53x53mm	32mm	0.867 Kg (1.9 lbs)	0.891 Kg (2.0 lbs)
6945-5025	6945-5038	Single	53x53mm	45mm	0.914 Kg (2.0 lbs)	0.938 Kg (2.1 lbs)
6945-5027	6945-5044	Single	Irregular Shape	55mm	1.043 Kg (2.3 lbs)	1.062 Kg (2.3 lbs)
6945-5028	6945-5045	Single	Irregular Shape	60mm	1.026 Kg (2.3 lbs)	1.053 Kg (2.3 lbs)
6945-5030	6945-5039	Double	74x74mm	55mm	1.186 Kg (2.6 lbs)	1.211 Kg (2.7 lbs)
6945-5031	6945-5041	Double	74x74mm	60mm	1.155 Kg (2.5 lbs)	1.181 Kg (2.6 lbs)
6945-5032	6945-5043	Double	74x74mm	64mm	1.117 Kg (2.5 lbs)	1.153 Kg (2.5 lbs)



ALPS (contact type) Sensor



KSR (non-contact type – obsolete after 2015) Sensor



CCVECS (non-contact type) Sensor

Figure 1-1. Available Throttle Body Sensor Types

After revision level E of the generic part numbers above, the ETB will include a shaft seal. The shaft seal will be located between the throttle bore and gear train/sensor compartment. The seal is intended to protect this compartment and its components against ingress from bore media.

Chapter 2.
Specifications & Performance

Throttle Body Data

Rated Voltage	10-32V*
Extreme Low Voltage Range (PWM) (No destruction, operation not required)	-13V to 6.5V
Low Voltage Range (PWM) (Over temp range, limited performance)	6.5V to 10V
PWM Drive Frequency	200-2000 Hz
Maximum Continuous Voltage (Within temp range)	13.5V
Maximum Continuous RMS Current at 125 °C (257 °F)	1.4A
Maximum Motor Current at 135°C (275 °F) See Table 1 for more detailed data	5A
Resistance at Room Temp	1.7 Ohms ± 10%
Inductance at 1 kHz	1.2 mH ± 10%
Typical Steady State Operating Motor Current	1.0A
Rated Stall Torque (Minimum)	100mNm (or 0.074lb.ft)

(*) PCM / ECM control ensures that current limits are not exceeded with increasing voltage.

Current & Voltage Data

The following chart shows current and voltage data taken with motor shaft locked until armature temperature reaches 220 °C (428 °F) in a 135 °C (275 °F) ambient environment.

Current (A)	Time (S)		Voltage (V)	Time (S)
1.56	>1800		5	>1800
1.58	>1800		6	>1800
1.6	>1800		7	803
1.9	726		8	562
2.3	475		9	325
3	261		10	198
3.99	143		12	117
5	60		14	71
6.07	47		16	60
7.06	32		18	46
8	26		26.5	19

Environmental Requirements

Storage Temperature	-40 °C to 135 °C (-40 °F to 275 °F)
Storage Life	600 hours @ maximum ambient
Operating Temperature Range	-40 °C to 105 °C * (-40 °F to 221 °F)
Atmospheric Pressure	60 to 100 kPa
Relative Humidity	0 to 100% RH

(*) ETB may be operated up to a maximum operating temperature of 125 °C *only for short durations* (i.e., hot soak re-start). Continuous operation at 125 °C is to be avoided.

NOTICE

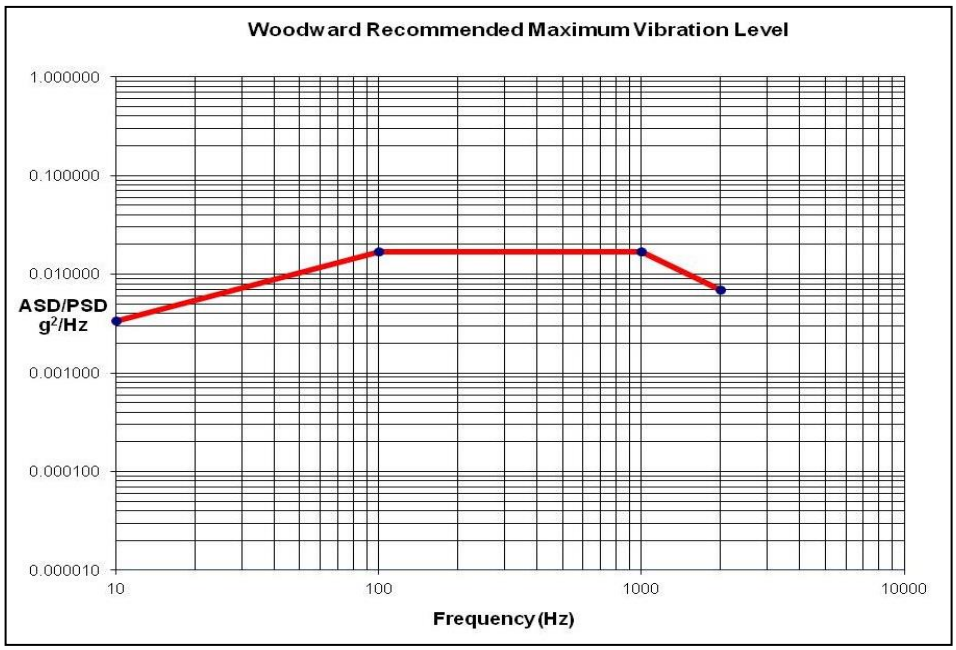
The OH-6 ECU estimates electric motor armature temperature. This information must be used on a continuous basis to maintain armature temperatures below 99 °C. Should the armature temperature approach 220 °C, immediate failure will result.

For OH-5 systems, the armature temperature approval will be application dependent and must be approved by the Woodward application team.

Vibration Specifications

The source of the vibration level of the ETB as measured at the base of the ETB shall not exceed the PSD amplitude as shown in the chart below. The vibration level should be verified by the engine OEM or final customer with all parts attached to the throttle body that are existing in the application.

During the vibration level measurement, the final application (i.e., a transportation bus) must be loaded to approximate no load, mid load, and full load. The vehicle should be operated from idle to its expected maximum operating set speed.



General Items for Collecting Vibration Data

When collecting vibration data on an engine, ensure that the following points are met.

1. Take data in three orthogonal axes, X, Y, and Z.
2. Orient X along the axis of the engine crankshaft, Y normal to the crankshaft in the horizontal plane, and Z in the vertical direction. If this orientation is not achievable, orient axes as close as possible and make sure to document axes with pictures.
3. Take data at the mounting point of the Woodward product. Locate the accelerometer as close as possible to a mounting bolt preferably on the Woodward product. Ensure the location is sufficiently stiff – for instance, sensor not located on a thin bracket.
4. Take data at two additional locations as shown in the photos below.
5. If the product is mounted to a bracket, ensure that data is taken where the Woodward product mounts to the bracket (per 2 above) and at the base of the bracket where it connects to the engine. It is recommended to take data where the product mounts to a bracket and where that system connects to the main engine block.
6. When collecting the above data, record data at multiple engine conditions. At a minimum, take data at the maximum or rated engine output condition, but also consider other output conditions that may create different vibration levels. It is recommended to take data at 75% and 100% load at a minimum.

NOTICE

Any measured deviation above the operational limit line will result in reduced product life. Any and all efforts must be made to minimize vibration levels impacting the ETB.

NOTICE

Any deviation above the operational limit line should be discussed with Woodward. Woodward has the right to withhold warranty for parts that operate at a vibration level above this specified level.

ETB Mechanical Performance

The construction of the throttle body is designed to meet the requirements set out in FMVSS 124, but the ability of the throttle to meet the intent of FMVSS-124 is somewhat dependent upon the customer defined default throttle angle and the vehicle operation at that angle.

Noise: The ETB cannot be heard by a human ear at a 1 m (3.3 ft) distance between the throttle body and the observer's ear with the engine at idle and the engine compartment door open. Woodward assumes there are no minimum noise requirements for the ETB with the engine off and key on.

Maximum shaft torque at 25 ºC (77 °F) (Vbatt greater than 8V):
291 in-ozs (2.04 N-m) not including return spring

In reference to FMVSS-124, at -40 deg F/C, the throttle plate returns to null position in <500ms

Return time above -40℃ to +121℃ (-40 ℉ to 250 ℉) is <0.35 seconds as measured with ETB not connected to a PCM, or measured with ETB connected to equipment that does not induce back EMF in the motor (i.e. PCM or End of Line Tester).

With the motor terminals shorted return time: <1 sec

Wide Open Throttle (WOT) stop plate position: 96.6° min to 102.4° max absolute

Max throttle opening:
86.89 Max from closed plate angle* = Commanded position + positional command tolerances + temp variation + overshoot

(*) Closed plate angle is set according to minimum airflow and equates to approx 7.5° absolute.

Plate and Sensor Speed Requirements

Plate and sensor rotation: maximum 1500 degrees/sec

Plate and sensor rotation for approach speed: 20 degrees/sec

NOTICE

DO NOT adjust the null position. It is factory set and adjustment will invalidate warranty and may cause serious harm.

Max plate to stop contact speed is 20°/sec although contact with the Upper Mechanical Stop (UMS) should be minimized. The design intent should NOT be to strike the UMS every time Wide Open Throttle is commanded.

Airflow Performance

Table 2-1. Airflow Performance (for new parts)

Bore Size	32mm	45mm	55mm	60mm	64mm
Minimum Closed Stop Airflow (Kg/Hr)	2.1 ± 0.4	2.14 ± 0.4	2.91 ± 0.4	4.20 ± 0.4	4.70 ± 0.4

Airflow measured at 60 kPa (18 in hg vacuum)

Default Plate Angle Setting

The default plate angle is set at approx 8° above the closed stop position.

Default airflow for the 45mm ETB will be approx 34 Kg/Hr +/-4.5 Kg/Hr at approximately 60 KPa delta pressure.

Wide Open Throttle—see chart below.

Table 2-2. WOT Air Flow

Throttle Size	Wide Open Throttle	Air Flow (approx.)	Delta Pressure (approx.)
32mm	90°	320 Kg/Hr	7 kPa
45mm	90°	550 Kg/Hr	7 kPa
55mm	90°	1000 Kg/Hr	7 kPa
60mm	90°	1200 Kg/Hr	7 kPa
64mm	90°	1350 Kg/Hr	7 kPa

Strength of Air Duct at Throttle Inlet

The clean side duct should also have a sufficient degree of stiffness to absorb some of the high-frequency vibration that can lead to terminal plating fretting.

Electrical Load Performance

- DC motor resistance and nominal current draw
    - Motor resistance ranges from 1.3Ω to 2.6Ω (typical over temperature).
    - Motor requires from 0.7 to 1.2 amps to balance the return spring at Wide Open Throttle (WOT).
    - Motor requires from 1.0 to 1.5 amps to balance the spring load at closed throttle.
- TPS element resistance:1.4KΩ +/-40% measured between Vref & GND, (parallel resistance of TP1 & TP2)
- Wiper current: Note assumes need for 330K load resistor or higher. This is a function of 5V supply and 330K load resistor. 1.5 x 10-5 amps
- Insulation resistance: TP1/TP2 >1MΩ (connector terminals to housing)
- Throttle plate position
    - Nominal TPS output transfer functions as a % of VREF based on the absolute throttle angle relative to throttle body flange.
        - % Output TPS #1 = 88% (+/- 2%) - (0.7813 % /deg)
        - % Output TPS #2 = 12.25% (+/- 2%) + 1.5625% / deg)
- Vref supply: 4.5 to 5.5 Vdc
- Power up time: < 1 ms
- Response time: < 1 ms
- When measuring the sensor output voltage, the sensor must have the PCM's pull-up or pull-down resistor.

Linearity Specifications

Figure 2-1 below shows saturated output and advanced contacting TPS transfer functions. Refer to **Table 2-3** for linearity specifications.

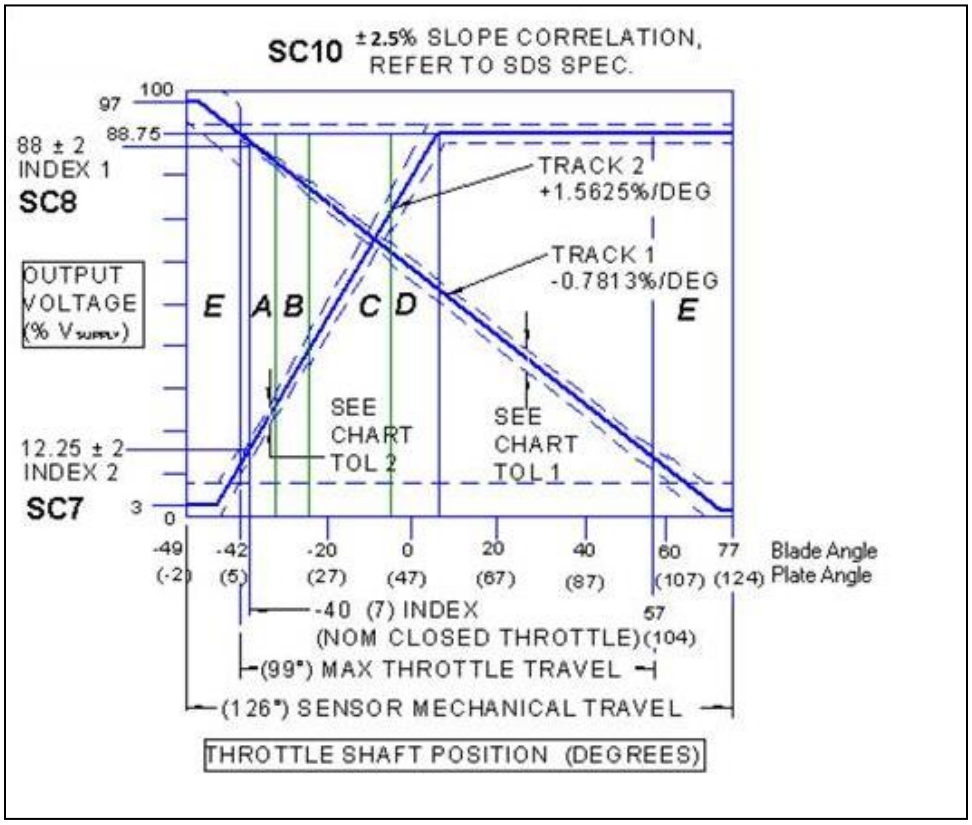


Figure 2-1. Saturated Output and Advanced Contacting TPS Transfer Functions

Table 2-3. Linearity Specifications

Values Valid for -40 °C to 125 °C (-40 °F to 257 °F)

REGION	TRACK 1 POINT-SLOPE LINEARITY SPEC	TRACK 2 POINT-SLOPE LINEARITY SPEC
A (5° to 12° Plate Angle)	± 0.375 % Vref	± 0.750 % Vref
B (12° to 20° Plate Angle)	± 0.625 % Vref	± 1.250 % Vref
C (20° to 40° Plate Angle)	± 0.938 % Vref	± 1.875 % Vref
D (40° to 99° Plate Angle)	± 1.875 % Vref	± 3.750 % Vref

Saturated Output TPS General Information

(**)The correlation limit of ± 2.5% is limited by the maximum spread of the output linearity until the linearity spread increases to above ± 2.5%.

Once the linearity increases to above the correlation value, the outputs can vary by the full linearity spec but cannot differ by more than the correlation spec.

TPS Open / Short Circuit Conditions

All throttle position sensors shall have output values that are distinct from the normal operating values when failed open, shorted to ground or shorted to outside of the reference voltage range.

Below is a summary of the predicted outputs under shorted conditions for the ETC sensor.

SOURCE	SENSOR TERMINALS			
	TP2-PS	Vref	GND	TP1-NS
TP2-PS	N/A	TP1-NS → no effect TP2-PS → HIGH	TP2-PS → LOW TP1-NS → no effect	See Figure 2-2
Vref	TP1-NS → no effect TP2-PS → HIGH	N/A	TP1-NS → Low TP2-PS → Low	TP1-NS → HIGH TP2-PS → no effect
GND	TP2-PS → LOW TP1-NS → no effect	TP1-NS → LOW TP2-PS → LOW	N/A	TP1-NS → LOW TP2-PS → no effect
TP1-NS	See Figure 2-2	TP1-NS → HIGH TP2-PS → no effect	TP1-NS → LOW TP2-PS → no effect	N/A
Nominal Vbatt = 12 vdc	TP2-PS → Vbatt TP1-NS → no effect	Sensor outputs are ratiometric with respect to Vbatt (i.e. Vref is now ~12V)	No effect on sensor outputs	TP1-NS →Vbatt TP2-PS → no effect
Nominal Vbatt = 24 vdc	TP2-PS → Vbatt TP1-NS → no effect	Sensor outputs are ratiometric with with respect to Vbatt (i.e. Vref is now ~24V)	No effect on sensor outputs	TP1-NS →Vbatt TP2-PS → no effect

NOTICE

Default nominal battery supply voltage is 12 Vdc. Battery supply voltage for the motor may be 24 Vdc but motor coil current must be limited to maximum specification by controller. DC current may be limited by use of a PWM-based drive signal.

NOTICE

Reversing the sensor supply voltage (switching Vref and GND) will cause permanent damage to the sensor (internal follower circuit). The sensor output will no longer be functional.

Saturated Throttle Sensor Shorted

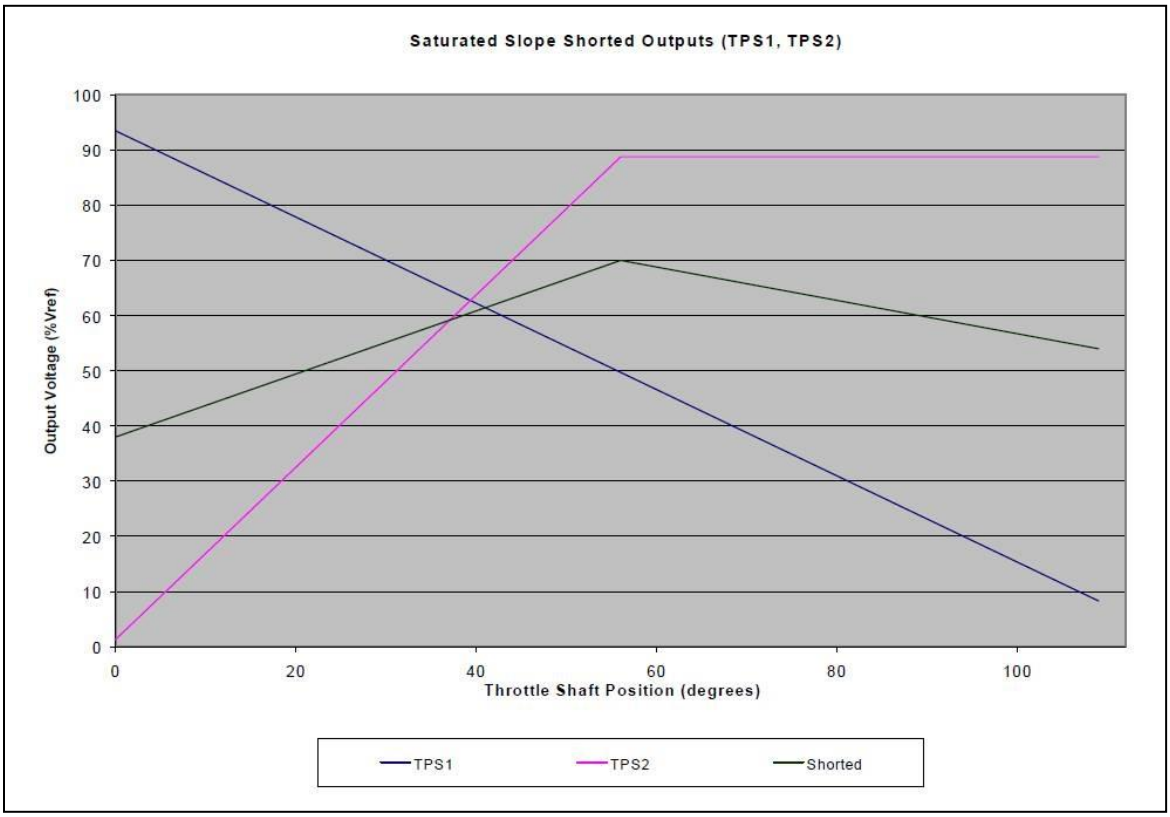


Figure 2-2. Approximate Output with TPS1 and TPS2 Shorted Together

Sensor Output Readings

	Sensor Output at Filter before Open Conditions	Open Sensor GND	Open Sensor POS	Open TPS1	Open TPS2
TP1-NS (TPS1)	4.401 Vdc	0.21Vdc	0.0 Vdc	0.0 Vdc	4.4 Vdc
TP2-PS (TPS2)	0.582 Vdc	5.0 Vdc	4.8 Vdc	0.6 Vdc	5.0 Vdc

NOTE: These sensor conditions are relevant for components before and after aging and temperature variation.

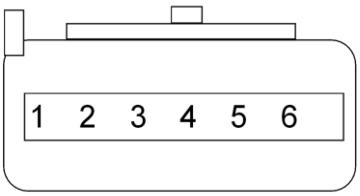
TPS Values at Plate Positions

The following TPS voltage values are taken from assembled ETBs and so take into account TPS mounting tolerances, temperature variation, vacuum effect, aging etc.

	Voltage Limits	
	Lower Limit	**Upper Limit**
TP1 @ TRC	4.292	4.527
TP1 @ DEF	3.976	4.211
TP2 @ TRC	0.408	0.871
TP2 @ DEF	0.997	1.449

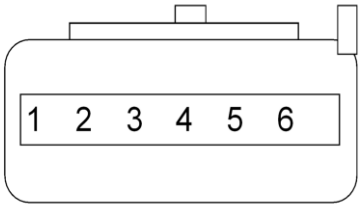
Chapter 3.
Wiring & Assembly

Electrical Connections



1) M(+) = Motor Positive Terminal
2) M(-) = Motor Negative Terminal
3) W1 = TP1-NS, Output 1 (Negative slope)
4) GND = Ground
5) (+) = TPS Supply Voltage (V-Ref)
6) W2 = TP2-PS, Output 2 (Positive slope)

Figure 3-1. Parallel Configuration – Contact Type



1) W1 = TP1-NS, Output 1 (Negative slope)
2) GND = Ground
3) (+) = TPS Supply Voltage (V-Ref)
4) W2 = TP2-PS, Output 2 (Positive slope)
5) M(+) = Motor Positive Terminal
6) M(-) = Motor Negative Terminal

Figure 3-2. Parallel Configuration – Non-Contact Type

NOTICE

Default nominal battery supply voltage is 12 Vdc. Battery supply voltage for the motor may be 24 Vdc but motor coil current must be limited to maximum specification by controller. DC current may be limited by use of a PWM-based drive signal.

Compression Gasket

A compression gasket comes installed in each ETB connector housing. Its use is required for proper performance of the connector assembly during operation and to optimize the life of the connector (including the mating wire harness). Care must be taken to ensure that the item is in place within the ETB connector housing when installing the ETB and when making electrical connection to the ETB via wire harness.

Compression Gasket

Gasket in Connector Housing

ETB Mating Connector Requirements

CONTACTING SENSOR

6-Pin Connector:

Supplier-1: OSRAM

V23542-G1506-D101 Connector Shell w/ CPA (1 per ETB)

V23540-X7000-Y20 Gold Plated Terminals for 18 AWG wire (4 per ETB [Saturated TPS])

V23540-X7000-Y21 Tin Plated Terminals for 18 AWG wire (2 per ETB [Motor])

Supplier-2: TYCO

1438153-1 Connector Shell w/ CPA (1 per ETB)

1393365-1 Gold Plated Terminals for 18 AWG wire (4 per ETB [Saturated TPS])

1393366-1 Tin Plated Terminals for 18 AWG wire (2 per ETB [Motor])

NON-CONTACTING SENSOR

6-Pin Connector:

Supplier: TYCO

1419168-2 Connector Shell w/ CPA (1 per ETB)

1393365-1 Gold Plated Terminals for 18 AWG wire (4 per ETB [Saturated TPS])

1393366-1 Tin Plated Terminals for 18 AWG wire (2 per ETB [Motor])

Connecting Cable Requirements, Parallel Configurations

All wires shall be automotive grade rated for -40°C/F to 135 °C (275 °F) ambient or better for under hood installation.

All wires shall be 18 – 20 AWG, (0.5 – 0.75 mm² [M(+), M(-), W1, GND, (+), W2].

IMPORTANT

Wire size 18-20 AWG is for ETB connector compatibility. For system compatibility the user should refer to the plant wire diagram for the system (example PCM128 may use a different wire size than ECM).

All wire insulation diameter shall be 1.40 – 2.06 mm

All mating type terminals must match throttle body type terminals
Ex: Tin terminal to Tin terminals and Gold terminals to Gold terminals

The four sensor signal pins are gold-plated to provide a durable low resistance connection for the low current, (around 30mA) whereas the 2 motor pins are left tin-plated as the higher current (around 1 A) can easily cross the oxidation layer that may build up over time.

ETB Wiring Harness Installation

To maintain electrical contact integrity, the throttle body harness should be secured to the ETB using proper connector assembly. Follow the instructions below to establish correct connector interface connection.

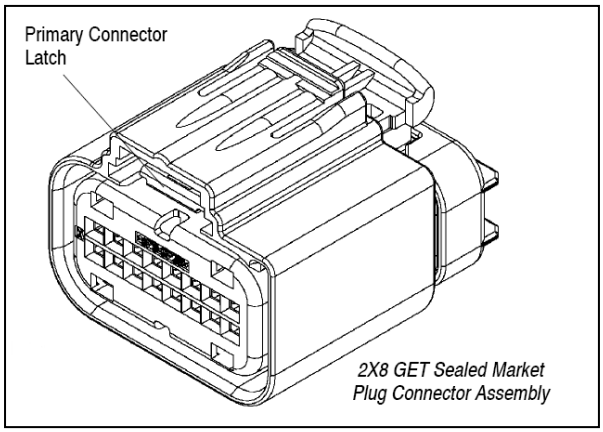


Figure 3-3. GET Sealed Market Plug Connector Assembly

The GET sealed market plug connectors are designed to operate in areas of the vehicle that are subject to environmental conditions such as water, moisture, and humidity. The connectors are also designed to seal out various fluids found in and around road vehicles. The connector also provides moisture resistance through the use of a mat seal and a perimeter seal in the interface area.

These plug connectors are available on 2.54 mm [.100 in.] centerline spacing between circuits. An optional CPA is available on each connector. A TPA is designed on each plug connector to lock the contacts in the housing.

A special extraction tool (Tyco part number 3-1579007-6) is required to remove the TPA and contacts. (See Tooling section.)

The 2x8 connector has 2 rows and 16 positions.

Wire Selection and Preparation

The socket contacts and plug connectors will accept a wire size range of 18-20 AWG having insulation diameters of 1.40 – 2.06 mm [.055-.081 in.]. Only wires with insulation diameters within the recommended range should be used.

Terminate the wires according to the procedures and information provided in Application Specification 114-13060, available upon request from any Tyco Electronics representative, or by calling the Product Information Center at (800) 522-6752). To view or download Application Specification 114-13060 click here.

NOTICE

DO NOT nick, scrape, or cut the wire conductor during the stripping operation.

Damaged product should not be used. If a damaged contact is evident, it should be cut from the wire and replaced with a new one. Contacts must not be re-terminated.

Interface Drawings

Interface drawings will be used to create the mating part for the plug connector assembly listed on this document. See chart below. The interface drawings are available upon request from any Tyco Electronics representative, or by calling the Product Information Center at (800) 522-6752).

Interface Drawing Number	Description
1438199	1x6 Sealed Market Receptacle Connector

Keying Configurations

Figure 3- 4 shows keying pattern for the 2x8 connector.

NOTE: the following 2x8 information is included to demonstrate assembly and disassembly procedures. These procedures are applicable to the 1x6 connector used in the throttles listed in this manual.

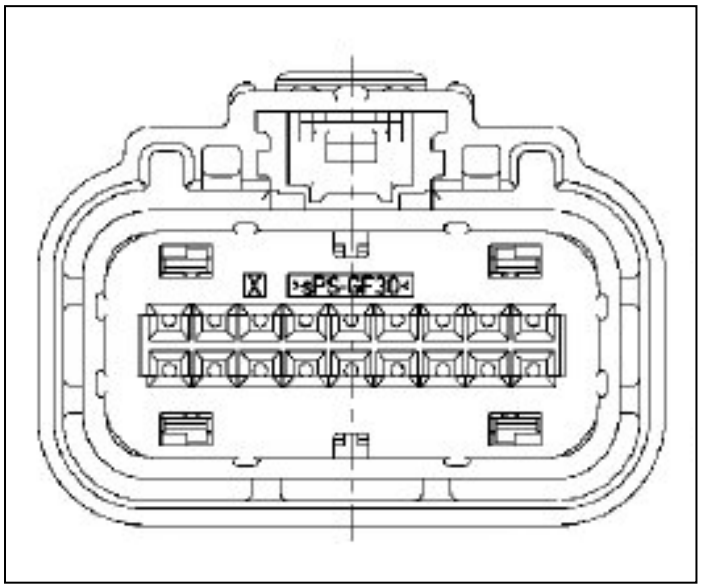


Figure 3-4. Keying Configurations

Assembly Procedures

After terminating the socket contacts with the correct wire sizes according to the requirements provided in Application Specification 114-13060, the assembly procedures are as follows.

NOTICE

The rear of the connector must be completely sealed. Unused circuits are blocked by molding shut the unused terminal opening on the rear cover. A pin molded on the blocked circuit passes through the mat seal to prevent any contamination from entering the seal. See Figure 3-3. Current blocked circuit configurations can be found on the TE Customer Drawing. New configurations can be obtained by contacting the Product Information Center at (800) 522-6752).

Contact retention features in the connector will not engage if the contacts are inserted into those connectors while the TPA is in the "locked" position.

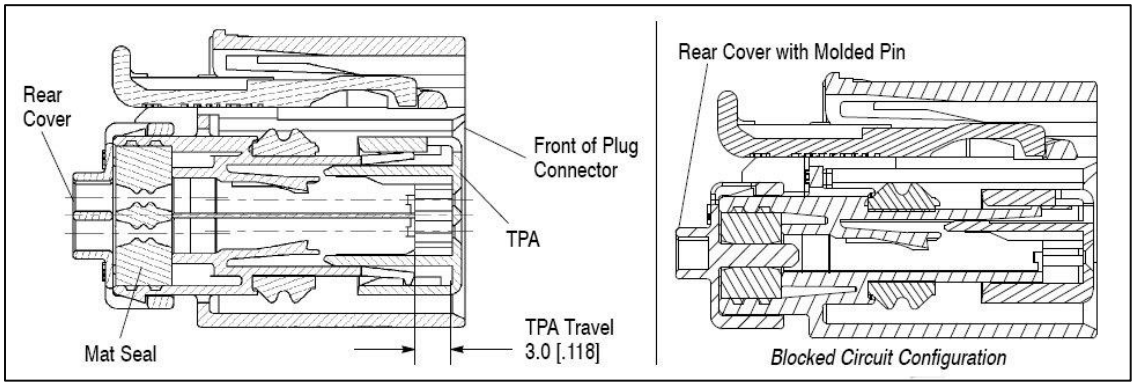


Figure 3-5. Connector Components

1. Contact and Connector Assembly

Crimped socket contacts shall be manually loaded into the plug connectors. Insert the contacts into the connector with the information as follows:

a) Verify that the TPA is in the pre-staged position (un-locked). Prior to installing the contacts, the TPA and the front of the connector should be almost flush with each other. See **Figure 3-5**.

b) Locate the desired circuit into which the individual socket contact will be loaded. The contact must be inserted from the wire end (rear) of the plug connector until it bottoms (there should be an audible and tactile “click”). Each socket contact must be locked in place. Gently pull on the wire to ensure proper contact locking and retention with a force of 4.5 to 8.9 N [1 to 2 lbf]. See **Figure 3-6**.

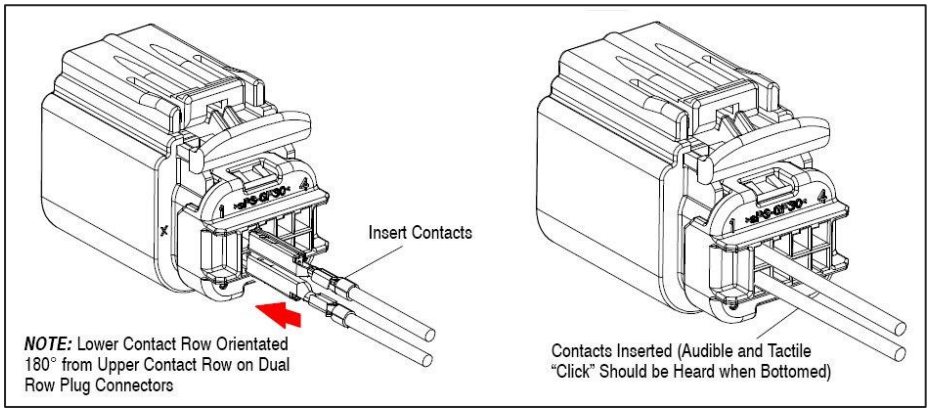


Figure 3-6. Inserting Contacts into Connector

c) When all of the required socket contacts have been inserted, complete the assembly by pushing the TPA into the fully locked position. The TPA may be fully locked by holding the rear of the plug connector assembly and pushing the TPA toward the rear of the connector. See **Figure 3-7**.

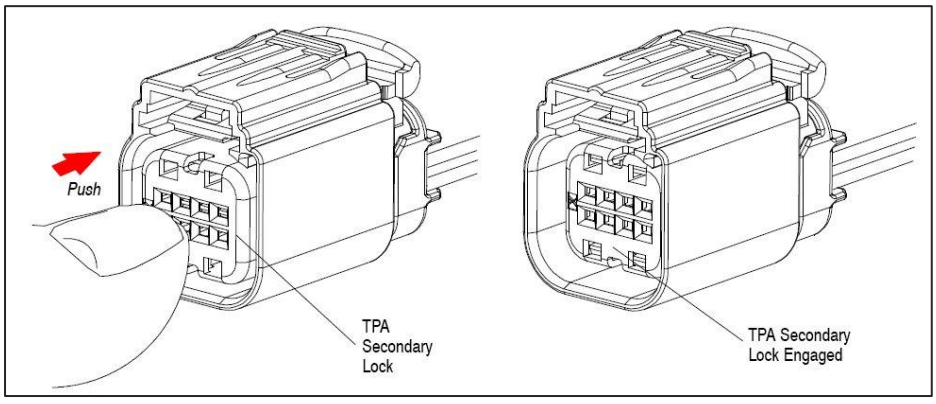


Figure 3-7. Engaging TPA Secondary Lock

NOTICE

If the TPA is not fully inserted and locked, repeat the previous step. When an audible and tactile “click” is heard and felt, the TPA secondary lock is in the final position.

2. Contact and Plug Connector Disassembly

TOOLING

Figure 3-8 shows the only tool needed for these connectors. Extraction Tool 3-1579007-6 is necessary to remove the Terminal Position Assurance (TPA) secondary lock from the set position.

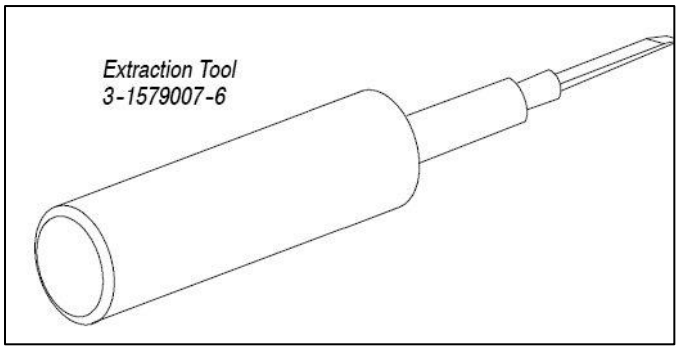


Figure 3-8. Extraction Tool

In order to remove the contacts for any reason, the following steps must be followed.

a) To disengage the TPA, insert Extraction Tool 3-1579007-6 in the center of the plug connector housing cutout on the TPA. Rotate the extraction tool toward the front of the connector to disengage the TPA. See **Figure 3-9**.

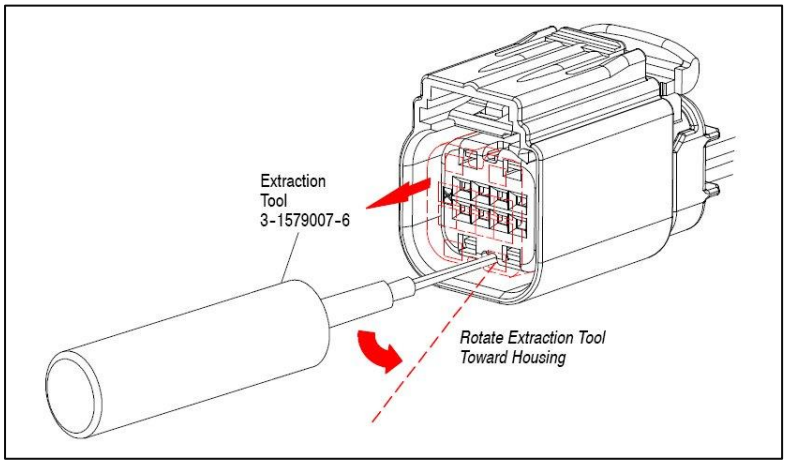


Figure 3-9. Disengaging TPA

b) Place the extraction tool under the beam that holds the contact in place as shown in **Figure 3-10**.

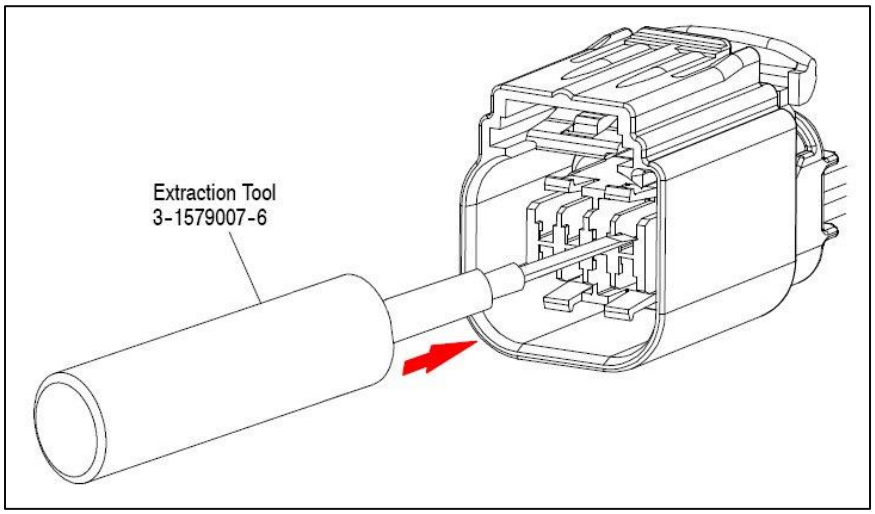


Figure 3-10. Removing Terminals from Connector

c) Refer to **Figure 3-11** for contact removal process.

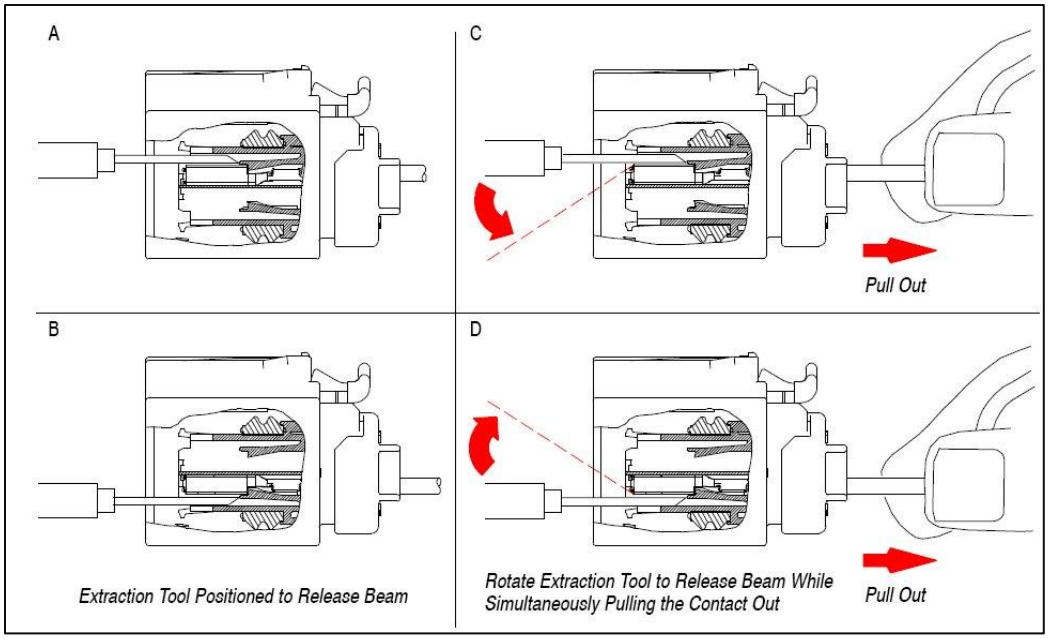


Figure 3-11. Terminal Removal Procedure

IMPORTANT

Do not re-use damaged or worn contacts. Damaged contacts should not be used. If a damaged contact is evident, it should be cut from the wire and replaced with a new one. Do not re-terminate contacts.

3. Receptacle and Plug Connector Assembly

A variety of customer supplied receptacle connectors may be available for mating with the GET sealed market plug connector assembly.

Refer to Tyco Electronics interface drawings for specific dimensions on these receptacle connectors or contact the Product Information Center at (800) 522-6752).

Mating instructions are provided as follows:

a) In **Figure 12**, the CPA is locked in Position “1” during shipping and handling before engaging the primary connector latch. The CPA cannot move forward until the connectors are mated and the primary connector latch is mated with an audible and tactile “click” which indicates connectors are engaged.

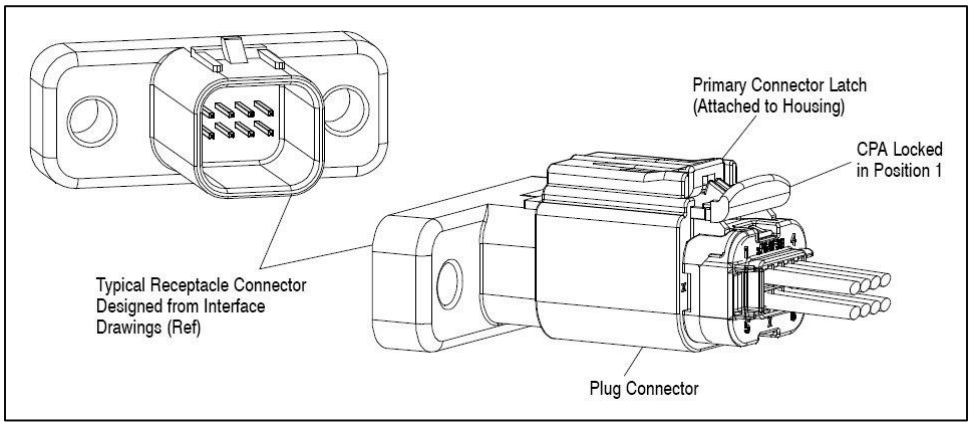


Figure 3-12. Primary Connector Latch

b) To mate the two connectors together, push on the housing base or sides only. Do not push the CPA forward until the primary connector latch “clicks” and engages. See **Figure 3-13A**.

c) Finally to lock, push the CPA forward until an audible and tactile “click” is heard and felt. This will engage the secondary lock and ensure proper CPA locking. See **Figure 3-13B**.

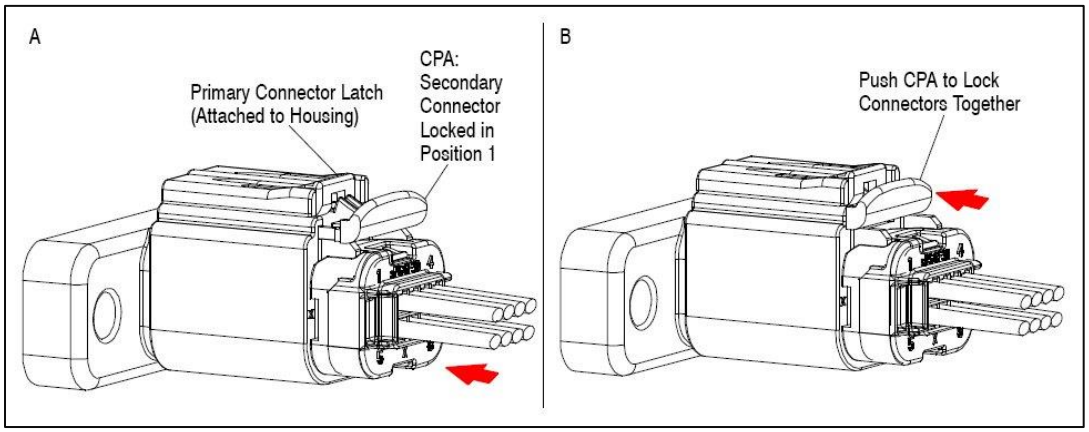


Figure 3-13. Locking Primary and Secondary Connectors

4. Un-mating of Receptacle and Plug Connector Assembly

a) To un-mate the receptacle and plug connector assemblies, lightly pull the CPA back to Position 1 (pre-installed position) until an audible and tactile “click” is heard and felt. See **Figure 3-14(A)**.

b) With the CPA in Position 1, depress the primary connector latch, then simultaneously pull the connectors/wires while gripping the housing with the thumb, index finger, and palm if using the wire bundle. See **Figure 3-14(B)**.

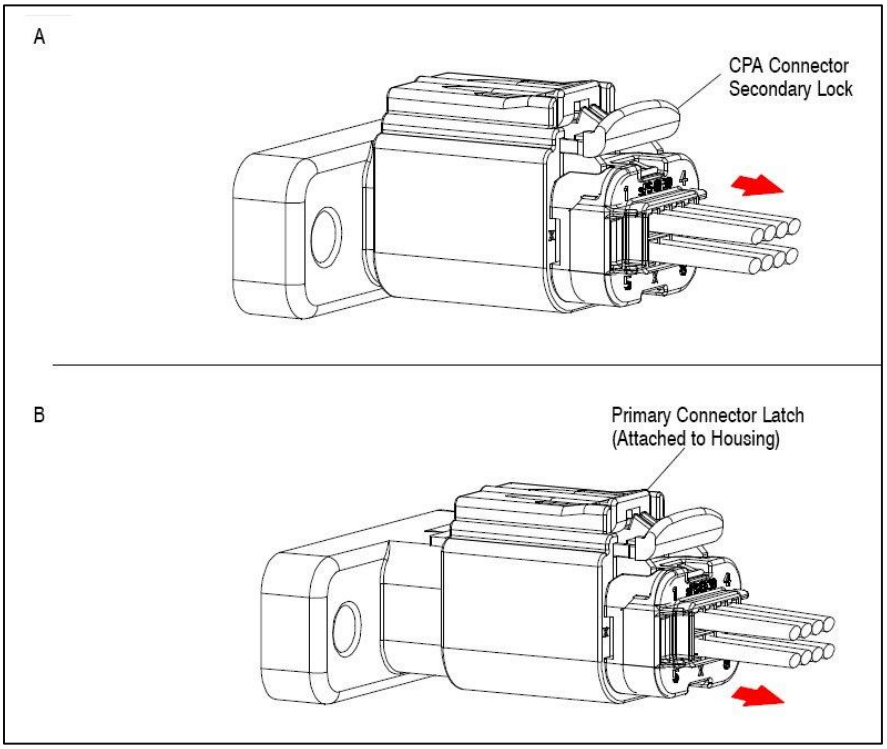


Figure 3-14. Unlocking Primary and Secondary Connectors

Final Assembly

Figure 3-15 shows a typical application of a GET sealed market plug connector assembly.

This illustration shows more than 6 terminals but should be used by production personnel to ensure a correctly applied product. Applications which DO NOT appear correct should be inspected using the information in the preceding pages of this manual.

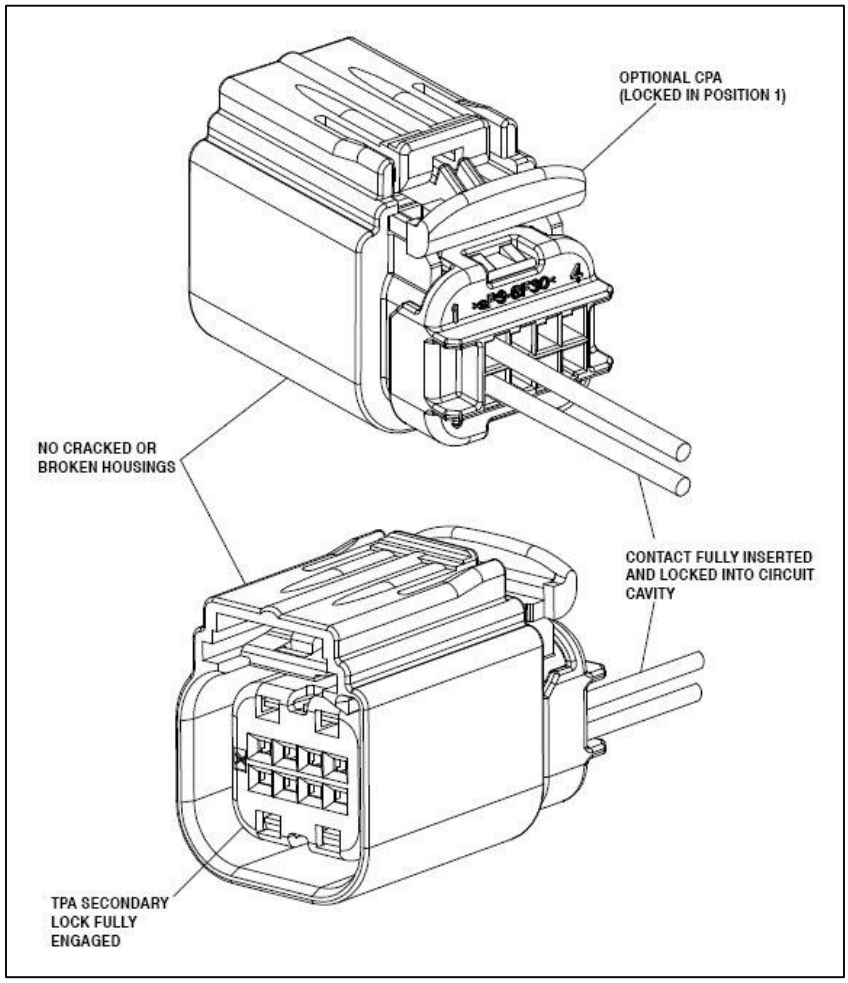


Figure 3-15. Final Assembly

Secure wire harness into fixed clip located on the rib feature of the ETB after connector interface connection is established (See NOTICE below and **Figure 3-16**). The harness shall have a 178mm ± 13mm [7” ± 0.5”] loop from the end of the connector to the clip to minimize terminal fretting.

NOTICE

Support of the wire harness by use of the fixed clip is required for durability purposes (see Figure 3-16). Failure to use this support clip correctly will result in premature failure of the connector system (including, but not limited to, intermittent faults and poor product performance), which could affect warranty terms.

Alternate wire harness support methods and/or locations must be approved by Woodward Engineering in writing to prevent voiding the manufacturer's warranty.

Figure 3-16. Wire Harness Clip

Chapter 4.
Installation

Installation Requirements

1. The ETB should be mounted such that the throttle shaft is horizontal. Mounting the ETB with the shaft in a vertical position is NOT recommended. See **Figure 4-1**.

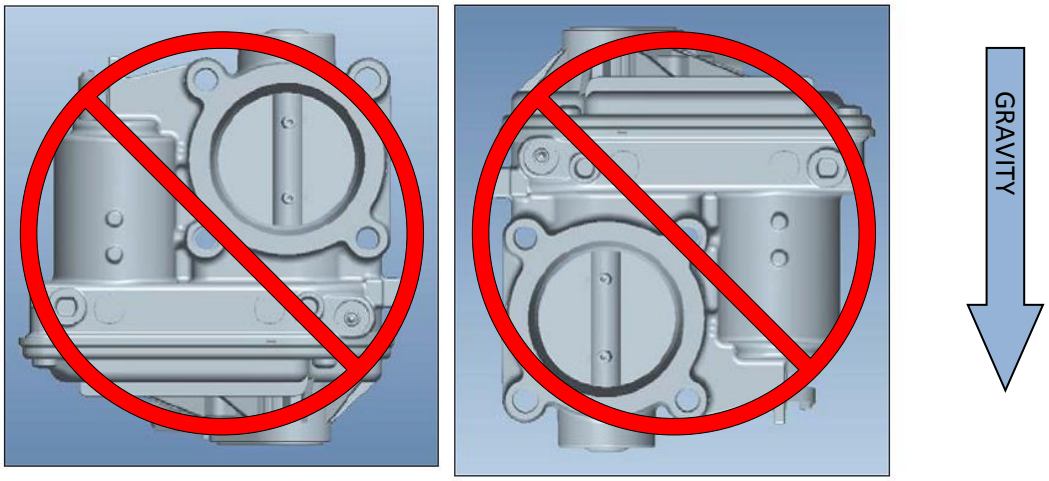


Figure 4-1. ETB Mounting with Shaft in Vertical Position (Not Recommended)

2. Approved fuels include gasoline, LPG, and CNG/LNG. For naturally-aspirated engines the fuel may be introduced before or after the throttle. For turbo-charged engines the fuel must be introduced *after* the throttle.
3. Remove all connectors prior to welding.
4. Mask ETB before welding to protect plastic components.
5. After installation of the ETB or PCM/ECM, allow the PCM/ECM to learn the settings of the ETB; turn on the key, wait 10 seconds, and then turn off the key and wait for communications with the diagnostics tool to cease.
6. In order to reduce interference during throttle mounting, the customer-designed mounting flange shall not touch the gear train housing (marked as “Mounting Flange Keep-out Area” in **Figure 4-2**). Interference may cause an air leak.

IMPORTANT **On turbo-charged (boosted) applications, fuel must be introduced downstream of the throttle.**

NOTICE **During operation, continuous water drop out (condensate) within the ETB is to be avoided. Warranty may be denied if water is damaging the throttle from within.**

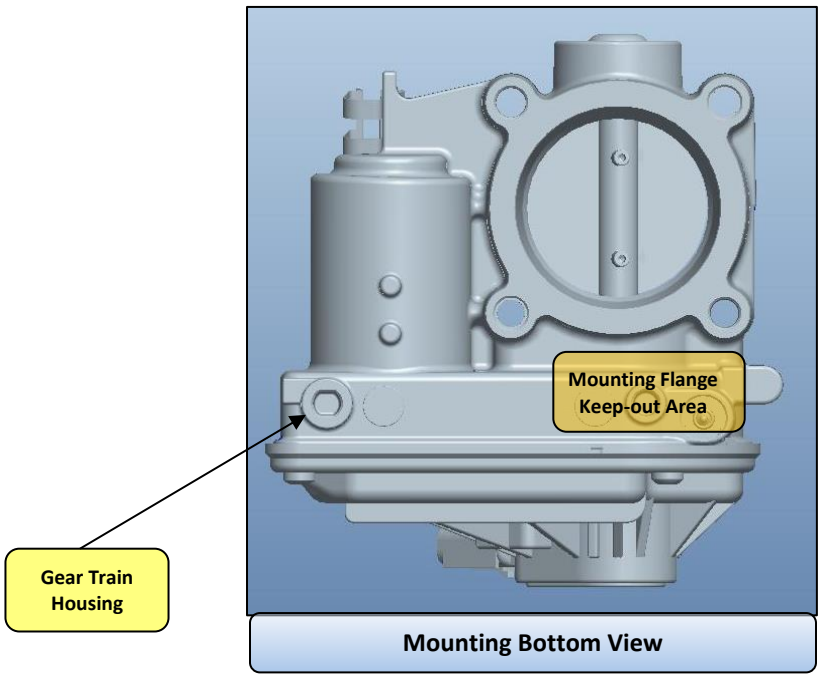


Figure 4-2. Mounting Flange Keep-Out Area

NOTICE: On double-flange throttle body designs, a feature has been included in the casting in the form of a notch near one of the bolt holes to allow for protection against installation errors (improper orientation – including clocking orientation and/or “upside down” installation). See **Figure 4-3**. Check the appropriate drawing for your part number for design details.

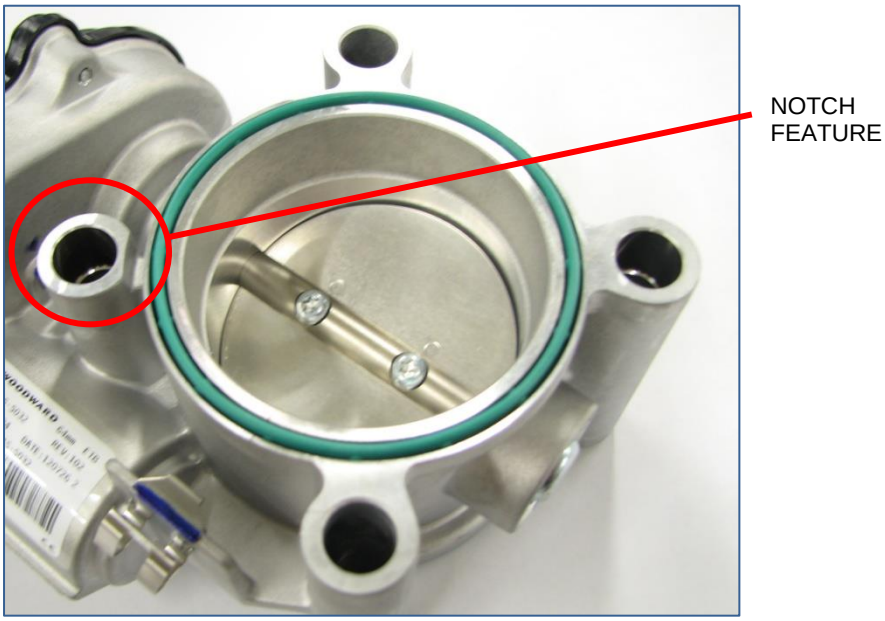


Figure 4-3. Notch Feature on Double-Flange Throttle Body Designs

Chapter 5.
System ETB Faults & Actions

ETC Diagnostic Default Fault Actions for Saturated TPS Throttle

Woodward recommends the following actions for each of the ETC faults.

Fault	Actions
TPS1 Voltage High Fault	MIL on for key cycle; Disable AL for key cycle; Torque derate most severe for key cycle
TPS1 Voltage Low Fault	
TPS2 Voltage High Fault	
TPS2 Voltage Low Fault	
TPS Sensor Conflict	
TPS Intermittent	
Both TPS1 & TPS2 High or Low	MIL on for key cycle; Electronic throttle shutdown for key cycle
TPS1 Adapt Low Min/Max Fault	
TPS2 Adapt Low Min/Max Fault	
ETC Spring Test Fault	
ETC Open Fault	
Manifold Pressure Higher than Expected Fault *	
ETC Shorted Fault	MIL on for key cycle; Electronic throttle shutdown for key cycle; Shutdown ECM Throttle Driver Output and LPLO
ETC Sticking Fault	

(*) Manifold Pressure Higher than Expected fault is an improved strategy for the OH-5 and OH-6 systems to better protect for out-of-control air flow conditions (potentially due to throttle plate damage, manifold leaks, etc.). Default calibration is not sufficient for all applications and needs special calibration and validation for each engine application.

Chapter 6.
PCM/ECM Control and Calibration

The ETB shall only be used in Woodward systems that have the proper control and diagnostic logic and calibration for this ETB design.

⚠CAUTION

Use of this ETB with incorrect control logic or calibration may result in underperformance, unstable performance, damage to the ETB, unsafe operating conditions, and/or loss of warranty.

PCM/ECM Control and Diagnostic Logic

The ETB shall be used only with approved PCMs/ECMs and systems where intended.

The software application position control logic is specially configured for this ETB and is not the same as that used by other manufacturers ETBs.

Only the approved GAP or MotoHawk position control and diagnostic software logic shall be used. No changes shall be made to the control and diagnostic logic without consulting the appropriate platform design team members.

PCM/ECM Calibration

The ETB shall be used only with the approved calibration settings released for each system type.

No changes shall be made to the calibration without consulting the appropriate platform design team members.

Failure Modes and Effect Tests (FMETs)

As the control and diagnosis of the ETB has significant impact to the system safety, Woodward requires that the customer releasing this ETB system perform FMET on the potential throttle or air flow control failure modes including validation of the fault action in the final application. The purpose of this testing is to ensure that the proper actions are taken at the proper condition and that the system including the customer wiring harness still results in the correct system faults be setting.

Failure modes that shall be tested include, but are not limited to, the following:

- All TPS sensor wiring failures as called out above
- Stuck throttle plate condition at wide open
- Shorted motor during operation

In addition to these ETB failures, the OEM shall test for:

- Conditions that the ETB positioning cannot detect
- Other system faults designed to detect the following:
  - Leakage of air in excess of the current throttle position (either due to a bent or damaged throttle plate or other manifold air leak)
  - The commanded ETB position is proper for the operator torque request (torque security).
  - Examples include mismatch of torque request and foot brake, high operator torque request at engine starting, CAN based torque request from other source and operator request.

Chapter 7.
Test Methods

Design Verification Plan and Report (DVP&R)

The electronic throttle body DVP&R consists of a series of tests that cover the following fundamental properties of electronic throttle body design:

1. Durability testing (simultaneous temperature, vibration, cycling)
2. Performance testing (step response and precision movements)
3. Airflow testing (flow mapping, set sensitivity)
4. EMC and ESD testing
5. Audio testing
6. Throttle efforts testing and mechanism characteristics
7. Under hood environment

In addition to the DVP&R testing, the sensor and actuator suppliers contribute significantly to the overall ETB testing effort.

Several hot and cold weather vehicle test trips have been conducted to ensure that the ETB's perform exceptionally under the harshest environmental conditions.

ETB Step Response Requirements

The following is an excerpt from the ETC system design specifications that govern the response time of the Woodward ETB. The performance values are derived by using a Woodward manufactured PCM/ECM approved control and diagnostic logic, and approved calibration.

THROTTLE BODY RESPONSE	
Steady State	With steady load on the throttle and steady position command, the steady state error shall always be less than ± 0.50% of full scale at all positions, unless TPS sensor noise can be documented. In that case the position error may grow with amount of TPS sensor noise.
	Steady state error shall be unaffected by variations in battery voltage from 16 to 30 VDC slow DC variation.
	Steady state error shall be unaffected by variations in ambient temperature from -40 °C to +125 °C (-40 °F to 257 °F).
	Steady state error shall be unaffected by operation on engine while the engine is running. Assuming the load is steady on the throttle and command is steady, testing shall be accomplished to quantify.
	Resolution of positioning shall be defined as comparing the smallest change that can be controllably adjusted by changing the command position percentage that can be seen in a 5-second average position feedback.
	Resolution of positioning shall be demonstrated to be better than 0.2% of full scale including command resolution to feedback from 2% to 100% position (including null point).
Large Step	Response time is defined as the time from the step command until the throttle reaches 90% of the target position, and stays within this target.
	For all large step responses, overshoot or oscillation shall not exceed 4.0% of throttle full scale travel.
	Closed loop step response times shall not change by more than ± 30% as a result of variations in battery voltage from 16 to 30 Vdc for slow DC change.
	Closed loop step response times shall not change by more than ± 30% as a result of variations in ambient temperature from -40 °C to +125 °C (-40 °F to 257 °F).
	Closed loop step response time from 10 to 90% throttle travel shall not exceed 400 msec.
	Closed loop step response time from 90 to 10% throttle travel shall not exceed 400 msec.
	On-engine testing shall quantify the small signal step response for a 3 to 8% step change (idle speed) and prove it does not degrade by more than 30% over the bench testing.
	On-engine testing shall quantify the small signal step response for a 8 to 3% step change (idle speed) and prove it does not degrade by more than 30% over the bench testing.

Throttle Body Response (cont'd.)

Small Step	Response time is defined as the time from the step command until the throttle reaches 90% of the target position, and stays within this target.
	For all small step responses, overshoot or oscillation shall not exceed 2.0% of throttle full scale travel.
	Closed loop step response times shall not change by more than ± 30% as a result of variations in battery voltage from 16 to 30 Vdc for slow DC change.
	Closed loop step response times shall not change by more than +/-30% as a result of variations in ambient temperature from -40 °C to +125 °C (-40 °F to 257 °F).
	Closed loop step response time from 47.5 to 52.5% throttle travel shall not exceed 400 msec.
	Closed loop step response time from 52.5 to 47.5% throttle travel shall not exceed 400 msec.
	Closed loop step response time from 2 to 6% throttle travel shall not exceed 400 msec
	Closed loop step response time from 6 to 2% throttle travel shall not exceed 400 msec.
	Closed loop step response time from 3 to 8% throttle travel shall not exceed 400 msec.
	Closed loop step response time from 8 to 3% throttle travel shall not exceed 400 msec.
	On-engine testing shall quantify the small signal step response for a 3 to 8% step change (idle speed) and prove it does not degrade by more than 30% over the bench testing.
	On-engine testing shall quantify the small signal step response for a 8 to 3% step change (idle speed) and prove it does not degrade by more than 30% over the bench testing.
Sine	Sine response testing shall be conducted on the subsystem for a sine wave command of amplitude of 47.5 to 52.5% from 0.5 to 10 Hz, and measure the gain and phase. The gain shall be better than -3dB from 0.5 to 2.5 Hz.
	Sine response testing shall be conducted for a sine wave command of amplitude of 4 to 6% from 0.5 to 10 Hz, and measure the gain and phase. The gain shall be better than -3dB from 0.5 to 2.5 Hz.
	Sine response testing shall be conducted for a sine wave command of amplitude of 3 to 8% from 0.5 to 10 Hz, and measure the gain and phase. The gain shall be better than -3dB from 0.5 to 2.5 Hz.
Slow Ramp	A slow ramp from 3% to 97% back to 3% shall be run, recording command and feedback, with a computation of error. Ramp time shall be 30 seconds opening and 30 seconds closing. . Purpose of this is to ensure that the PID settings do not result in problems following slow changing signal response and jerky throttle behavior or other anomalies.
Gain Stability Margin	Gain stability margin will be measured on 10-90% step while gain error is increased until throttle becomes unstable. Throttle must be stable with error gain of 1.5 or less

Chapter 8.
Basic Troubleshooting

Visual/Physical Check

The Visual/Physical check is very important, as it can often correct a problem without further troubleshooting and save valuable time.

Perform the following during your visual check:

- Check the motor resistance.
- Check physical wiring connections.
- Check plate for binding and spring return action both above and below null point.
- Check for proper null point positioning.

Resistance Check
(Applicable for the Contacting TPS Only)

To determine if TPS sensor is damaged, a check of the resistances below should be performed.

TPS BOARD DAMAGE CHECK		
Description	**Plate Position**	**Resistance ± 30%**
Ground to TP2	Default	0.45 kΩ
Ground to TP2	WOT (90°)	0.67 kΩ
Ground to TP1	Default	0.75 kΩ
Ground to TP1	WOT (90°)	0.45 kΩ
Vref to TP2	Default	0.65 kΩ
Vref to TP2	WOT (90°)	0.33 kΩ
Vref to TP1	Default	0.50 kΩ
Vref to TP1	WOT (90°)	0.74 kΩ

Difficult Starting, Launch or Stall Issues

Prerequisite

Prior to any subsequent work being undertaken the following tasks must be performed.

1. Check for the presence of a diagnostic trouble code (SFC).
    a. If codes are indicated, record the codes onto the appropriate paperwork.
    b. Compare the SFC with those listed under “Procedure” section below.
    c. If the SFC code found is not on the list then resolve and clear the fault code.
    d. Recheck that difficulty in starting, launch or stall issues are still present.

e. If the listed codes are indicated, then undertake the procedure.

2. If difficult starting, launch or stall issues still occur and there are no SFCs other than those listed in the appendix, then visually check the ETB.

   If contamination is present then undertake the ETB cleaning procedure outlined below.

Electronic Throttle Body Cleaning Procedure

NOTICE

The electronic throttle body (ETB) and its associated parts are sensitive instruments; care should be exercised to avoid risk of damage to the ETB and its ancillary parts.

The incidence of foreign matter into the manifold is increased when the ETB is being removed and refitted.

Items required

- Clean work surface
- Good quality carburetor cleaner in spray form
- New gasket, if required
- Clean cloths (one for cleaning, the other to wipe dry) and a clean covering, either cloth or a plate, to place over the manifold
- Face masks, protective eye wear, and gloves

Procedure

NOTICE

No cleaning procedure should commence until engine diagnostics has been run and SFCs noted. If the codes are not on the list relevant to the procedure (see below), clear those codes first.

1. Be sure the vehicle has been switched off.
2. Locate and separate the ETB electrical connector.
3. Using the appropriate tools, carefully remove the ETB assembly.
4. When the ETB has been removed, cover the exposed manifold opening with a clean cloth or plate.
5. On a clean work surface remove the ETB contamination, using soft clean cloth and, if necessary, a throttle body/injector cleaner.
   a. **DO NOT** apply the throttle body/injector in a confined space or near incandescent flames. Read and comply with instructions for the cleaning solutions.
   b. **DO NOT** apply the throttle body/injector cleaner to the bearing and grease at the throttle shaft.
   c. **DO NOT** use petrol and/or alcohol.
   d. **DO NOT** use wire brushes, scourers, sand and emery paper or any other abrasive agents when removing the contamination.

6. Proper cleaning will result in a smooth aluminum surface of the bore and plate (flat face and edges).
7. Any pieces of contamination which do not readily dissolve should be re-sprayed with the cleaner and left for at least 5 minutes to dissolve. Again, removal of contamination should only be undertaken using soft cloths.
8. When satisfied that the ETB is free of contamination around the throttle plate and bore, indent the square boss on the housing (refer to Figure 5) sufficiently to leave a permanent mark.
9. When the ETB is clean; wipe the unit dry with a clean soft dry cloth.
10. Check the gasket and replace it if necessary.
11. Remove the cloth or plate from the manifold and, using the correct tools, refit the ETB.
12. Reconnect the ETB plug and socket. Recheck all other connections and fixings.
13. Ensure the vehicle is safe and can be operated without impairing safety to operator or vehicle.
14. Check that the vehicle is fully operational and that fault codes have been removed.

Service Fault Codes (SFC) Relevant to this Cleaning Procedure

1. **SFC 555 – Throttle Valve Stuck**

   SFC 555 will be set if the throttle set point and position deviate by a calibrated amount (default 10%) for a duration that exceeds the calibrated delay time (default 1s). Also, the Throttle Spring Test Fault, TPS1 Adapt Low Min Fault, TPS1 Adapt Low Max Fault, TPS2 Adapt Low Min Fault, or TPS2 Adapt Low Max Fault could occur due to contamination or icing.

Codes observed other than those listed may indicate that the ETB is NOT contaminated.

Any codes other than those listed must be rectified and cleared first.

NOTE: Once the other SFCs are cleared you must retest the vehicle.

Chapter 9
Valve Application Review

Application Checklist

For full application warranty of the product, the following items at a minimum must be reviewed with Woodward application engineering team.

- Use of proper electrical termination/connector practices, including terminal material and plating, proper support of wire harness, wire size, etc.
- Mounting location and orientation of the throttle
- Manifold Pressure Higher-Than-Expected Fault to be calibrated properly (not all air leaks can be managed by the throttle)
- Application vibration levels are measured and approved by Woodward
- Armature temperature (maximum and steady state) of the motor is determined and approved by Woodward
- Throttle motion counters measured and correlated to warranty period, as excessive throttle movements will reduce throttle life.
- A maximum of ninety (90) 1% movements of the throttle plate per kilometer of driving is required on bus applications with 100k kilometers of usage. Any throttle movement count higher than this must be approved by Woodward. Truck applications will vary by application and should be discussed with the Woodward application team at initial development.
- When used in an application with an EGR system, EGR must be introduced downstream of the throttle to prevent water condensation in motor housing or throttle plate icing to avoid stuck throttle or damaged throttle components. Throttle warranty will be void if EGR is introduced upstream of the throttle. Consult Woodward for application approval of all other EGR configurations.
- Throttle size for each application must be approved by Woodward application team.
- Customers who approve/stock multiple throttle sizes should have a method in place to prevent mixing the parts in stock and/or at installation.
- Approved software and calibration is being used for ECU throttle control.

Chapter 10
Product Support and Service Options

Product Support Options

If you are experiencing problems with the installation, or unsatisfactory performance of a Woodward product, the following options are available:

1. Consult the troubleshooting guide in the manual.
2. Contact the **OE Manufacturer or Packager** of your system.
3. Contact the **Woodward Business Partner** serving your area.
4. Contact Woodward technical assistance via email (**EngineHelpDesk@Woodward.com**) with detailed information on the product, application, and symptoms. Your email will be forwarded to an appropriate expert on the product and application to respond by telephone or return email.
5. If the issue cannot be resolved, you can select a further course of action to pursue based on the available services listed in this chapter.

OEM or Packager Support: Many Woodward controls and control devices are installed into the equipment system and programmed by an Original Equipment Manufacturer (OEM) or Equipment Packager at their factory. In some cases, the programming is password-protected by the OEM or packager, and they are the best source for product service and support. Warranty service for Woodward products shipped with an equipment system should also be handled through the OEM or Packager. Please review your equipment system documentation for details.

Woodward Business Partner Support: Woodward works with and supports a global network of independent business partners whose mission is to serve the users of Woodward controls, as described here:

- A **Full-Service Distributor** has the primary responsibility for sales, service, system integration solutions, technical desk support, and aftermarket marketing of standard Woodward products within a specific geographic area and market segment.
- An **Authorized Independent Service Facility (AISF)** provides authorized service that includes repairs, repair parts, and warranty service on Woodward's behalf. Service (not new unit sales) is an AISF's primary mission.
- A **Recognized Engine Retrofitter (RER)** is an independent company that does retrofits and upgrades on reciprocating gas engines and dual-fuel conversions, and can provide the full line of Woodward systems and components for the retrofits and overhauls, emission compliance upgrades, long term service contracts, emergency repairs, etc.

A current list of Woodward Business Partners is available at **www.woodward.com/directory**.

Product Service Options

Depending on the type of product, the following options for servicing Woodward products may be available through your local Full-Service Distributor or the OEM or Packager of the equipment system.

- Replacement/Exchange (24-hour service)
- Flat Rate Repair
- Flat Rate Remanufacture

Replacement/Exchange: Replacement/Exchange is a premium program designed for the user who is in need of immediate service. It allows you to request and receive a like-new replacement unit in minimum time (usually within 24 hours of the request), providing a suitable unit is available at the time of the request, thereby minimizing costly downtime.

This option allows you to call your Full-Service Distributor in the event of an unexpected outage, or in advance of a scheduled outage, to request a replacement control unit. If the unit is available at the time of the call, it can usually be shipped out within 24 hours. You replace your field control unit with the like-new replacement and return the field unit to the Full-Service Distributor.

Flat Rate Repair: Flat Rate Repair is available for many of the standard mechanical products and some of the electronic products in the field. This program offers you repair service for your products with the advantage of knowing in advance what the cost will be.

Flat Rate Remanufacture: Flat Rate Remanufacture is very similar to the Flat Rate Repair option, with the exception that the unit will be returned to you in "like-new" condition. This option is applicable to mechanical products only.

Returning Equipment for Repair

If a control (or any part of an electronic control) is to be returned for repair, please contact your Full-Service Distributor in advance to obtain Return Authorization and shipping instructions.

When shipping the item(s), attach a tag with the following information:

- return number;
- name and location where the control is installed;
- name and phone number of contact person;
- complete Woodward part number(s) and serial number(s);
- description of the problem;
- instructions describing the desired type of repair.

Packing a Control

Use the following materials when returning a complete control:

- protective caps on any connectors;
- antistatic protective bags on all electronic modules;
- packing materials that will not damage the surface of the unit;
- at least 100 mm (4 inches) of tightly packed, industry-approved packing material;
- a packing carton with double walls;
- a strong tape around the outside of the carton for increased strength.

NOTICE

To prevent damage to electronic components caused by improper handling, read and observe the precautions in Woodward manual 82715, *Guide for Handling and Protection of Electronic Controls, Printed Circuit Boards, and Modules*.

Replacement Parts

When ordering replacement parts for controls, include the following information:

- the part number(s) (XXXX-XXXX) that is on the enclosure nameplate;
- the unit serial number, which is also on the nameplate.

Engineering Services

Woodward's Full-Service Distributors offer various Engineering Services for our products. For these services, you can contact the Distributor by telephone or by email.

- Technical Support
- Product Training
- Field Service

Technical Support is available from your equipment system supplier, your local Full-Service Distributor, or from many of Woodward's worldwide locations, depending upon the product and application. This service can assist you with technical questions or problem solving during the normal business hours of the Woodward location you contact.

Product Training is available as standard classes at many Distributor locations. Customized classes are also available, which can be tailored to your needs and held at one of our Distributor locations or at your site. This training, conducted by experienced personnel, will assure that you will be able to maintain system reliability and availability.

Field Service engineering on-site support is available, depending on the product and location, from one of our Full-Service Distributors. The field engineers are experienced both on Woodward products as well as on much of the non-Woodward equipment with which our products interface.

For information on these services, please contact one of the Full-Service Distributors listed at **www.woodward.com/directory**.

Contacting Woodward's Support Organization

For the name of your nearest Woodward Full-Service Distributor or service facility, please consult our worldwide directory at **www.woodward.com/directory**, which also contains the most current product support and contact information.

You can also contact the Woodward Customer Service Department at one of the following Woodward facilities to obtain the address and phone number of the nearest facility at which you can obtain information and service.

Products Used in Electrical Power Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
Germany:	
Kempen	+49 (0) 21 52 14 51
Stuttgart	+49 (711) 78954-510
India	+91 (124) 4399500
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
Poland	+48 12 295 13 00
United States	+1 (970) 482-5811

Products Used in Engine Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
Germany	+49 (711) 78954-510
India	+91 (124) 4399500
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
The Netherlands	+31 (23) 5661111
United States	+1 (970) 482-5811

Products Used in Industrial Turbomachinery Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
India	+91 (124) 4399500
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
The Netherlands	+31 (23) 5661111
Poland	+48 12 295 13 00
United States	+1 (970) 482-5811

Technical Assistance

If you need to contact technical assistance, you will need to provide the following information. Please write it down here before contacting the Engine OEM, the Packager, a Woodward Business Partner, or the Woodward factory:

General

Your Name _____

Site Location _____

Phone Number _____

Fax Number

Prime Mover Information

Manufacturer _____

Engine Model Number _____

Number of Cylinders _____

Type of Fuel (gas, gaseous, diesel, dual-fuel, etc.) _____

Power Output Rating _____

Application (power generation, marine, etc.)

Control/Governor Information

Control/Governor #1

Woodward Part Number & Rev. Letter _____

Control Description or Governor Type _____

Serial Number

Control/Governor #2

Woodward Part Number & Rev. Letter _____

Control Description or Governor Type _____

Serial Number

Control/Governor #3

Woodward Part Number & Rev. Letter _____

Control Description or Governor Type _____

Serial Number

Symptoms

Description _____

_____

If you have an electronic or programmable control, please have the adjustment setting positions or the menu settings written down and with you at the time of the call.

Revision History

Changes in Revision B—

- Added a paragraph explaining the addition of a shaft seal in Chapter 1.
- Changed response times in Chapter 7 for Large Step (10-90%, 90-10%) and Small Step (47.5-52.5%, 52.5-47.5%) to 400ms from 200ms.
- Renamed document from an application note to a manual.

Changes in Revision A—

- Added images of each sensor type (Chapter 1).
- Removed the ±10° mounting angle limitations about the shaft axis (Chapter 4).
- Included clarifying statement on EGR use (Chapter 9).

Released

We appreciate your comments about the content of our publications.

Send comments to: icinfo@woodward.com

Please reference publication 36746.

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Woodward has company-owned plants, subsidiaries, and branches, as well as authorized distributors and other authorized service and sales facilities throughout the world.

Complete address / phone / fax / email information for all locations is available on our website.