3 HARDWARE AND WIRING

Section **Page**

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3.1 SUPPLIED HARDWARE

Original Equipment Manufacturer (OEM) supplied hardware and DDC supplied hardware is required to install DDEC V. The following sections list the minimum hardware required.

3.1.1 OEM-SUPPLIED HARDWARE

The minimum OEM-supplied hardware required is listed in Table 3-1.

Hardware	Description
Vehicle Interface Harness (VIH) (refer to section 3.4)	Connects the vehicle functions and battery power (12/24 volts) and ground to the ECU and includes fuse(s) or circuit breaker(s). Also connects the ECU J1939 node to other vehicle systems.
Connector Shroud for VIH Connector (refer to section 3.2.1)	The shroud protects the connectors from dirt and direct spray and routes the wires in the correct orientation.
Throttle Input Device (refer to section 3.12)	An Accelerator Pedal (AP) with an Idle Validation Switch (required), hand throttle, or alternative throttle device
Ignition Switch (refer to section 3.4.2)	Switched 12 or 24 volt ignition source
Amber Warning Lamp (AWL) (refer to section 3.13.1)	A panel-mounted amber indicator light.
Red Stop Lamp (RSL) (refer to section 3.13.2)	A panel-mounted red indicator light.
Engine Coolant Level Sensor (ECL Sensor) (refer to section 3.11.20)	A radiator top tank- or remote surge tank-mounted sensor
Diagnostic Connector, Cab (DCC) (refer to section 3.7.3)	Cab-mounted diagnostic connector

Table 3-1 OEM-Supplied Hardware

3.1.2 DDC-SUPPLIED HARDWARE

The minimum DDC-supplied hardware required is listed in Table 3-2.

Hardware	Description
Engine Harness (refer to section 3.3)	Factory installed harness that facilitates the receipt of input and output signals, controlling the fuel injection process and engine speed. Harness is connected to DDC installed sensors, the injection unit and the ECU(s).
Electronic Control Unit (ECU) Refer to section 3.2.	Engine mounted ECU provides control logic for overall engine management.
Engine Sensors Refer to section 3.11.1.	Various engine mounted sensors for engine control.
Turbo Compressor In Temperature Sensor Refer to section 3.11.23.	Sensor to measure turbo compressor inlet temperature. MUST be installed by the OEM. Series 60 only.

Table 3-2 Minimum DDC-Supplied Hardware

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3.2 ELECTRONIC CONTROL UNIT

The engine-mounted Electronic Control Unit (ECU) (see Figure 3-1) includes control logic to provide overall engine management. The ECU continuously performs self-diagnostic checks and monitors other system components. System diagnostic checks are made at ignition-on and continue throughout all engine-operating modes.

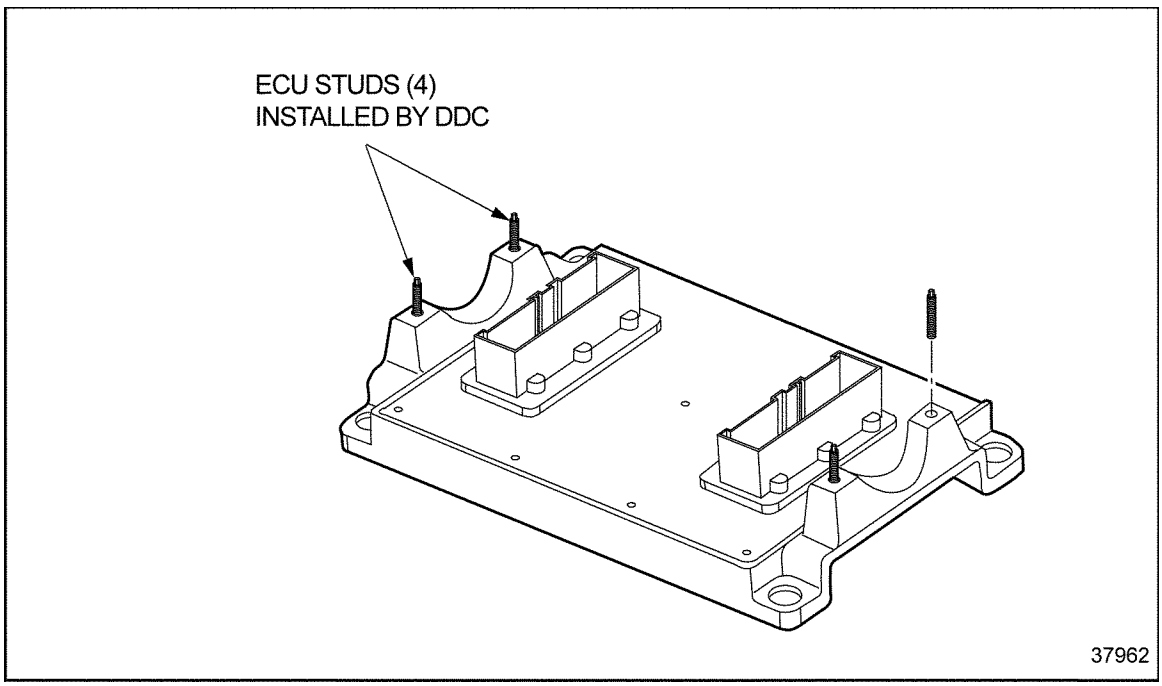


Figure 3-1 Electronic Control Unit

The DDEC V ECU has two 68-pin Tyco connectors - one for the engine and the other for the vehicle.

DDEC V supports three independent data links. There are two links on the Vehicle Interface Harness (VIH). One link is based on SAE J1708, and the second is SAE J1939. The other link, on the Engine Harness, is CAN based and will be used for proprietary communications such as multi-ECU applications and DDC factory programming.

The following warning label is found on the ECU (see Figure 3-2).

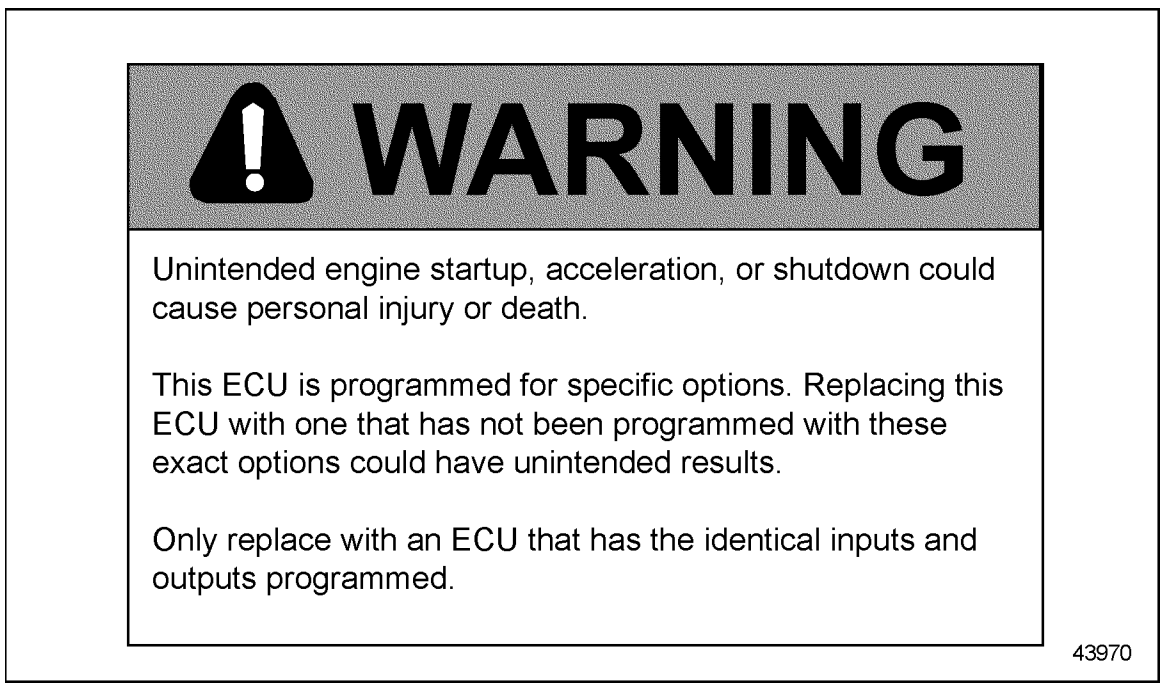


Figure 3-2 ECU Warning Label

Connector shrouds protect the two 68-pin Tyco connectors (see Figure 3-3).

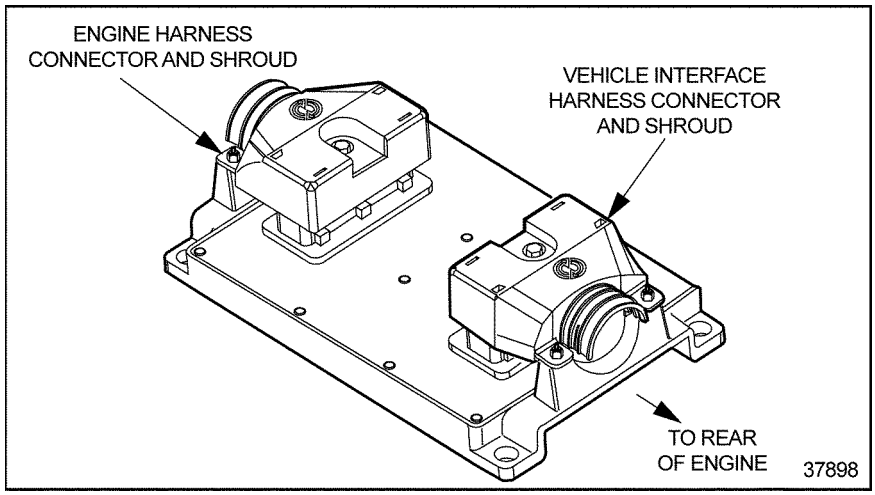


Figure 3-3 Electronic Control Unit with Connector Shrouds

The shrouds are fastened to the ECU studs with lock nuts.

See Figure 3-4 for the ECU outline and dimensions.

The DDEC V ECU has the same footprint as DDEC II, III, and IV.

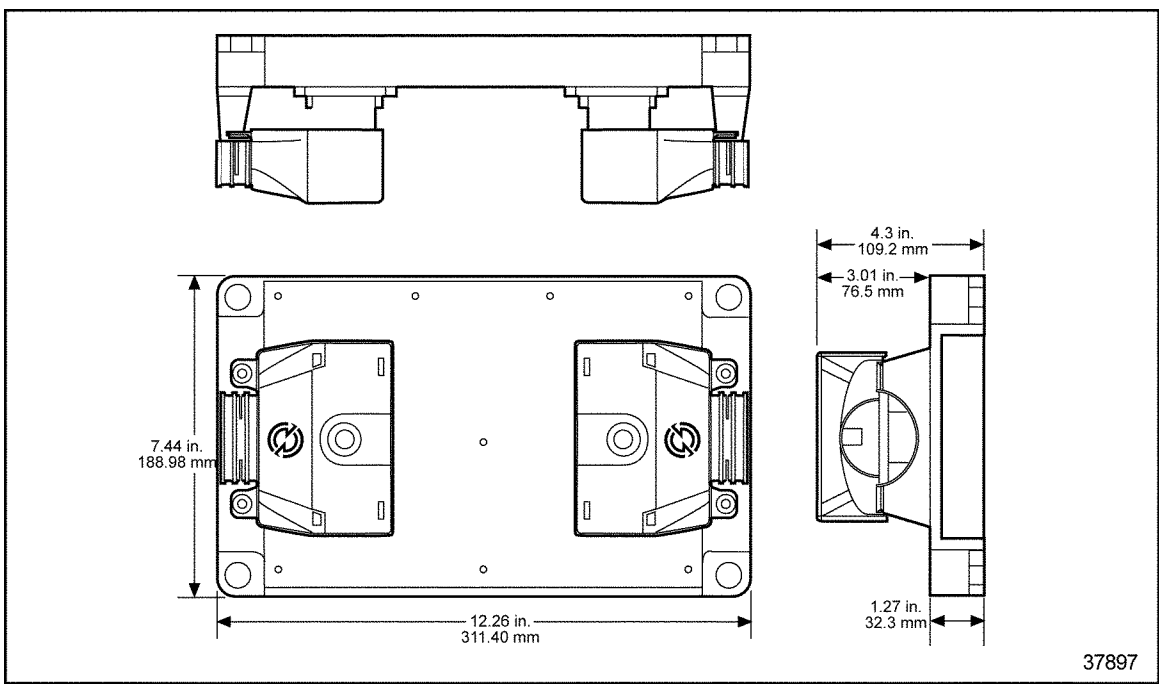


Figure 3-4 Dimensions of Electronic Control Unit with Connector Shrouds

3.2.1 CONNECTOR SHROUD

The shroud is used to protect the connectors from dirt and direct spray and to route the wires in the correct orientation. The shroud is designed for 25-30 mm conduit. The shroud is REQUIRED.

Different views of the connector shroud may be seen in the next illustration (see Figure 3-5).

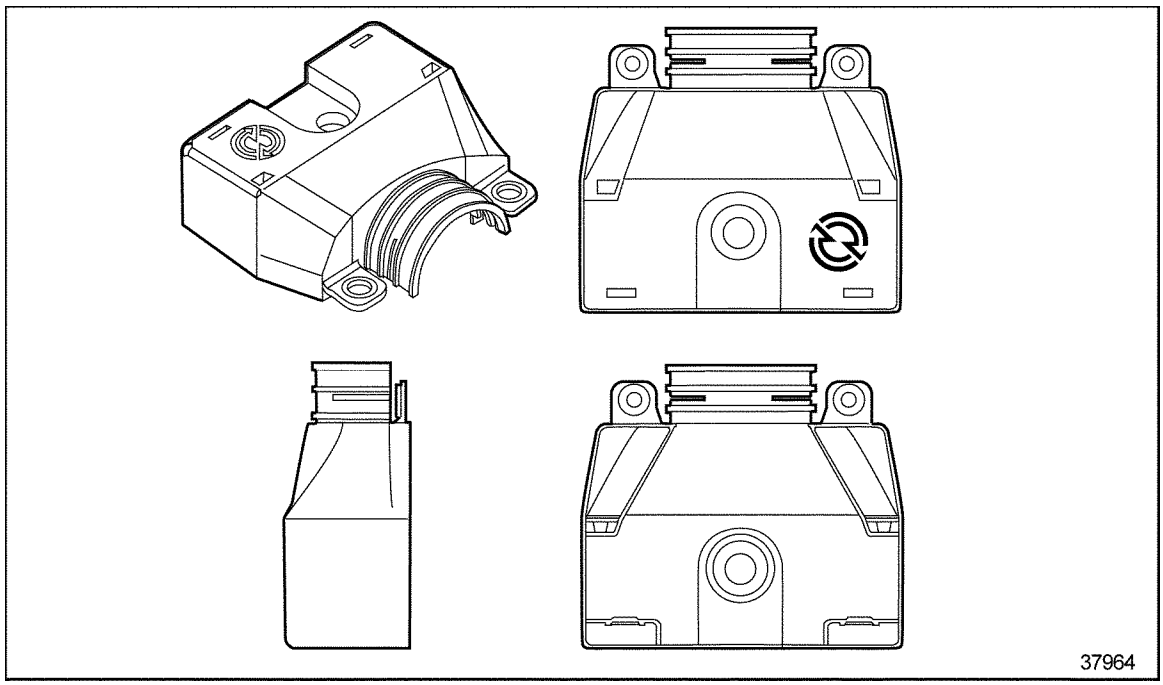


Figure 3-5 Electronic Control Unit Connector Shroud

Two lock nuts are required to attach the shroud to the ECU studs. The torque specification for the lock nuts is 30 in.·lb (3.4 N·m).

3.2.2 ECU PART NUMBERS

Part number for the DDEC V ECU is listed in Table 3-3.

Description	Part Number	Voltage	No. of Cylinders
DDEC V – ECU	23530802	12/24 Volts	6

Table 3-3 ECU Part Numbers

The part numbers for the ECU connectors are listed in Table 3-4.

Description	DDC Part Number	Tyco Part Number
Vehicle Interface Harness Connector Assembly	23528252	776315-1
Engine Harness Connector Assembly	23528253	776315-2
Shroud	23532347	776501-1
Shroud Lock Nuts (M6x1.0 Nylon Insert Lock Nut Plated with Yellow Zinc)	23533607	—
ECU Stud	23533606	—
14 AWG Terminal (Large) (Terminal only)	23528272	776492-1
18 AWG Terminal (Standard) (Terminal only)	23528271	776326-4
14 AWG Terminal (Large) (crimped with 12 in. wire)	23528255	—
18 AWG Terminal (Standard) (crimped with 12 in. wire)	23528254	—
Cavity Plug	23528274	776364

Table 3-4 ECU Connector Part Numbers

3.2.3 ENVIRONMENTAL CONDITIONS

The following environmental conditions must be considered.

Temperature

The ambient operating temperature range is -40°F (-40°C) minimum and 221°F (105°C) maximum.

Atmospheric Pressure

The engine-mounted ECU can withstand atmospheric pressures ranging from 62.0 to 120 kPa absolute that result from altitude and weather changes in the operating and non-operating conditions.

Water Intrusion

The ECU can be exposed to steam cleaning and pressure washing. Care should be taken not to pressure spray the connectors.

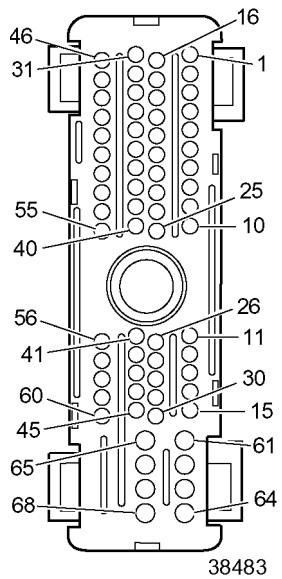
3.3 ENGINE HARNESS

The Engine Harness (EH) is installed at the factory and is delivered connected to all engine sensors, the fuel injection system and the ECU.

3.3.1 EH CONNECTOR AND TYPICAL REQUIRED FUNCTIONS

The EH 68-pin Tyco connector pinout for the Series 60® is listed in Table 3-5 and Table 3-6.

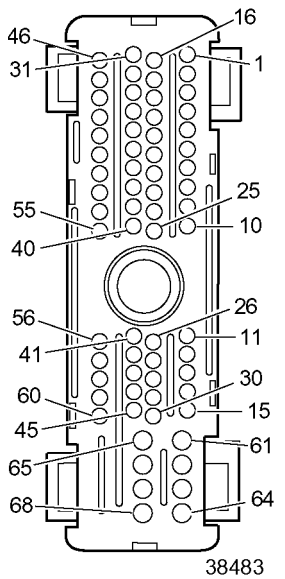
Pin	Wire Color	Signal Type	Function	Connector
E-1	Blk	PWM Output – Low Side	EGR Hydraulic Valve Control	
E-2	Wht	Analog Input – 1.5k Pull-up	Air Temp	
E-3	—	Analog Input – 51k Pull-down	Spare	
E-4	Blk	PWM Output – Low Side	VGT VPOD Control	
E-5	Yel	Analog Input – 1.5k Pull-up	Coolant Temp	
E-6	—	Analog Input – 51k Pull-down	Spare	
E-7	Tan	Analog Input – 1.5k Pull-up	Oil Temp	
E-8	—	PWM Output – Low Side	Spare	
E-9	Orn	Analog Input – 1.5k Pull-up	Fuel Temp	
E-10	—	Analog Input – 1.5k Pull-up	EGR Temp	
E-11	—	PWM Output – Low Side	Spare	
E-12	Gra	Sensor Supply #3	Sensor Supply	
E-13	—	Digital Output – Low Side	Spare	
E-14	Blk	Sensor Return #4	Sensor Return	
E-15	Blk	Sensor Return #3	Sensor Return	
E-16	Yel	Analog Input – 51k Pull-down	Fuel Restriction (MAS)	
E-17	Ppl	TRS (CKP) (-)	TRS (CKP) (-)	
E-18	Dk Grn	TRS (CKP) (+)	TRS (CKP) (+)	
E-19	Lt Blu	SRS (CMP) (+)	SRS (CMP) (+)	
E-20	Wht	SRS (CMP) (-)	SRS (CMP) (-)	
E-21	Dk Grn	Analog Input – 51k Pull-down	Oil Level (MAS)	
E-22	Dk Blu	Analog Input – 1.5k Pull-up	Turbo Compressor Out Temp	
E-23	—	Analog Input – 1.5k Pull-up	Spare	
E-24	—	Analog Input – 51k Pull-down	Spare	
E-25	—	Analog Input – 51k Pull-down	Spare	
E-26	Gra	Sensor Supply #4	Sensor Supply	
E-27	—	Analog Input – 1.5k Pull-up	Spare	
E-28	—	Ground Pin	Spare	
E-29	—	Ground Pin	Spare	
E-30	—	Ground Pin	Spare	
E-31	Brn	Analog Input – 51k Pull-down	Oil Pressure	
E-32	—	Frequency Input (+) — Aux 3	Spare	



Shroud Side of Connector

Table 3-5 Series 60 Engine Harness Connector - Pins E-1 Through E-32

Pin	Wire Color	Signal Type	Function	Connector
E-33	—	Frequency Input (-) – Aux3	Spare	
E-34	Brn	Frequency Input (-) – Aux2	Turbo Speed Sensor (+)	
E-35	Blk	Frequency Input (+) – Aux2	Turbo Speed Sensor (-)	
E-36	—	Analog Input – 1.5k Pull-up	Spare	
E-37	Pnk	Analog Input – 51k Pull-down	Barometric Pressure	
E-38	—	Analog Input – 51k Pull-down	EGR Delta Pressure	
E-39	Lt Grn	Analog Input – 51k Pull-down	Turbo Boost	
E-40	Dk Blue	CAN2 (+)	CAN2 (+)	
E-41	—	Analog Input – 51k Pull-down	Spare	
E-42	Bk	Ground Pin	VGT VPOD Gnd	
E-43	Bk	Ground Pin	Spare	
E-44	—	Ground Pin	Spare	
E-45	—	Ground Pin	Spare	
E-46	Lt Grn	Digital Output – High Side	Switched Battery (+) – VGT	
E-47	—	Digital Output – High Side	Spare	
E-48	Red	Digital Output – High Side	Jake Med/High	
E-49	Orn	Digital Output – High Side	Jake Low	
E-50	—	Digital Output – High Side	Spare	
E-51	Yel	Digital Output – High Side	Switch Battery (+) — EGR	
E-52	Red	Digital Output – High Side	Spare	
E-53	—	Digital Output – High Side	Spare	
E-54	Pnk	CAN2 (-)	CAN2 (-)	
E-55	Blk	CAN2S	CAN2 Shield	
E-56	—	Analog Input – 51k Pull-down	Spare	
E-57	—	Analog Input – HWOLS	No Connection	
E-58	—	Analog Input – 1.5k Pull-up	Spare	
E-59	—	RTC BATT+	External RTC Battery (+)	
E-60	—	Ground Pin	Spare	
E-61	Wht	Injector High Common	S60 Common Cyl #1,2,3	
E-62	Wht	Injector High Common	S60 Common Cyl #4,5, 6	
E-63	Wht	Injector A – LO1	S60 Cylinder #1	
E-64	Wht	Injector A – LO2	S60 Cylinder #3	
E-65	Wht	Injector A – LO3	S60 Cylinder #2	
E-66	Wht	Injector B – LO1	S60 Cylinder #5	
E-67	Wht	Injector B – LO2	S60 Cylinder #6	
E-68	Wht	Injector B– LO3	S60 Cylinder #4	

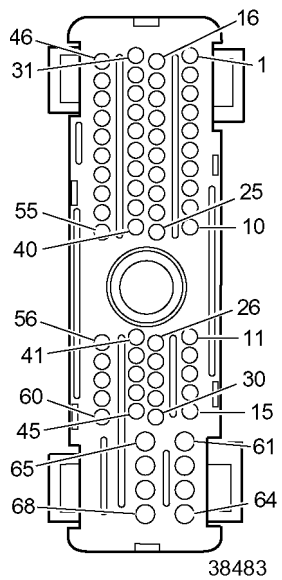


Shroud Side of Connector

Table 3-6 Series 60 Engine Harness Connector - Pins E-33 Through E-68

The EH 68-pin Tyco connector pinout for Series 60® non-road equipment is listed in Table 3-7 and Table 3-8.

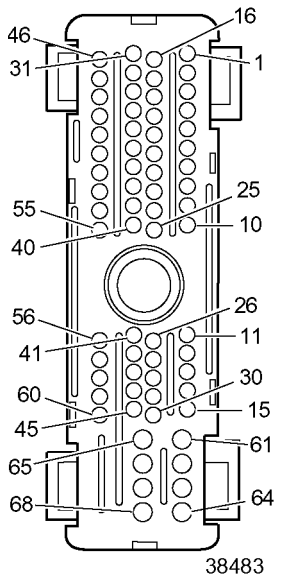
Pin	Wire Color	Signal Type	Function	Connector
E-1	—	PWM Output – Low Side	Spare	
E-2	Wht	Analog Input – 1.5k Pull-up	Air Temp	
E-3	—	Analog Input – 51k Pull-down	Spare	
E-4	—	PWM Output – Low Side	Spare	
E-5	Yel	Analog Input – 1.5k Pull-up	Coolant Temp	
E-6	—	Analog Input – 51k Pull-down	Spare	
E-7	Tan	Analog Input – 1.5k Pull-up	Oil Temp	
E-8	—	PWM Output – Low Side	Spare	
E-9	Orn	Analog Input – 1.5k Pull-up	Fuel Temp	
E-10	—	Analog Input – 1.5k Pull-up	Spare	
E-11	—	PWM Output – Low Side	Spare	
E-12	Gra	Sensor Supply #3	Sensor Supply	
E-13	—	Digital Output – Low Side	Spare	
E-14	Blk	Sensor Return #4	Sensor Return	
E-15	Blk	Sensor Return #3	Sensor Return	
E-16	Yel	Analog Input – 51k Pull-down	Spare	
E-17	Ppl	TRS (CKP) (-)	TRS (CKP) (-)	
E-18	Dk Grn	TRS (CKP) (+)	TRS (CKP) (+)	
E-19	Lt Blu	SRS (CMP) (+)	SRS (CMP) (+)	
E-20	Wht	SRS (CMP) (-)	SRS (CMP) (-)	
E-21	Dk Grn	Analog Input – 51k Pull-down	Spare	
E-22	—	Analog Input – 1.5k Pull-up	Spare	
E-23	—	Analog Input – 1.5k Pull-up	Spare	
E-24	—	Analog Input – 51k Pull-down	Spare	
E-25	—	Analog Input – 51k Pull-down	Spare	
E-26	Gra	Sensor Supply #4	Sensor Supply	
E-27	—	Analog Input – 1.5k Pull-up	Spare	
E-28	—	Ground Pin	Spare	
E-29	—	Ground Pin	Spare	
E-30	—	Ground Pin	Spare	
E-31	Brn	Analog Input – 51k Pull-down	Oil Pressure	
E-32	—	Frequency Input (+) — Aux 3	Spare	



Shroud Side of Connector

Table 3-7 Series 60 Engine Harness Connector for Non-Road Equipment - Pins E-1 Through E-32

Pin	Wire Color	Signal Type	Function	Connector
E-33	—	Frequency Input (-) – Aux3	Spare	
E-34	—	Frequency Input (-) – Aux2	Spare	
E-35	—	Frequency Input (+) – Aux2	Spare	
E-36	—	Analog Input – 1.5k Pull-up	Spare	
E-37	Pnk	Analog Input – 51k Pull-down	Spare	
E-38	—	Analog Input – 51k Pull-down	Spare	
E-39	Lt Grn	Analog Input – 51k Pull-down	Turbo Boost	
E-40	Dk Blue	CAN2 (+)	CAN2 (+)	
E-41	—	Analog Input – 51k Pull-down	Spare	
E-42	—	Ground Pin	Spare	
E-43	Bk	Ground Pin	Spare	
E-44	—	Ground Pin	Spare	
E-45	—	Ground Pin	Spare	
E-46	—	Digital Output – High Side	Spare	
E-47	—	Digital Output – High Side	Spare	
E-48	Red	Digital Output – High Side	Jake Med/High	
E-49	Orn	Digital Output – High Side	Jake Low	
E-50	—	Digital Output – High Side	Spare	
E-51	Yel	Digital Output – High Side	Spare	
E-52	Red	Digital Output – High Side	Spare	
E-53	—	Digital Output – High Side	Spare	
E-54	Pnk	CAN2 (-)	CAN2 (-)	
E-55	Blk	CAN2S	CAN2 Shield	
E-56	—	Analog Input – 51k Pull-down	Spare	
E-57	—	Analog Input – HWOLS	No Connection	
E-58	—	Analog Input – 1.5k Pull-up	Spare	
E-59	—	RTC BATT+	External RTC Battery (+)	
E-60	—	Ground Pin	Spare	
E-61	Wht	Injector High Common	S60 Common Cyl #1,2,3	
E-62	Wht	Injector High Common	S60 Common Cyl #4,5, 6	
E-63	Wht	Injector A – LO1	S60 Cylinder #1	
E-64	Wht	Injector A – LO2	S60 Cylinder #3	
E-65	Wht	Injector A – LO3	S60 Cylinder #2	
E-66	Wht	Injector B – LO1	S60 Cylinder #5	
E-67	Wht	Injector B – LO2	S60 Cylinder #6	
E-68	Wht	Injector B– LO3	S60 Cylinder #4	



Shroud Side of Connector

Table 3-8 Series 60 Engine Harness Connector for Non-Road Equipment Pins E-33 Through E-68

3.4 VEHICLE INTERFACE HARNESS

The OEM supplied Vehicle Interface Harness (VIH) connects the ECU to other vehicle systems as shown in the VIH illustration (see Figure 3-6). Refer to Appendix B for a harness schmatic.

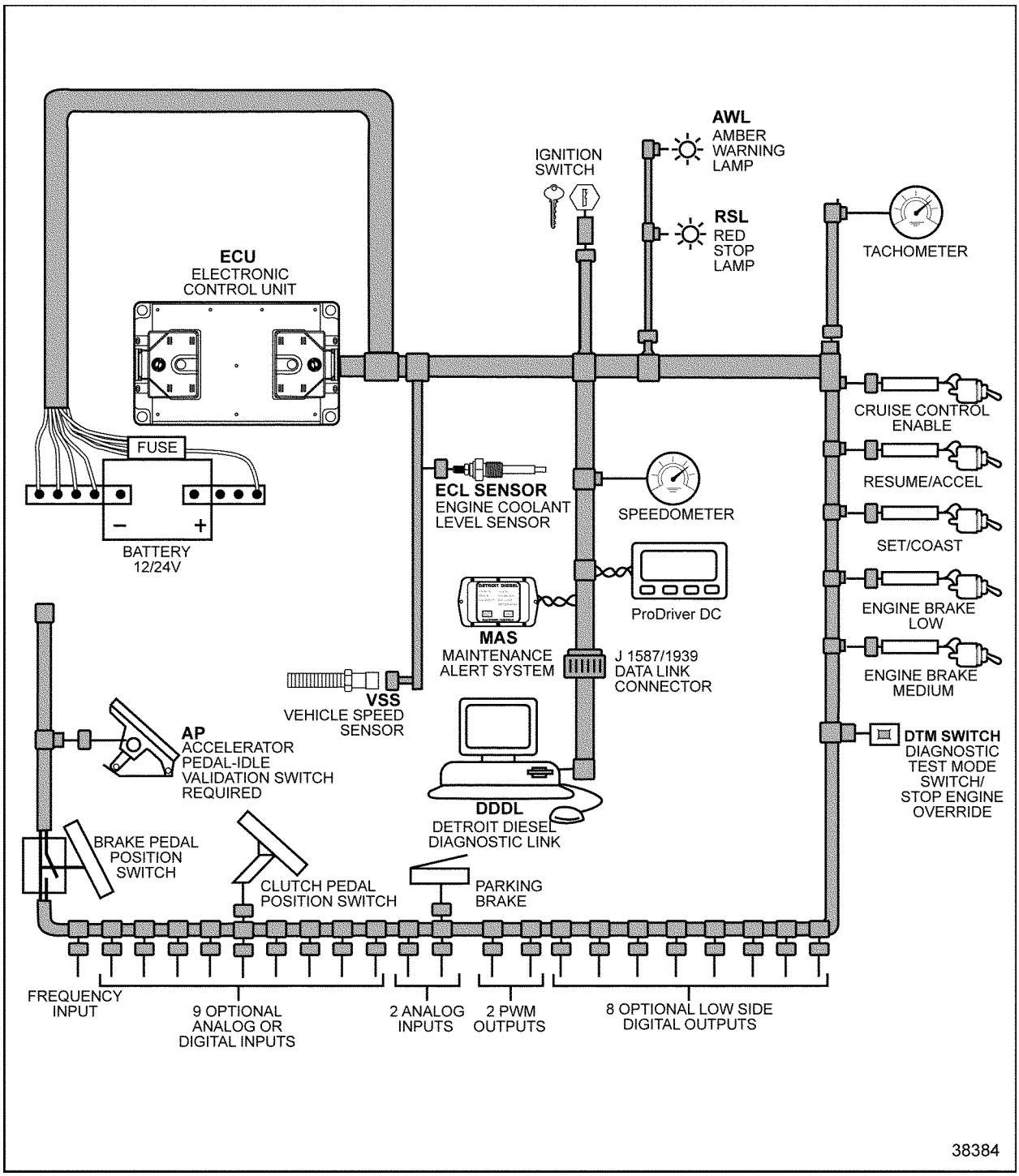
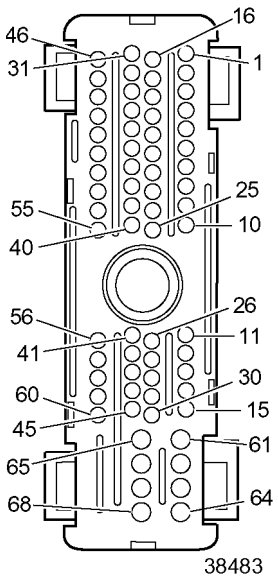


Figure 3-6 Typical On-highway Vehicle Interface Harness

3.4.1 VIH CONNECTOR AND TYPICAL REQUIRED FUNCTIONS

The VIH 68-pin Tyco connector pinout for the Series 60 is listed in Table 3-9 and Table 3-10.

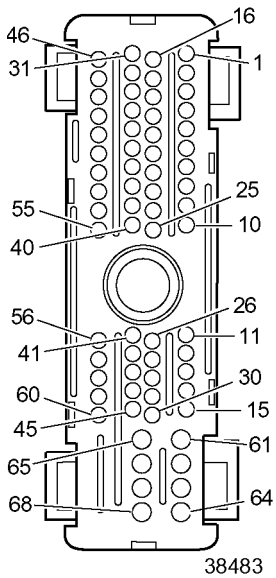
Pin	Wire Color	Signal Type	Function	Req/Typical	Connector
V-1	Dk Grn/Blk	Digital Output - Low Side	AWL	Required	
V-2	Blk/Yel	Digital Output - Low Side	RSL	Required	
V-3	Wht/Dk Grn	Analog Input - 1.5k Pull-up	Service Brake Released	Required	
V-4	Blk/Lt Blu	Digital Output - Low Side	Fan Control #1	Typical: Fan	
V-5	Blk/Lt grn	Digital Output - Low Side	Top2 Shift Solenoid	Typical: Top2	
V-6	Blk/Orn	Digital Output - Low Side	Top2 Lockout Solenoid	Typical: Top2	
V-7	Blk/Wht	Digital Output - Low Side	Vehicle Power Shtdn	Typical	
V-8	Wht/Orn	Analog Input - 1.5k Pull-up	Resume/Accel	Typical: CC	
V-9	Ppl/Wht	Analog Input - 1.5k Pull-up	Cruise Enable	Typical: CC	
V-10	Lt Grn/Wht	Analog Input - 1.5k Pull-up	Clutch Released	Typical: CC	
V-11	Yel/Red	Sensor Supply #1	Sensor Supply #1	Required	
V-12	Wht/ Red	Sensor Supply #2	Sensor Supply #2	Required	
V-13	Lt Blu/Yel	Analog Input - 300k Pull-down	Throttle Position	Required	
V-14	Ppl/Yel	Analog Input - 300k Pull-down	VSG or No Function	Typical	
V-15	Pnk	Ignition	Ignition	Required	
V-16	Red/Wht	Analog Input - 1.5k Pull-up	Idle Validation	Required	
V-17	Lt Blu/ Orn	Frequency Input (+) VSS	Vehicle Speed (+)	Required	
V-18	Lt Blu/ Blk	Frequency Input (-) VSS	Vehicle Speed (-)	Required	
V-19	—	No Connection	No Connection	No Conn	
V-20	—	No Connection	No Connection	No Conn	
V-21	—	No Connection	No Connection	No Conn	
V-22	Yel/Lt Blu	Analog Input – 51k Pull-down	Air Filter Restriction	Typical: MAS	
V-23	Yel/Dk Grn	Analog Input - 1.5k Pull-up	Exhaust Temp (Bus/Coach)	Typical	
V-24	Dk Grn/Wht	Analog Input - 1.5k Pull-up	SEO/Diag Request	Required	
V-25	Grey/Wht	Analog Input - 1.5k Pull-up	A/C Status	Typical: Fan	
V-26	Yel/Lt Grn	Analog Input - 1.5k Pull-up	Engine Brake Disable	Typical	
V-27	Yel/Wht	Analog Input - 1.5k Pull-up	Turbo Compressor In Temp	Required	
V-28	—	No Connection	No Connection	No Conn	
V-29	Wht/Yel	Analog Input – 51k Pull-down	Exhaust Back Press or Water Pump Press or Air Compressor Press	Typical	
V-30	—	No Connection	No Connection	No Conn	
V-31	Tan	Frequency Output	Tachometer	Typical	



Shroud Side of Connector

Table 3-9 Series 60 VIH Connector On-highway Trucks – Pins V-1 – V-31

Pin	Wire Color	Signal Type	Function	Req/ Typical	Connector
V-32	Dk Blu/Orn	Frequency Input (+) Aux 1	Spare	—	
V-33	Dk Blu/Blk	Frequency Input (-) Aux 1	Spare	—	
V-34	—	No Connection	No Connection	No Conn	
V-35	—	No Connection	No Connection	No Conn	
V-36	—	No Connection	No Connection	No Conn	
V-37	Orn/Yel	Analog Input – 120k Pull-up	Add Coolant Level	Typical: MAS	
V-38	Lt Gr/Yel	Analog Input – 120k Pull-up	Coolant Level Shtdn	Req	
V-39	Lt Blu/Wht	Analog Input – 1.5k Pull-up	Engine Brake Low	Typical: Jake	
V-40	Orn/Blk	Digital Output – Low Side	OI Alarm	Typical: OI	
V-41	Dk Grn/Yel	Analog Input – 1.5k Pull-up	Aux Shtdn #1	—	
V-42	Grey/Yel	Analog Input – 1.5k Pull-up	OI Thermostat	Typical: OI	
V-43	Dk Blu/Red	J1939+	J1939+	Req	
V-44	Dk Blu/Yel	J1939S	J1939 Shield	Required	
V-45	—	No Connection	No Connection	No Conn	
V-46	Dk Grn/Brn	PWM Output - Low Side	Variable Speed Fan	—	
V-47	Wht/Lt Blu	Analog Input - 1.5k Pull-up	Set/Coast	Typical; CC	
V-48	Tan/ Yel	Analog Input - 1.5k Pull-up	Throttle Inhibit	Typical	
V-49	Pink/Wht	Analog Input - 1.5k Pull-up	Fan Control Override	Typical	
V-50	Tan/ Wht	Analog Input - 1.5k Pull-up	Park Brake	Typical	
V-51	Dk Blu/Wht	Analog Input - 1.5k Pull-up	Engine Brake Medium	Typical: Jake	
V-52	Dk Grn/Orn	PWM Output Low Side	Trans % Load	—	
V-53	Blk/Red	Digital Output - Low Side	Ether Start	—	
V-54	Blk/Pnk	Digital Output - Low Side	OI Starter	Typical: OI	
V-55	Lt Grn/Blk	Digital Output - Low Side	OI Active Lamp	Typical: OI	
V-56	Dk Grn/ Grey	J1587 (+)	J1587 (+)	Required	
V-57	Dk Grn	J1587(-)	J1587 (-)	Required	
V-58	Dk Blu	J1939 (-)	J1939 (-)	Required	
V-59	Dk Blu	Sensor Return #2	Sensor Return	Required	
V-60	Yel/ Blk	Sensor Return #1	Sensor Return	Required	
V-61	Red/Blk	Battery (+)	+12V / +24V	Required	
V-62	Red/ Lt Blu	Battery (+)	+12V / +24V	Required	
V-63	Brn/Blk	Battery (-)	Ground	Required	
V-64	Brn/ Lt Grn	Battery (-)	Ground	Required	
V-65	Red/ Lt Grn	Battery (+)	+12V / +24V	Required	
V-66	Red/ Pnk	Battery (+)	+12V / +24V	Required	
V-67	Brn/Wht	Battery (-)	Ground	Required	
V-68	Brn/Yel	Battery (-)	Ground	Required	

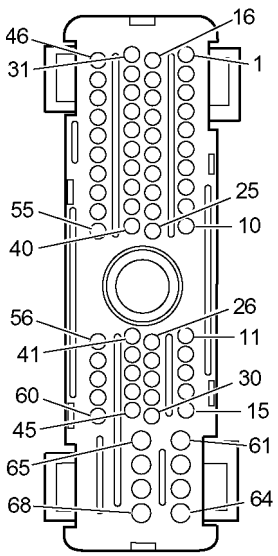


Shroud Side of Connector

Table 3-10 Series 60 VIH Connector On-highway Trucks – Pins V-32 – V-68

The VIH 68–pin Tyco connector pinout for Series 60 Bus/Coach applications is listed in Table 3-11 and Table 3-12.

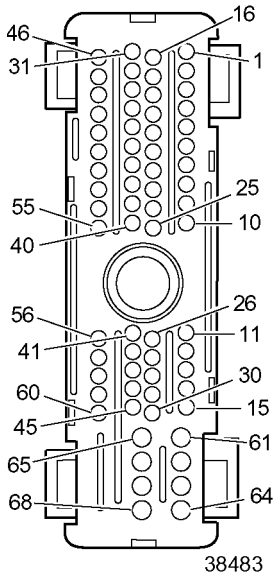
Pin	Wire Color	Signal Type	Function	Req/Typical	Connector
V-1	Dk Grn/Blk	Digital Output - Low Side	AWL	Required	
V-2	Blk/Yel	Digital Output - Low Side	RSL	Required	
V-3	Wht/Dk Grn	Analog Input - 1.5k Pull-up	Service Brake Released	Required	
V-4	Blk/Lt Blu	Digital Output - Low Side	Fan Control #1	Typical: Fan	
V-5	Blk/Lt grn	Digital Output - Low Side	Fan Control #2	Typical: Fan	
V-6	Blk/Orn	Digital Output - Low Side	Decleration Lamp	Typical	
V-7	Blk/Wht	Digital Output - Low Side	Starter Lockout	Typical	
V-8	Wht/Orn	Analog Input - 1.5k Pull-up	Resume/Accel	Typical: CC	
V-9	Ppl/Wht	Analog Input - 1.5k Pull-up	Cruise Enable	Typical: CC	
V-10	Lt Grn/Wht	Analog Input - 1.5k Pull-up	Spare	—	
V-11	Yel/Red	Sensor Supply #1	Sensor Supply #1	Required	
V-12	Wht/ Red	Sensor Supply #2	Sensor Supply #2	Required	
V-13	Lt Blu/Yel	Analog Input - 300k Pull-down	Throttle Position	Required	
V-14	Ppl/Yel	Analog Input - 300k Pull-down	VSG or No Function	Typical	
V-15	Pnk	Ignition	Ignition	Required	
V-16	Red/Wht	Analog Input - 1.5k Pull-up	Idle Validation	Required	
V-17	Lt Blu/ Orn	Frequency Input (+) VSS	Vehicle Speed (+)	Required	
V-18	Lt Blu/ Blk	Frequency Input (-) VSS	Vehicle Speed (-)	Required	
V-19	—	No Connection	No Connection	No Conn	
V-20	—	No Connection	No Connection	No Conn	
V-21	—	No Connection	No Connection	No Conn	
V-22	Yel/Lt Blu	Analog Input – 51k Pull-down	Air Filter Restriction	Typical: MAS	
V-23	Yel/Dk Grn	Analog Input - 1.5k Pull-up	Exhaust Temp (Bus/Coach)	Typical	
V-24	Dk Grn/Wht	Analog Input - 1.5k Pull-up	SEO/Diag Request	Required	
V-25	Grey/Wht	Analog Input - 1.5k Pull-up	A/C Status	Typical: Fan	
V-26	Yel/Lt Grn	Analog Input - 1.5k Pull-up	Engine Brake Disable	Typical	
V-27	Yel/Wht	Analog Input - 1.5k Pull-up	Turbo Compressor In Temp	Required	
V-28	—	No Connection	No Connection	No Conn	
V-29	Wht/Yel	Analog Input – 51k Pull-down	Exhaust Back Pressure	Typical	
V-30	—	No Connection	No Connection	No Conn	
V-31	Tan	Frequency Output	Tachometer	Typical	



Shroud Side of Connector

Table 3-11 Series 60 VIH Connector Bus/Coach – Pins V-1 – V-31

Pin	Wire Color	Signal Type	Function	Req/ Typical	Connector
V-32	Dk Blu/Orn	Frequency Input (+) Aux 1	Spare	—	
V-33	Dk Blu/Blk	Frequency Input (-) Aux 1	Spare	—	
V-34	—	No Connection	No Connection	No Conn	
V-35	—	No Connection	No Connection	No Conn	
V-36	—	No Connection	No Connection	No Conn	
V-37	Orn/Yel	Analog Input – 120k Pull-up	Add Coolant Level	Typical: MAS	
V-38	Lt Gr/Yel	Analog Input – 120k Pull-up	Coolant Level Shtdn	Req	
V-39	Lt Blu/Wht	Analog Input – 1.5k Pull-up	Engine Brake Low	Typical: Jake	
V-40	Orn/Blk	Digital Output – Low Side	Engine Brake Active	Typical	
V-41	Dk Grn/Yel	Analog Input – 1.5k Pull-up	Aux Shtdn #1	—	
V-42	Grey/Yel	Analog Input – 1.5k Pull-up	Alt Min VSG / Fast Idle	Typical	
V-43	Dk Blu/Red	J1939 (+)	J1939 (+)	Req	
V-44	Dk Blu/Yel	J1939S	J1939 Shield	Required	
V-45	—	No Connection	No Connection	No Conn	
V-46	Dk Grn/Brn	PWM Output - Low Side	Variable Speed Fan	—	
V-47	Wht/Lt Blu	Analog Input - 1.5k Pull-up	Set/Coast	Typical; CC	
V-48	Tan/ Yel	Analog Input - 1.5k Pull-up	Throttle Inhibit	Typical	
V-49	Pink/Wht	Analog Input - 1.5k Pull-up	Fan Control Override	Typical	
V-50	Tan/ Wht	Analog Input - 1.5k Pull-up	Park Brake	Typical	
V-51	Dk Blu/Wht	Analog Input - 1.5k Pull-up	Engine Brake Medium	Typical: Jake	
V-52	Dk Grn/Orn	PWM Output Low Side	Trans % Load	—	
V-53	Blk/Red	Digital Output - Low Side	Coolant Level Low Lamp	Typical	
V-54	Blk/Pnk	Digital Output - Low Side	No Connection	No Conn	
V-55	Lt Grn/Blk	Digital Output - Low Side	Cruise Active Lamp	Typical	
V-56	Dk Grn/ Grey	J1587 (+)	J1587 (+)	Required	
V-57	Dk Grn	J1587 (-)	J1587 (-)	Required	
V-58	Dk Blu	J1939 (-)	J1939 (-)	Required	
V-59	Dk Blu	Sensor Return #2	Sensor Return	Required	
V-60	Yel/ Blk	Sensor Return #1	Sensor Return	Required	
V-61	Red/Blk	Battery (+)	+12V / +24V	Required	
V-62	Red/ Lt Blu	Battery (+)	+12V / +24V	Required	
V-63	Brn/Blk	Battery (-)	Ground	Required	
V-64	Brn/ Lt Grn	Battery (-)	Ground	Required	
V-65	Red/ Lt Grn	Battery (+)	+12V / +24V	Required	
V-66	Red/ Pnk	Battery (+)	+12V / +24V	Required	
V-67	Brn/Wht	Battery (-)	Ground	Required	
V-68	Brn/Yel	Battery (-)	Ground	Required	

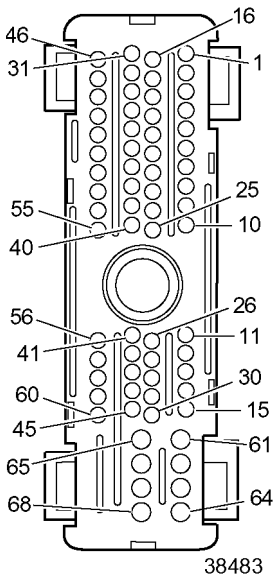


Shroud Side of Connector

Table 3-12 Series 60 VIH Connector Bus/Coach – Pins V-32 – V-68

The VIH 68–pin Tyco connector pinout for Series 60 non-road equipment is listed in Table 3-13 and Table 3-14.

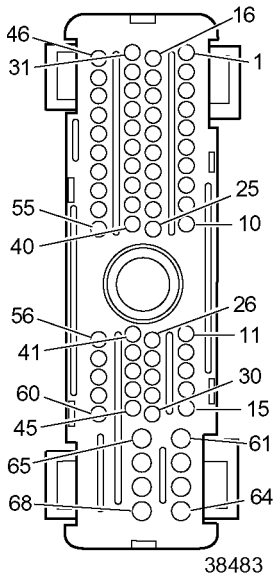
Pin	Wire Color	Signal Type	Function	Req/Typical	Connector
V-1	Dk Grn/Blk	Digital Output - Low Side	AWL	Required	
V-2	Blk/Yel	Digital Output - Low Side	RSL	Required	
V-3	Wht/Dk Grn	Analog Input - 1.5k Pull-up	Service Brake Released	Required	
V-4	Blk/Lt Blu	Digital Output - Low Side	Fan Control #1	Typical: Fan	
V-5	Blk/Lt grn	Digital Output - Low Side	Fan Control #2	Typical: Fan	
V-6	Blk/Orn	Digital Output - Low Side	Spare	—	
V-7	Blk/Wht	Digital Output - Low Side	Starter Lockout	Typical	
V-8	Wht/Orn	Analog Input - 1.5k Pull-up	Resume/Accel	Typical: CC	
V-9	Ppl/Wht	Analog Input - 1.5k Pull-up	Cruise Enable	Typical: CC	
V-10	Lt Grn/Wht	Analog Input - 1.5k Pull-up	Spare	—	
V-11	Yel/Red	Sensor Supply #1	Sensor Supply #1	Required	
V-12	Wht/ Red	Sensor Supply #2	Sensor Supply #2	Required	
V-13	Lt Blu/Yel	Analog Input - 300k Pull-down	Throttle Position (ALSG)	Required	
V-14	Ppl/Yel	Analog Input - 300k Pull-down	VSG	Typical	
V-15	Pnk	Ignition	Ignition	Required	
V-16	Red/Wht	Analog Input - 1.5k Pull-up	Idle Validation	Required	
V-17	Lt Blu/ Orn	Frequency Input (+) VSS	Vehicle Speed (+)	Required	
V-18	Lt Blu/ Blk	Frequency Input (-) VSS	Vehicle Speed (-)	Required	
V-19	—	No Connection	No Connection	No Conn	
V-20	—	No Connection	No Connection	No Conn	
V-21	—	No Connection	No Connection	No Conn	
V-22	Yel/Lt Blu	Analog Input – 51k Pull-down	Air Filter Restriction	Typical: MAS	
V-23	Yel/Dk Grn	Analog Input - 1.5k Pull-up	Exhaust Temp	Typical	
V-24	Dk Grn/Wht	Analog Input - 1.5k Pull-up	SEO/Diag Request	Required	
V-25	Grey/Wht	Analog Input - 1.5k Pull-up	A/C Status	Typical: Fan	
V-26	Yel/Lt Grn	Analog Input - 1.5k Pull-up	Engine Brake Disable	Typical	
V-27	Yel/Wht	Analog Input - 1.5k Pull-up	Spare	—	
V-28	—	No Connection	No Connection	No Conn	
V-29	Wht/Yel	Analog Input – 51k Pull-down	Exhaust Back Pressure or Water Pump Pressure or Air Compressor Pressure	Typical	
V-30	—	No Connection	No Connection	No Conn	
V-31	Tan	Frequency Output	Tachometer	Typical	



Shroud Side of Connector

Table 3-13 Series 60 VIH Connector Non-Road Equipment – Pins V-1 – V-31

Pin	Wire Color	Signal Type	Function	Req/ Typical	Connector
V-32	Dk Blu/Orn	Frequency Input (+) Aux 1	Spare	—	
V-33	Dk Blu/Blk	Frequency Input (-) Aux 1	Spare	—	
V-34	—	No Connection	No Connection	No Conn	
V-35	—	No Connection	No Connection	No Conn	
V-36	—	No Connection	No Connection	No Conn	
V-37	Orn/Yel	Analog Input – 120k Pull-up	Add Coolant Level	Typical: MAS	
V-38	Lt Gr/Yel	Analog Input – 120k Pull-up	Coolant Level Shtdn	Req	
V-39	Lt Blu/Wht	Analog Input – 1.5k Pull-up	Engine Brake Low	Typical: Jake	
V-40	Orn/Blk	Digital Output – Low Side	Spare	—	
V-41	Dk Grn/Yel	Analog Input – 1.5k Pull-up	Aux Shtdn #1	—	
V-42	Grey/Yel	Analog Input – 1.5k Pull-up	Spare	—	
V-43	Dk Blu/Red	J1939 (+)	J1939 (+)	Req	
V-44	Dk Blu/Yel	J1939S	J1939 Shield	Required	
V-45	—	No Connection	No Connection	No Conn	
V-46	Dk Grn/Brn	PWM Output - Low Side	Variable Speed Fan	—	
V-47	Wht/Lt Blu	Analog Input - 1.5k Pull-up	Set/Coast	Typical; CC	
V-48	Tan/ Yel	Analog Input - 1.5k Pull-up	Throttle Inhibit	Typical	
V-49	Pink/Wht	Analog Input - 1.5k Pull-up	Fan Control Override	Typical	
V-50	Tan/ Wht	Analog Input - 1.5k Pull-up	Park Brake	Typical	
V-51	Dk Blu/Wht	Analog Input - 1.5k Pull-up	Engine Brake Medium	Typical: Jake	
V-52	Dk Grn/Orn	PWM Output Low Side	Trans % Load	—	
V-53	Blk/Red	Digital Output - Low Side	Coolant Level Low Lamp	Typical	
V-54	Blk/Pnk	Digital Output - Low Side	No Connection	No Conn	
V-55	Lt Grn/Blk	Digital Output - Low Side	Spare	—	
V-56	Dk Grn/ Grey	J1587 (+)	J1587 (+)	Required	
V-57	Dk Grn	J1587 (-)	J1587 (-)	Required	
V-58	Dk Blu	J1939 (-)	J1939 (-)	Required	
V-59	Dk Blu	Sensor Return #2	Sensor Return	Required	
V-60	Yel/ Blk	Sensor Return #1	Sensor Return	Required	
V-61	Red/Blk	Battery (+)	+12V / +24V	Required	
V-62	Red/ Lt Blu	Battery (+)	+12V / +24V	Required	
V-63	Brn/Blk	Battery (-)	Ground	Required	
V-64	Brn/ Lt Grn	Battery (-)	Ground	Required	
V-65	Red/ Lt Grn	Battery (+)	+12V / +24V	Required	
V-66	Red/ Pnk	Battery (+)	+12V / +24V	Required	
V-67	Brn/Wht	Battery (-)	Ground	Required	
V-68	Brn/Yel	Battery (-)	Ground	Required	

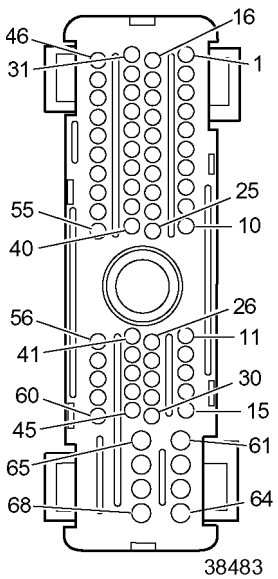


Shroud Side of Connector

Table 3-14 Series 60 VIH Connector Non-Road Equipment – Pins V-32 – V-68

The 68–pin Tyco connector pinout for the Series 60 firetruck application is listed in Table 3-15 and Table 3-16.

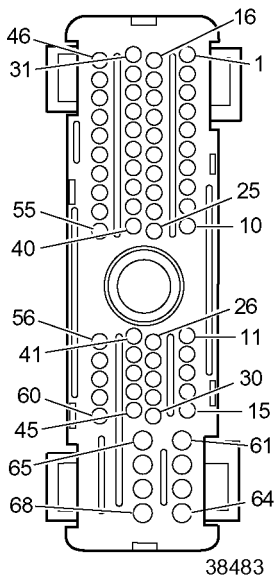
Pin	Wire Color	Signal Type	Function	Req/Typical	Connector
V-1	Dk Grn/Blk	Digital Output - Low Side	AWL	Required	
V-2	Blk/Yel	Digital Output - Low Side	RSL	Required	
V-3	Wht/Dk Grn	Analog Input - 1.5k Pull-up	Service Brake Released	Required	
V-4	Blk/Lt Blu	Digital Output - Low Side	Fan Control #1	Typical: Fan	
V-5	Blk/Lt grn	Digital Output - Low Side	Low DDEC Voltage	Typical	
V-6	Blk/Orn	Digital Output - Low Side	Spare	—	
V-7	Blk/Wht	Digital Output - Low Side	PSG Pressure Mode Lamp	Typical: PSG	
V-8	Wht/Orn	Analog Input - 1.5k Pull-up	Resume/Accel	Typical: PSG	
V-9	Ppl/Wht	Analog Input - 1.5k Pull-up	PSG Enable	Typical: PSG	
V-10	Lt Grn/Wht	Analog Input - 1.5k Pull-up	Spare	—	
V-11	Yel/Red	Sensor Supply #1	Sensor Supply #1	Required	
V-12	Wht/ Red	Sensor Supply #2	Sensor Supply #2	Required	
V-13	Lt Blu/Yel	Analog Input - 300k Pull-down	Throttle Position	Required	
V-14	Ppl/Yel	Analog Input - 300k Pull-down	VSG or No Function	Typical	
V-15	Pnk	Ignition	Ignition	Required	
V-16	Red/Wht	Analog Input - 1.5k Pull-up	Idle Validation	Required	
V-17	Lt Blu/ Orn	Frequency Input (+) VSS	Vehicle Speed (+)	Required	
V-18	Lt Blu/ Blk	Frequency Input (-) VSS	Vehicle Speed (-)	Required	
V-19	—	No Connection	No Connection	No Conn	
V-20	—	No Connection	No Connection	No Conn	
V-21	—	No Connection	No Connection	No Conn	
V-22	Yel/Lt Blu	Analog Input – 51k Pull-down	Air Filter Restriction	Typical: MAS	
V-23	Yel/Dk Grn	Analog Input - 1.5k Pull-up	Pressure / RPM Mode	Typical: PSG	
V-24	Dk Grn/Wht	Analog Input - 1.5k Pull-up	SEO/Diag Request	Required	
V-25	Grey/Wht	Analog Input - 1.5k Pull-up	A/C Status	Typical: Fan	
V-26	Yel/Lt Grn	Analog Input - 1.5k Pull-up	Engine Brake Disable	Typical	
V-27	Yel/Wht	Analog Input - 1.5k Pull-up	Turbo Compressor In Temp	Required	
V-28	—	No Connection	No Connection	No Conn	
V-29	Wht/Yel	Analog Input – 51k Pull-down	Water Pump Press	Typical	
V-30	—	No Connection	No Connection	No Conn	
V-31	Tan	Frequency Output	Tachometer	Typical	
V-32	Dk Blu/Orn	Frequency Input (+) Aux 1	Spare	—	
V-33	Dk Blu/Blk	Frequency Input (-) Aux 1	Spare	—	



Shroud Side of Connector

Table 3-15 Series 60 VIH Connector Firetruck – Pins V-1 – V-33

Pin	Wire Color	Signal Type	Function	Req/ Typical	Connector
V-34	—	No Connection	No Connection	No Conn	
V-35	—	No Connection	No Connection	No Conn	
V-36	—	No Connection	No Connection	No Conn	
V-37	Orn/Yel	Analog Input – 120k Pull-up	Add Coolant Level	Typical: MAS	
V-38	Lt Gr/Yel	Analog Input – 120k Pull-up	Coolant Level Shtdn	Req	
V-39	Lt Blu/Wht	Analog Input – 1.5k Pull-up	Engine Brake Low	Typical: Jake	
V-40	Orn/Blk	Digital Output – Low Side	Engine Brake Active	Typical	
V-41	Dk Grn/Yel	Analog Input – 1.5k Pull-up	Aux Shtdn #1	—	
V-42	Grey/Yel	Analog Input – 1.5k Pull-up	Alt Min VSG / Fast Idle	Typical	
V-43	Dk Blu/Red	J1939 (+)	J1939 (+)	Req	
V-44	Dk Blu/Yel	J1939S	J1939 Shield	Required	
V-45	—	No Connection	No Connection	No Conn	
V-46	Dk Grn/Brn	PWM Output - Low Side	Variable Speed Fan	—	
V-47	Wht/Lt Blu	Analog Input - 1.5k Pull-up	Set/Coast	Typical: PSG	
V-48	Tan/ Yel	Analog Input - 1.5k Pull-up	Throttle Inhibit	Typical	
V-49	Pink/Wht	Analog Input - 1.5k Pull-up	Fan Control Override	Typical	
V-50	Tan/ Wht	Analog Input - 1.5k Pull-up	Park Brake	Typical	
V-51	Dk Blu/Wht	Analog Input - 1.5k Pull-up	Engine Brake Medium	Typical: Jake	
V-52	Dk Grn/Orn	PWM Output Low Side	Trans % Load	—	
V-53	Blk/Red	Digital Output - Low Side	Coolant Level Low Lamp	Typical	
V-54	Blk/Pnk	Digital Output - Low Side	No Connection	No Conn	
V-55	Lt Grn/Blk	Digital Output - Low Side	Cruise/PSG Active Lamp	Typical	
V-56	Dk Grn/ Grey	J1587 (+)	J1587 (+)	Required	
V-57	Dk Grn	J1587 (-)	J1587 (-)	Required	
V-58	Dk Blu	J1939 (-)	J1939 (-)	Required	
V-59	Dk Blu	Sensor Return #2	Sensor Return	Required	
V-60	Yel/ Blk	Sensor Return #1	Sensor Return	Required	
V-61	Red/Blk	Battery (+)	+12V / +24V	Required	
V-62	Red/ Lt Blu	Battery (+)	+12V / +24V	Required	
V-63	Brn/Blk	Battery (-)	Ground	Required	
V-64	Brn/ Lt Grn	Battery (-)	Ground	Required	
V-65	Red/ Lt Grn	Battery (+)	+12V / +24V	Required	
V-66	Red/ Pnk	Battery (+)	+12V / +24V	Required	
V-67	Brn/Wht	Battery (-)	Ground	Required	
V-68	Brn/Yel	Battery (-)	Ground	Required	



Shroud Side of Connector

Table 3-16 Series 60 VIH Connector Firetruck – Pins V-34 – V-68

3.4.2 VIH DESIGN GUIDELINES

The following criteria are to be used when designing the VIH.

Criteria: VIH Design

The 60 18 AWG terminals (pins V-1 through V-60) on the VIH 68-pin connector are designed to accept 16 or 18 AWG wire with Outer Diameter (OD) of 2.0-2.5 mm.

The eight 14 AWG (pins V-61 through V-68) on the VIH 68-pin connector are used for battery connections. These terminals are designed to accept 14 AWG wire with an OD of 2.50-3.18 mm.

The conductor must be annealed copper, not aluminum, and must comply with the industry standard SAE J1128 document.

Color code the wires as shown in the schematics. If the wires used are the same color, hot stamp the cavity number on the wires.

NOTE:
The Vehicle Speed Sensor (VSS) and the SAE J1708/J1587 Data Link circuits must be twisted pairs. The twists are a minimum of 12 turns per foot (305 mm) and are required to minimize electromagnetic field coupling. The maximum length for the SAE J1708/J1587 Data Link is 40 m (130 ft).

NOTE:
All output loads (PWM and digital outputs), ignition and ECU power must be powered from the same battery voltage source.

Pin functions for the VIH are listed in Table 3-17.

Function	Number of Pins
Analog Inputs	24 (18 can be used for Digital Inputs)
PWM Low-Side Output	2
Digital Low-Side Output	10
Frequency Input (two pins each)	4
Battery +	4
Battery -	4
Frequency Output (Tach)	1
SAE J1587 DATA LINK	2
SAE J1939 DATA LINK	3
Sensor Supply/Return	4
Ignition	1
Spare	9

Table 3-17 ECU Pin Functions

Frequency Inputs

The ECU has two frequency inputs on the VIH that can accept a variable reluctance sensor or open collector output device (i.e. Hall Effect sensor, transmission controller) signal types. Typical frequency input functions are: Vehicle Speed Sensor (VSS). Requirements for a variable reluctance signal interface are listed in Table 3-18.

Parameter	Range
Input Amplitude Range	800 mV - 100 V peak to peak
Input Frequency Range	1 to 3000 Hz

Table 3-18 Variable Reluctance Signal Interface

The open collector input is defined as a single wire input that alternates between a high voltage of at least 4 V DC and a low voltage of 1.0 V DC or less. Typically, the input is connected to a transistor collector output whether open or through a Pull-up resistor. A Pull-up resistor is preferred as this eliminates the need to configure the signal type as open collector.

The open collector signal is connected to the (+) input while the (-) input must remain an open circuit. The requirements for an open collector signal interface are listed in Table 3-19.

Parameter	Range
High State	$4.0 < E_{in} <$ Battery(+) V with $I_{leakage} < 0.2$ mA
Low State	$-2.0 < E_{in} < 1.0$ V while $I_{source} < 5.0$ mA
Input Frequency Range	1 to 3000 Hz

Table 3-19 Open Collector Signal Interface

Analog Inputs

The ECU has 24 analog inputs located on the VIH.

Analog inputs with a 1.5kΩ Pull-up to 5 volts internal to the ECU can be used for digital input functions.

These inputs are in low state by shorting to sensor return and placed in high state by opening.

Input Requirements for Analog Inputs Used as Digital Inputs:

High State:	4.0 V < E_{in} < Battery (+) with $I_{leakage}$ < 0.2 mA.
Low State:	-2.0 < E_{in} < 1.0 V while I_{source} < 5.0 mA.
I_{source}:	Capable of sourcing up to 5.0 mA.

NOTE:
Use switches that will not oxidize with the passage of time and environmental factors due to the low source current.

Analog inputs must use the sensor supply and/or the sensor return circuit as listed in Table 3-20.

Cavity	Signal Type	Sensor Supply	Sensor Return
V-3	Analog Input - 1.5k Pull-up	Sensor Supply #2 (V-12)	Sensor Return #2 (V-59)
V-8	Analog Input - 1.5k Pull-up	Sensor Supply #2 (V-12)	Sensor Return #2 (V-59)
V-9	Analog Input - 1.5k Pull-up	Sensor Supply #2 (V-12)	Sensor Return #2 (V-59)
V-10	Analog Input - 1.5k Pull-up	Sensor Supply #2 (V-12)	Sensor Return #2 (V-59)
V-13	Analog Input - 300k Pull-down	Sensor Supply #1 (V-11)	Sensor Return #1 (V-60)
V-14	Analog Input - 300k Pull-down	Sensor Supply #1 (V-11)	Sensor Return #1 (V-60)
V-16	Analog Input - 1.5k Pull-up	Sensor Supply #2 (V-12)	Sensor Return #2 (V-59)
V-22	Analog Input - 51k Pull-down	Sensor Supply #1 (V-11)	Sensor Return #1 (V-60)
V-23	Analog Input - 1.5k Pull-up	Sensor Supply #1 (V-11)	Sensor Return #1 (V-60)
V-24	Analog Input - 1.5k Pull-up	Sensor Supply #2 (V-12)	Sensor Return #2 (V-59)
V-25	Analog Input - 1.5k Pull-up	Sensor Supply #2 (V-12)	Sensor Return #2 (V-59)
V-26	Analog Input - 1.5k Pull-up	Sensor Supply #1 (V-11)	Sensor Return #1 (V-60)
V-27	Analog Input - 1.5k Pull-up	Sensor Supply #1 (V-11)	Sensor Return #1 (V-60)
V-29	Analog Input - 51k Pull-down	Sensor Supply #1 (V-11)	Sensor Return #1 (V-60)
V-37	Analog Input - 120k Pull-up	Sensor Supply #1 (V-11)	Sensor Return #1 (V-60)
V-38	Analog Input - 120k Pull-up	Sensor Supply #1 (V-11)	Sensor Return #1 (V-60)
V-39	Analog Input - 1.5k Pull-up	Sensor Supply #2 (V-12)	Sensor Return #2 (V-59)
V-41	Analog Input - 1.5k Pull-up	Sensor Supply #1 (V-11)	Sensor Return #1 (V-60)
V-42	Analog Input - 1.5k Pull-up	Sensor Supply #1 (V-11)	Sensor Return #1 (V-60)
V-47	Analog Input - 1.5k Pull-up	Sensor Supply 21 (V-12)	Sensor Return #2 (V-59)
V-48	Analog Input - 1.5k Pull-up	Sensor Supply #1 (V-11)	Sensor Return #1 (V-60)
V-49	Analog Input - 1.5k Pull-up	Sensor Supply #2 (V-12)	Sensor Return #2 (V-59)
V-50	Analog Input - 1.5k Pull-up	Sensor Supply #2 (V-12)	Sensor Return #2 (V-59)
V-51	Analog Input - 1.5k Pull-up	Sensor Supply #2 (V-12)	Sensor Return #2 (V-59)

Table 3-20 Analog Inputs and the Sensor Supply/Return Circuits

Pulse Width Modulated Output

There are two low-side PWM outputs on the VIH. These outputs are capable of providing 100 to 1000 Hz modulation between 0 and 100% duty cycle with a resolution of 0.10% duty cycle.

Output Characteristics:

Output On: E_{out} is less than 1.0 V with respect to ECU ground.
(average) I_{sink} = 3.0 A
Output On: E_{out} is less than 2.0 V with respect to ECU ground.
(peak) I_{sink} = 6.0 A
Output Off: $I_{leakage}$ (I_{sink}) is less than 700 µA while $0 < E_{out} < V_{battery.}$

The outputs default to the off (open circuit) state until enabled by the software.

Load Drive Capability of Each PWM Output:

I_{sink}: Capable of sinking an average current of 3.0 A or less and peak current of 6.0 A or less.

Total Load Drive Capability of Both PWM Outputs:

$I_{sinkTotal}$: Capable of sinking an average current of 3.0 A or less and peak current of 6.0 A or less.

Frequency Output

The frequency output on the VIH typically provides an engine speed signal to a tachometer, gauge or another DDEC V ECU. The output frequency transfer function can be calibrated and is 12 pulses per RPM for a tachometer output. The output characteristics are listed in Table 3-21.

Parameter	Output
Frequency Range	10 to 2000 Hz
High State @ Max I_{source} = 5.0 mA	$4.0 < E_{out}$ < Battery (+) V
Duty Cycle	50% ± 10%

Table 3-21 Frequency Output Characteristics

Digital Outputs

There are ten low-side digital outputs located on the VIH. The outputs default to off.

Low-Side Output Characteristics:

Output On:	E_{out} < 1.0 V with respect to ECU ground. I_{sink} (max) = 2.0 A.
Output Off:	$I_{leakage}$ < 210 µA while 0 < E_{out} < Battery (+) V

Load Drive Capabilities of Each Low Side Digital Output:

Resistance:	Capable of driving a resistance greater than or equal to 8 Ω at 16.0 V. Capable of driving a resistance greater than or equal to 16 Ω at 32.0 V.
Inductance:	Capable of connecting to an inductance less than or equal to 100 mH. If load is >100 mH then external clamping is required.
I_{sink}:	Capable of sinking less than or equal to 2.0 A.

Total Load Drive Capability of All Ten Low Side Digital Outputs:

$I_{sink-Total}$:	Total current of all ten low-side digital outputs must be less than or equal to 10.0 A.

Ignition

The ignition source may be either 12 or 24 volts. The DDEC ignition must be an independent input sourced directly from the battery post via a weatherproof blade type fuse, circuit breaker, or equivalent. Ignition sinks a maximum of 10 mA. The ignition fuse rating must be sized for the loads utilized in the application; however, a rating between 5 and 10 amps is usually sufficient. Fuse holders for blade type fuses may be purchased from the DDC Parts Distribution Center. The fuse holder accepts a wire diameter with an OD of 2.89 - 3.65 mm. Part numbers are listed in Table 3-22.

Part	Part Number
Fuse Holder	12033769
Cover	12033731
Terminals	12066614

Table 3-22 Fuse Holder Part Numbers

Ignition voltage must be provided in the crank and run modes.

3.4.3 VIH POWER WIRING

The OEM-supplied VIH power wiring (see Figure 3-7) supplies either 12 or 24 volts to the ECU. The system must be sourced directly from the battery. The eight larger terminals (pins V-61 through V-68) on the VIH connector are used to supply power to the ECU. The terminals are designed to accept 14 AWG standard-wall wire with an OD of 2.5-3.18 mm.

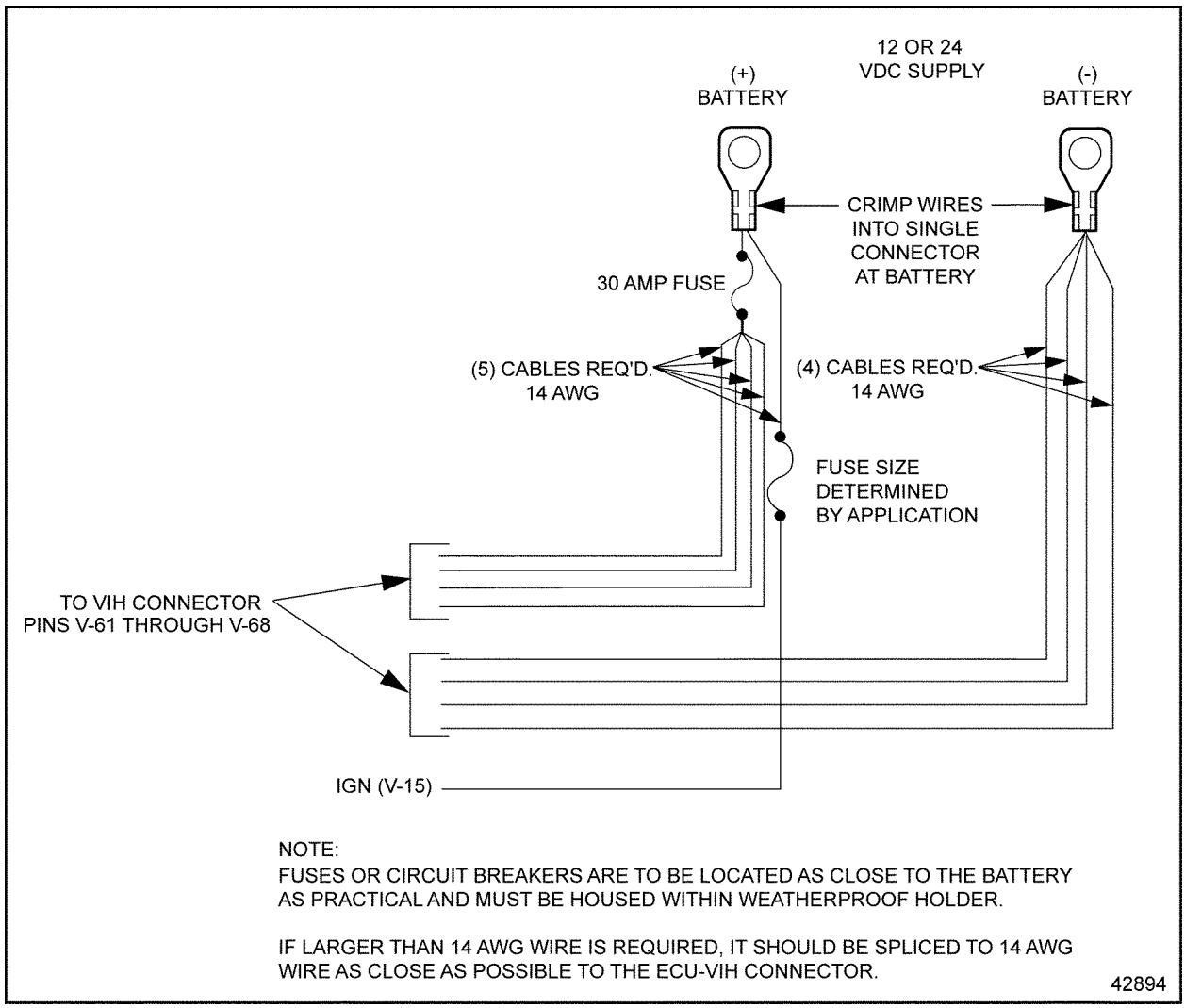


Figure 3-7 Power Wiring - Single-ECU, Single-Fuse

Power must be sourced directly from the battery. An electrically sound connection to the battery or bus bar is required so the battery can filter electrical noise from the power lines. Power for other vehicle systems must not be sourced from the VIH power wires. ***Do not*** use chassis ground.

NOTE:
The DDEC ground wire must be electrically separate from chassis ground.

Power and ground bus bars may be used. The bus bar must be connected to the battery posts with 0 AWG or larger wire depending upon the total vehicle current requirement. The connecting wires must be as short as possible to minimize circuit resistance. ***Do not*** connect the ground wire to the chassis ground.

Provide maximum physical separation of the VIH power wiring from other vehicle electrical systems. Other electrical system wires should ideally be at least three feet away from the VIH power wiring and should not be parallel to the VIH power wiring. This will eliminate coupling electromagnetic energy from other systems into the VIH power wiring.

NOTICE:
Connection to reverse polarity will damage the system if not properly fused.

If larger than 14 AWG wire is required, it should be spliced to 14 AWG wire as close as possible to the ECU VIH connector.

A 30 amp fuse must be used and installed as close to the battery as possible (see Figure 3-7).

The conductor must be annealed copper not aluminum and must comply with the industry standard, *SAE J1128 JAN 95 Low Tension Primary Cable*. Contact the Society of Automotive Engineers to obtain documents, refer to Appendix for their address.

Splices must be soldered and sealed with a waterproof insulator. Alpha FIT-300, Raychem TAT-125 or any equivalent heat shrink - dual wall epoxy encapsulating adhesive polyolefin is required.

Detroit Diesel Corporation recommends color coding. Alternatively, wires may be hot stamped with the cavity number.

Wire Resistances

VIH power terminals require 14 AWG wire. The total resistance of the power harness cannot exceed 60 mΩ. The characteristics for Teflon coated and GXL type wire gauges are listed in Table 3-23.

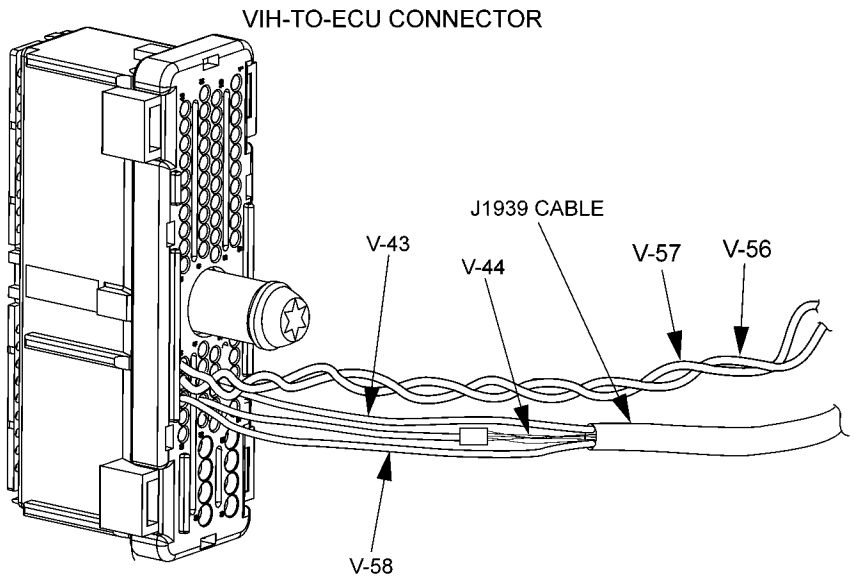
SAE Wire Gauge	Metric Gauge #	Area mm^2	Resistance mΩ/m	Resistance mΩ/ft @ 20°C	Resistance mΩ/ft @ 120°C	Diameter mm
16	1	1.129	15.300	4.66	6.50	0.72
14	2	1.859	9.290	2.83	3.94	1.18
12	3	2.929	5.900	1.80	2.50	1.86
10	5	4.663	3.720	1.13	1.58	2.97
8	8	7.277	2.400	0.73	1.02	4.63

Table 3-23 Wire Characteristics

Total power harness resistance is determined by shorting together the eight terminals in the ECU connector, and then measuring the resistance from the battery (+) to battery (-) terminal at the maximum operating temperature (105°C). Disconnect the harness from the batteries before measuring the resistance.

3.4.4 COMMUNICATION WIRING

SAE J1939 Data Link+, SAE J1939 Data Link-, and SAE J1939 Data Link Shield are used as the J1939 communication link. J1939 cable is required for the J1939 data link. Termination resistors are required per the SAE specification. Refer to SAE J1939–11 for specific requirements. SAE J1587 DL+ and SAE J1587 DL- are used for the SAE J1708/J1587 communication link. See Figure 3-8.



LABEL	VIH-TO-ECU CONNECTOR CAVITY	WIRE COLOR
SAE J1708/1587 DATA LINK (+)	V-56	DK GRN/GRAY
SAE J1708/1587 DATA LINK (-)	V-57	DK GRN
SAE J1939 DATA LINK (+)	V-43	DK BLU/RED
SAE J1939 DATA LINK (-)	V-58	DK BLU
SAE J1939 SHIELD	V-44	BLU/YEL

NOTE: THE J1939 DL WIRES (V43, V44, V58) MUST USE A SHORT LENGTH (APPROX. 6 IN.) OF 18 AWG GXL WIRE INTO THE CAVITIES OF THE CONNECTOR. THE SHORT GXL WIRE CAN BE SPLICED INTO THE J1939 COMMUNICATIONS CABLE. THE SPLICE MUST BE WRAPPED OR COVERED WITH A MATERIAL SUITABLE TO PREVENT DAMAGE TO THE WIRES. THE ENTIRE ASSEMBLY MUST BE COVERED WITH GLUE-LINED HEAT SHRINK.

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Figure 3-8 Communication Wiring

The maximum length for the SAE J1939 Data Link is 130 ft (40 m).

The SAE J1587/J1708 Data Link must be twisted pairs. The twists are a minimum of 12 turns per foot (305 mm). The maximum length for the SAE J1587/J1708 Data Link is 130 ft (40 m).

The following SAE documents cover the SAE J1939 Data Link. Contact the Society of Automotive Engineers to obtain documents, refer to Appendix for their address.

SAE J1939	*Top Layer (Overview)*
SAE J1939/11	*Physical Layer*
SAE J1939/21	*Data Link Layer*
SAE J1939/71	*Application Layer*
SAE J1939/01	*Recommended Practice for Control and Communication Network for On-highway Equipment*
SAE J1939/73	*Application Layer Diagnostics*

The following SAE documents cover the SAE J1587/J1708 Data Link.

SAE J1587	*Electronic Data Interchange Between Microcomputer Systems in Heavy-duty Vehicle Applications*
SAE J1708	*Serial Data Communications Between Microcomputer Systems in Heavy-duty Vehicle Applications*

Contact the Society of Automotive Engineers to obtain documents, refer to Appendix F for their address.

For a list of supported messages, refer to Chapter 6, "Communications Protocols."

J1939 cable is available from the following vendors:

Belden Electronics Division
2200 U.S. 27 South
Richmond, IN 47374
Phone: 1–800–235–3361
www.belden.com

Tyco Electronics Corporation
Raychem Wire and Harnessing
300 Constitution Drive
Menlo Park, CA 94025
Phone: 1–800–926–2425
www.raychem.com

3.4.5 VIH INSTALLATION

The connector shroud is used to protect the connectors from dirt and direct spray, and to route the wires in the correct orientation. The shroud is designed for 25-30 mm conduit. The shroud is REQUIRED.

The following concepts have proven to be effective in installing the VIH.

Criteria: VIH Installation

Provide maximum physical separation of the VIH from other vehicle electrical systems. Other electrical system wires should ideally be at least three feet away from the VIH and should not be parallel to the VIH. This will eliminate coupling electromagnetic energy from other systems into the VIH.

Do not route the harness near any vehicle moving parts, exhaust or any high heat source.

Use a protective sheath to prevent wires from being cut or frayed when weaving harness through the frame.

Adhere to industry standards for relief length and maximum wire bend radius at the connectors.

The 68-pin VIH-to-ECU connector center screw must be torqued to 50 in·lb (5.6 N·m).

The shroud lock nuts must be torqued to 30 in·lb (3.4 N·m).

3.5 POWER SUPPLY

Normal operating voltage for DDEC V is 11-32 VDC.

NOTICE:
Operating the ECU over the voltage limits of 32 volts will cause damage to the ECU.

Operating the ECU between 6 and 11 volts may result in degraded engine operation. (Transient operation in this range during engine starting is considered normal for 12 volt systems.)

NOTICE:
Reversing polarity will cause damage to the ECU if the Power Harness is not properly fused.

3.5.1 AVERAGE CURRENT DRAW

The maximum average current draw is listed in Table 3-24. This information should be used to size the alternator.

System	Maximum Average Current Draw	
	Idle	Full Load/ Rated Speed
Injectors	2.0 A total	10.0 A total
Engine Loads (6 High-side Digital Outputs, 3 Low-side Digital Outputs, 4 Low-side PWM Outputs)	12.0 A total	12.0 A total
Vehicle Loads* (10 Low-side Digital Outputs, 2 PWM Outputs)	15.0 A total	15.0 A total

* Vehicle loads are controlled by the OEMs who can best determine the total maximum current draw for their installation.

Table 3-24 Maximum Average Current Draw

The current draw for a single-ECU configuration is listed in Table 3-25.

Configuration	Condition	Current*
Single-ECU	Ignition Off	25 mA
	Ignition On and Engine Stopped	500 mA

* Add up to 2.0 A to the current draw total for every digital output.

Table 3-25 Current Draw for Single-ECU Configuration

3.5.2 MAIN POWER SHUTDOWN

The main power supply shutdown schematic shows the DDC approved method for main power switch implementation. See Figure 3-9.

NOTE:
Disconnecting positive power is not sufficient to isolate the ECU for welding purposes.

NOTICE:
When welding, the following must be done to avoid damage to the electronic controls or the engine: □ Both the positive (+) and negative (-) battery leads must be disconnected before welding. □ The welding ground wire must be in close proximity to welding location - the engine must never be used as a grounding point. □ Welding on the engine or engine mounted components is NEVER recommended.

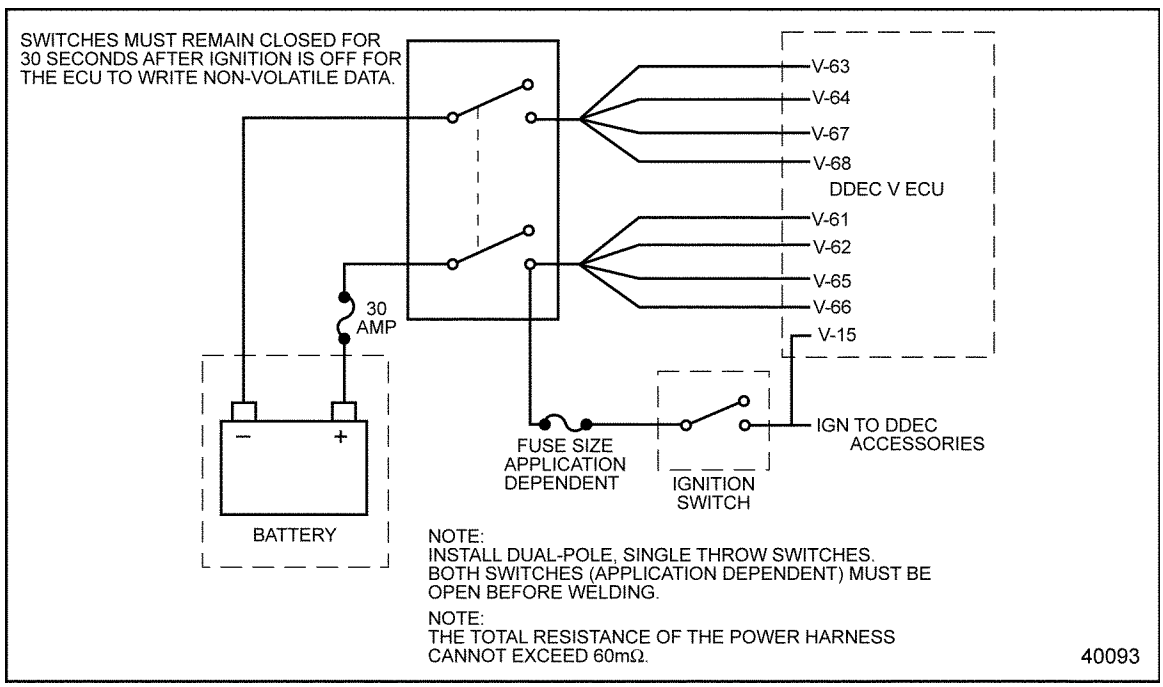


Figure 3-9 Main Power Supply Shutdown 12 or 24 Volt Systems

3.6 FUSES

A Battery (+) fuse and an ignition circuit fuse must be provided by the vehicle wiring harness. Blade-type automotive fuses are normally utilized; however, manual or automatic reset circuit breakers which meet the following requirements are also acceptable. The fuse voltage rating must be compatible with the ECU's maximum operating voltage of 32 volts.

CAUTION:

FIRE

To avoid injury from fire, additional loads should not be placed on existing circuits. Additional loads may blow the fuse (or trip the circuit breaker) and cause the circuit to overheat and burn.

CAUTION:

FIRE

To avoid injury from fire, do not replace an existing fuse with a larger amperage fuse. The increased current may overheat the wiring, causing the insulation and surrounding materials to burn.

The ignition fuse current rating must be sized for the loads utilized in each application; however, a rating of between 5 and 10 amps is usually sufficient.

The Battery (+) fuse current rating must satisfy two criteria:

- Must not open during normal operation
- Must open before the ECU is damaged during a reverse battery condition

Bussmann ATC-30 and Delphi Packard Electric Systems MaxiFuse 30 amp rated fuses or equivalent will satisfy these requirements. Acceptable blow times versus current and temperature derating characteristics are listed in Table 3-26 and Table 3-27.

% of Rated Fuse Current	Minimum Blow Time	Maximum Blow Time
100%	100 hours	-
135%	1 minute	30 minutes
200%	6 seconds	40 seconds

Table 3-26 Fuse Current and Blow Time

Temperature	% of Rated Fuse Current
-40°C	110% max
+25°C	100%
+120°C	80% min

Table 3-27 Fuse Temperature and Current

3.7 CONNECTORS

The DDEC V ECU has two 68-pin Tyco connectors - one for the engine and the other for the vehicle. Each connector has 60 18 AWG terminals and eight 14 AWG terminals (see Figure 3-10).

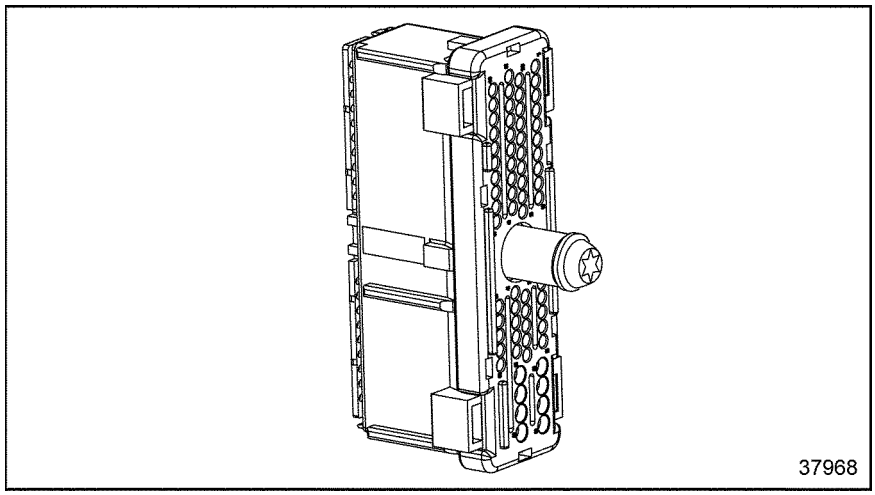
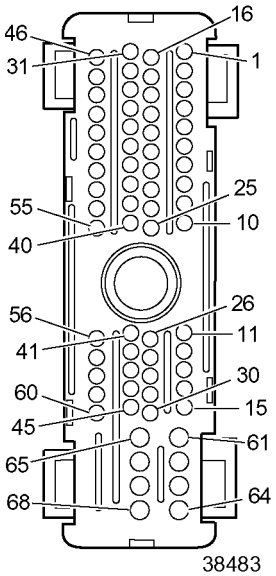


Figure 3-10 ECU 68-pin Tyco Connector

3.7.1 ECU VEHICLE INTERFACE HARNESS CONNECTOR

The VIH 68-pin Tyco connector pinout is listed in Table 3-28 and Table 3-29.

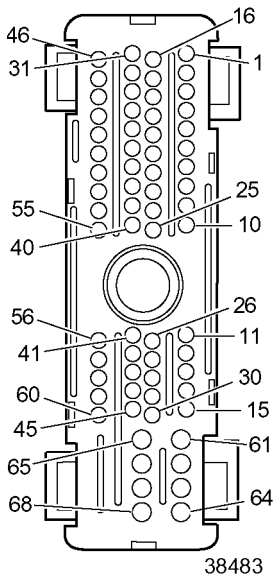
Pin	Wire Color	Signal Type	Function	Req/Typical	Connector
V-1	Dk Grn/Blk	Digital Output - Low Side	AWL	Required	
V-2	Blk/Yel	Digital Output - Low Side	RSL	Required	
V-3	Wht/Dk Grn	Analog Input - 1.5k Pull-up	Service Brake Released	Required	
V-4	Blk/Lt Blu	Digital Output - Low Side	Fan Control #1	Typical: Fan	
V-5	Blk/Lt grn	Digital Output - Low Side	Top2 Shift Solenoid	Typical: Top2	
V-6	Blk/Orn	Digital Output - Low Side	Top2 Lockout Solenoid	Typical: Top2	
V-7	Blk/Wht	Digital Output - Low Side	Vehicle Power Shtdn	Typical	
V-8	Wht/Orn	Analog Input - 1.5k Pull-up	Resume/Accel	Typical: CC	
V-9	Ppl/Wht	Analog Input - 1.5k Pull-up	Cruise Enable	Typical: CC	
V-10	Lt Grn/Wht	Analog Input - 1.5k Pull-up	Clutch Released	Typical: CC	
V-11	Yel/Red	Sensor Supply #1	Sensor Supply #1	Required	
V-12	Wht/ Red	Sensor Supply #2	Sensor Supply #2	Required	
V-13	Lt Blu/Yel	Analog Input - 300k Pull-down	Throttle Position	Required	
V-14	Ppl/Yel	Analog Input - 300k Pull-down	VSG or No Function	Typical	
V-15	Pnk	Ignition	Ignition	Required	
V-16	Red/Wht	Analog Input - 1.5k Pull-up	Idle Validation	Required	
V-17	Lt Blu/ Orn	Frequency Input (+) VSS	Vehicle Speed (+)	Required	
V-18	Lt Blu/ Blk	Frequency Input (-) VSS	Vehicle Speed (-)	Required	
V-19	—	No Connection	No Connection	No Conn	
V-20	—	No Connection	No Connection	No Conn	
V-21	—	No Connection	No Connection	No Conn	
V-22	Yel/Lt Blu	Analog Input – 51k Pull-down	Air Filter Restriction	Typical: MAS	
V-23	Yel/Dk Grn	Analog Input - 1.5k Pull-up	Exhaust Temp (Bus/Coach)	Typical	
V-24	Dk Grn/Wht	Analog Input - 1.5k Pull-up	SEO/Diag Request	Required	
V-25	Grey/Wht	Analog Input - 1.5k Pull-up	A/C Status	Typical: Fan	
V-26	Yel/Lt Grn	Analog Input - 1.5k Pull-up	Engine Brake Disable	—	
V-27	Yel/Wht	Analog Input - 1.5k Pull-up	Turbo Compressor In Temp	Required	
V-28	—	No Connection	No Connection	No Conn	
V-29	Wht/Yel	Analog Input – 51k Pull-down	Exhaust Back Press or Water Pump Press or Air Compressor Press	Typical	
V-30	—	No Connection	No Connection	No Conn	
V-31	Tan	Frequency Output	Tachometer	Typical	



Shroud Side of Connector

Table 3-28 Series 60 VIH Connector - On-highway Truck – Pins V-1 – V-31

Pin	Wire Color	Signal Type	Function	Req/ Typical	Connector
V-32	Dk Blu/Orn	Frequency Input (+) Aux 1	Spare	—	
V-33	Dk Blu/Blk	Frequency Input (-) Aux 1	Spare	—	
V-34	—	No Connection	No Connection	No Conn	
V-35	—	No Connection	No Connection	No Conn	
V-36	—	No Connection	No Connection	No Conn	
V-37	Orn/Yel	Analog Input – 120k Pull-up	Add Coolant Level	Typical: MAS	
V-38	Lt Gr/Yel	Analog Input – 120k Pull-up	Coolant Level Shtdn	Req	
V-39	Lt Blu/Wht	Analog Input – 1.5k Pull-up	Engine Brake Low	Typical: Jake	
V-40	Orn/Blk	Digital Output – Low Side	OI Alarm	Typical: OI	
V-41	Dk Grn/Yel	Analog Input – 1.5k Pull-up	Aux Shtdn #1	—	
V-42	Grey/Yel	Analog Input – 1.5k Pull-up	OI Thermostat	Typical: OI	
V-43	Dk Blu/Red	J1939 (+)	J1939 (+)	Req	
V-44	Dk Blu/Yel	J1939S	J1939 Shield	Required	
V-45	—	No Connection	No Connection	No Conn	
V-46	Dk Grn/Brn	PWM Output - Low Side	Variable Speed Fan	—	
V-47	Wht/Lt Blu	Analog Input - 1.5k Pull-up	Set/Coast	Typical; CC	
V-48	Tan/ Yel	Analog Input - 1.5k Pull-up	Throttle Inhibit	—	
V-49	Pink/Wht	Analog Input - 1.5k Pull-up	Fan Control Override	Typical	
V-50	Tan/ Wht	Analog Input - 1.5k Pull-up	Park Brake	Typical	
V-51	Dk Blu/Wht	Analog Input - 1.5k Pull-up	Engine Brake Medium	Typical: Jake	
V-52	Dk Grn/Orn	PWM Output Low Side	Trans % Load	—	
V-53	Blk/Red	Digital Output - Low Side	Ether Start	—	
V-54	Blk/Pnk	Digital Output - Low Side	OI Starter	Typical: OI	
V-55	Lt Grn/Blk	Digital Output - Low Side	OI Active Lamp	Typical: OI	
V-56	Dk Grn/ Grey	J1587 (+)	J1587 (+)	Required	
V-57	Dk Grn	J1587 (-)	J1587 (-)	Required	
V-58	Dk Blu	J1939 (-)	J1939 (-)	Required	
V-59	Dk Blu	Sensor Return #2	Sensor Return	Required	
V-60	Yel/ Blk	Sensor Return #1	Sensor Return	Required	
V-61	Red/Blk	Battery (+)	+12V / +24V	Required	
V-62	Red/ Lt Blu	Battery (+)	+12V / +24V	Required	
V-63	Brn/Blk	Battery (-)	Ground	Required	
V-64	Brn/ Lt Grn	Battery (-)	Ground	Required	
V-65	Red/ Lt Grn	Battery (+)	+12V / +24V	Required	
V-66	Red/ Pnk	Battery (+)	+12V / +24V	Required	
V-67	Brn/Wht	Battery (-)	Ground	Required	
V-68	Brn/Yel	Battery (-)	Ground	Required	

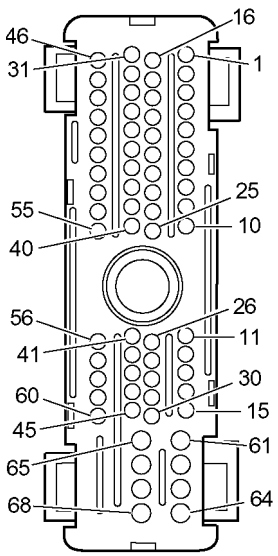


Shroud Side of Connector

Table 3-29 Series 60 VIH Connector - On-highway Truck - Pins V-32 — V-68

The VIH 68–pin Tyco connector pinout for Series 60 Bus/Coach applications is listed in Table 3-30 and Table 3-31.

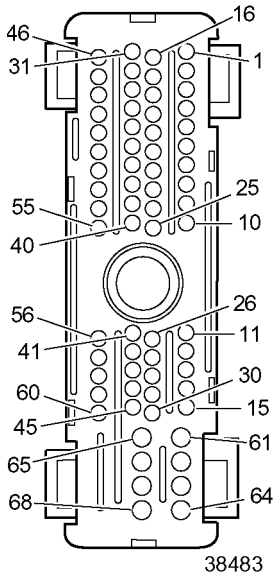
Pin	Wire Color	Signal Type	Function	Req/Typical	Connector
V-1	Dk Grn/Blk	Digital Output - Low Side	AWL	Required	
V-2	Blk/Yel	Digital Output - Low Side	RSL	Required	
V-3	Wht/Dk Grn	Analog Input - 1.5k Pull-up	Service Brake Released	Required	
V-4	Blk/Lt Blu	Digital Output - Low Side	Fan Control #1	Typical: Fan	
V-5	Blk/Lt grn	Digital Output - Low Side	Fan Control #2	Typical: Fan	
V-6	Blk/Orn	Digital Output - Low Side	Decleration Lamp	Typical	
V-7	Blk/Wht	Digital Output - Low Side	Starter Lockout	Typical	
V-8	Wht/Orn	Analog Input - 1.5k Pull-up	Resume/Accel	Typical: CC	
V-9	Ppl/Wht	Analog Input - 1.5k Pull-up	Cruise Enable	Typical: CC	
V-10	Lt Grn/Wht	Analog Input - 1.5k Pull-up	Spare	—	
V-11	Yel/Red	Sensor Supply #1	Sensor Supply #1	Required	
V-12	Wht/ Red	Sensor Supply #2	Sensor Supply #2	Required	
V-13	Lt Blu/Yel	Analog Input - 300k Pull-down	Throttle Position	Required	
V-14	Ppl/Yel	Analog Input - 300k Pull-down	VSG or No Function	Typical	
V-15	Pnk	Ignition	Ignition	Required	
V-16	Red/Wht	Analog Input - 1.5k Pull-up	Idle Validation	Required	
V-17	Lt Blu/ Orn	Frequency Input (+) VSS	Vehicle Speed (+)	Required	
V-18	Lt Blu/ Blk	Frequency Input (-) VSS	Vehicle Speed (-)	Required	
V-19	—	No Connection	No Connection	No Conn	
V-20	—	No Connection	No Connection	No Conn	
V-21	—	No Connection	No Connection	No Conn	
V-22	Yel/Lt Blu	Analog Input – 51k Pull-down	Air Filter Restriction	Typical: MAS	
V-23	Yel/Dk Grn	Analog Input - 1.5k Pull-up	Exhaust Temp (Bus/Coach)	Typical	
V-24	Dk Grn/Wht	Analog Input - 1.5k Pull-up	SEO/Diag Request	Required	
V-25	Grey/Wht	Analog Input - 1.5k Pull-up	A/C Status	Typical: Fan	
V-26	Yel/Lt Grn	Analog Input - 1.5k Pull-up	Engine Brake Disable	Typical	
V-27	Yel/Wht	Analog Input - 1.5k Pull-up	Turbo Compressor In Temp	Required	
V-28	—	No Connection	No Connection	No Conn	
V-29	Wht/Yel	Analog Input – 51k Pull-down	Exhaust Back Pressure	Typical	
V-30	—	No Connection	No Connection	No Conn	
V-31	Tan	Frequency Output	Tachometer	Typical	



Shroud Side of Connector

Table 3-30 Series 60 VIH Connector Bus/Coach – Pins V-1 – V-31

Pin	Wire Color	Signal Type	Function	Req/ Typical	Connector
V-32	Dk Blu/Orn	Frequency Input (+) Aux 1	Spare	—	
V-33	Dk Blu/Blk	Frequency Input (-) Aux 1	Spare	—	
V-34	—	No Connection	No Connection	No Conn	
V-35	—	No Connection	No Connection	No Conn	
V-36	—	No Connection	No Connection	No Conn	
V-37	Orn/Yel	Analog Input – 120k Pull-up	Add Coolant Level	Typical: MAS	
V-38	Lt Gr/Yel	Analog Input – 120k Pull-up	Coolant Level Shtdn	Req	
V-39	Lt Blu/Wht	Analog Input – 1.5k Pull-up	Engine Brake Low	Typical: Jake	
V-40	Orn/Blk	Digital Output – Low Side	Engine Brake Active	Typical	
V-41	Dk Grn/Yel	Analog Input – 1.5k Pull-up	Aux Shtdn #1	—	
V-42	Grey/Yel	Analog Input – 1.5k Pull-up	Alt Min VSG / Fast Idle	Typical	
V-43	Dk Blu/Red	J1939 (+)	J1939 (+)	Req	
V-44	Dk Blu/Yel	J1939S	J1939 Shield	Required	
V-45	—	No Connection	No Connection	No Conn	
V-46	Dk Grn/Brn	PWM Output - Low Side	Variable Speed Fan	—	
V-47	Wht/Lt Blu	Analog Input - 1.5k Pull-up	Set/Coast	Typical; CC	
V-48	Tan/ Yel	Analog Input - 1.5k Pull-up	Throttle Inhibit	Typical	
V-49	Pink/Wht	Analog Input - 1.5k Pull-up	Fan Control Override	Typical	
V-50	Tan/ Wht	Analog Input - 1.5k Pull-up	Park Brake	Typical	
V-51	Dk Blu/Wht	Analog Input - 1.5k Pull-up	Engine Brake Medium	Typical: Jake	
V-52	Dk Grn/Orn	PWM Output Low Side	Trans % Load	—	
V-53	Blk/Red	Digital Output - Low Side	Coolant Level Low Lamp	Typical	
V-54	Blk/Pnk	Digital Output - Low Side	No Connection	No Conn	
V-55	Lt Grn/Blk	Digital Output - Low Side	Cruise Active Lamp	Typical	
V-56	Dk Grn/ Grey	J1587 (+)	J1587 (+)	Required	
V-57	Dk Grn	J1587 (-)	J1587 (-)	Required	
V-58	Dk Blu	J1939 (-)	J1939 (-)	Required	
V-59	Dk Blu	Sensor Return #2	Sensor Return	Required	
V-60	Yel/ Blk	Sensor Return #1	Sensor Return	Required	
V-61	Red/Blk	Battery (+)	+12V / +24V	Required	
V-62	Red/ Lt Blu	Battery (+)	+12V / +24V	Required	
V-63	Brn/Blk	Battery (-)	Ground	Required	
V-64	Brn/ Lt Grn	Battery (-)	Ground	Required	
V-65	Red/ Lt Grn	Battery (+)	+12V / +24V	Required	
V-66	Red/ Pnk	Battery (+)	+12V / +24V	Required	
V-67	Brn/Wht	Battery (-)	Ground	Required	
V-68	Brn/Yel	Battery (-)	Ground	Required	

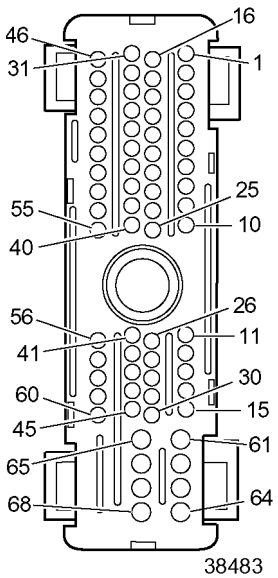


Shroud Side of Connector

Table 3-31 Series 60 VIH Connector Bus/Coach – Pins V-32 – V-68

The VIH 68–pin Tyco connector pinout for Series 60 non-road equipment is listed in Table 3-32 and listed in Table 3-33.

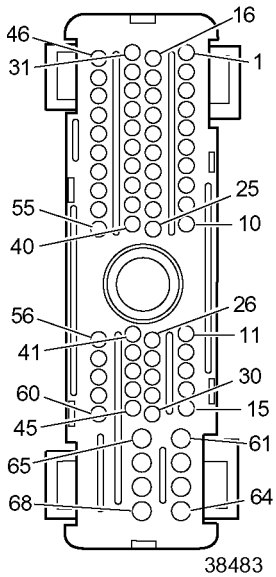
Pin	Wire Color	Signal Type	Function	Req/Typical	Connector
V-1	Dk Grn/Blk	Digital Output - Low Side	AWL	Required	
V-2	Blk/Yel	Digital Output - Low Side	RSL	Required	
V-3	Wht/Dk Grn	Analog Input - 1.5k Pull-up	Service Brake Released	Required	
V-4	Blk/Lt Blu	Digital Output - Low Side	Fan Control #1	Typical: Fan	
V-5	Blk/Lt grn	Digital Output - Low Side	Fan Control #2	Typical: Fan	
V-6	Blk/Orn	Digital Output - Low Side	Spare	—	
V-7	Blk/Wht	Digital Output - Low Side	Starter Lockout	Typical	
V-8	Wht/Orn	Analog Input - 1.5k Pull-up	Resume/Accel	Typical: CC	
V-9	Ppl/Wht	Analog Input - 1.5k Pull-up	Cruise Enable	Typical: CC	
V-10	Lt Grn/Wht	Analog Input - 1.5k Pull-up	Spare	—	
V-11	Yel/Red	Sensor Supply #1	Sensor Supply #1	Required	
V-12	Wht/ Red	Sensor Supply #2	Sensor Supply #2	Required	
V-13	Lt Blu/Yel	Analog Input - 300k Pull-down	Throttle Position (ALSG)	Required	
V-14	Ppl/Yel	Analog Input - 300k Pull-down	VSG	Typical	
V-15	Pnk	Ignition	Ignition	Required	
V-16	Red/Wht	Analog Input - 1.5k Pull-up	Idle Validation	Required	
V-17	Lt Blu/ Orn	Frequency Input (+) VSS	Vehicle Speed (+)	Required	
V-18	Lt Blu/ Blk	Frequency Input (-) VSS	Vehicle Speed (-)	Required	
V-19	—	No Connection	No Connection	No Conn	
V-20	—	No Connection	No Connection	No Conn	
V-21	—	No Connection	No Connection	No Conn	
V-22	Yel/Lt Blu	Analog Input – 51k Pull-down	Air Filter Restriction	Typical: MAS	
V-23	Yel/Dk Grn	Analog Input - 1.5k Pull-up	Exhaust Temp	Typical	
V-24	Dk Grn/Wht	Analog Input - 1.5k Pull-up	SEO/Diag Request	Required	
V-25	Grey/Wht	Analog Input - 1.5k Pull-up	A/C Status	Typical: Fan	
V-26	Yel/Lt Grn	Analog Input - 1.5k Pull-up	Engine Brake Disable	Typical	
V-27	Yel/Wht	Analog Input - 1.5k Pull-up	Spare	—	
V-28	—	No Connection	No Connection	No Conn	
V-29	Wht/Yel	Analog Input – 51k Pull-down	Exhaust Back Pressure or Water Pump Pressure or Air Compressor Pressure	Typical	
V-30	—	No Connection	No Connection	No Conn	
V-31	Tan	Frequency Output	Tachometer	Typical	



Shroud Side of Connector

Table 3-32 Series 60 VIH Connector Non-Road Equipment – Pins V-1 – V-31

Pin	Wire Color	Signal Type	Function	Req/ Typical	Connector
V-32	Dk Blu/Orn	Frequency Input (+) Aux 1	Spare	—	
V-33	Dk Blu/Blk	Frequency Input (-) Aux 1	Spare	—	
V-34	—	No Connection	No Connection	No Conn	
V-35	—	No Connection	No Connection	No Conn	
V-36	—	No Connection	No Connection	No Conn	
V-37	Orn/Yel	Analog Input – 120k Pull-up	Add Coolant Level	Typical: MAS	
V-38	Lt Gr/Yel	Analog Input – 120k Pull-up	Coolant Level Shtdn	Req	
V-39	Lt Blu/Wht	Analog Input – 1.5k Pull-up	Engine Brake Low	Typical: Jake	
V-40	Orn/Blk	Digital Output – Low Side	Spare	—	
V-41	Dk Grn/Yel	Analog Input – 1.5k Pull-up	Aux Shtdn #1	—	
V-42	Grey/Yel	Analog Input – 1.5k Pull-up	Spare	—	
V-43	Dk Blu/Red	J1939 (+)	J1939 (+)	Req	
V-44	Dk Blu/Yel	J1939S	J1939 Shield	Required	
V-45	—	No Connection	No Connection	No Conn	
V-46	Dk Grn/Brn	PWM Output - Low Side	Variable Speed Fan	—	
V-47	Wht/Lt Blu	Analog Input - 1.5k Pull-up	Set/Coast	Typical; CC	
V-48	Tan/ Yel	Analog Input - 1.5k Pull-up	Throttle Inhibit	Typical	
V-49	Pink/Wht	Analog Input - 1.5k Pull-up	Fan Control Override	Typical	
V-50	Tan/ Wht	Analog Input - 1.5k Pull-up	Park Brake	Typical	
V-51	Dk Blu/Wht	Analog Input - 1.5k Pull-up	Engine Brake Medium	Typical: Jake	
V-52	Dk Grn/Orn	PWM Output Low Side	Trans % Load	—	
V-53	Blk/Red	Digital Output - Low Side	Coolant Level Low Lamp	Typical	
V-54	Blk/Pnk	Digital Output - Low Side	No Connection	No Conn	
V-55	Lt Grn/Blk	Digital Output - Low Side	Spare	—	
V-56	Dk Grn/ Grey	J1587 (+)	J1587 (+)	Required	
V-57	Dk Grn	J1587 (-)	J1587 (-)	Required	
V-58	Dk Blu	J1939 (-)	J1939 (-)	Required	
V-59	Dk Blu	Sensor Return #2	Sensor Return	Required	
V-60	Yel/ Blk	Sensor Return #1	Sensor Return	Required	
V-61	Red/Blk	Battery (+)	+12V / +24V	Required	
V-62	Red/ Lt Blu	Battery (+)	+12V / +24V	Required	
V-63	Brn/Blk	Battery (-)	Ground	Required	
V-64	Brn/ Lt Grn	Battery (-)	Ground	Required	
V-65	Red/ Lt Grn	Battery (+)	+12V / +24V	Required	
V-66	Red/ Pnk	Battery (+)	+12V / +24V	Required	
V-67	Brn/Wht	Battery (-)	Ground	Required	
V-68	Brn/Yel	Battery (-)	Ground	Required	

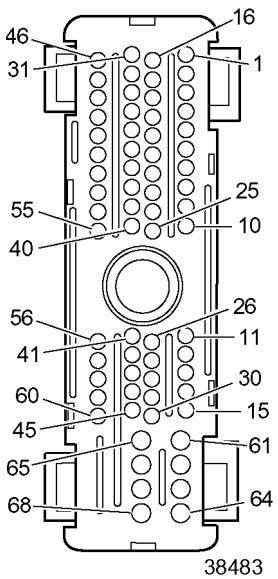


Shroud Side of Connector

Table 3-33 Series 60 VIH Connector Non-Road Equipment – Pins V-32 – V-68

The 68–pin Tyco connector pinout for the Series 60 firetruck application is listed in Table 3-34 and Table 3-35.

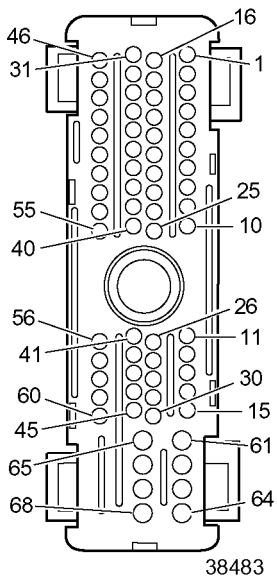
Pin	Wire Color	Signal Type	Function	Req/Typical	Connector
V-1	Dk Grn/Blk	Digital Output - Low Side	AWL	Required	
V-2	Blk/Yel	Digital Output - Low Side	RSL	Required	
V-3	Wht/Dk Grn	Analog Input - 1.5k Pull-up	Service Brake Released	Required	
V-4	Blk/Lt Blu	Digital Output - Low Side	Fan Control #1	Typical: Fan	
V-5	Blk/Lt grn	Digital Output - Low Side	Low DDEC Voltage	Typical	
V-6	Blk/Orn	Digital Output - Low Side	Deceleration Lamp	Typical	
V-7	Blk/Wht	Digital Output - Low Side	PSG Pressure Mode Lamp	Typical	
V-8	Wht/Orn	Analog Input - 1.5k Pull-up	Resume/Accel	Typical: PSG	
V-9	Ppl/Wht	Analog Input - 1.5k Pull-up	PSG Enable	Typical: PSG	
V-10	Lt Grn/Wht	Analog Input - 1.5k Pull-up	Spare	—	
V-11	Yel/Red	Sensor Supply #1	Sensor Supply #1	Required	
V-12	Wht/ Red	Sensor Supply #2	Sensor Supply #2	Required	
V-13	Lt Blu/Yel	Analog Input - 300k Pull-down	Throttle Position	Required	
V-14	Ppl/Yel	Analog Input - 300k Pull-down	VSG or No Function	Typical	
V-15	Pnk	Ignition	Ignition	Required	
V-16	Red/Wht	Analog Input - 1.5k Pull-up	Idle Validation	Required	
V-17	Lt Blu/ Orn	Frequency Input (+) VSS	Vehicle Speed (+)	Required	
V-18	Lt Blu/ Blk	Frequency Input (-) VSS	Vehicle Speed (-)	Required	
V-19	—	No Connection	No Connection	No Conn	
V-20	—	No Connection	No Connection	No Conn	
V-21	—	No Connection	No Connection	No Conn	
V-22	Yel/Lt Blu	Analog Input – 51k Pull-down	Air Filter Restriction	Typical: MAS	
V-23	Yel/Dk Grn	Analog Input - 1.5k Pull-up	Pressure / RPM Mode	Typical: PSG	
V-24	Dk Grn/Wht	Analog Input - 1.5k Pull-up	SEO/Diag Request	Required	
V-25	Grey/Wht	Analog Input - 1.5k Pull-up	A/C Status	Typical: Fan	
V-26	Yel/Lt Grn	Analog Input - 1.5k Pull-up	Engine Brake Disable	Typical	
V-27	Yel/Wht	Analog Input - 1.5k Pull-up	Turbo Compressor In Temp	Required	
V-28	—	No Connection	No Connection	No Conn	
V-29	Wht/Yel	Analog Input – 51k Pull-down	Water Pump Press	Typical	
V-30	—	No Connection	No Connection	No Conn	
V-31	Tan	Frequency Output	Tachometer	Typical	
V-32	Dk Blu/Orn	Frequency Input (+) Aux 1	Spare	—	
V-33	Dk Blu/Blk	Frequency Input (-) Aux 1	Spare	—	



Shroud Side of Connector

Table 3-34 Series 60 VIH Connector Firetruck – Pins V-1 – V-33

Pin	Wire Color	Signal Type	Function	Req/ Typical	Connector
V-34	—	No Connection	No Connection	No Conn	
V-35	—	No Connection	No Connection	No Conn	
V-36	—	No Connection	No Connection	No Conn	
V-37	Orn/Yel	Analog Input – 120k Pull-up	Add Coolant Level	Typical: MAS	
V-38	Lt Gr/Yel	Analog Input – 120k Pull-up	Coolant Level Shtdn	Req	
V-39	Lt Blu/Wht	Analog Input – 1.5k Pull-up	Engine Brake Low	Typical: Jake	
V-40	Orn/Blk	Digital Output – Low Side	Engine Brake Active	Typical	
V-41	Dk Grn/Yel	Analog Input – 1.5k Pull-up	Aux Shtdn #1	—	
V-42	Grey/Yel	Analog Input – 1.5k Pull-up	Alt Min VSG / Fast Idle	Typical	
V-43	Dk Blu/Red	J1939 (+)	J1939 (+)	Req	
V-44	Dk Blu/Yel	J1939S	J1939 Shield	Required	
V-45	—	No Connection	No Connection	No Conn	
V-46	Dk Grn/Brn	PWM Output - Low Side	Variable Speed Fan	—	
V-47	Wht/Lt Blu	Analog Input - 1.5k Pull-up	Set/Coast	Typical: PSG	
V-48	Tan/ Yel	Analog Input - 1.5k Pull-up	Throttle Inhibit	Typical	
V-49	Pink/Wht	Analog Input - 1.5k Pull-up	Fan Control Override	Typical	
V-50	Tan/ Wht	Analog Input - 1.5k Pull-up	Park Brake	Typical	
V-51	Dk Blu/Wht	Analog Input - 1.5k Pull-up	Engine Brake Medium	Typical: Jake	
V-52	Dk Grn/Orn	PWM Output Low Side	Trans % Load	—	
V-53	Blk/Red	Digital Output - Low Side	Coolant Level Low Lamp	Typical	
V-54	Blk/Pnk	Digital Output - Low Side	No Connection	No Conn	
V-55	Lt Grn/Blk	Digital Output - Low Side	Cruise/PSG Active Lamp	Typical	
V-56	Dk Grn/ Grey	J1587 (+)	J1587 (+)	Required	
V-57	Dk Grn	J1587 (-)	J1587 (-)	Required	
V-58	Dk Blu	J1939 (-)	J1939 (-)	Required	
V-59	Dk Blu	Sensor Return #2	Sensor Return	Required	
V-60	Yel/ Blk	Sensor Return #1	Sensor Return	Required	
V-61	Red/Blk	Battery (+)	+12V / +24V	Required	
V-62	Red/ Lt Blu	Battery (+)	+12V / +24V	Required	
V-63	Brn/Blk	Battery (-)	Ground	Required	
V-64	Brn/ Lt Grn	Battery (-)	Ground	Required	
V-65	Red/ Lt Grn	Battery (+)	+12V / +24V	Required	
V-66	Red/ Pnk	Battery (+)	+12V / +24V	Required	
V-67	Brn/Wht	Battery (-)	Ground	Required	
V-68	Brn/Yel	Battery (-)	Ground	Required	



Shroud Side of Connector

Table 3-35 Series 60 VIH Connector Firetruck – Pins V-34 – V-68

The 68-pin VIH-to-ECU connector part numbers are listed in Table 3-36.

Description	DDC Part Number	Tyco Part Number
Vehicle Harness Connector Assembly	23528252	776315-1
Shroud	23532347	776501-1
Shroud Lock Nuts (M6–1.0 Nylon Insert Lock Nut Plated with Yellow Zinc)	23533607	—
ECU Stud	23533606	—
14 AWG Terminal (Large) (Terminal only)	23528272	776492-1
18 AWG Terminal (Standard) (Terminal only)	23528271	776326-4
14 AWG Terminal (Large) (crimped with 12 in. wire)	23528255	—
18 AWG Terminal (Standard) (crimped with 12 in. wire)	23528254	—
Cavity Plug	23528274	776364

Table 3-36 VIH-to-ECU Connector Part Numbers

The 68-pin connector center screw must be torqued to 50 in·lb (5.6 N·m)

The shroud is required to protect the connectors from dirt and direct spray and to route the wires in the correct orientation. The shroud lock nuts must be torqued to 30 in·lb (3.4 N·m).

If a replacement wire and/or terminal is required, the wires will arrive assembled with the terminals crimped on the wires (see Figure 3-11).

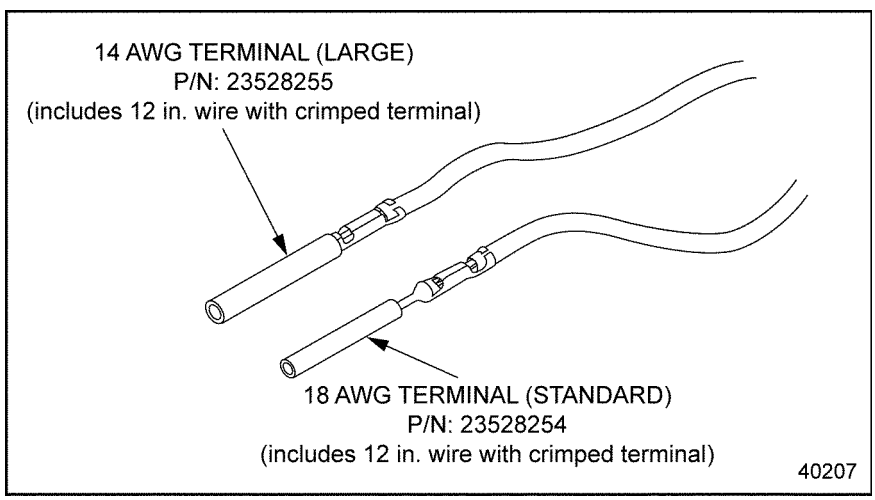
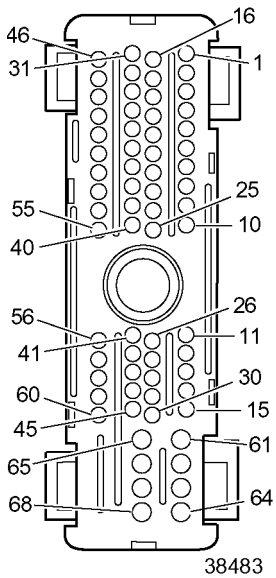


Figure 3-11 68-pin Connector Wires and Terminal

3.7.2 ECU ENGINE HARNESS CONNECTOR

The EH 68-pin Tyco connector pinout for the Series 60 is listed in listed in Table 3-37 and listed in Table 3-38.

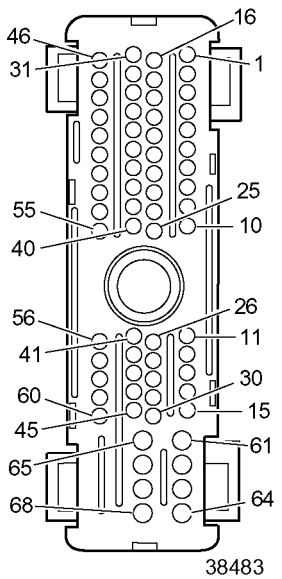
Pin	Wire Color	Signal Type	Function	Connector
E-1	Blk	PWM Output – Low Side	EGR Hydraulic Valve Control	
E-2	Wht	Analog Input – 1.5k Pull-up	Air Temp	
E-3	—	Analog Input – 51k Pull-down	Spare	
E-4	Blk	PWM Output – Low Side	VGT VPOD Control	
E-5	Yel	Analog Input – 1.5k Pull-up	Coolant Temp	
E-6	—	Analog Input – 51k Pull-down	Spare	
E-7	Tan	Analog Input – 1.5k Pull-up	Oil Temp	
E-8	—	PWM Output – Low Side	Spare	
E-9	Orn	Analog Input – 1.5k Pull-up	Fuel Temp	
E-10	—	Analog Input – 1.5k Pull-up	EGR Temp	
E-11	—	PWM Output – Low Side	Spare	
E-12	Gra	Sensor Supply #3	Sensor Supply	
E-13	—	Digital Output – Low Side	Spare	
E-14	Blk	Sensor Return #4	Sensor Return	
E-15	Blk	Sensor Return #3	Sensor Return	
E-16	Yel	Analog Input – 51k Pull-down	Fuel Restriction (MAS)	
E-17	Ppl	TRS (CKP) (-)	TRS (CKP) (-)	
E-18	Dk Grn	TRS (CKP) (+)	TRS (CKP) (+)	
E-19	Lt Blu	SRS (CMP) (+)	SRS (CMP) (+)	
E-20	Wht	SRS (CMP) (-)	SRS (CMP) (-)	
E-21	Dk Grn	Analog Input – 51k Pull-down	Oil Level (MAS)	
E-22	Dk Blu	Analog Input – 1.5k Pull-up	Turbo Compressor Out Temp	
E-23	—	Analog Input – 1.5k Pull-up	Spare	
E-24	—	Analog Input – 51k Pull-down	Spare	
E-25	—	Analog Input – 51k Pull-down	Spare	
E-26	Gra	Sensor Supply #4	Sensor Supply	
E-27	—	Analog Input – 1.5k Pull-up	Spare	
E-28	—	Ground Pin	Spare	
E-29	—	Ground Pin	Spare	
E-30	—	Ground Pin	Spare	
E-31	Brn	Analog Input – 51k Pull-down	Oil Pressure	
E-32	—	Frequency Input (+) — Aux 3	Spare	



Shroud Side of Connector

Table 3-37 Series 60 Engine Harness Connector - Pins E-1 Through E-32

Pin	Wire Color	Signal Type	Function	Connector
E-33	—	Frequency Input (-) – Aux3	Spare	
E-34	Brn	Frequency Input (-) – Aux2	Turbo Speed Sensor (+)	
E-35	Blk	Frequency Input (+) – Aux2	Turbo Speed Sensor (-)	
E-36	—	Analog Input – 1.5k Pull-up	Spare	
E-37	Pnk	Analog Input – 51k Pull-down	Barometric Pressure	
E-38	—	Analog Input – 51k Pull-down	EGR Delta Pressure	
E-39	Lt Grn	Analog Input – 51k Pull-down	Turbo Boost	
E-40	Dk Blue	CAN2 (+)	CAN2 (+)	
E-41	—	Analog Input – 51k Pull-down	Spare	
E-42	Blk	Ground Pin	VGT VPOD Gnd	
E-43	Blk	Ground Pin	Spare	
E-44	—	Ground Pin	Spare	
E-45	—	Ground Pin	Spare	
E-46	Lt Grn	Digital Output – High Side	Switched Battery (+) - VGT	
E-47	—	Digital Output – High Side	Spare	
E-48	Red	Digital Output – High Side	Jake Med/High	
E-49	Orn	Digital Output – High Side	Jake Low	
E-50	—	Digital Output – High Side	Spare	
E-51	Yel	Digital Output – High Side	Spare	
E-52	Red	Digital Output – High Side	Spare	
E-53	—	Digital Output – High Side	Spare	
E-54	Pnk	CAN2 (-)	CAN2 (-)	
E-55	Blk	CAN2S	CAN2 Shield	
E-56	—	Analog Input – 51k Pull-down	Spare	
E-57	—	Analog Input – HWOLS	No Connection	
E-58	—	Analog Input – 1.5k Pull-up	Spare	
E-59	—	RTC BATT+	External RTC Battery (+)	
E-60	—	Ground Pin	Spare	
E-61	Wht	Injector High Common	S60 Common Cyl #1,2,3	
E-62	Wht	Injector High Common	S60 Common Cyl #4,5, 6	
E-63	Wht	Injector A – LO1	S60 Cyl #1	
E-64	Wht	Injector A – LO2	S60 Cyl #3	
E-65	Wht	Injector A – LO3	S60 Cyl #2	
E-66	Wht	Injector B – LO1	S60 Cyl #5	
E-67	Wht	Injector B – LO2	S60 Cyl #6	
E-68	Wht	Injector B– LO3	S60 cyl #4	



Shroud Side of Connector

Table 3-38 Series 60 Engine Harness Connector - Pins E-33 Through E-68

The 68–pin connector part numbers are listed in Table 3-39.

Description	DDC Part Number	Tyco Part Number
Engine Harness Connector Assembly	23528253	776315-2
Shroud	23532347	776501-1
Shroud Lock Nuts (M6–1.0 Nylon Insert Lock Nut Plated with Yellow Zinc)	23533607	—
ECU Stud	23533606	—
14 AWG Terminal (Large) (Terminal only)	23528272	776492-1
18 AWG Terminal (Standard) (Terminal only)	23528271	776326-4
14 AWG Terminal (Large) (crimped with 12 in. wire)	23528255	—
18 AWG Terminal (Standard) (crimped with 12 in. wire)	23528254	—
Cavity Plug	23528274	776364

Table 3-39 EH-to-ECU Connector Part Numbers

The 68-pin connector center screw must be torqued to 50 in·lb (5.6 N·m)

The shroud is required to protect the connectors from dirt and direct spray and to route the wires in the correct orientation. The shroud lock nuts must be torqued to 30 in·lb (3.4 N·m).

If a replacement wire and/or terminal is required, the wires will arrive assembled with the terminals crimped on the wires (see Figure 3-12).

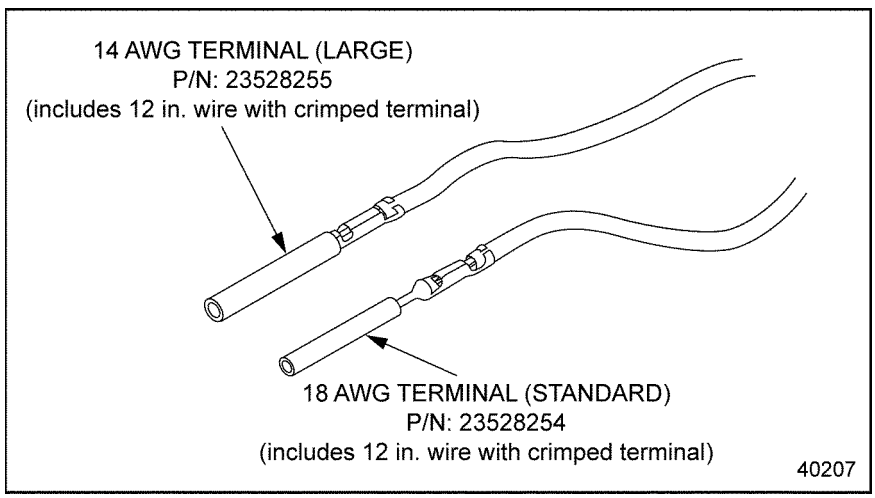


Figure 3-12 68 Pin Connector Wires and Terminals

3.7.3 DATA LINK CONNECTOR

The SAE J1708/J1587 nine-pin data link connector is required. DDC recommends that the OEM-supplied Data Link Connector be conveniently positioned in a well protected location facilitating subsequent DDDL usage (i.e., reprogramming, diagnostics, etc.).

The components listed in Table 3-40 are required to incorporate a SAE J1939/J1587 Data Link in a VIH for diagnostic and reprogramming devices.

Component	DDC Part Number	Deutsch Part Number
Nine-pin Deutsch Connector	23529496	HD10-9-1939P
Connector Cover	23529497	HDC 16–9
Two (2) Cavity Plugs	23507136	114017
Seven (7) Terminals	23507132	0460-202-16141

Table 3-40 Required Components to Incorporate an SAE J1939/J1587 Data Link in the VIH

The following illustration shows the wiring for the nine-pin connector (see Figure 3-13).

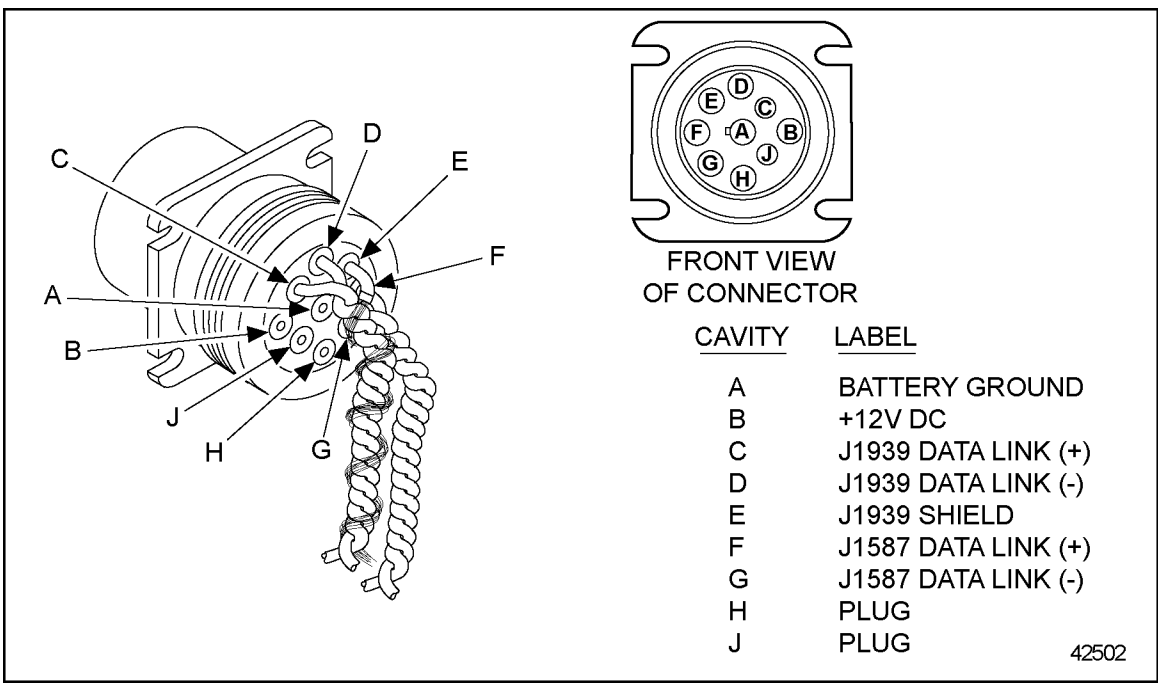


Figure 3-13 Wiring for 9-pin Data Link Connector

The maximum length for the SAE J1939 Data Link is 130 ft (40 m).

The SAE J1587/J1708 Data Link must be twisted pairs. The twists are a minimum of 12 turns per foot (305 mm). The maximum length for the SAE J1587/J1708 Data Link is 130 ft (40 m).

3.7.4 FCI CONNECTORS

An FCI connector for the Turbo Compressor In Temperature Sensor is the OEM responsibility. FCI connectors are available from:

FCI Automotive
Telephone: 1–800–303–3577 or 734–728–2100

NTI, LLC
300 Randall Street, Suite B
Greer SC 29651
Telephone: 864–877–4800
Fax: 864–877–2997

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3.8 WIRES AND WIRING

This section contains recommendations and requirements for the VIH and EH connectors and wiring.

3.8.1 GENERAL WIRE RECOMMENDATIONS

Detroit Diesel Corporation recommends color coding or hot stamping of wires.

NOTE:
Color code the wires as shown in the schematics. If the wires used are the same color, hot stamp the cavity number on the wires.

NOTICE:
DDC does not recommend using any type of terminal lubricant or grease compounds. These products may cause dirt or other harmful substances to be retained in the connector.

NOTICE:
Insulation must be free of nicks.

Tape, conduit, loom or a combination thereof must be used to protect the wires. Refer to sections 3.9 and 3.10. All wires must be annealed copper wire (not aluminum). All wires must comply with *SAE J1128 JAN 95 Low Tension Primary Cable*. Contact the Society of Automotive Engineers to obtain documents, refer to Appendix for their address.

3.8.2 ECU CONNECTOR WIRE INTO SHROUD INSTALLATION

The following procedures for using tape, ties, and conduit must be followed to enusre proper placement of the shroud over the ECU connectors:

1. Use heavy electrical tape where wires exit conduit into the shroud (see Figure 3-14, A).

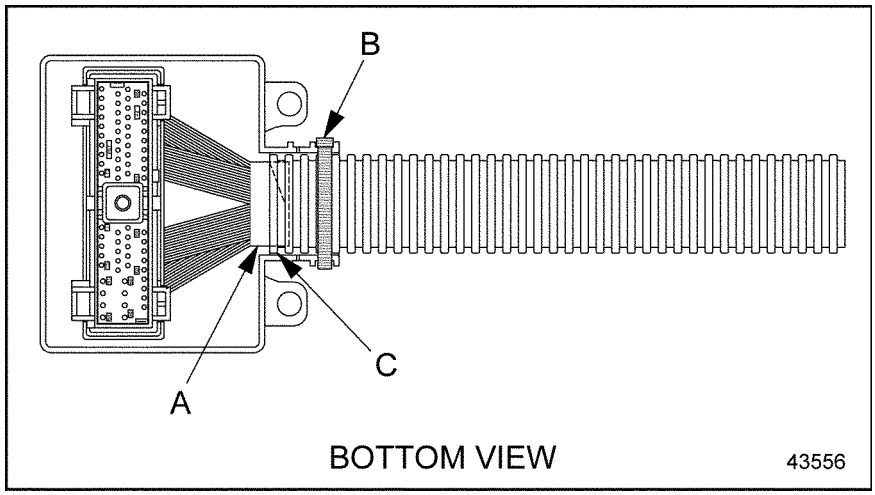

Figure 3-14 Bottom View of Shroud, ECU Connector and Conduit

2. Use a tie strap to secure the shroud to the conduit and connector (see Figure 3-14, B).
3. Check that the conduit extends past the innermost ring on the shroud inlet. The conduit ***must*** extend this far (see Figure 3-14, C).

4. The two locking tabs in the shroud furthest from the wire inlet must be securely latched into the connector. The two tabs closest to the wire inlet should be snapped over the connector tabs (see Figure 3-15).

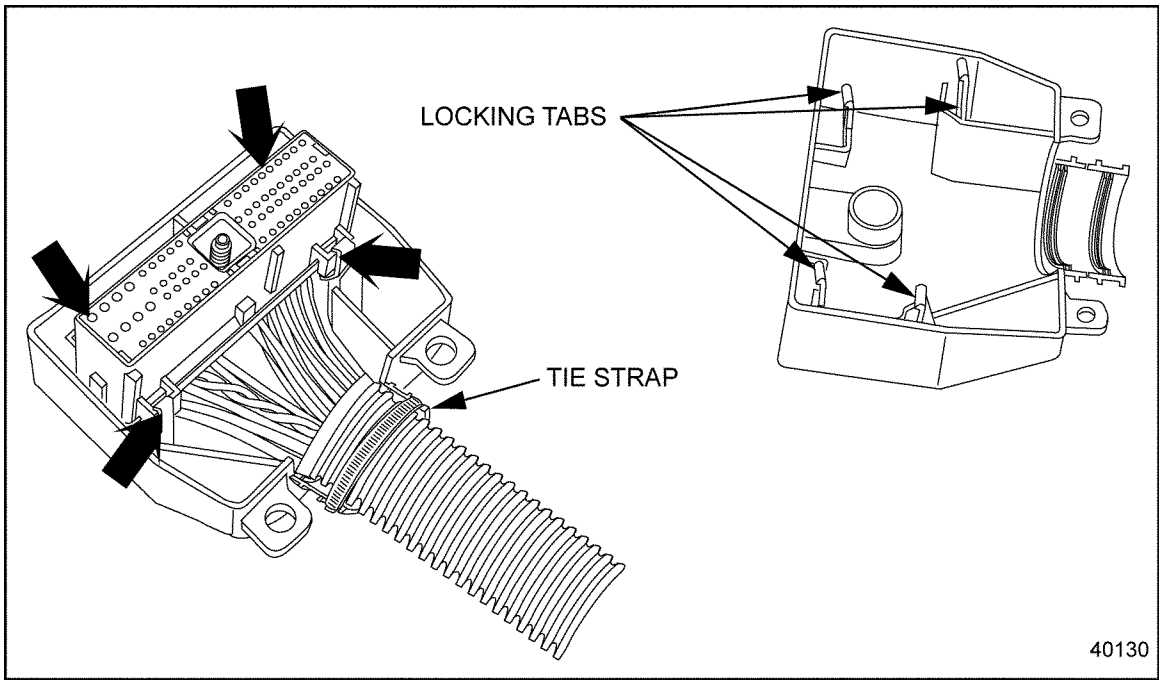

Figure 3-15 Shroud Tabs

5. Ensure that the wires are not pinched between the connector and any of the shroud's protrusions during assembly (see Figure 3-16, D).

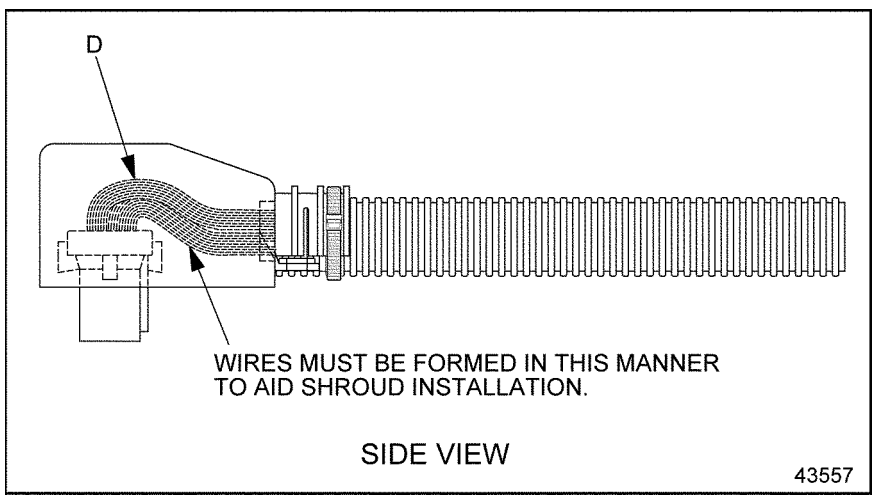

Figure 3-16 Side View of Shroud, ECU Connector and Conduit

3.8.3 TERMINAL INSTALLATION AND REMOVAL

The method of terminal installation and removal varies, depending on the terminal/connector design. No other terminals are to be removed or installed on the Engine Harness.

Wire and Terminal Installation - Tyco ECU Connector

To install the wires and terminals into the Tyco connector:

1. Remove the Terminal Position Assurance (TPA) from the connector using a jewelers (small) screwdriver (see Figure 3-18).
2. Push the terminal into the cavity until it clicks.
3. Replace the TPA.
4. Secure the harness in the shroud neck with two tie wraps (see Figure 3-17).

NOTE:
The conduit must cover the harness wires in the neck of the shroud.

Wire and Terminal Removal - Tyco ECU Connector

Use a jewelers (small) screwdriver as your extraction tool. To remove the terminals from the connector body:

1. Cut the tie wraps holding the harness in the neck of the shroud.
2. Remove the connector from the shroud by pushing the four locking tabs (arrows) back from the connector. Use the screwdriver to push back the tabs closest to the shroud wall (see Figure 3-17).

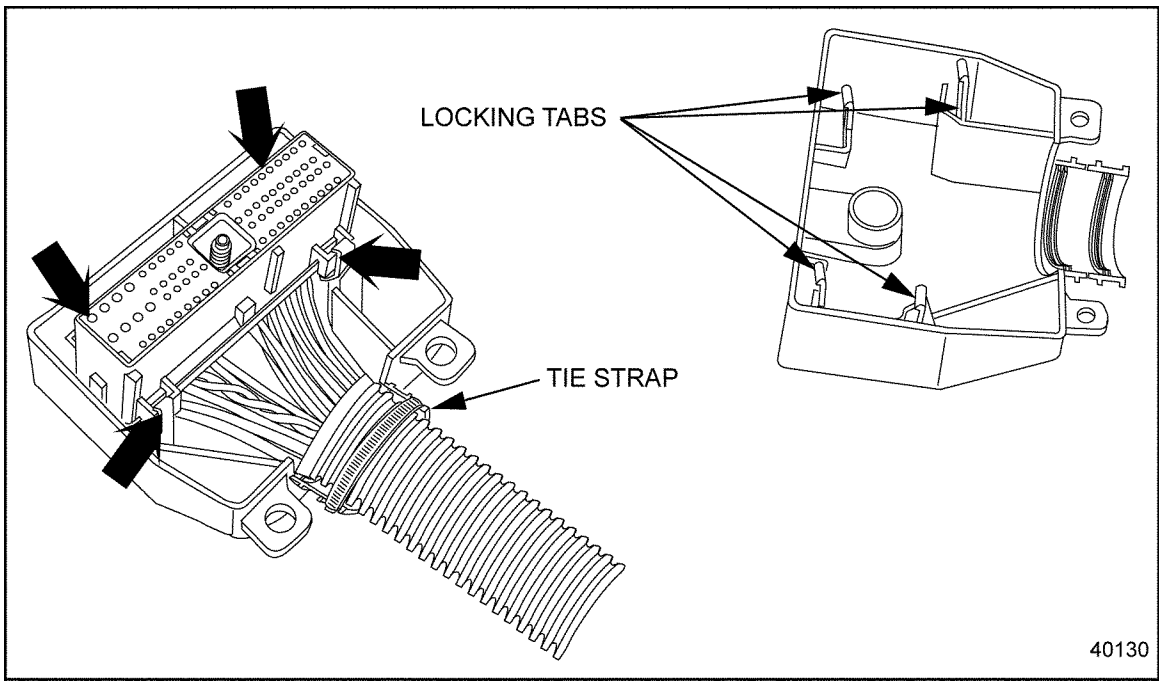

Figure 3-17 Tyco Connector and Locking Tabs

3. Remove the Terminal Position Assurance from the connector with the screwdriver (see Figure 3-18).

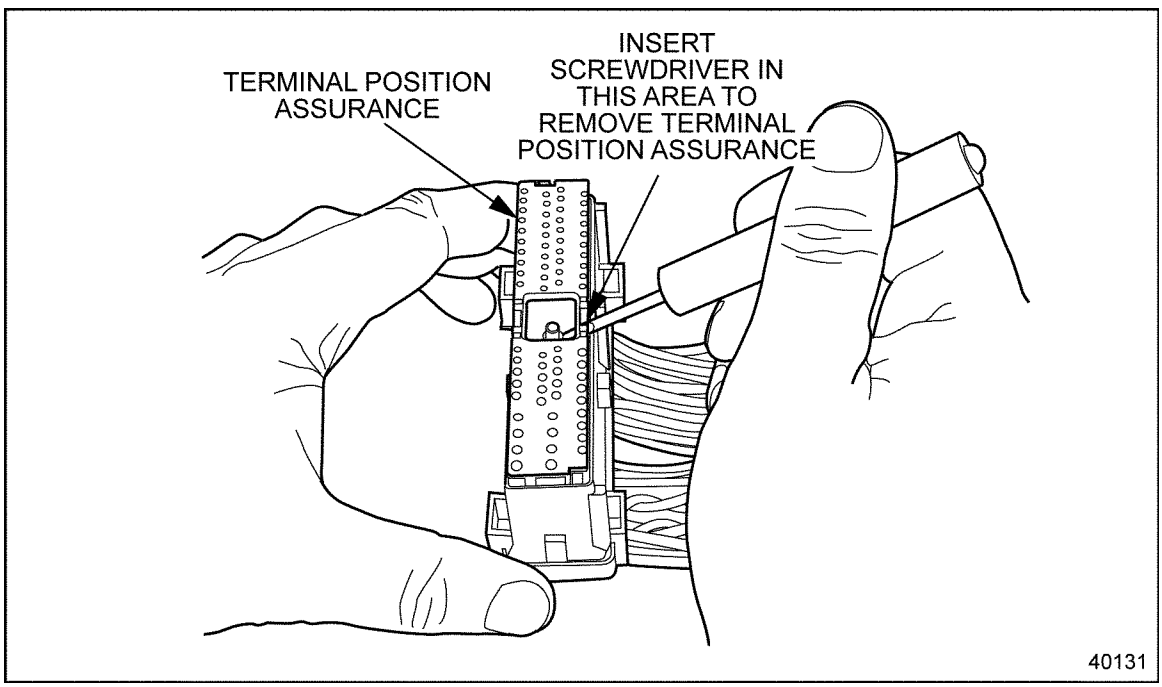

Figure 3-18 Removing the Terminal Position Assurance

4. Use the screwdriver to gently pry back the tab holding the terminal you wish to remove (see Figure 3-19).

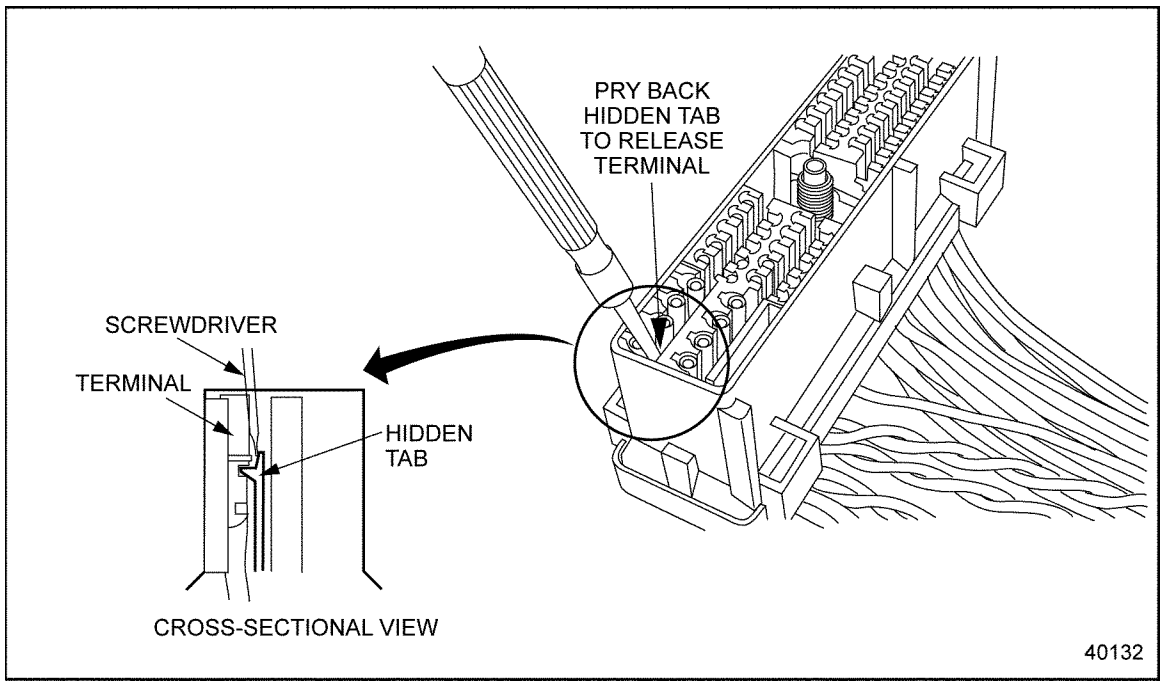

Figure 3-19 Removing the Terminal

5. While holding the tab back, carefully pull the wire and terminal out of the connector.

Deutsch Terminal Installation Guidelines

Deutsch connectors have wire seals molded into the connector. These connectors are push-to-seat connectors with cylindrical terminals.

NOTICE:
Improper selection and use of crimp tools have varying adverse effects on crimp geometry and effectiveness. Proper installation of terminals require specialized tools. Do not attempt to use alternative tools.

The crimp tool to use in Deutsch terminal installation is J 34182 (Kent-Moore part number).

NOTICE:
Terminal crimps must be made with the Deutsch crimp tool P/N: HDT-48-00 to assure gas tight connections.

NOTICE:
If a separate seal is required, be sure to install the seal onto the wire before stripping the insulation.

Use the following instructions for installing Deutsch terminals:

1. Strip approximately 1/4 in. (6 mm) of insulation from the wire.
2. Remove the lock clip, raise the wire gage selector, and rotate the knob to the number matching the gauge wire that is being used.
3. Lower the selector and insert the lock clip.
4. Position the terminal so that the crimp barrel is 1/32 of an inch above the four indenters. See Figure 3-20. Crimp the wire.

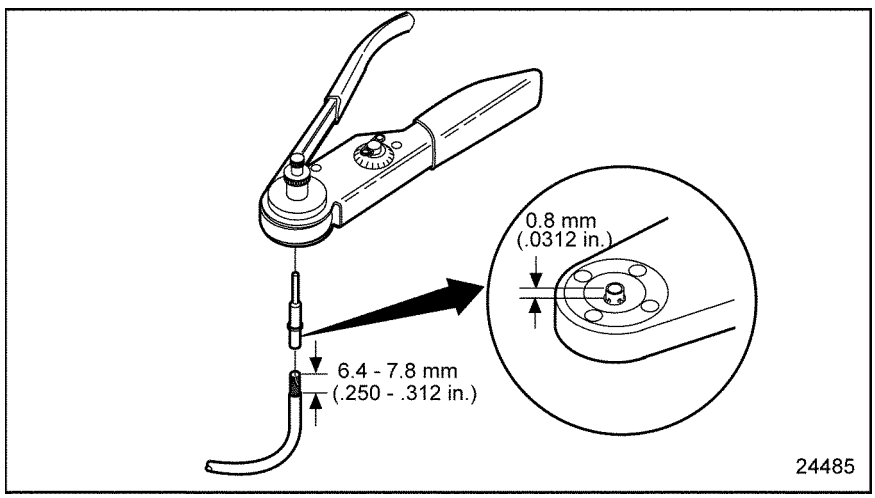

Figure 3-20 Setting Wire Gage Selector and Positioning the Terminal

5. Grasp the terminal approximately one inch behind the terminal crimp barrel. Hold the connector with the rear grommet facing you. See Figure 3-21.

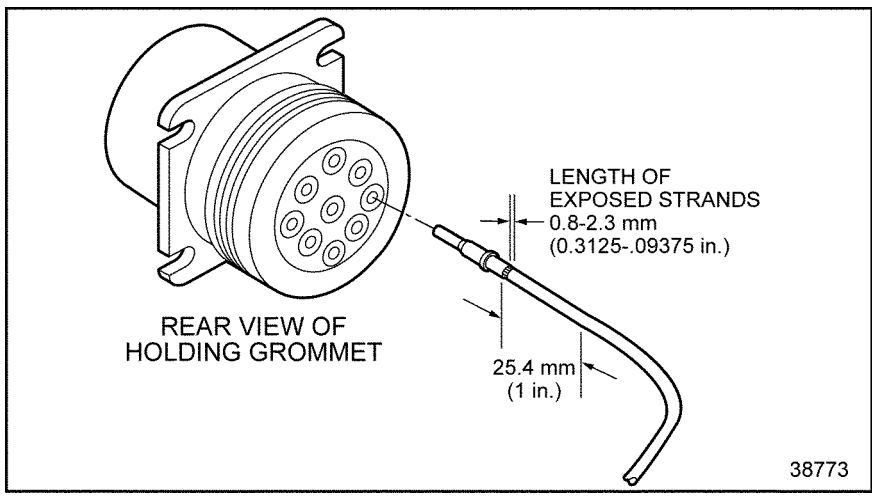

Figure 3-21 Pushing Terminal Into Grommet

6. Push the terminal into the grommet until a positive stop is felt. See Figure 3-21. A slight tug will confirm that it is properly locked into place. See Figure 3-22.

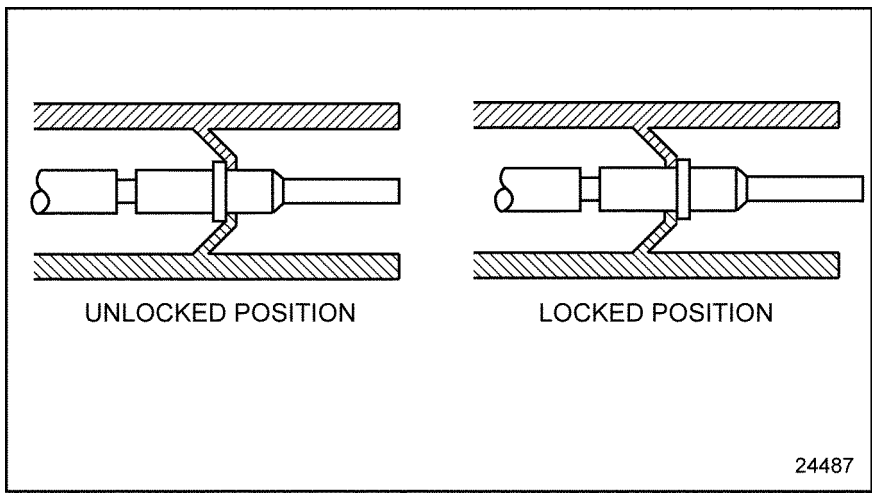

Figure 3-22 Locking Terminal Into Connector

Deutsch Terminal Removal

The appropriate size removal tool should be used when removing wires from connectors. The proper removal tools are listed in Table 3-41.

Tool	Kent-Moore Part Number
Removing (12 AWG)	J 37451
Removing (16-18 AWG)	J 34513-1

Table 3-41 Removal Tools for Deutsch Terminals

Remove Deutsch terminals as follows:

1. With the rear insert toward you, snap the appropriate size remover tool over the wire of the terminal to be removed. See Figure 3-23.

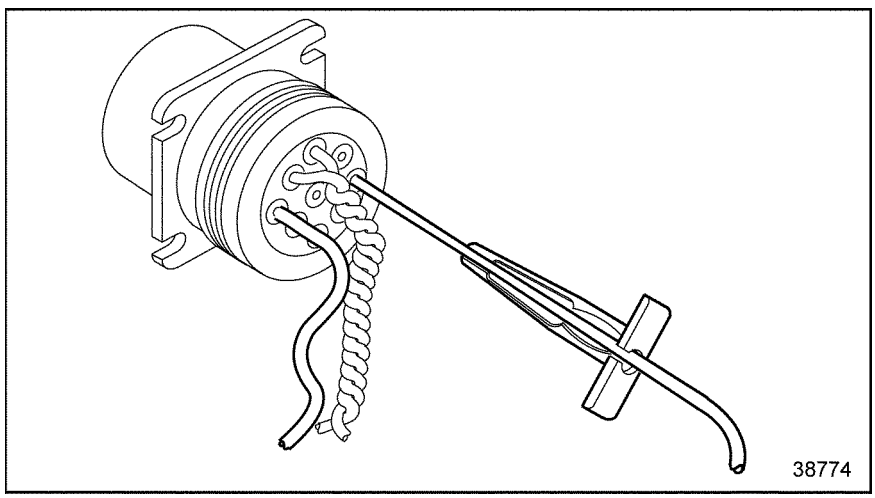

Figure 3-23 Removal Tool Position

2. Slide the tool along the wire into the insert cavity until it engages and resistance is felt. Do not twist or insert tool at an angle. See Figure 3-24.

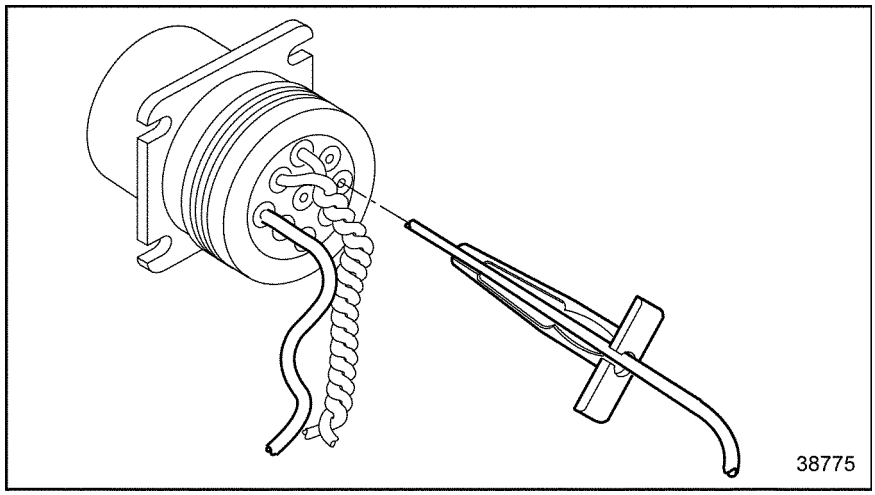

Figure 3-24 Removal Tool Insertion

3. Pull terminal wire assembly out of the connector. Keep reverse tension on the wire and forward tension on the tool.

3.8.4 FCI APEX TERMINAL INSTALLATION AND REMOVAL

The following sections cover FCI APEX male and female terminal installation and removal.

FCI Apex Male Terminal Installation

Install the FCI APEX male terminal as follows:

1. Determine if the connector is new or used.
   [a] If the connector is new, the red Terminal Assurance Position (TPA) is in an unlocked position so go to step 2.
   [b] If the connector is used, pull the TPA out (see Figure 3-25).
2. Insert the crimped terminal into the connector until it clicks (see Figure 3-25). The orientation of the terminal is not critical.

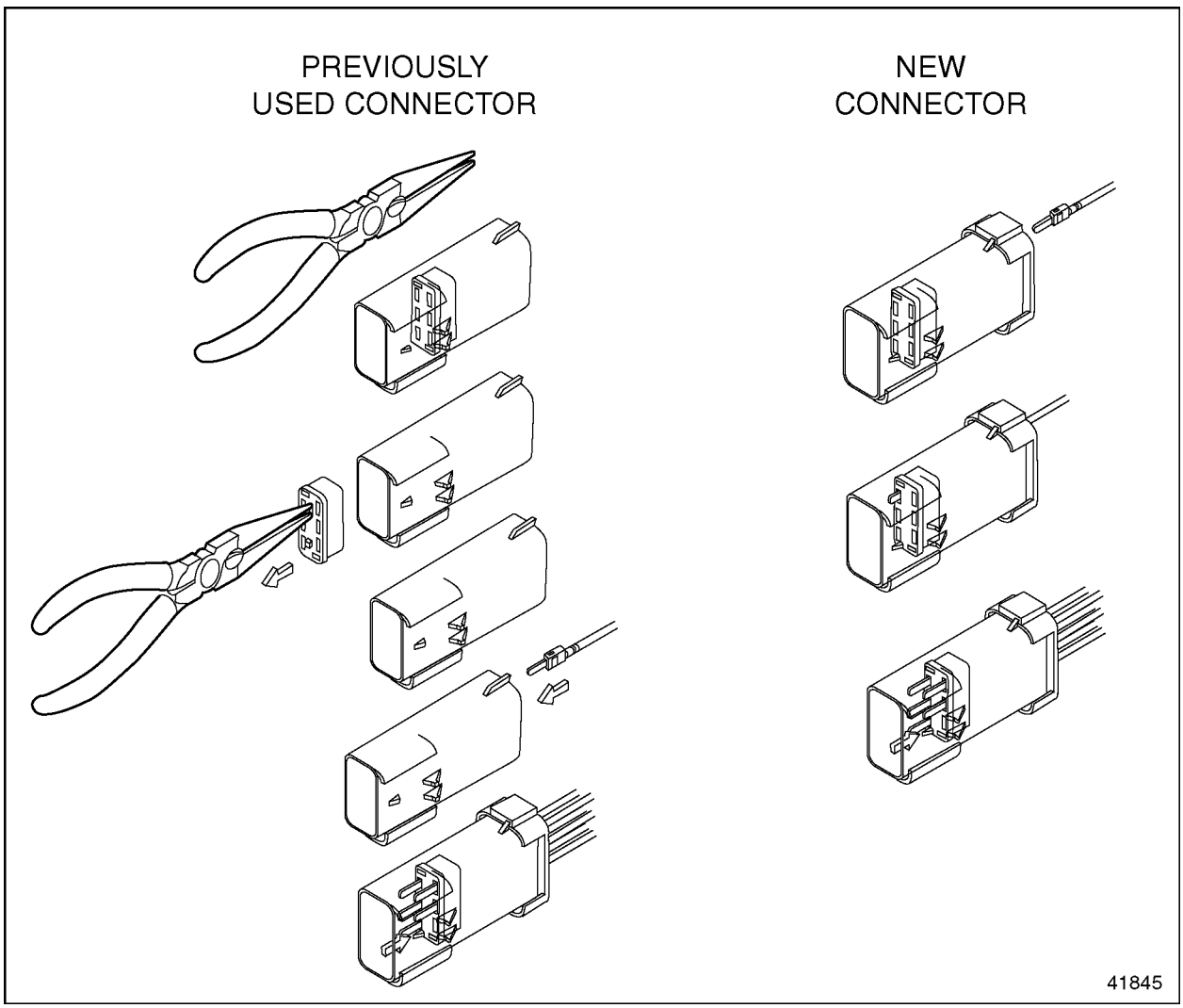

Figure 3-25 Installing the FCI Male Terminal

3. Push the TPA into the locked (fully seated) position.

NOTE:
The TPAs will self lock when the connectors are mated.

FCI Apex Male Terminal Removal

Remove the terminal as follows:

1. Using pliers pull out the red Terminal Position Assurance (TPA) (see Figure 3-26).

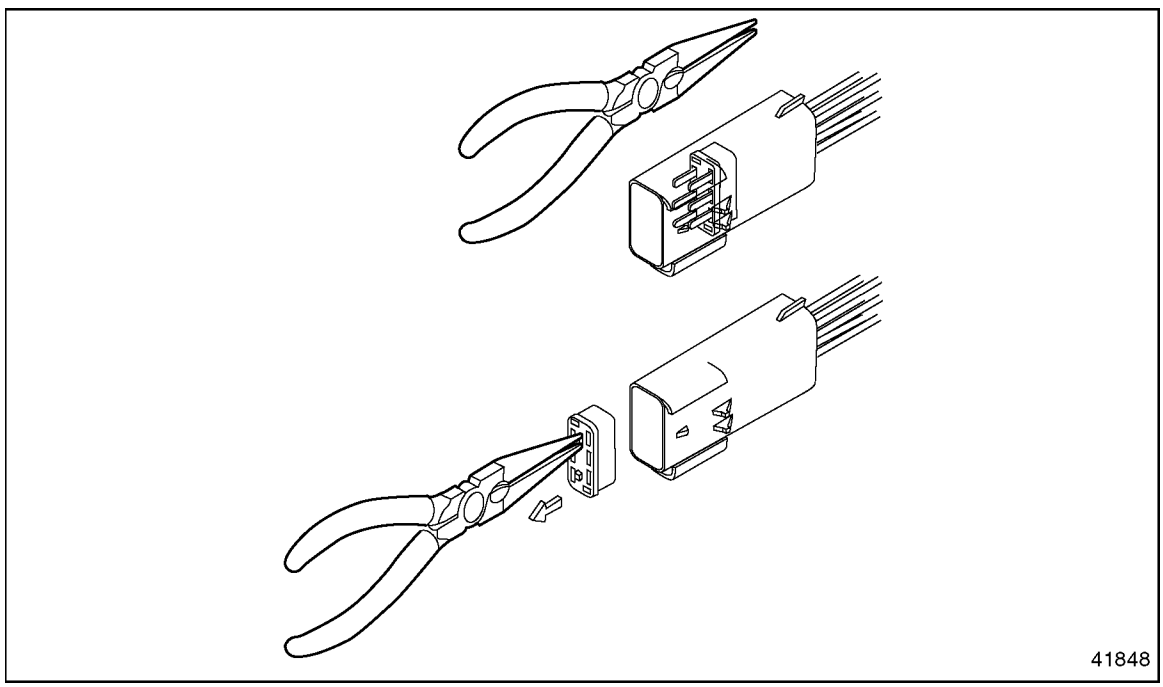

Figure 3-26 Removing the Terminal

2. Using a FCI APEX repair tool (P/N: 54900002) or a #2 jeweler's screwdriver, press back the terminal locking tang (see Figure 3-27).

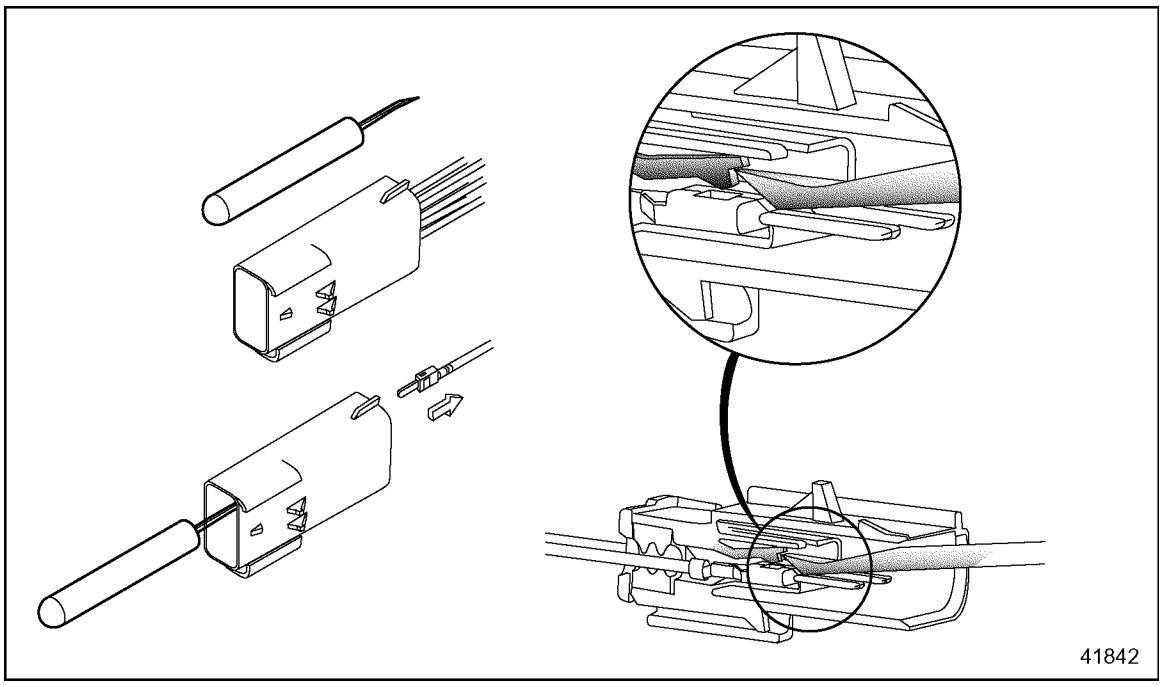

Figure 3-27 Pressing the Locking Tang

3. Pull the cable back through the connector (see Figure 3-26).

FCI Apex Female Terminal Installation

Install the terminal as follows:

1. Determine if the connector is new or used.
   [a] If the connector is new, the blue Terminal Assurance Position (TPA) is in an unlocked position so go to 2.
   [b] If the connector is used, pull the TPA out (see Figure 3-28).
2. Insert the crimped terminal into the connector until it clicks (see Figure 3-28).

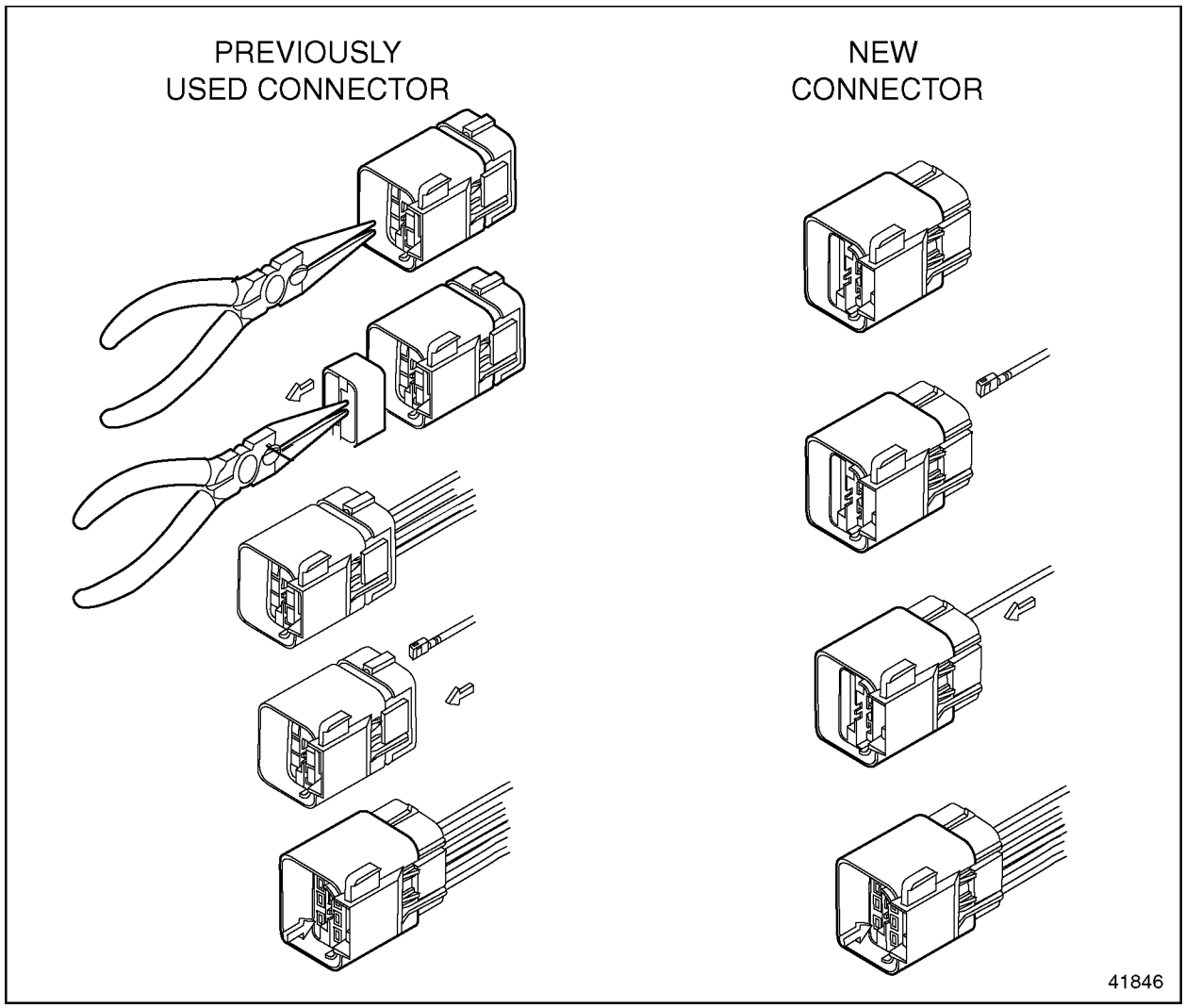

Figure 3-28 Installing the Terminal

3. Push the TPA into the locked (fully seated) position.

NOTE:
The TPAs will self lock when the connectors are mated.

FCI Apex Female Terminal Removal

Remove the terminal as follows:

1. Using pliers pull out the blue Terminal Position Assurance (TPA) that is located inside the connector (see Figure 3-29).

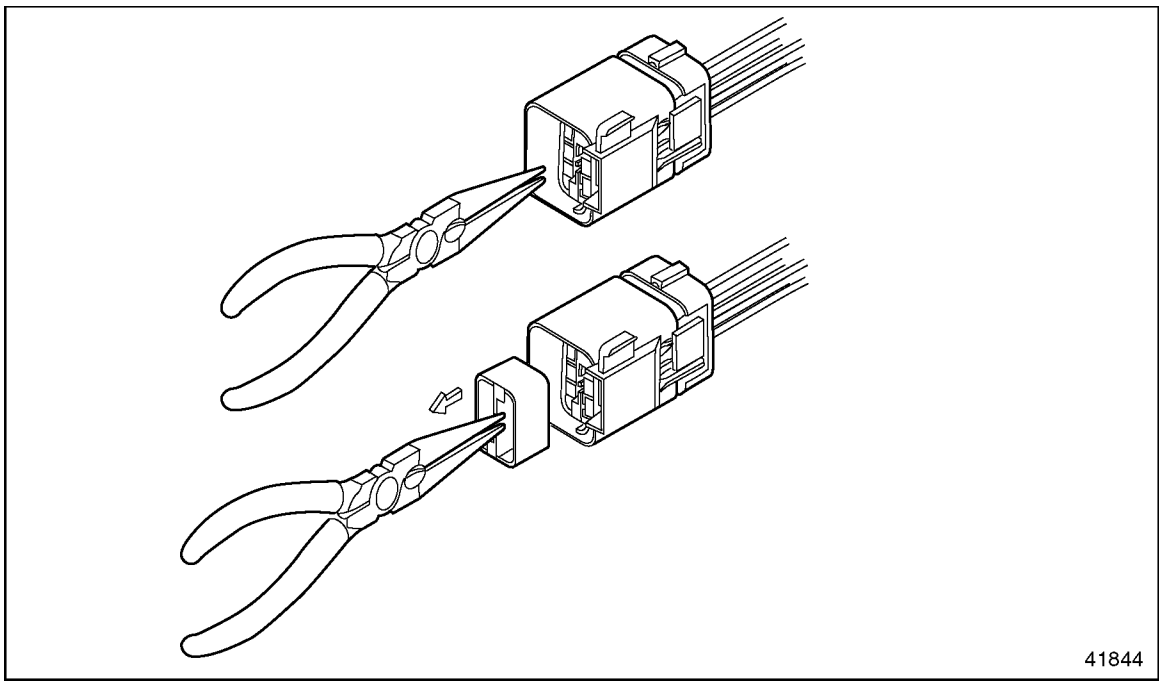

Figure 3-29 Removing the Terminal

2. Using a FCI APEX repair tool (P/N: 54900002) or a #2 jeweler's screwdriver, press back the terminal locking tang (see Figure 3-30).

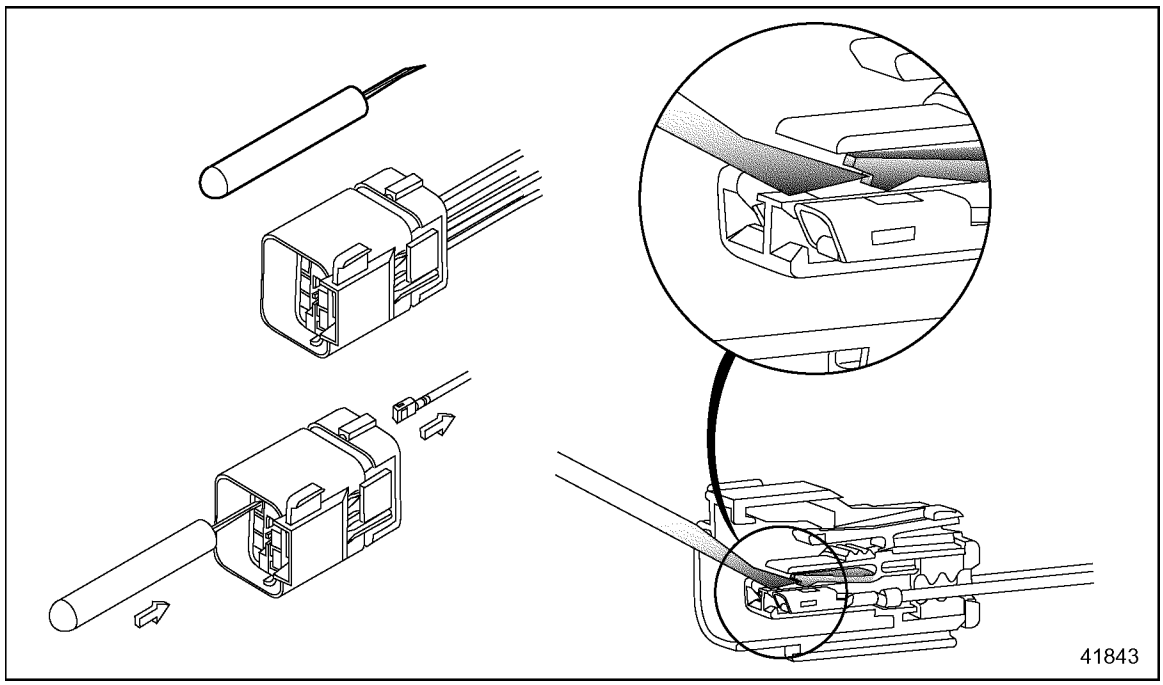

Figure 3-30 Pressing the Locking Tang

3. Pull the cable back through the connector (see Figure 3-29).

3.8.5 SPLICING GUIDELINES

The following are guidelines which may be used for splices. The selection of crimpers and splice connectors is optional. Select a high quality crimper equivalent to the Kent-Moore tool, J 38706, and commercially available splice clips.

The recommended technique for splicing and repairing circuits (other than power and ignition circuits) is a clipped and soldered splice. Alternatively, any method that produces a high quality, tight (mechanically and electronically sound) splice with durable insulation is considered to be acceptable.

Clipped and Soldered Splicing Method

The tools required are listed in Table 3-42.

Tool	Part Number
Heat Gun	--
Sn 60 solder with rosin core flux	--
Wire Stripper	Kent-Moore J 35615 or equivalent
Splice Clips (commercially available)	Wire size dependent
Heat Shrink Tubing	Raychem HTAT or equivalent

Table 3-42 Recommended Splicing Tools

Criteria: Splicing Straight Leads

No more than one strand in a 16 strand wire may be cut or missing.

Use Sn 60 solder with rosin core flux.

The exposed wire must be clean before the splice is soldered.

Soldering splice connectors is optional. To solder splice connectors:

1. Position the leads, so one overlaps the other. See Figure 3-31.

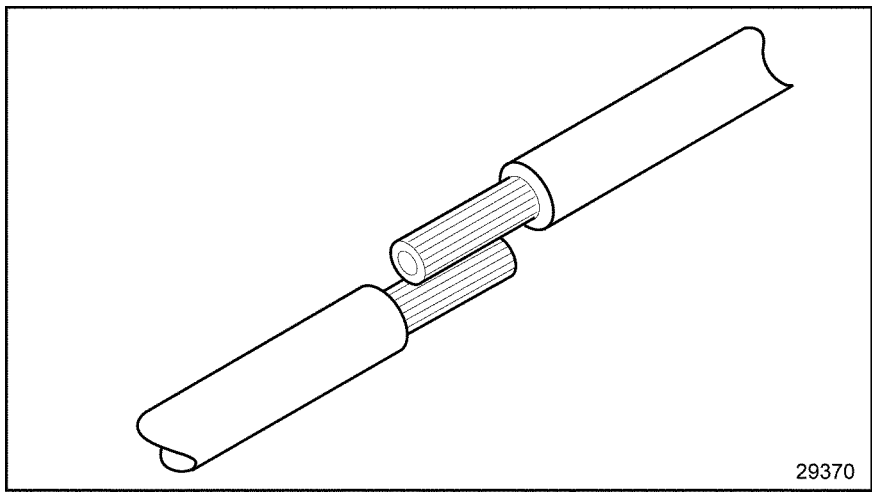

Figure 3-31 Positioning the Leads

2. Secure the leads with a commercially available clip and hand tool. See Figure 3-32.

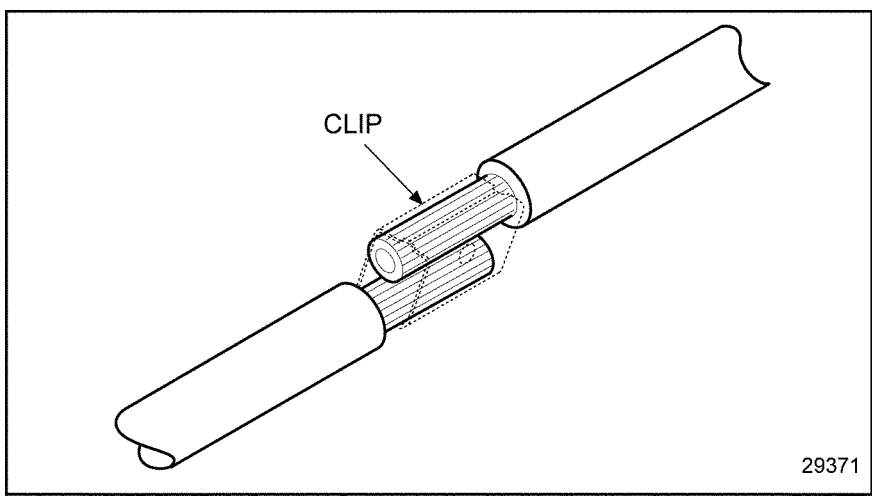

Figure 3-32 Securing the Leads With a Clip

3. Use a suitable electronic soldering iron to heat the wires. Apply the solder to the heated wire and clip (not to the soldering iron) allowing sufficient solder flow into the splice joint.
4. Pull on wire to assure crimping and soldering integrity. The criteria listed in Table 3-43 must be met.

Wire Gauge	Must Withstand Applied Load
14 AWG	45 lb (200 N)
16 AWG	27 lb (120 N)
18 AWG	20 lb (90 N)

Table 3-43 Applied Load Criteria for Terminals

5. Shrink wrap.
6. Loop the lead back over the spliced joint and tape. See Figure 3-33.

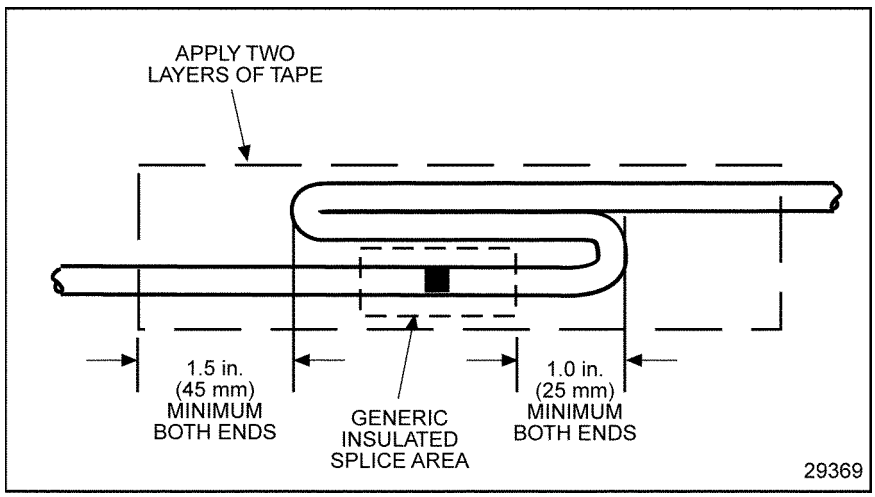

Figure 3-33 Recommended Strain Relief of Spliced Joint

Splicing and Repairing Straight Leads-Alternate Method 1

The tools required are listed in Table 3-44.

Tool	Part Number
Heat Gun	--
Wire Stripper	Kent-Moore J 35615 or equivalent
Splice Clips (commercially available)	Wire size dependent
Heat Shrink Tubing	Raychem HTAT or equivalent

Table 3-44 Recommended Splicing Tools

Criteria: Splicing Straight Leads

No more than one strand in a 16 strand wire may be cut or missing.

The recommended method to splice straight leads follows:

1. Locate broken wire.
2. Remove insulation as required; be sure exposed wire is clean and not corroded.
3. Insert one wire into the splice clip until it butts against the clip. Stop and crimp (see Figure 3-34, A).
4. Insert the other wire into the splice clip until it butts against the clip stop (see Figure 3-34, B).

NOTICE:
Any terminal that is cracked or ruptured is unacceptable as malfunctions may occur.

5. Visually inspect the splice clip for cracks, rupture, or other crimping damage. Remove and replace damaged clips before proceeding.
6. Pull on wire to ensure the splice integrity. The criteria listed in Table 3-45 must be met.

Wire Gage	Must Withstand Applied Load
14 AWG	45 lb (200 N)
16 AWG	27 lb (120 N)
18 AWG	20 lb (90 N)

Table 3-45 Applied Load Criteria for Terminals

7. Shrink the splice clip insulative casing with a heat gun to seal the splice (see Figure 3-34, C).
8. Loop the lead back over the spliced joint and tape. See Figure 3-33.

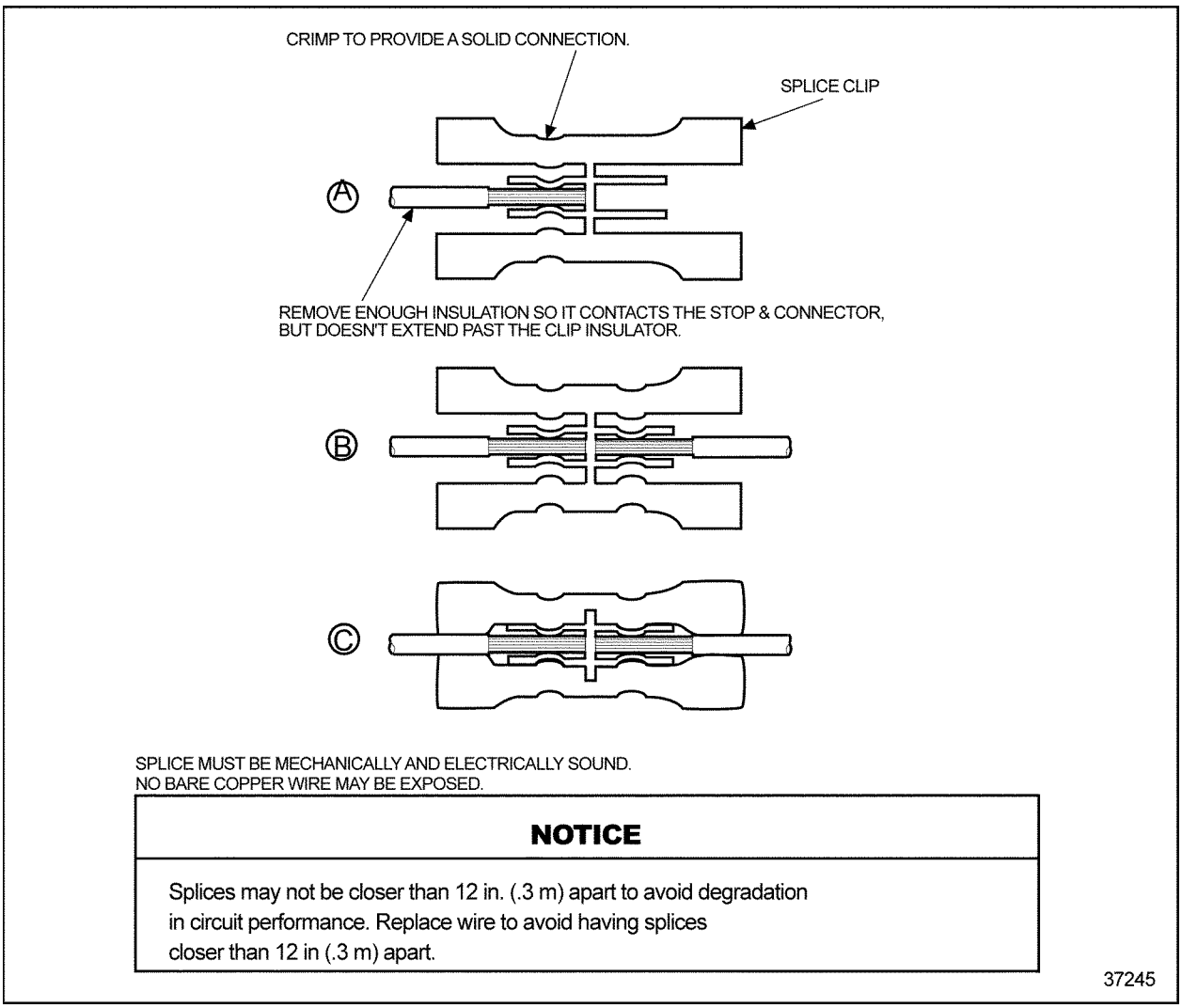

Figure 3-34 Splicing Straight Leads - Alternate Method 1

Splicing and Repairing Straight Leads - Alternate Method 2

This method is not allowed or recommended for power, ignition, or injector circuits. The tools required are listed in Table 3-46.

Tool	Part Number
Heat Gun	--
Wire Stripper	Kent-Moore J 35615 or equivalent
Splice Clips (commercially available)	Wire size dependent
Heat Shrink Tubing	Raychem HTAT or equivalent

Table 3-46 Recommended Splicing Tools

Criteria: Splicing Straight Leads

No more than one strand in a 16 strand wire may be cut or missing.

An acceptable option for splicing straight leads is:

1. Locate broken wire.
2. Remove insulation as required; be sure exposed wire is clean and not corroded.
3. Slide a sleeve of glue lined, shrink tubing (Raychem HTAT or equivalent) long enough to cover the splice clip on the wire and overlap the wire insulation, about ¼ in. (6 mm) on both sides (see Figure 3-35, A).
4. Insert one wire into splice clip until it butts against the splice clip. Stop and crimp (see Figure 3-35, B).
5. Insert the remaining wires into the splice clip one at a time until each butts against the splice clip; stop and crimp (see Figure 3-35, B).

NOTICE:
Any terminal that is cracked or ruptured is unacceptable as malfunctions may occur.

6. Visually inspect the terminal for cracks, rupture, or other crimping damage. Remove and replace damaged terminal before proceeding.
7. Slide the shrink tubing over the crimped splice clip (see Figure 3-35, C).
8. Shrink tubing with a heat gun to seal the splice (see Figure 3-35, D).

NOTICE:
A minimum of two layers of heat shrink tubing must be applied to splices that have more than one lead in or out.

9. Loop the lead back over the spliced joint and tape. See Figure 3-33.

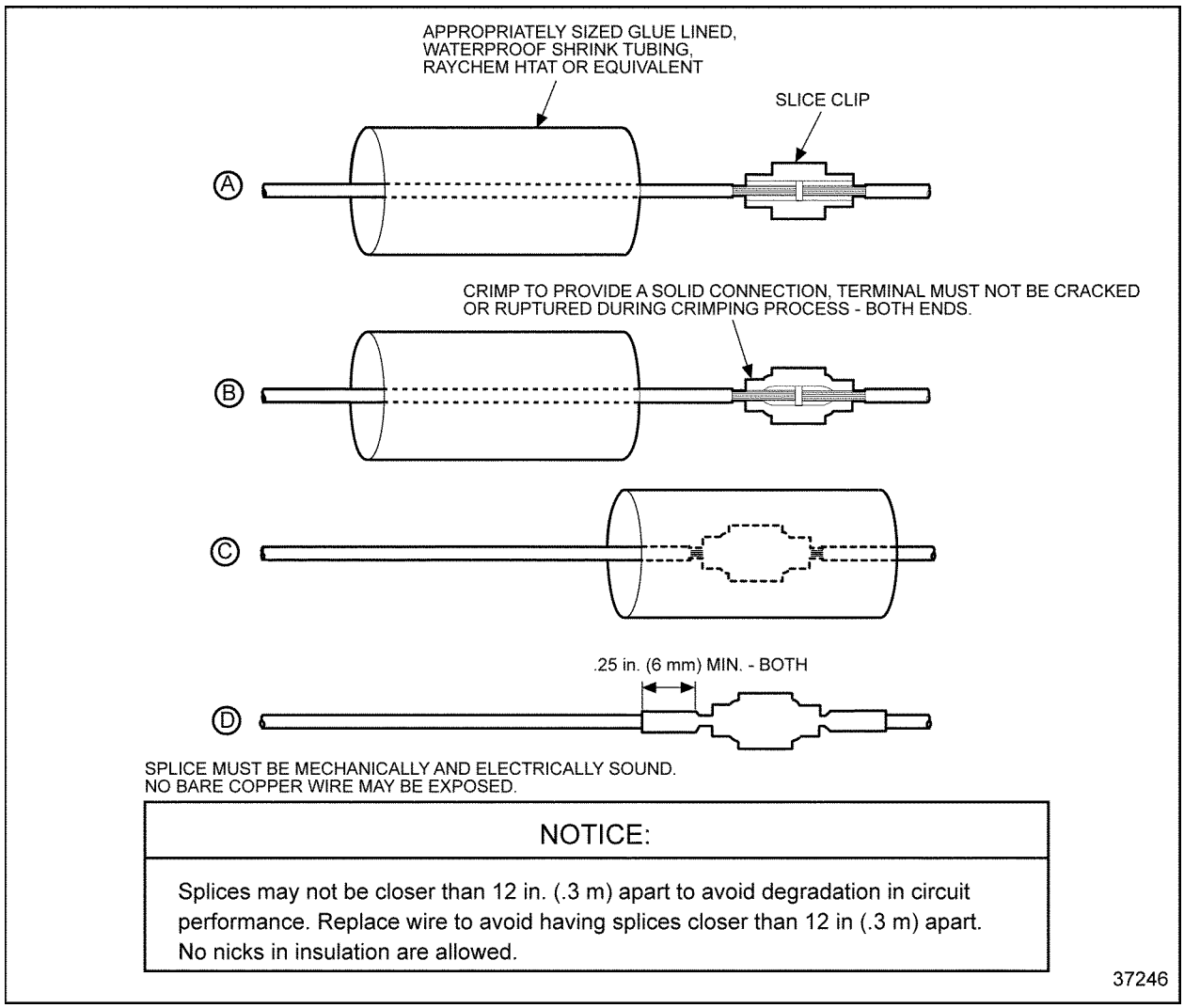

Figure 3-35 Splicing Straight Leads - Alternate Method 2

Shrink Wrap

Shrink wrap is required when splicing non insulated connections. Raychem HTAT or any equivalent heat shrink dual wall epoxy encapsulating adhesive polyolefin is required. Shrink wrap must extend at least .25 in. (6 mm) over wire insulation past splice in both directions.

Alpha Wire Corporation	**Tyco Electronics Corporation**
711 Lidgerwood Ave	Raychem Cable Identification and Protection
P.O. Box 711	300 Constitution Drive
Elizabeth, New Jersey 07207-0711	Menlo Park, CA 94025
1-800-52ALPHA	Phone: 1–800–926–2425
www.alphawire.com	www.raychem.com

To heat shrink wrap a splice:

NOTICE:
The heat shrink wrap must overlap the wire insulation about .25 in. (6 mm) on both sides of the splice.

1. Select the correct diameter to allow a tight wrap when heated.
2. Heat the shrink wrap with a heat gun; do not concentrate the heat in one location, but apply the heat over the entire length of shrink wrap until the joint is complete.
3. Repeat step 2 to apply a second layer of protection (if required by splicing guidelines).

Staggering Wire Splices

Position spliced wires properly as follows:

NOTICE:
You must stagger positions to prevent a large bulge in the harness and to prevent the wires from chafing against each other.

1. Stagger the position of each splice (see Figure 3-36) so there is at least a 2.5 in. (65 mm) separation between splices.

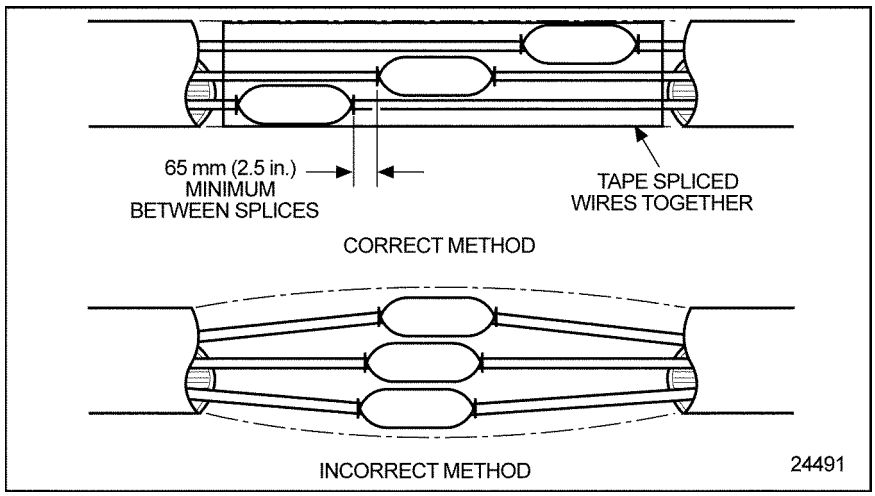

Figure 3-36 The Correct and Incorrect Method of Staggering Multiple Splices

NOTICE:
A minimum of two layers of heat shrink tubing extending 0.25 in. (6 mm) past the splice must be used to complete the splice.

2. Heat shrink a minimum of two layers of heat shrink tubing.
3. Tape the spliced wires to each other. Refer to section 3.10.

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3.9 CONDUIT AND LOOM

Conduit must be used to protect the harness wires and wire splices.

NOTICE:
The conduit must not cover any connectors, switches, relays, fuses, or sensors.

The following guidelines should be used when designing a harness:

NOTICE:
Wires should be sized and cut to near equal length prior to installing conduit.

- The distance between the back of the connector or other listed devices to the end of the conduit should not exceed:
  - 1.0 in. (25 mm) for a single connector/device
  - 3.0 in. (75 mm) for multiple connectors/devices
- All wire breakouts and conduit ends must be secured in place with conduit outlet rings or tape.

Criteria: Conduit and Loom

Due to the wide variety of operating conditions and environments, it is the responsibility of the OEM to select a conduit that will survive the conditions of the specific applications. Flame retardant convoluted polypropylene conduit or equivalent may be used for most installations. Heat retardant nylon conduit or oil, water, acid, fire, and abrasion resistant non-metallic loom conforming to *SAE J562 APR86 Nonmetallic Loom (A)** is also acceptable. The diameter of conduit should be selected based on the number of wires being protected.

* If non-metallic loom is used, secure the ends with tightly wrapped nylon straps to prevent unraveling.

Conduit should cover the wires without binding and without being excessively large.

Contact the Society of Automotive Engineers to obtain documents, refer to Appendix for their address.

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3.10 TAPE AND TAPING

Tape must be used when conduit is utilized. Be sure to follow the tape manufacturers' guidelines. The harness manufacturer may use tape under the harness covering (conduit or loom) to facilitate harness building. Tape must be tightly wrapped at all conduit interconnections with a minimum of two layers (refer to section 3.9). Be sure to firmly secure the start and finish ends of tape.

NOTICE:
Black vinyl electrical tape should not be used in applications where the temperature exceeds 176°F (80°C).

Criteria: Tape

In applications where the temperature doesn't exceed 176°F (80°C), black vinyl electrical tape that is flame retardant and weather resistant may be used.

In applications where temperature exceeds 176°F (80°C), vinyl electrical tape should not be used. For these applications, adhesive cloth backed, flame retardant polyethylene or fiber glass tape (Delphi #PM-2203, Polikan #165 or equivalent) is recommended.

Criteria: Taping

The tape must extend a minimum of 1 in. (25 mm) past the conduit.

The tape must be crossed over butted conduit ends.

The tape must be extended a minimum of 1 in. (25 mm) in each direction at all branches.

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3.11 SENSORS

The DDEC V system is designed to operate with several types of sensors as listed in Table 3-47.

Sensor Type	Description
Variable Reluctance	Used to monitor the crankshaft position and the engine speed.
Thermistor	Used to monitor temperatures.
Variable Capacitance	Used to monitor barometric air, manifold, oil gallery and optional pump pressures.
Variable Resistance (Potentiometer)	Used to sense throttle position.
Switch	Used to signal coolant level, inlet air restriction, and oil level.
Magnetic Pick-up	Used to sense vehicle speed, accumulate trip distance, and enable several vehicle features.

Table 3-47 Sensor Types

The sensors integrated into the Engine Harness are factory-installed (refer to section 3.11.1). The sensors integrated into the Vehicle Interface Harness are installed by the OEM (refer to section 3.11.16).

Starting with DDEC V, DDC has begun using the nomenclature found in SAE J2403 which is industry standard. The previously used names and the SAE J2403 names are listed in Table 3-48.

Old/New	Old/New
ACLS/AECL Sensor	Add Coolant Level Sensor/Add Engine Coolant Level Sensor
AFRS/AFR Sensor	Air Filter Restriction Sensor
ATS/IAT Sensor	Air Temperature Sensor/Intake Air Temperature Sensor
CEL/AWL	Check Engine Light/Amber Warning Lamp
CLS/ECL Sensor	Coolant Level Sensor/Engine Coolant Level Sensor
CPS/ECP Sensor	Coolant Pressure Sensor/Engine Coolant Pressure Sensor
CTS/ECT Sensor	Coolant Temperature Sensor/Engine Coolant Temperature Sensor
ECM/ECU	Electronic Control Module/Electronic Control Unit
EFPA/AP	Electronic Foot Pedal Assembly/Accelerator Pedal
ESH/EH	Engine Sensor Harness/Engine Harness
ETS/ET Sensor	Exhaust Temperature Sensor
FRS/Fuel Restriction Sensor	Fuel Restriction Sensor
FTS/SFT Sensor	Fuel Temperature Sensor/Supply Fuel Temperature Sensor
LSG/ALSG	Limiting Speed Governor/Automotive Limiting Speed Governor
OLS/EOL Sensor	Oil Level Sensor/Engine Oil Level Sensor
OPS/EOP Sensor	Oil Pressure Sensor/Engine Oil Pressure Sensor
OTS/EOT Sensor	Oil Temperature Sensor/Engine Oil Temperature Sensor
SEL/RSL	Stop Engine Light/Red Stop Light
SRS/CMP	Synchronous Reference Sensor/Camshaft Position Sensor
TBS/IMP Sensor	Turbo Boost Sensor/Intake Manifold Pressure Sensor
TPS/AP Sensor	Throttle Position Sensor/Accelerator Pedal Sensor
TRS/CKP	Timing Reference Sensor/Crankshaft Position Sensor

Table 3-48 Old and New Terminology

3.11.1 FACTORY-INSTALLED SENSORS

The sensors integrated into the factory-installed Engine Harness are listed in Table 3-49.

Sensor	Function
Barometric Pressure Sensor (Baro Sensor)	Senses barometric pressure. Refer to section 3.11.2.
EGR Delta Pressure Sensor	Senses EGR pressure for EGR control. Refer to section 3.11.3.
EGR Temperature Sensor	Senses EGR temperature for EGR control. Refer to section 3.11.4
Engine Coolant Temperature Sensor (ECT Sensor)	Senses coolant temperature for functions such as engine protection, fan control and engine fueling. Refer to section 3.11.5.
Engine Oil Level (EOL Sensor)	Detects oil level at four quarts low. Used in the Maintenance Alert System.
Engine Oil Pressure Sensor (EOP Sensor)	Senses gallery oil pressure for functions such as engine protection. Refer to section 3.11.7.
Engine Oil Temperature Sensor (EOT Sensor)	Senses oil temperature for functions such as reducing variation in fuel injection and fan control. Refer to section 3.11.8.
Fuel Restriction Sensor	Detects fuel restriction for replacement of fuel filter. Used in Maintenance Alert System.
Intake Air Temperature Sensor (IAT Sensor)	Senses air temperature for functions such as fan control and engine fueling. Refer to section 3.11.10.
Intake Manifold Pressure Sensor (IMP Sensor)	Senses turbo boost for functions such as smoke control and engine protection. Refer to section 3.11.11.
Synchronus Reference Sensor (SRS or CMP)	Indicates a specific cylinder in the firing order. Refer to section 3.11.12.
Supply Fuel Temperature Sensor (SFT Sensor)	Senses fuel temperature for functions such as engine fueling. Refer to section 3.11.13.
Timing Reference Sensor (TRS or CKP)	Senses crankshaft position and engine speed for functions such as fuel control strategy. Refer to section 3.11.12.
Turbo Compressor Temperature Out Sensor	Senses turbo out air temperature. Refer to section 3.11.14.
Turbo Speed Sensor (TSS)	Senses turbo speed for overspeed conditions. Refer to section 3.11.15.

Table 3-49 Function of Factory-installed Sensors

3.11.2 BAROMETRIC PRESSURE SENSOR

The Barometric Pressure Sensor (see Figure 3-37) senses barometric pressure for EGR control.

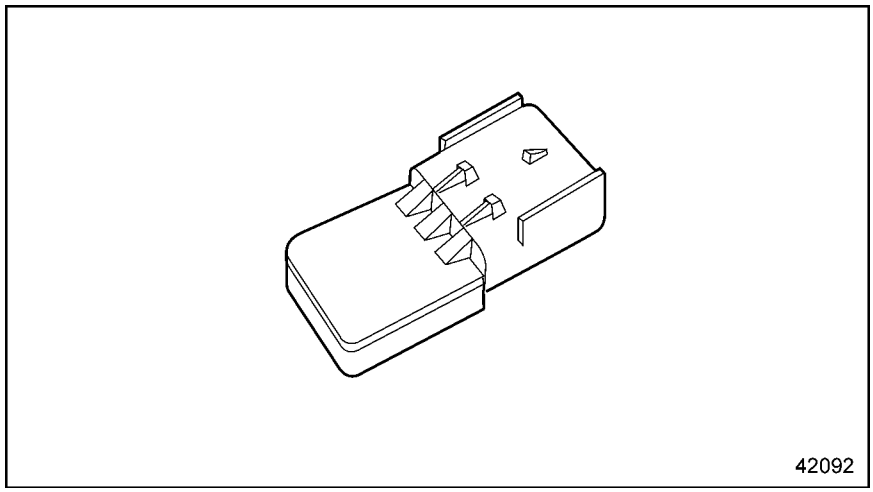


Figure 3-37 Barometric Pressure Sensor — Series 60

3.11.3 EGR DELTA PRESSURE SENSOR

The EGR Delta Pressure Sensor (EGR Delta P) senses EGR pressure for EGR control. See Figure 3-38.

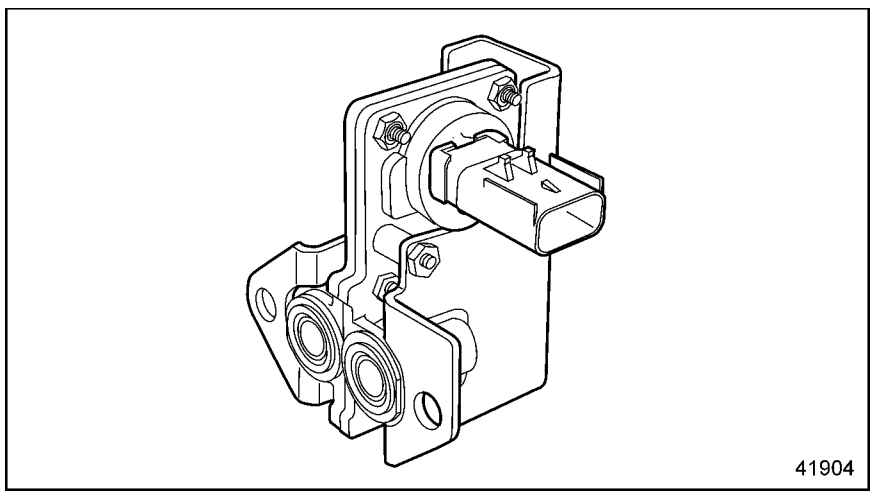


Figure 3-38 EGR Delta Pressure Sensor – Series 60

3.11.4 EGR TEMPERATURE SENSOR

The EGR Temperature Sensor senses EGR temperature for EGR control. See Figure 3-39.

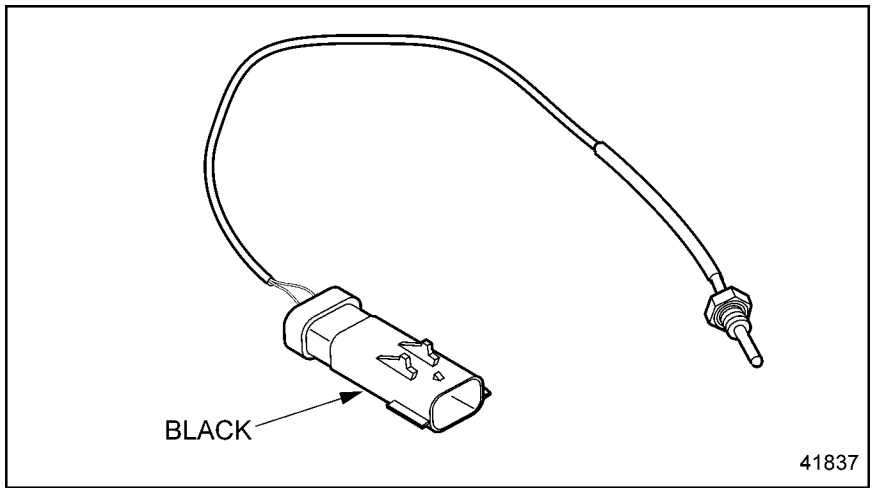


Figure 3-39 EGR Temperature Sensor – Series 60

3.11.5 ENGINE COOLANT TEMPERATURE SENSOR

The ECT Sensor is a thermistor type sensor that has a variable resistance, when exposed to different temperatures. The ECT Sensor senses coolant temperature. See Figure 3-40 for the ECT Sensor for the Series 60.

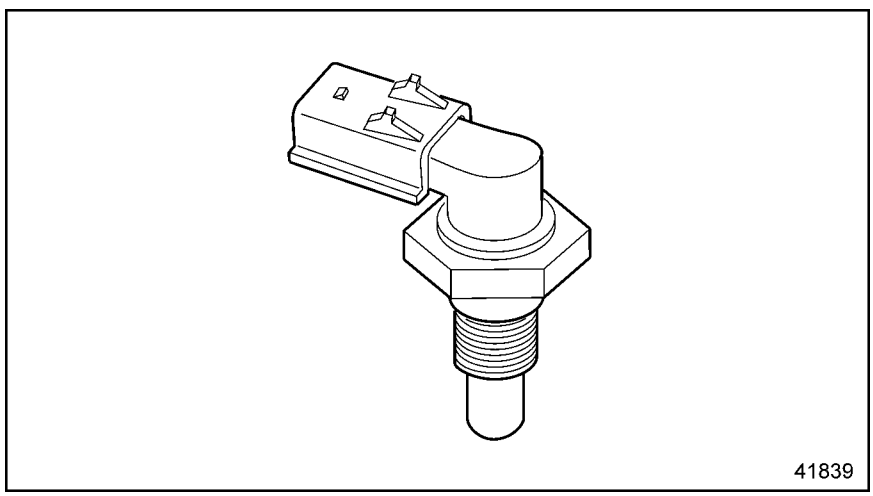


Figure 3-40 Engine Coolant Temperature Sensor — Series 60

3.11.6 ENGINE OIL LEVEL SENSOR

The EOL Sensor (see Figure 3-41) is factory installed at DDC and is incorporated into the DDC Engine Harness for applications which have the Maintenance Alert system (MAS).

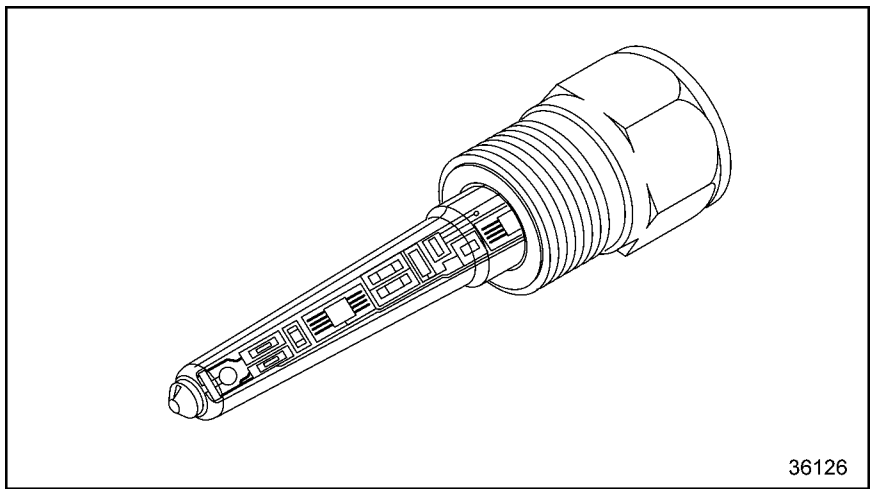


Figure 3-41 Engine Oil Level Sensor — Series 60

3.11.7 ENGINE OIL PRESSURE SENSOR

The EOP Sensor is a variable capacitance sensor that produces a linear analog signal, indicating engine oil pressure.

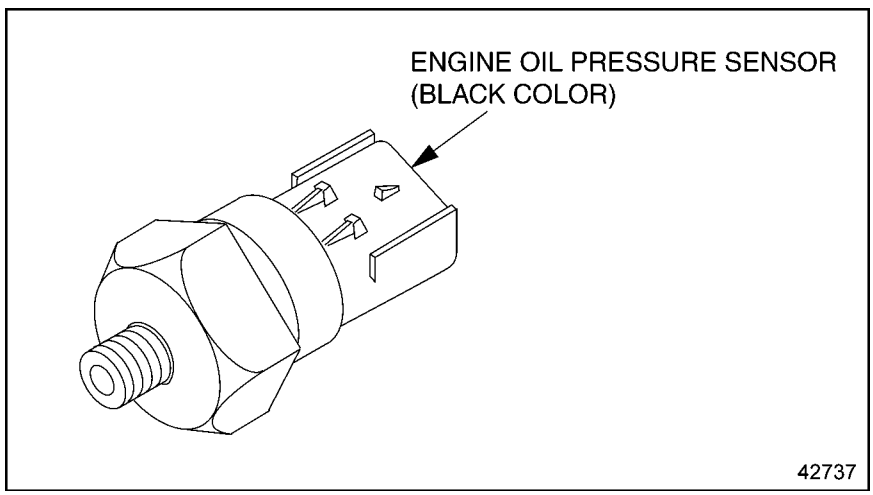


Figure 3-42 Engine Oil Pressure Sensor — Series 60

3.11.8 ENGINE OIL TEMPERATURE SENSOR

The EOT Sensor (Figure 3-43) is a thermistor type sensor that has a variable resistance, when exposed to different temperatures.

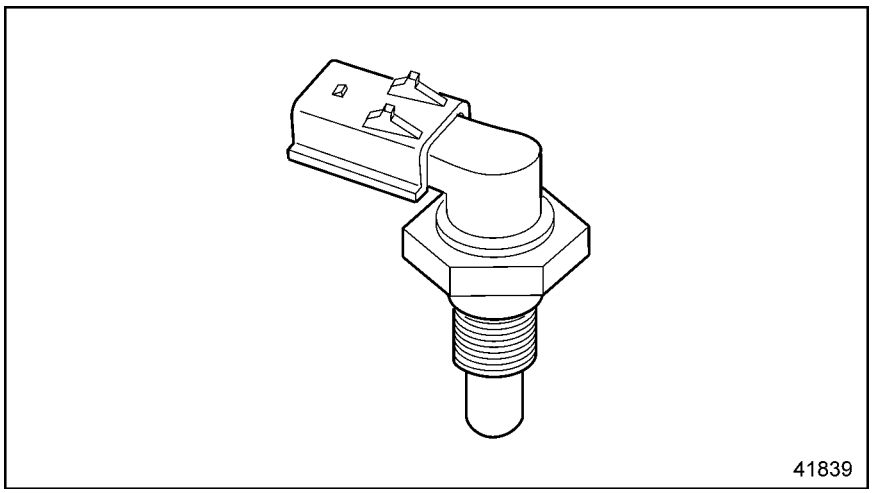


Figure 3-43 Engine Oil Temperature Sensor — Series 60

The ECU uses the EOT Sensor signal to determine the quantity and timing of fuel required to optimize starting over a range of temperatures. The EOT Sensor provides a signal to vary idle speed and injection timing resulting in improved cold starts and reduced white smoke. It also activates the engine protection, if the oil temperature exceeds the specified limits.

3.11.9 FUEL RESTRICTION SENSOR

The Fuel Restriction Sensor (see Figure 3-44) monitors the condition of the fuel filter. The sensor is factory installed at DDC for applications which have the Maintenance Alert System (MAS).

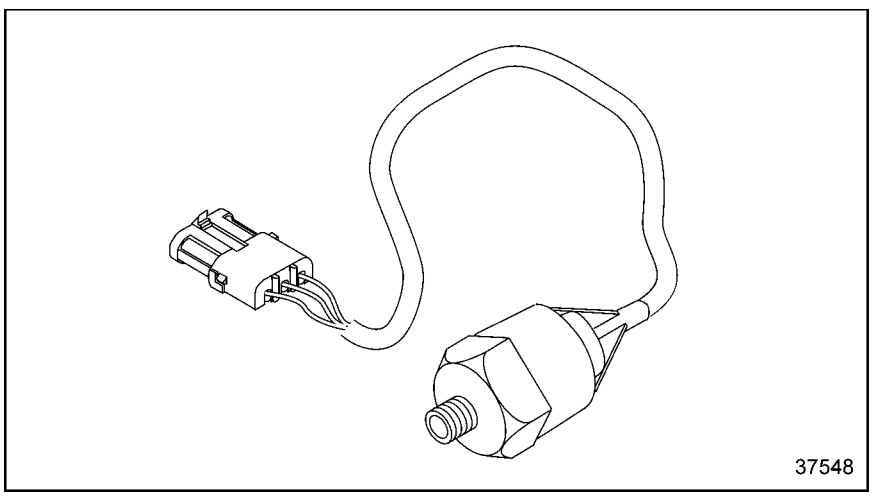


Figure 3-44 Fuel Restriction Sensor — Series 60

3.11.10 INTAKE AIR TEMPERATURE SENSOR

The IAT Sensor (see Figure 3-45) is a thermistor type sensor that has a variable resistance, when exposed to different temperatures. The IAT Sensor provides necessary input for various functions such as varying hot idle speed, fan control, and injection timing which results in improved cold starts and reduced white smoke.

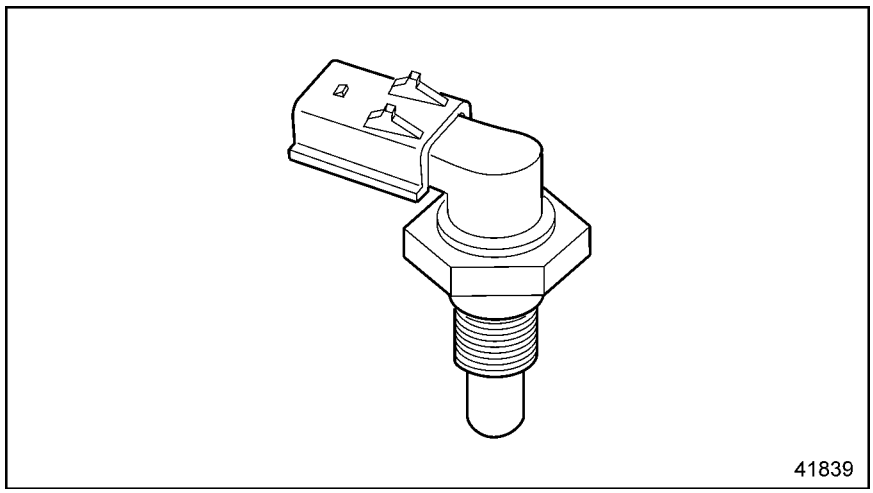


Figure 3-45 Intake Air Temperature Sensor — Series 60

3.11.11 INTAKE MANIFOLD PRESSURE SENSOR

The IMP Sensor provides data to the ECU for use in engine fueling (smoke control). See Figure 3-46 for the sensor used in on-highway applications.

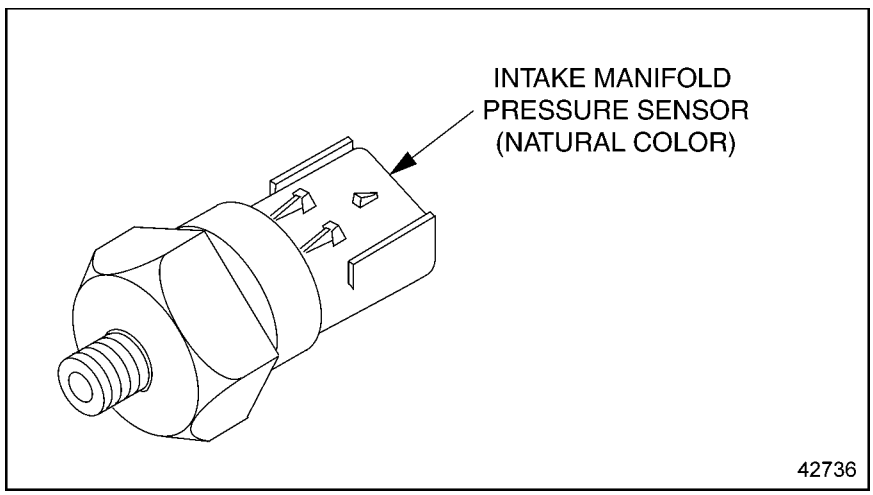


Figure 3-46 The Intake Manifold Pressure Sensor — Series 60

3.11.12 SYNCHRONOUS AND TIMING REFERENCE SENSORS

The Synchronous Reference Sensor (SRS or CMP) indicates a specific cylinder in the firing order.

The Timing Reference Sensor (TRS or CKP) is a variable reluctance type sensor that indicates crank position of every cylinder. The TRS tells the ECM where the position of the crankshaft is or when to fuel each cylinder.

See Figure 3-47 for the Series 60 engine TRS and SRS.

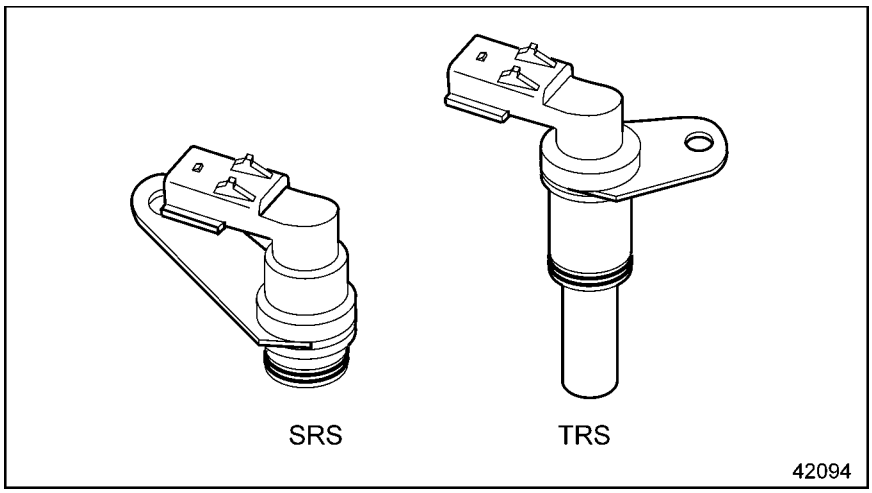


Figure 3-47 SRS and TRS — Series 60

3.11.13 SUPPLY FUEL TEMPERATURE SENSOR

The SFT Sensor (see Figure 3-48) is a thermistor type sensor that has a variable resistance, when exposed to different temperatures. The EFT Sensor measures fuel temperatures necessary for fuel consumption calculations and fuel input compensation.

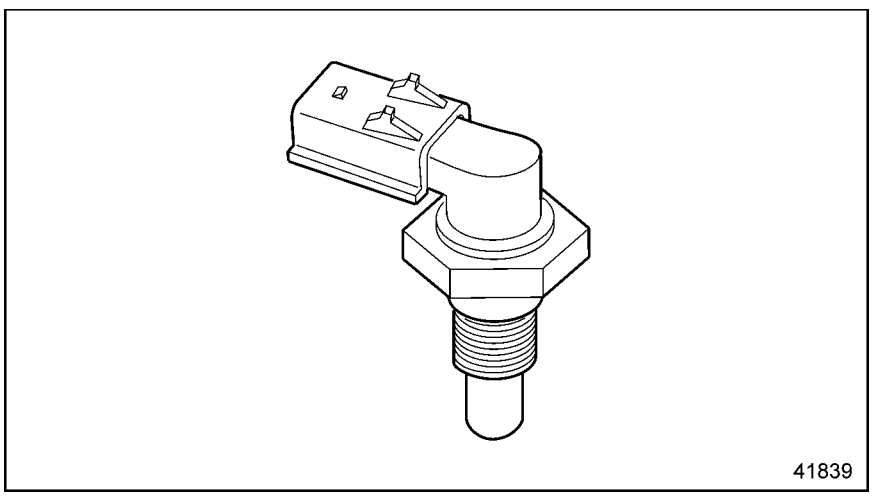


Figure 3-48 Supply Fuel Temperature Sensor — Series 60

3.11.14 TURBO COMPRESSOR TEMPERATURE OUT SENSOR

The Turbo Compressor Temperature Out Sensor senses turbo out air temperature. See Figure 3-49 for the sensor used with the Series 60 engine.

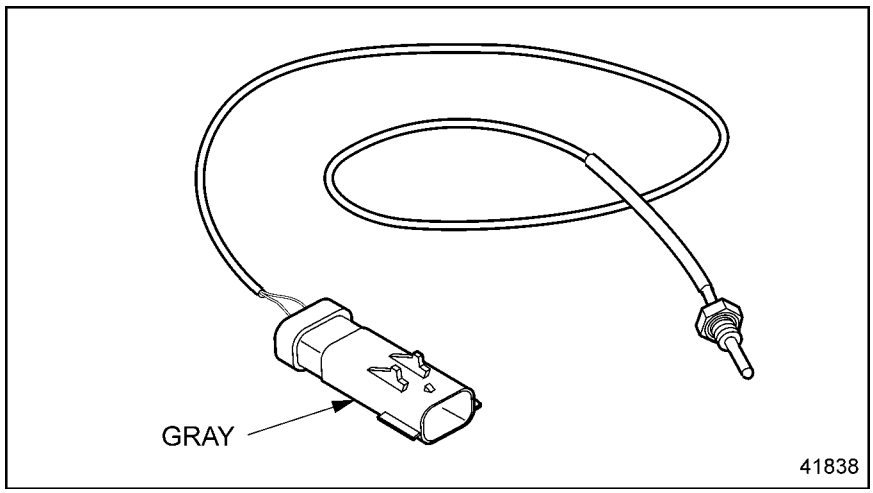


Figure 3-49 Turbo Compressor Temperature Out Sensor — Series 60

3.11.15 TURBO SPEED SENSOR

The Turbo Speed Sensor (TSS) senses turbo speed for overspeed conditions. See Figure 3-50.

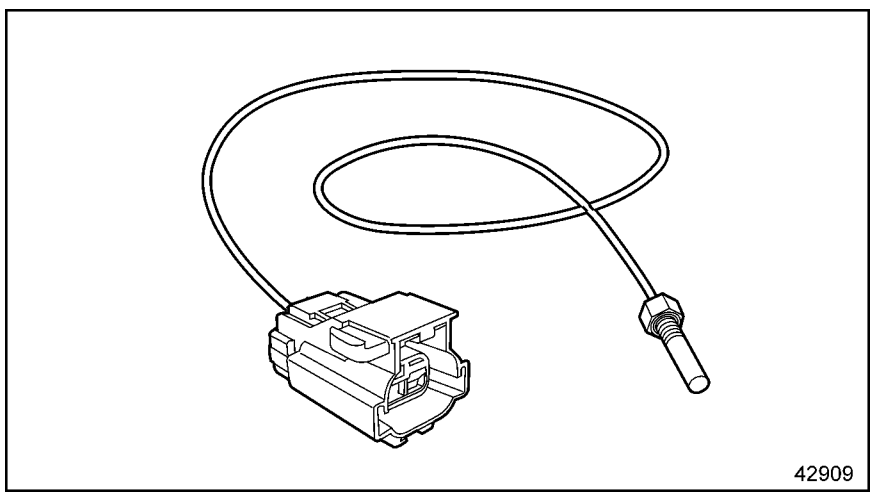


Figure 3-50 Turbo Speed Sensor — Series 60

3.11.16 OEM-INSTALLED SENSORS

Starting with DDEC V, DDC has begun using the nomenclature found in SAE J2403 which is industry standard. The previously used names and the SAE J2403 names are listed in Table 3-50.

Old/New	Old/New
ACLS/AECL Sensor	Add Coolant Level Sensor/Add Engine Coolant Level Sensor
AFRS/AFR Sensor	Air Filter Restriction Sensor
CLS/ECL Sensor	Coolant Level Sensor/Engine Coolant Level Sensor
TPS/AP Sensor	Throttle Position Sensor/Accelerator Pedal Sensor

Table 3-50 Old and New Terminology

The OEM is responsible for installing the sensors listed in Table 3-51.

Sensor	Part Number	Function
Accelerator Pedal Sensor (AP Sensor)	—	Senses operator's input to the ECU for throttle input. Refer to section 3.11.17.
Add Engine Coolant Level Sensor (AECL Sensor)	23526905 23526906 23526907	Senses coolant level for engine maintenance. Refer to section 3.11.21.
Air Filter Restriction Sensor (AFR Sensor)	23523756	Senses the condition of the air inlet filter for engine maintenance. Refer to section 3.11.18.
Ambient Air Temperature Sensor (AAT Sensor)	23518328	Senses ambient air temperature specifically for the Ambient Air Temperature Override Disable feature or for OI. Refer to section 3.11.19.
Engine Coolant Level Sensor (ECL Sensor)	23526905 23526906 23526907	Senses coolant level for engine protection. Refer to section 3.11.20.
Fire Truck Pump Pressure Sensor *	23520795	Senses water pump pressure to maintain a constant fire truck pump pressure. Refer to section 3.11.22.
Turbo Compressor In Temperature Sensor	23527831	Senses the temperature of the turbo compressor inlet. Refer to section 3.11.23. Series 60 only.
Vehicle Speed Sensor (VSS)	—	Senses vehicle speed for Cruise Control and PTO Control. Total distance accumulation required for ProDriver and a speedometer. Refer to section 3.11.24.

* Available in some applications

Table 3-51 Function and Guidelines for OEM-installed Sensors

All sensors must be of the proper type and continuously monitor vehicular and environmental conditions, so the ECU can react to changing situations.

NOTE:
The OEM harness must be securely fastened every 6 in. It is required that the harness be fastened within 6 in. of the sensor.

3.11.17 ACCELERATOR PEDAL SENSOR

The Accelerator Pedal contains the AP Sensor which converts the operator's hand throttle and/or foot pedal input into a signal for the ECU. Refer to section 3.12.1 for additional information on the Accelerator Pedal.

3.11.18 AIR FILTER RESTRICTION SENSOR

The AFR Sensor (see Figure 3-51) has two indicator points, the first indicates the air filter has approximately 50% life left, the second indicates that the filter is plugged. This sensor is only used with the Maintenance Alert System.

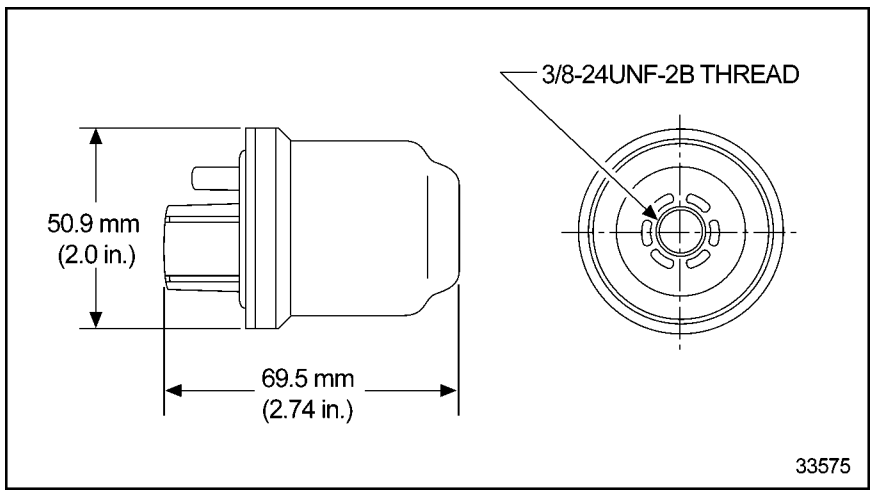
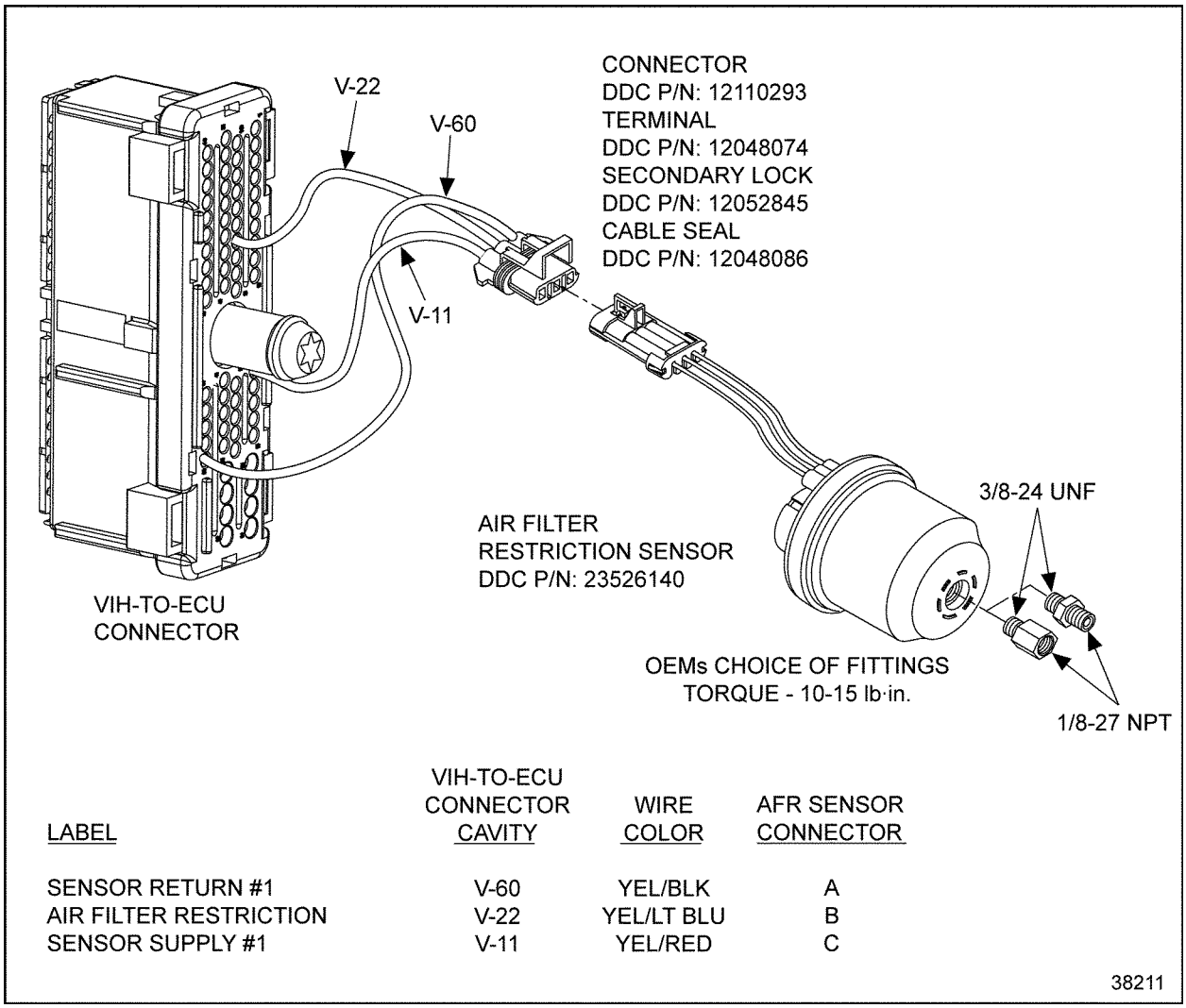


Figure 3-51 Air Filter Restriction Sensor

The AFR Sensor is mounted downstream of the air filter and upstream of the turbocharger. The AFR Sensor must be in a straight section of pipe or where the OEM mechanical unit is normally mounted. This sensor must be enabled with the Vehicle Electronic Programming System (VEPS) or the DDEC Reprogramming System (DRS).

The AFR Sensor must be wired as shown (see Figure 3-52).



LABEL	VIH-TO-ECU CONNECTOR CAVITY	WIRE COLOR	AFR SENSOR CONNECTOR
SENSOR RETURN #1	V-60	YEL/BLK	A
AIR FILTER RESTRICTION	V-22	YEL/LT BLU	B
SENSOR SUPPLY #1	V-11	YEL/RED	C

Figure 3-52 Air Filter Restriction Wiring Diagram

3.11.19 AMBIENT AIR TEMPERATURE SENSOR

The AAT Sensor is a thermistor type sensor with a variable resistance that produces an analog signal between 0 and 5 V, representing the temperature of the ambient air. The AAT Sensor (see Figure 3-53) is used with the Idle Shutdown Timer, specifically for the Ambient Air Temperature Override Disable feature or for Optimized Idle. For additional information on these features refer to Chapter 5.

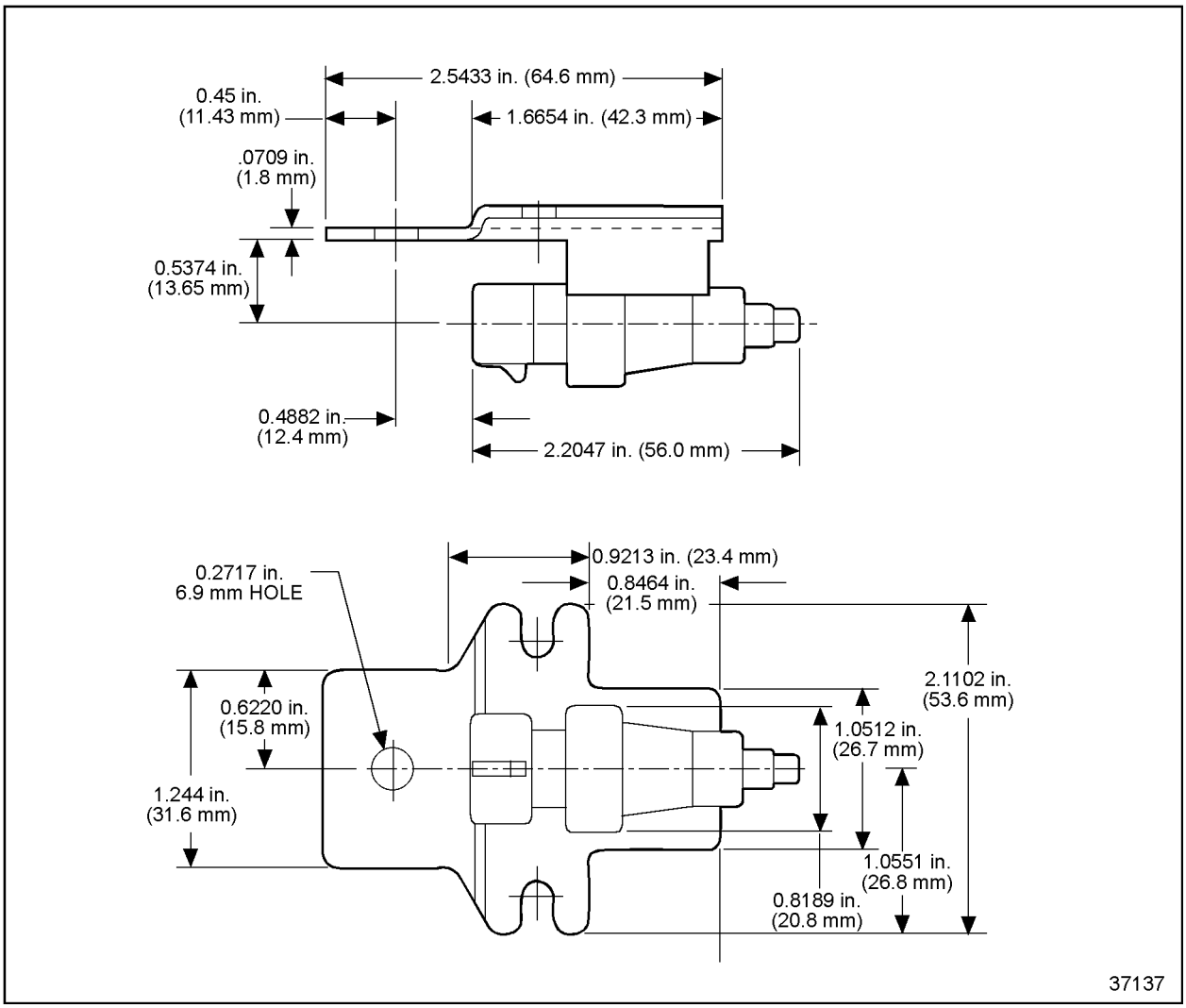


Figure 3-53 Ambient Air Temperatures Sensor Dimensions

Ambient Air Temperature Sensor Installation

Install the AAT Senaor where ambient air temperature can be read. A protected location on the frame rails where it will not be splattered with dirt and grime and is removed from any heat source such as exhaust is preferred. See Figure 3-54 for AAT Sensor installation.

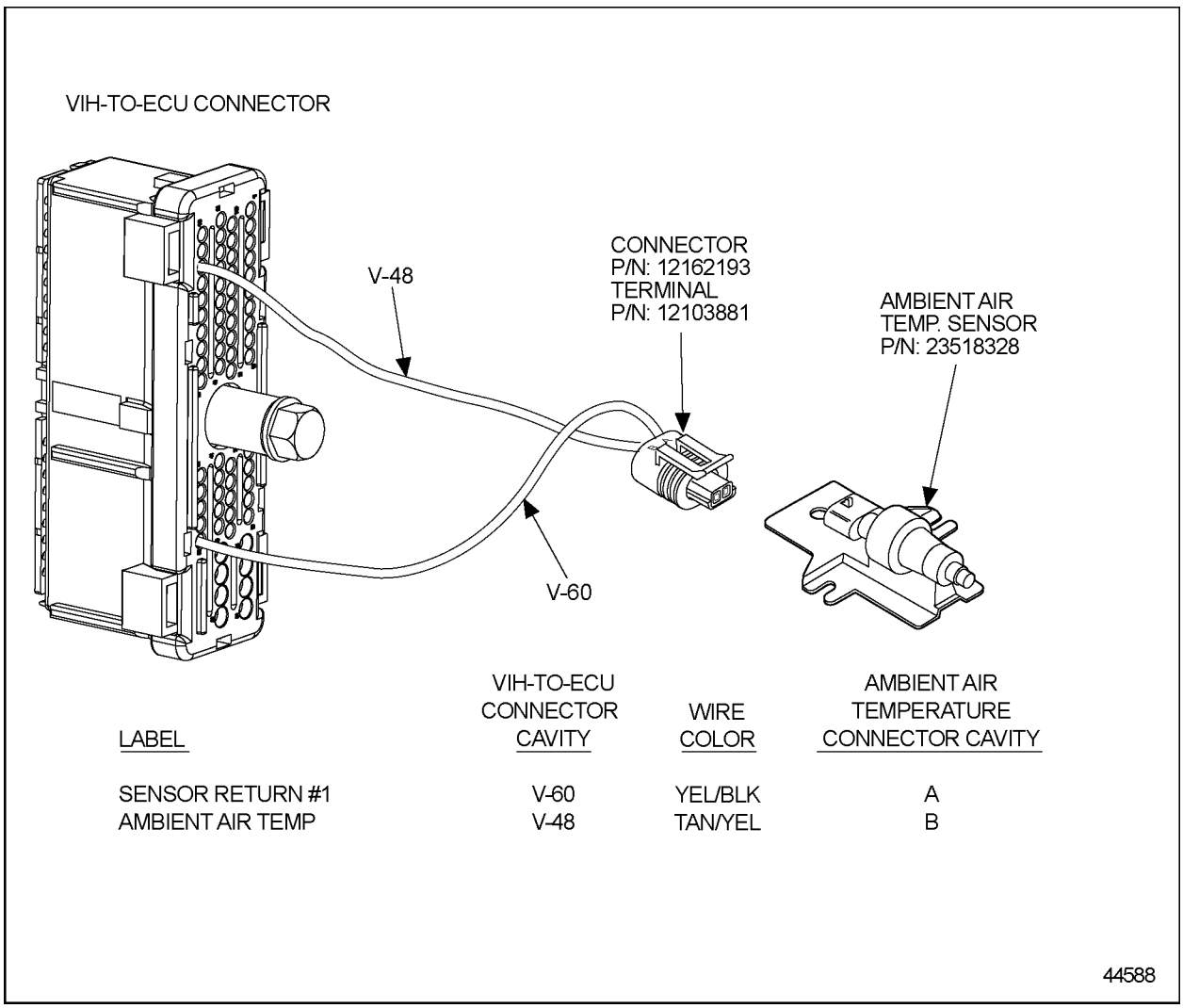


Figure 3-54 Ambient Air Temperature Sensor Installation

3.11.20 ENGINE COOLANT LEVEL SENSOR

The ECL Sensor is required for DDEC V installations. Its purpose is to provide an input to the engine protection system and warn the operator if a low coolant level has been reached. Other non-DDC supplied engine coolant level sensors may be used but may require the use of a signal interface.

The main component of the ECL Sensor consists of a conductivity probe, which connects to the ECU (see Figure 3-55).

NOTICE:
The probe has an operational temperature range of -40 to 257°F (-40 to 125°C). Exposure to temperatures beyond this range may result in unacceptable component life, or degraded sensor accuracy.

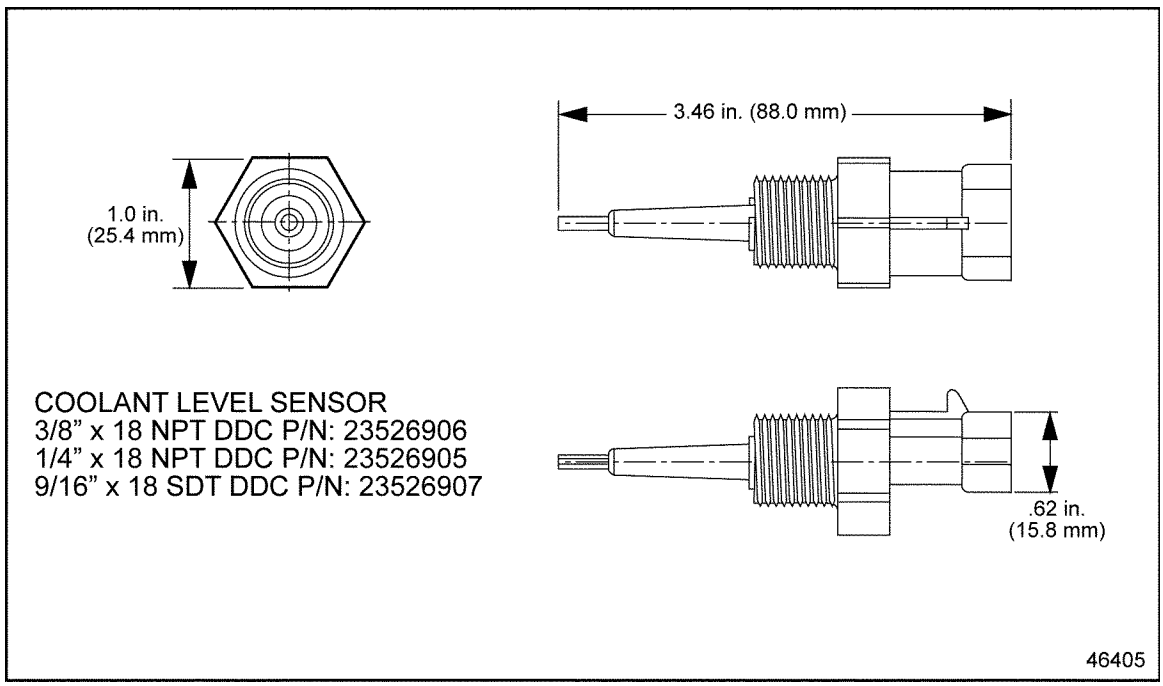


Figure 3-55 Engine Coolant Level Sensor Specifications

The connector listed in Table 3-52 is a Metri-Pack 280 series push-to-seat connector.

Coolant Level Sensor Connector	
Connector	P/N: 15300027
Terminal	P/N: 12077411
Seal	P/N: 12015323
Secondary Lock	P/N: 15300014

Table 3-52 Metri-Pack 280 Connectors and Part Numbers

The OEM must connect the ECL Sensor probe as shown in the next illustration (see Figure 3-56). Polarity of the ground and signal must be correct for proper operation.

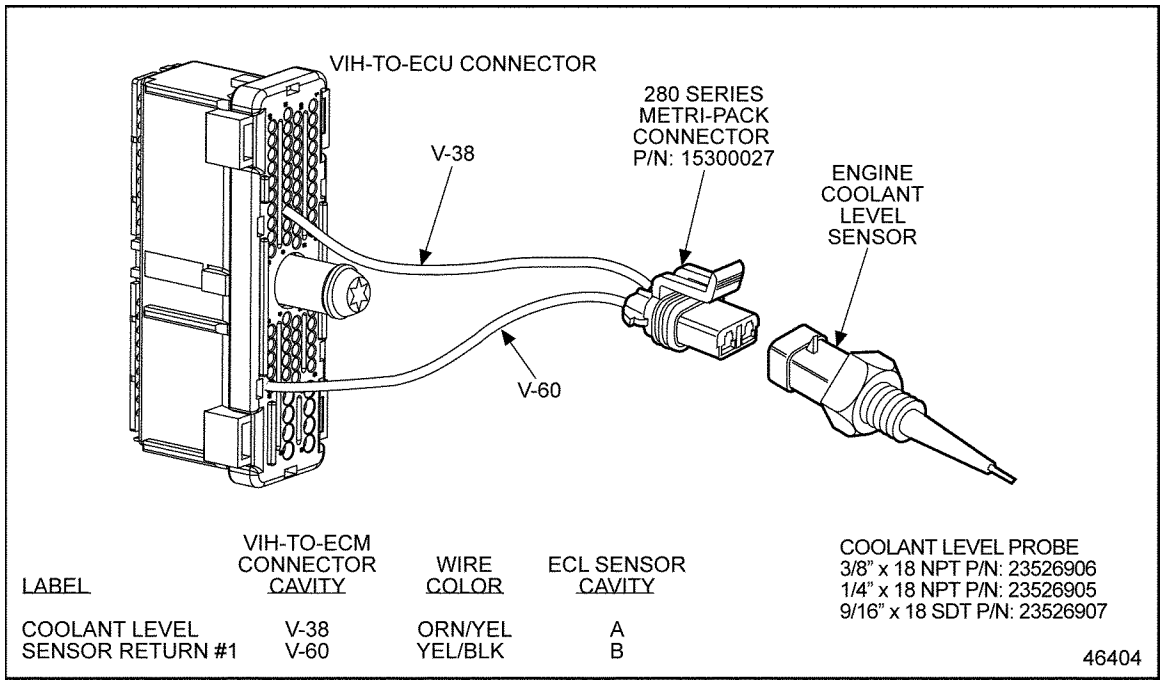


Figure 3-56 Engine Coolant Level Sensor Installation

The probe should be located in either the radiator top tank or a remote mounted surge tank. It should be mounted horizontally in the center of the tank and must be in a position to signal low coolant before aeration occurs. Typically, this is a height representing 98% of the drawdown quantity.

The probe should be located so that it is not splashed by deaeration line, stand pipe or coolant return line flows. The insulated portion of the probe should be inserted into the coolant 1/2 in. or more past the inside wall of the tank. See Figure 3-57.

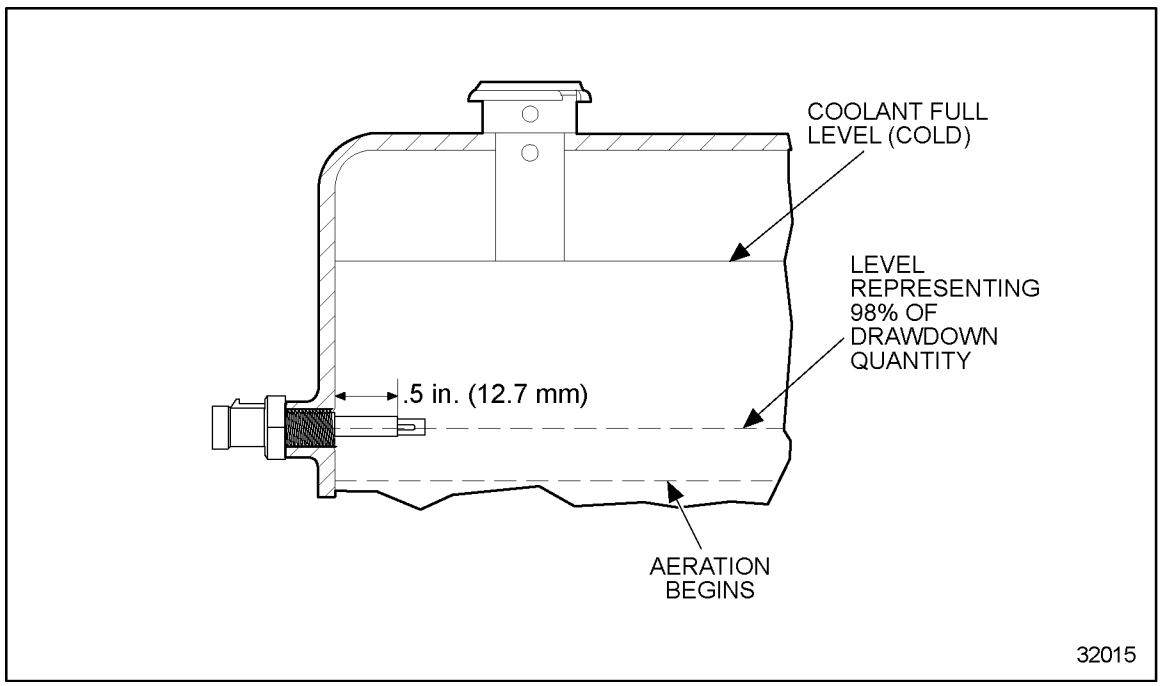


Figure 3-57 Engine Coolant Level Sensor Location - Top of Radiator Tank

Determine proper location for low coolant level sensor while running the drawdown test. It *must* actuate a warning before the satisfactory drawdown level is reached.

The ECL Sensor components are OEM supplied hardware and can be purchased as kits or individual components, depending on OEM requirements.

The following kits listed in Table 3-53 and Table 3-54 provide all the necessary hardware for proper installation of the ECL Sensor. Kits are available through the DDC parts distribution network.

Component	Part Number
ECL Sensor	23526905
Metri-Pack Connector Kit	15300027
Metri-Pack Terminals	12077411
Secondary Lock	15300014
Wire Seal	12015323
Terminal	12103881

Table 3-53 ECL Sensor Installation Kit 1/4 in. NPTF P/N: 23515397

Component	Part Number
ECL Sensor	23526906
Metri-Pack Connector Kit	15300027
Metri-Pack Terminals	12077411
Secondary Lock	15300014
Wire Seal	12015323
Terminal	12103881

Table 3-54 ECL Sensor Installation Kit 3/8 in. NPTF P/N: 23515398

3.11.21 ADD ENGINE COOLANT LEVEL SENSOR

The AECL Sensor is used to warn the driver that the coolant level is below the recommended level. If the tank is equipped with an "ADD" level, the sensor should be installed there. This sensor will be activated approximately mid-way between the cold full level and the level where the standard (engine protection) ECL Sensor is located (see Figure 3-58).

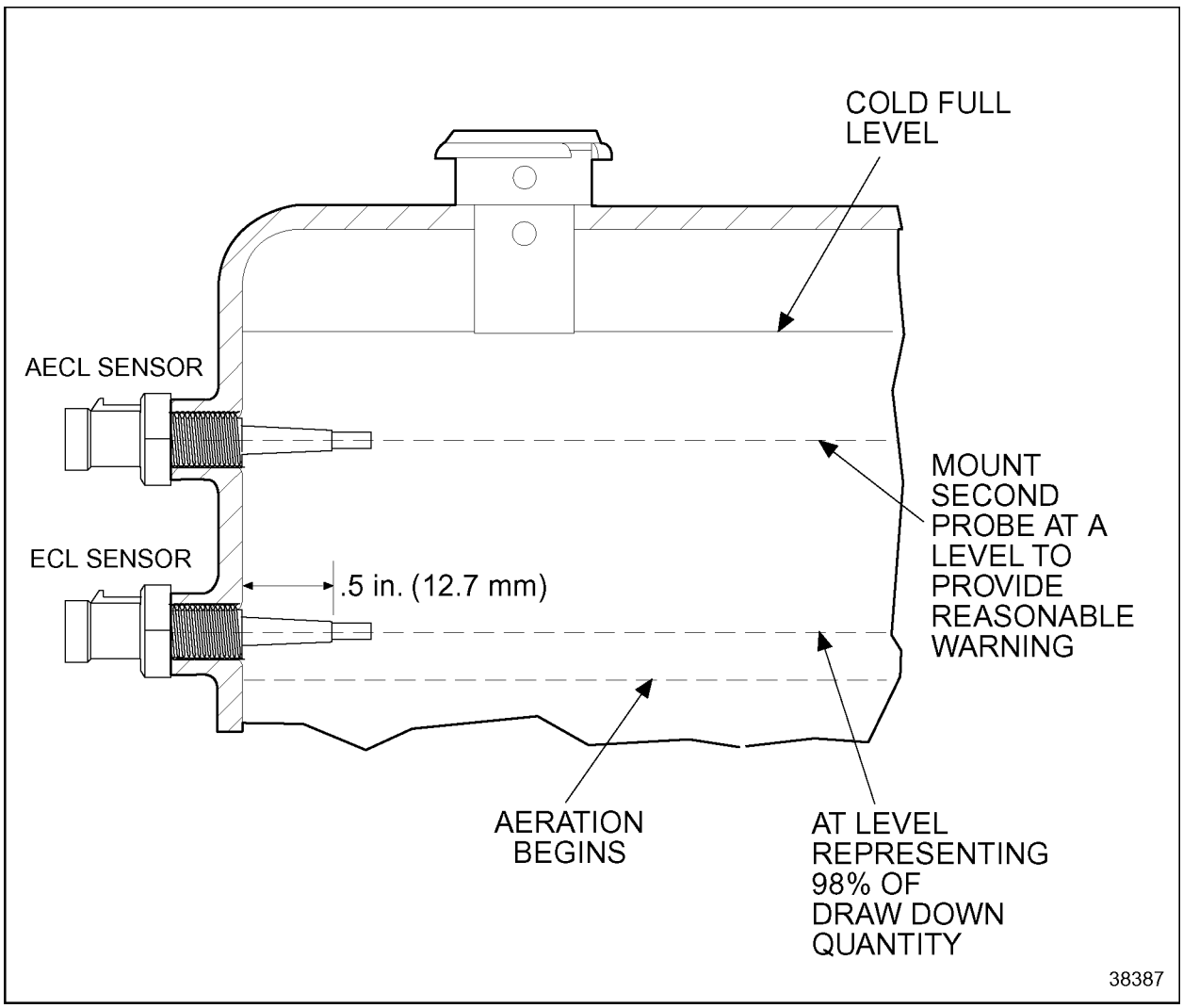
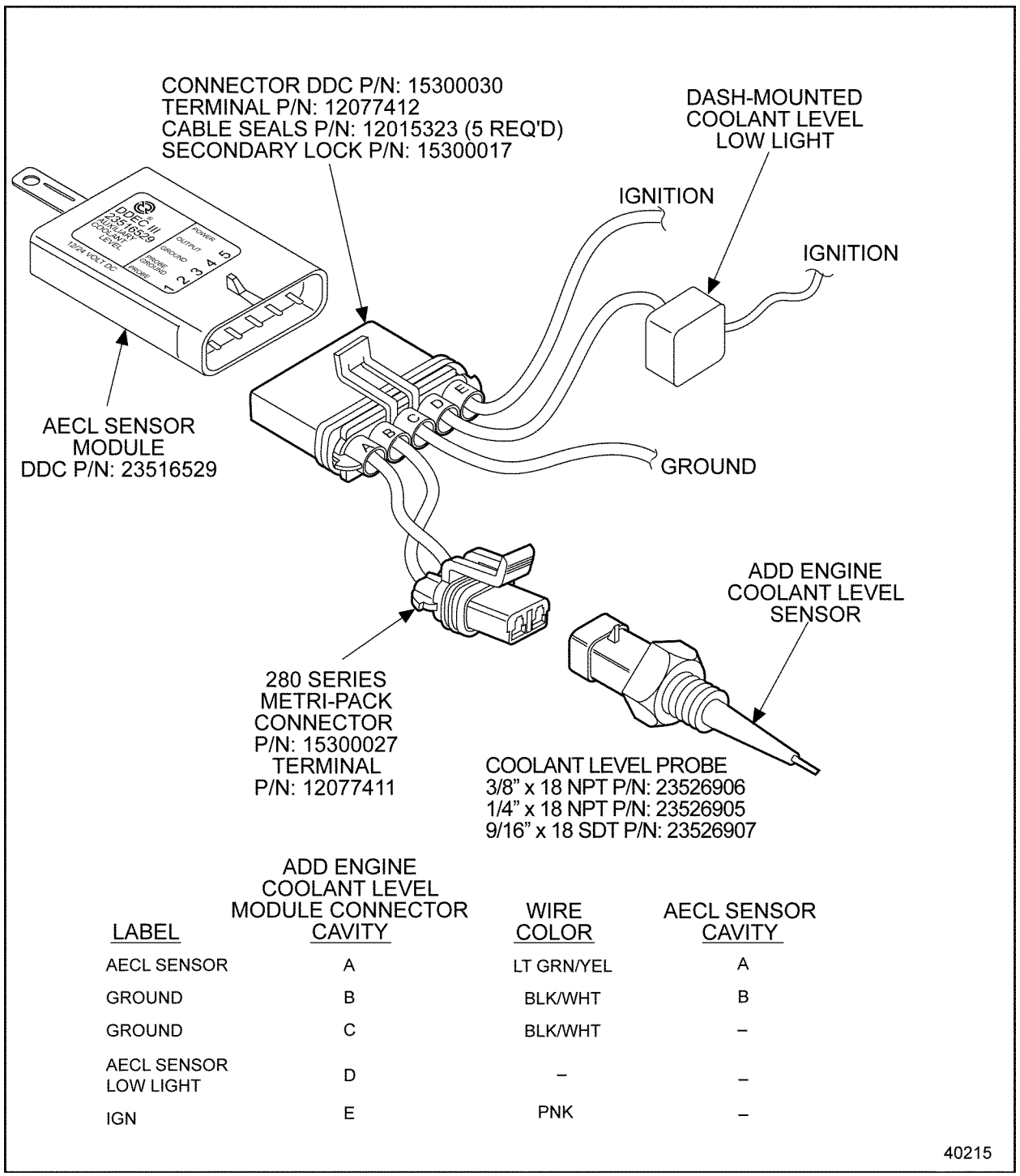


Figure 3-58 Add Engine Coolant Level Sensor Location - Radiator Surge Tank

The AECL Sensor probe is connected to a separate module when used for a Coolant Level Low Lamp. The module provides an output to drive an indicator light on the dash. See Figure 3-59 for the installation of a Coolant Level Low Lamp.



LABEL	ADD ENGINE COOLANT LEVEL MODULE CONNECTOR CAVITY	WIRE COLOR	AECL SENSOR CAVITY
AECL SENSOR	A	LT GRN/YEL	A
GROUND	B	BLK/WHT	B
GROUND	C	BLK/WHT	–
AECL SENSOR LOW LIGHT	D	–	–
IGN	E	PNK	–

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Figure 3-59 Add Engine Coolant Level Sensor with Dash-mounted Lamp Installation

DDC recommends this installation for the AECL Sensor (see Figure 3-60).

This sensor must be enabled with VEPS or the DDEC Reprogramming System.

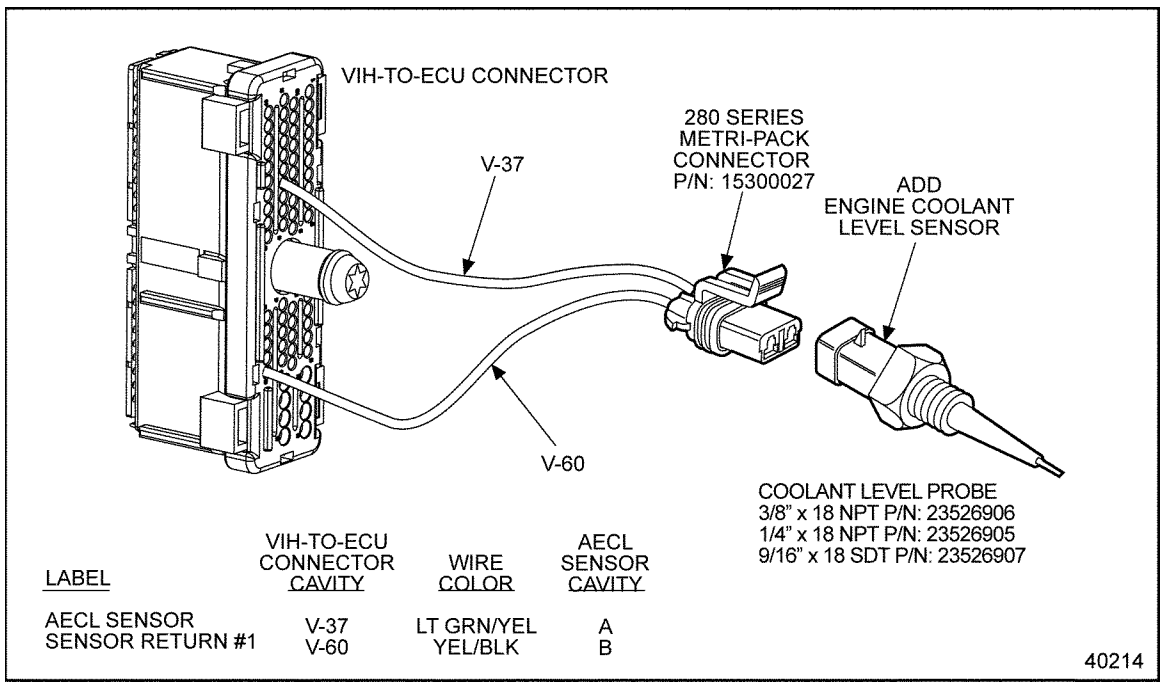


Figure 3-60 Add Engine Coolant Level Sensor Installation

3.11.22 FIRE TRUCK PUMP PRESSURE SENSOR

The Fire Truck Pump Pressure Sensor is used with the Pressure Sensor Governor. It provides a fire truck pump pressure signal to the ECU, which modulates engine fueling to maintain a constant fire truck pump pressure. See Figure 3-61. The Pressure Sensor is capable of reading up to 400 PSIA and is located in the water pump discharge manifold.

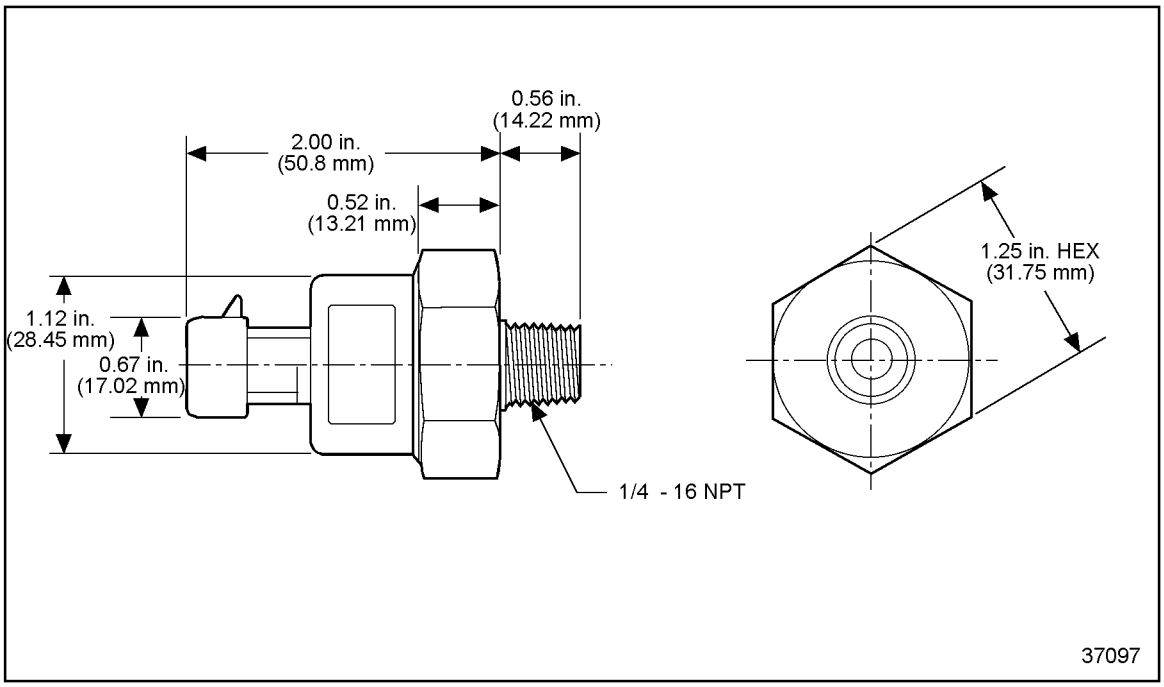


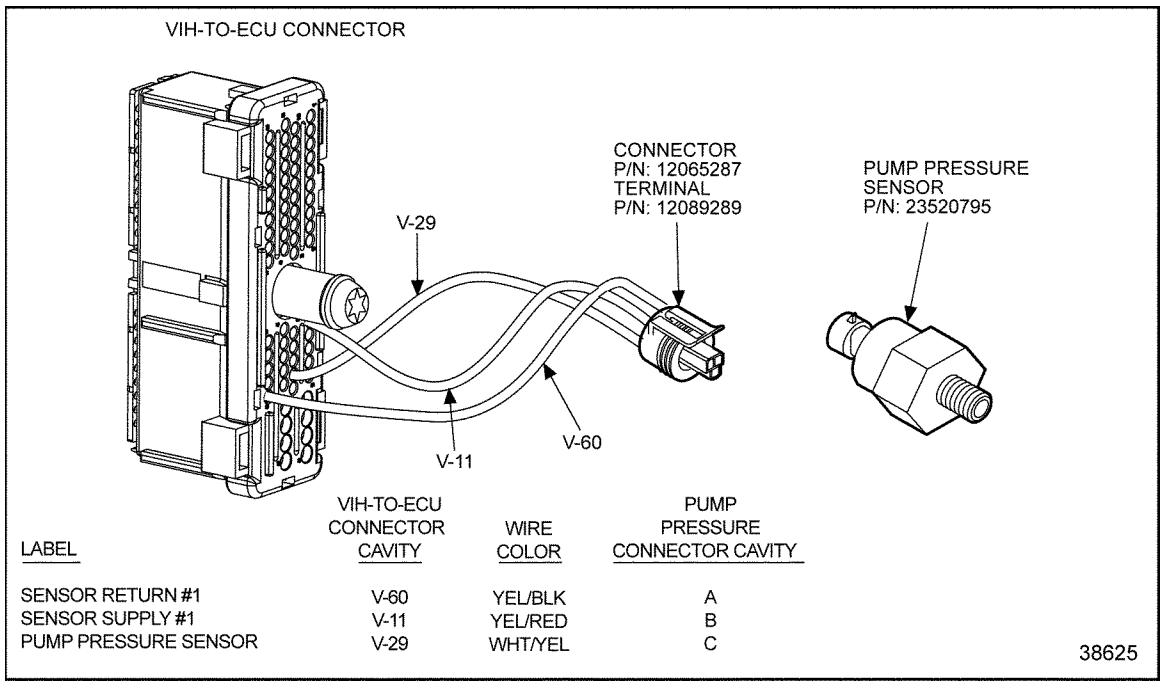
Figure 3-61 The Fire Truck Pump Pressure Sensor

The Fire Truck Pump Pressure Sensor connector, listed in Table 3-55, is a Metri-Pack 150 series pull-to-seat connector.

Fire Truck Pressure Sensor	
Connector	P/N: 12065287
Terminal	P/N: 12089289
Seal	In Connector

Table 3-55 Fire Truck Pump Pressure Sensor Connector

DDC recommends this installation for the Fire Truck Pump Pressure Sensor (see Figure 3-62).



LABEL	VIH-TO-ECU CONNECTOR CAVITY	WIRE COLOR	PUMP PRESSURE CONNECTOR CAVITY
SENSOR RETURN #1	V-60	YEL/BLK	A
SENSOR SUPPLY #1	V-11	YEL/RED	B
PUMP PRESSURE SENSOR	V-29	WHT/YEL	C

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Figure 3-62 Fire Truck Pump Pressure Sensor Installation

3.11.23 TURBO COMPRESSOR IN TEMPERATURE SENSOR

The Turbo Compressor In Temperature Sensor (TCI Sensor) produces a signal representing the temperature of the turbo compressor inlet. See Figure 3-63.

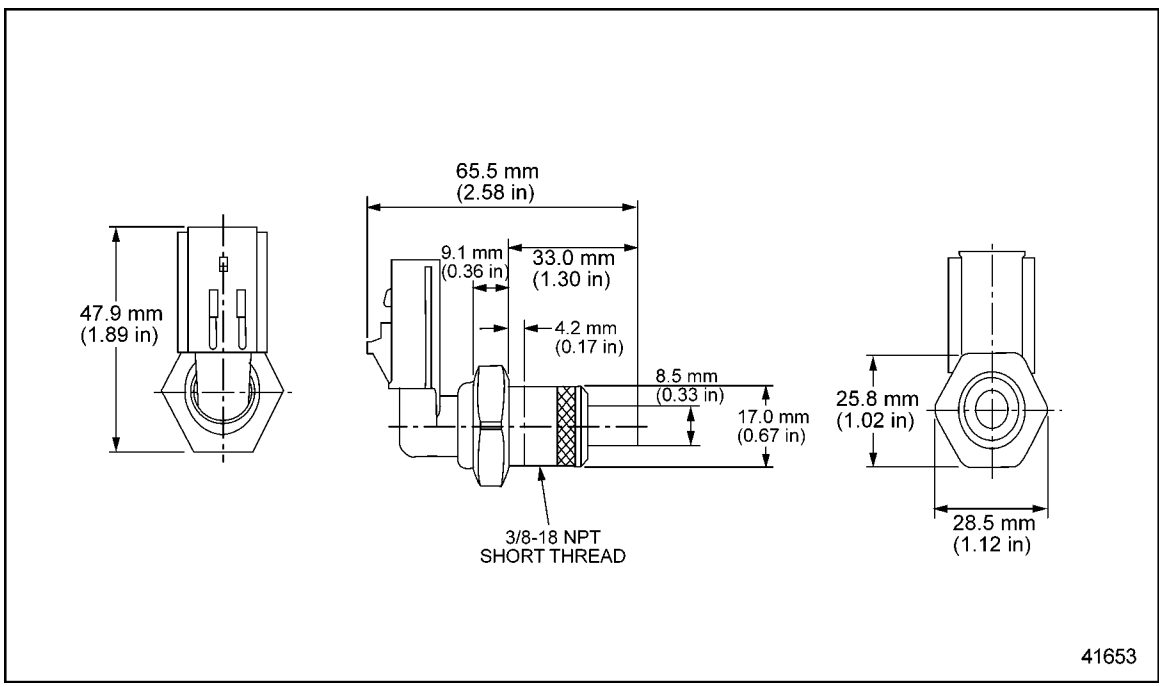

Figure 3-63 Turbo Compressor In Temperature Sensor

This sensor is required for the Series 60.

The maximum vibration for the sensor is 5 g. The sensor must be torqued between 10 ft lb and 20 ft lb. The harness must be fastened within 6 in of the sensor. The maximum operating temperature for this sensor is 248°F (120°C).

Install the Turbo Compressor In Temperature Sensor in the filtered air side of the air filter canister. Otherwise it must be mounted between the air cleaner and the turbocharger compressor inlet. See Figure 3-64.

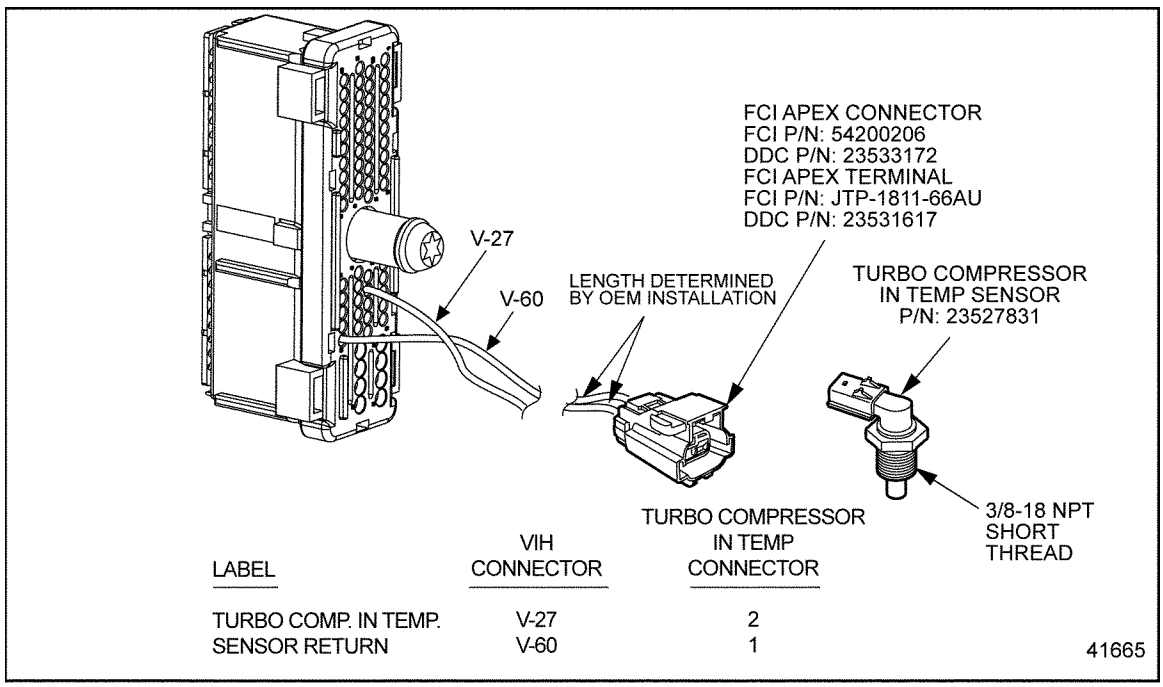

Figure 3-64 Turbo Compressor In Temperature Sensor Installation

FCI connectors are available from the following:

FCI Automotive
Telephone: 1–800–303–3577 or 734–728–2100

NTI, LLC
300 Randall Street, Suite B
Greer SC 29651
Telephone: 864–877–4800
Fax: 864–877–2997

3.11.24 VEHICLE SPEED SENSOR

The DDEC ECU can calculate vehicle speed providing that the ECU is properly programmed and interfaced with a Vehicle Speed Sensor (VSS) that meets DDC requirements. The VSS (see Figure 3-65) provides a vehicle speed signal for use in Cruise Control and Vehicle Speed Limiting. The VSS signal type can be changed with the VEPS, or DRS.

NOTE:
DDC does not approve of the use of signal generator sensors.

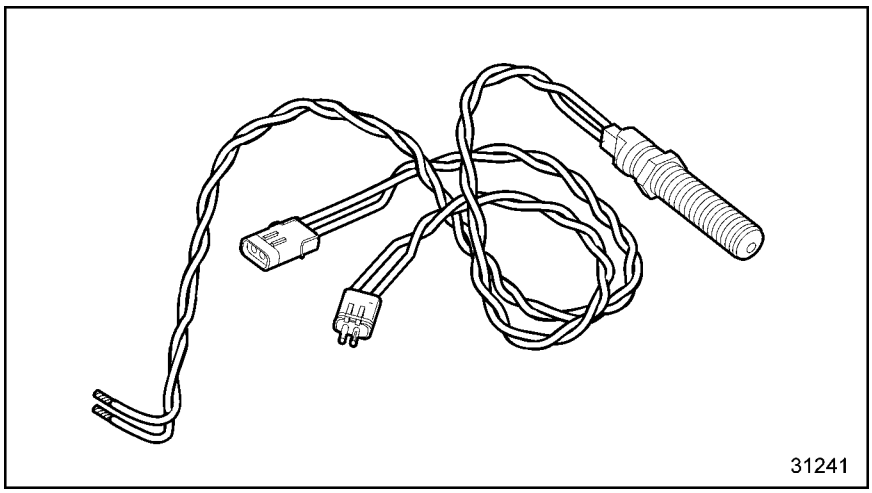

Figure 3-65 Vehicle Speed Sensor

To obtain accurate vehicle mileage, the parameters listed in Table 3-56 must be programmed with DDDL, VEPS or DRS.

Parameter	Description	Choice / Display
Enable Vehicle Speed Sensor	Enables or disables the vehicle speed sensor input.	YES, NO
VSS Type	Type of vehicle speed sensor used	TAIL, WHEEL
VSS Teeth	Number of teeth on the vehicle speed sensor wheel.	0 to 250
VSS Signal	Type of vehicle speed sensor signal.	SWITCHED, MAGNETIC
Tire Size	Vehicle tire revolutions per mile.	100 to 999
Axle Ratio	Indicates the rear axle ratio of the vehicle.	2.00 to 19.99
Top Gear Ratio	Indicates the vehicle transmission final drive ratio.	0.5 to 2.55

Table 3-56 Vehicle Speed Sensor Parameters

Magnetic Pickup

The magnetic pickup requirements are listed in Table 3-57. Magnetic Pickup size is determined by installation requirements. Both cavity V-17 and V-18 must be used.

Parameters	Range
Input amplitude Range	800 mV-100V peak to peak
Input Frequency Range	1 - 3000 Hz

Table 3-57 Magnetic Pickup Vehicle Speed Sensor Requirements

See Figure 3-66 for the installation of magnetic pickup VSS.

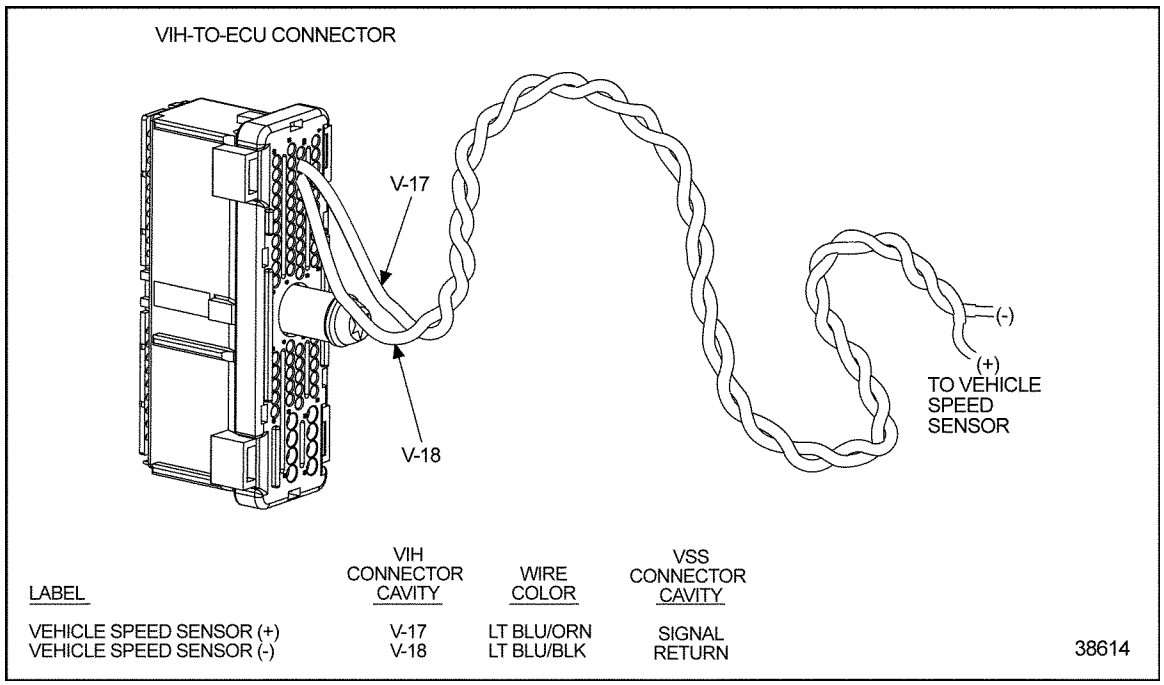

Figure 3-66 Magnetic Pickup Vehicle Speed Sensor Installation

Magnetic Vehicle Speed Sensors can be obtained from the following sources:

Wabash Technologies

1375 Swan Street
Huntington, Indiana
46750-0829
Tel: 260-356-8300

www.wabashtech.com

Airpax Instruments

Phillips Technologies

150 Knotter Drive

Chesire, Connecticut 06410

Tel: 800-643-0643

Invensys Electro Corporation

1845 57th Street

Sarasota, Florida 34231

Tel: 1–800–446–5762
Fax: 941-355-3120
www.electrocorp.com

Open Collector

The open collector input is defined as a single wire input that alternates between a high voltage of at least 4 V DC and a low voltage of 1.0 VDC or less. Typically, the input is connected to a transistor collector output whether open or through a Pull-up resistor. A Pull-up resistor is preferred as this eliminates the need to configure the signal type as open collector. See Figure 3-67 for open collector VSS installation.

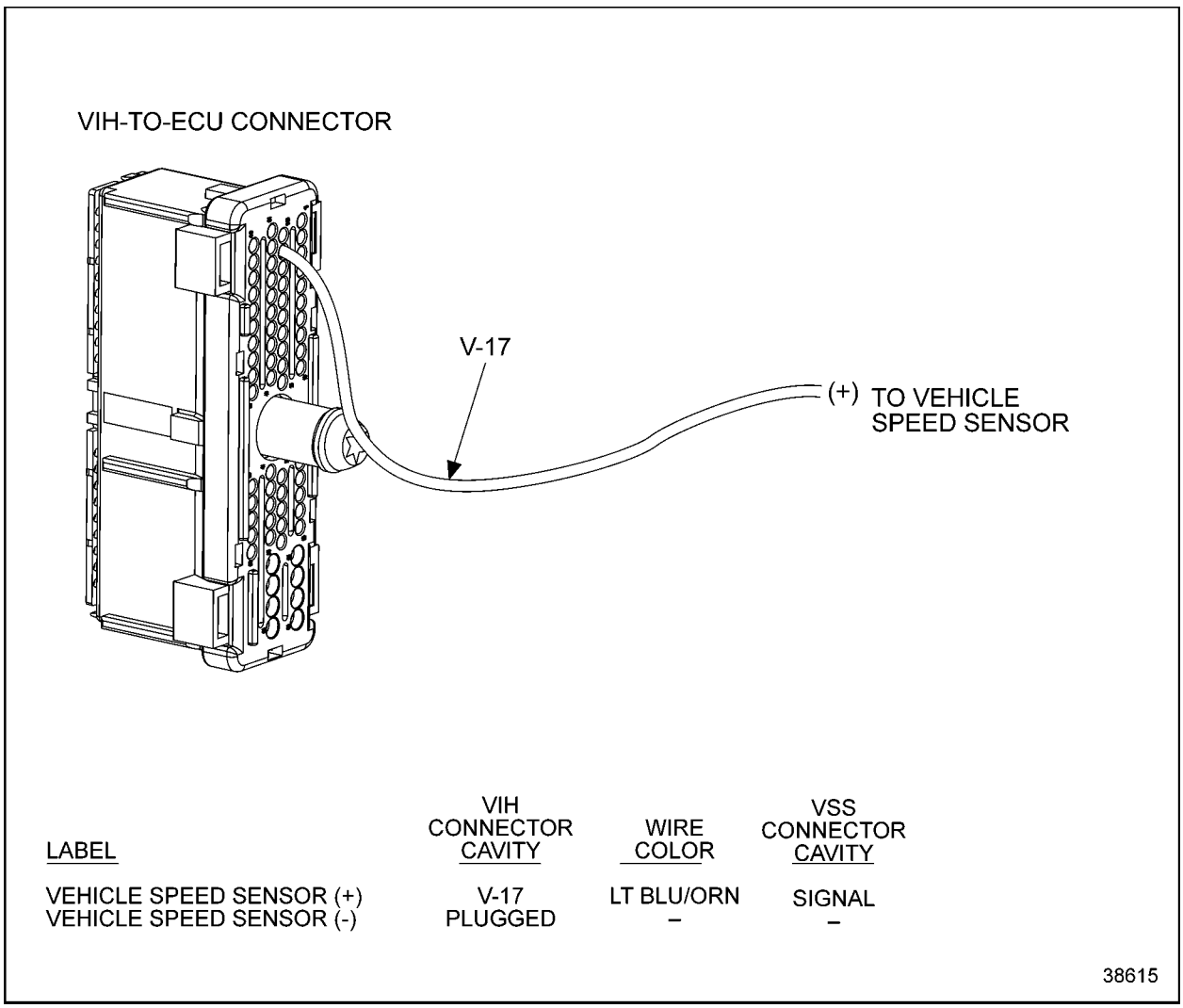

Figure 3-67 Open Collector Vehicle Speed Sensor Installation

The open collector requirements are listed in Table 3-58. Only cavity V-17 is used. Cavity V-18 must be empty.

Parameters	Range
High State	4.0 <E_{in} <Battery (+) with $I_{leakage}$ <0.2mA
Peak to Peak Voltage Maximum	-2.0 <E_{in} <1.0 V while I_{source} <5.0mA
Input Frequency Range	1 - 3000 Hz

Table 3-58 Open Collector Vehicle Speed Sensor Requirements

SAE J1939 Data Link

A VSS wired to the ECU is not required if the transmission output shaft speed message is being transmitted over the SAE J1939 Data Link. To obtain accurate vehicle mileage, the parameters listed in Table 3-59 must be programmed with DDDL, VEPS, or DRS. The VSS type will automatically be set to SAE J1939 when the appropriate transmission type is selected (tran type = 16).

Parameter	Description	Choice / Display
Tire Size	Vehicle tire revolutions per mile.	100 to 999
Axle Ratio	Indicates the rear axle ratio of the vehicle.	2.00 to 19.99

Table 3-59 Vehicle Speed Sensor Parameters

Two faults (SID 216 FMI 14 and PID 84 FMI 12) will be logged simultaneously if DDEC is calibrated to receive output shaft speed over a SAE J1939 Data Link and the data is not being received or the data is incorrect. This indicates that there is a problem with the sensor on the transmission or the transmission controller. If these faults are received in addition to a SAE J1939 Data Link failure (SID 231, FMI 12), then the problem is with the SAE J1939 Data Link itself.

VSS Anti-tamper

If the sensor appears to be working improperly, but the vehicle speed is not zero, VSS Anti-Tamper will log a VSS fault. The engine speed in all gears will be limited for the duration of the ignition cycle to the engine speed at vehicle speed limit in top gear. Refer to section 5.30 for more information on VSS Anti-tamper.

3.11.25 AFTERMARKET INSTALLED SENSORS

Sensors that can be installed aftermarket are listed in Table 3-60.

Sensor	Part Number	Function
Ambient Air Temperature Sensor (AAT Sensor)	23518328	Senses ambient air temperature specifically for the Ambient Air Temperature Override Disable feature or for OI. Refer to section 3.11.26.

Table 3-60 Aftermarket Installed Sensor

3.11.26 AMBIENT AIR TEMPERATURE SENSOR

The AAT Sensor is a thermistor type sensor with a variable resistance that produces an analog signal between 0 and 5 V, representing the temperature of the ambient air. The AAT Sensor (see Figure 3-68) is used with the Idle Shutdown Timer, specifically for the Ambient Air Temperature Override Disable feature or for Optimized Idle. For additional information on these features refer to Chapter 5.

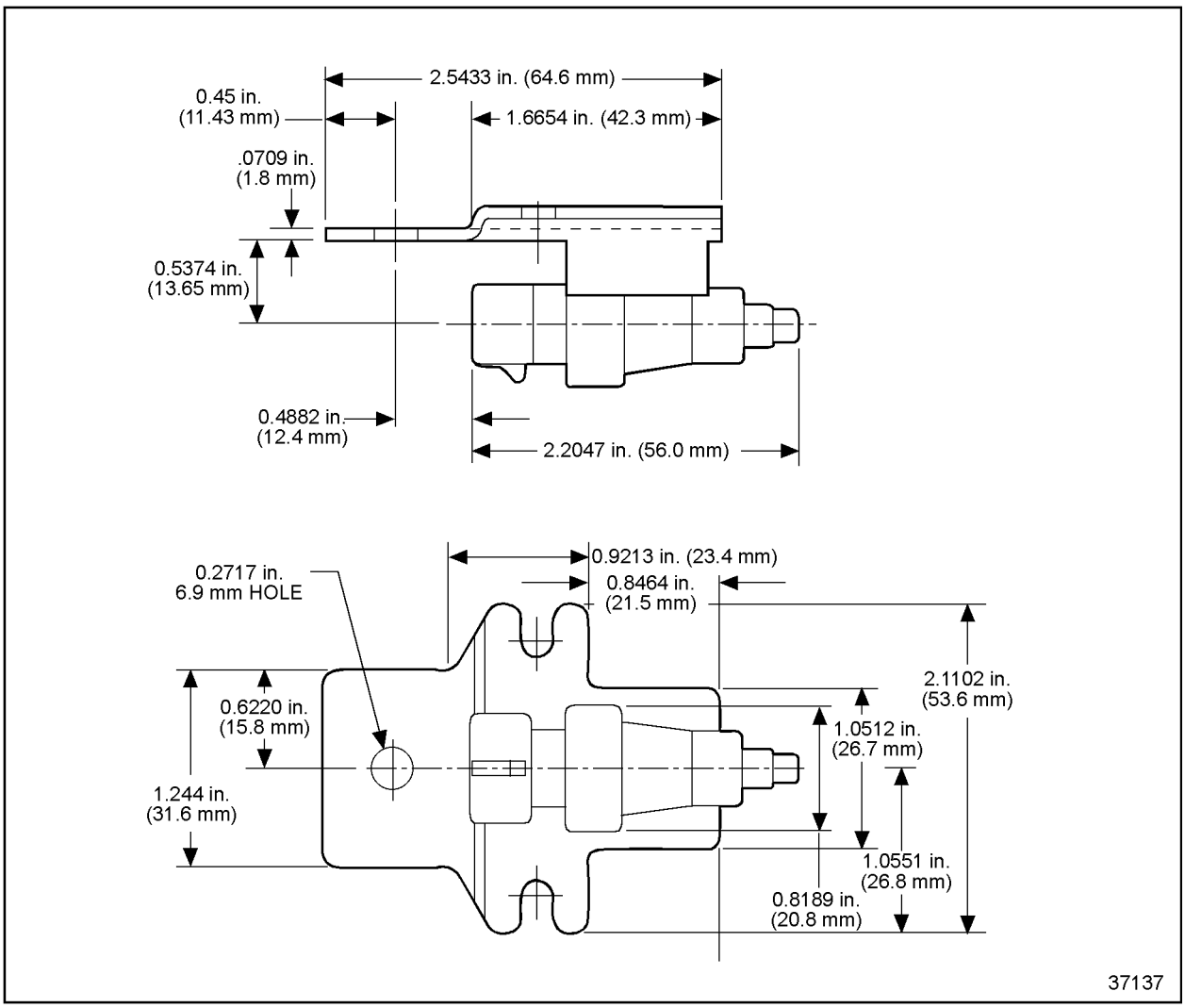

Figure 3-68 Ambient Air Temperatures Sensor Dimensions

Install the AAT Senaor where ambient air temperature can be read. A protected location on the frame rails where it will not be splattered with dirt and grime and is removed from any heat source such as exhaust is preferred.

An aftermarket kit P/N: 23534278 is available as listed in Table 3-61.

Description	Part Number	Quanity
Harness, Ambient Air Temp	23534225	1
Sensor Ambient Air Temp (with Bracket)	23518328	1
Connector – Air Temp Sensor	12162193	1
Terminal, Female	12103881	4
18SP583 – Installation Instructions	18SP583	1

Table 3-61 Ambient Air Temp Kit P/N: 23534278

Ambient Air Temp Sensor Kit Installation

Install the kit as follows:

1. Unplug the connector from the Intake Manifold Pressure Sensor (IMP Sensor).
2. Take the ambient AAT Sensor harness and plug the IMP Sensor connector into the IMP Sensor. Plug the IMP Sensor(from the Engine Harness) into the 3-pin connector (IMP Sensor connector mate) on the AAT Sensor harness.
3. Route the harness along the Engine Harness towards the ECU 68-pin connector.
4. Remove the Vehicle Interface Harness 68-pin connector from the ECU.
5. Insert lead into the connector cavity V-48 and reinstall the 68-pin connector. See Figure 3-69.

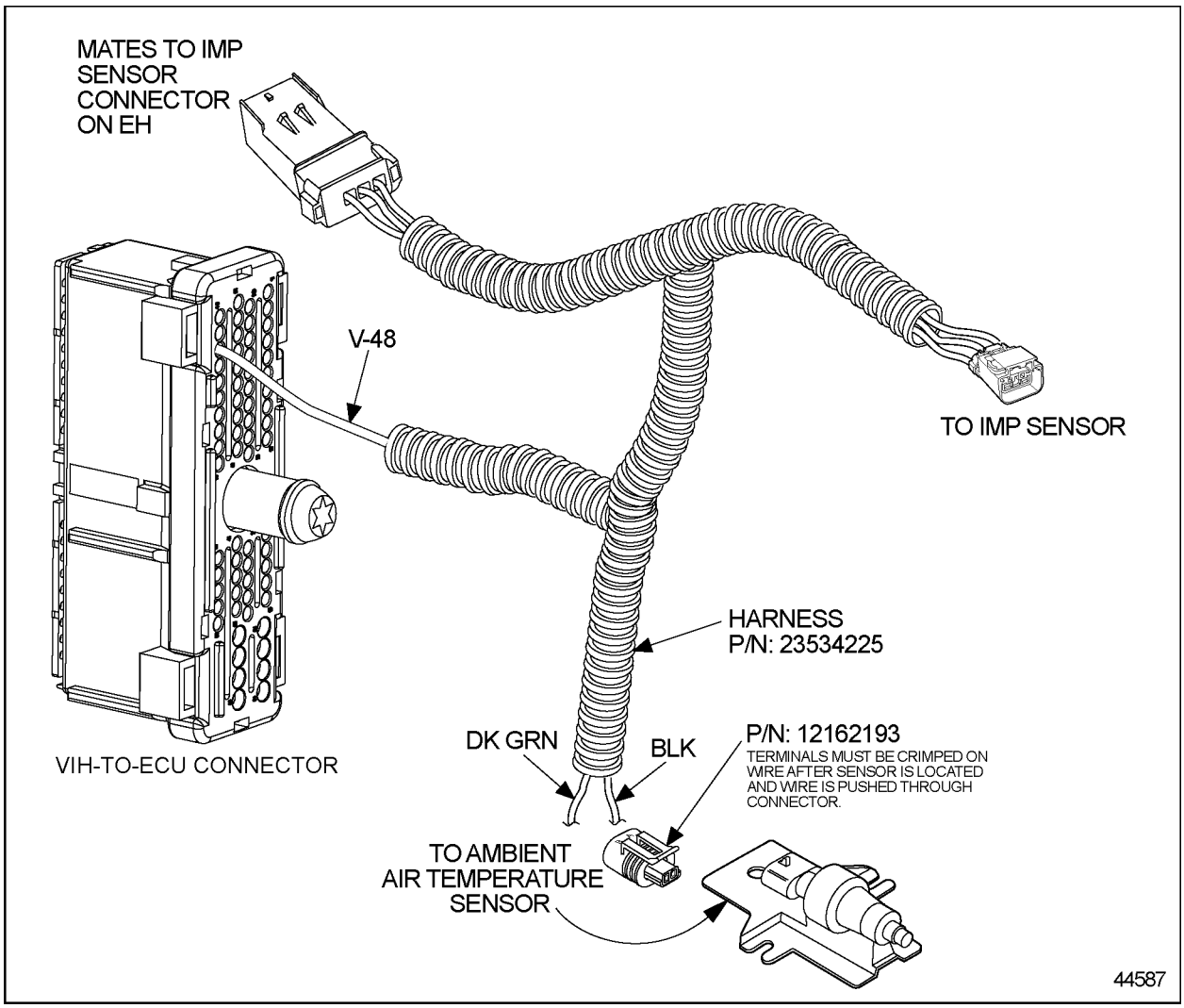

Figure 3-69 Ambient Air Temperature Sensor Harness

6. Route the body of the harness to the desired location for the AAT Sensor. Remove any excess harness material and discard.
7. Install the black lead (circuit E-15) into cavity “A” of AAT Sensor connector (P/N: 12162193) and the green lead (circuit V-48) into cavity “B.” Crimp the terminals (P/N: 12103881)on each lead using tool J 35123. Insert the terminals into the connector.
8. Secure the sensor to the desired location and plug in the AAT Sensor connector.

NOTE:
Preferred mounting location for the sensor is on the front bumper away from any heat sources.

9. Secure the harness to adjacent components with wire ties.
10. Sensor must be enabled with a Distributor Reprogramming Station. Choose DDEC V Ambient Air Temperature Sensor.

3.12 THROTTLE DEVICES

Starting with DDEC V, DDC has begun using the nomenclature found in SAE J2403 which is industry standard. The previously used names and the SAE J2403 names are listed in Table 3-62.

Old/New	Old/New
EFPA/AP	Electronic Foot Pedal Assembly/Accelerator Pedal
LSG/ALSG	Limiting Speed Governor/Automotive Limiting Speed Governor
TPS/AP Sensor	Throttle Position Sensor/Accelerator Pedal Sensor

Table 3-62 Old and New Terminology

There are several types of throttle controls which may be used for engine control.

- □ Hand throttle
- □ Accelerator Pedal Assembly (AP)
- □ Cruise Control switches
- □ Fast Idle Switch
- □ Voltage dividers
- □ Frequency input

The throttle input device is OEM supplied.

There are two types of engine governors that are used with throttle controls. The engine governors are:

- □ The Automotive Limiting Speed Governor (ALSG) for torque control
- □ The Variable Speed Governor (VSG) for speed control

3.12.1 ACCELERATOR PEDAL ASSEMBLY

The AP contains the Accelerator Pedal Sensor (AP Sensor) and the Idle Validation Switch which converts the operator's hand throttle and/or foot pedal input into a signal for the ECU. The AP and the AP Sensor are shown in Figure 3-70.

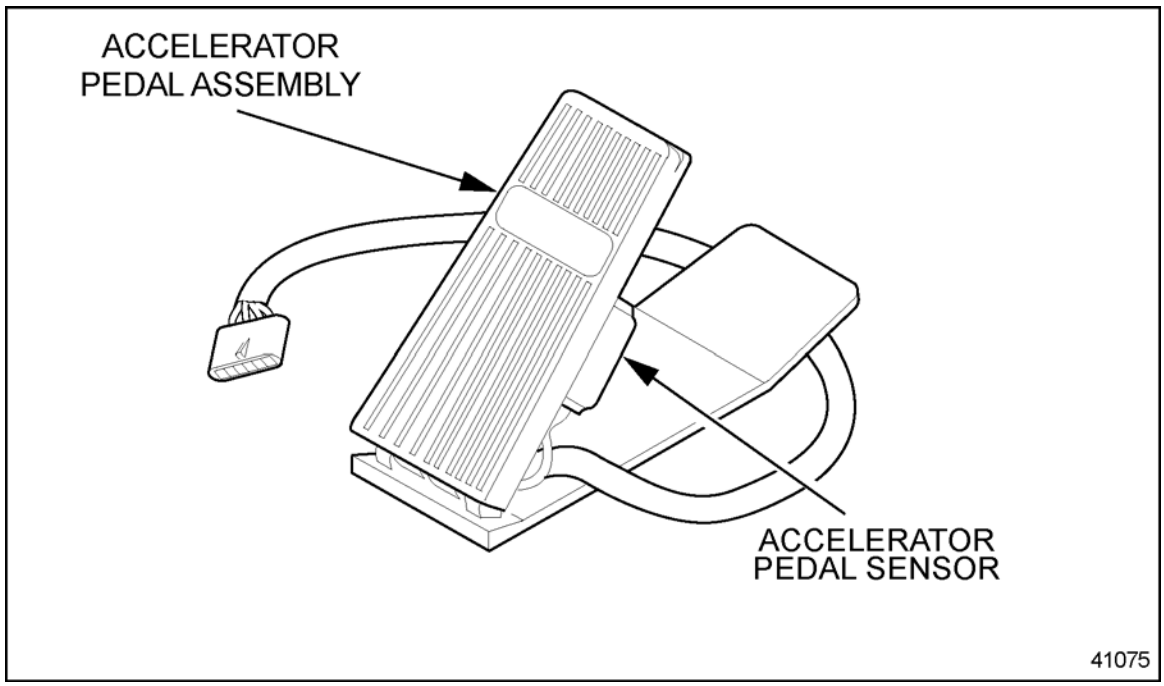

Figure 3-70 Typical AP Throttle Device (Shown with 6-pin Connector)

The AP sends the ECU an input signal which controls engine power on the ALSG, proportional to the foot pedal position. This assembly is also referred to as the Accelerator Pedal Sensor assembly.

NOTE:
An Accelerator Pedal with an Idle Validation Switch is required.

The system fault detection diagnostics will return the engine to idle speed in the event of a sensor or associated wiring malfunction. An idle validation switch provides redundancy to assure that the engine will be at idle in the event of an in-range malfunction.

The AP can be used with either or both ALSG and VSG.

3.12.2 CRUISE CONTROL SWITCHES

The Cruise Control switches can be used to control the VSG set speed. This feature is referred to as Cruise Switch VSG. For more information on Cruise Switch VSG, refer to section 5.3.3 and section 5.25.2 .

3.12.3 HAND THROTTLE

A hand throttle (potentiometer) may be used to control engine speed on the VSG between the minimum VSG speed and maximum VSG speed. The total resistance must be between 1 kΩ and 10 kΩ. For more information on the hand throttle, refer to section 5.25.2 .

3.12.4 FAST IDLE SWITCH (ALTERNATE MINIMUM VSG)

The Alternate Minimum VSG option allows a customer to select an alternate idle speed when its digital input is switched to battery ground.

For more information on Alternate Minimum VSG/Fast Idle, refer to section 5.25.2 .

3.12.5 VOLTAGE DIVIDERS

Voltage dividers can be used with the VSG input to provide a means to select a predetermined engine speed. Voltage dividers can be used to provide a fast idle operation or other engine operations where a fixed engine speed is desired.

For more information on voltage dividers, refer to section 5.25.2.

3.12.6 FREQUENCY INPUT

A frequency input can be used to control the VSG. This frequency is connected to a frequency input. Frequency speed control offers better resolution than analog throttles. For more information on frequency input, refer to section 5.25.2 .

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3.13 LIGHTS

Starting with DDEC V, DDC has begun using the nomenclature found in SAE J2403 which is industry standard. The previously used names and the SAE J2403 names are listed in Table 3-63.

Old/New	Old/New
CEL/AWL	Check Engine Light/Amber Warning Lamp
SEL/RSL	Stop Engine Light/Red Stop Light

Table 3-63 Old and New Terminology

The instrument panel warning lights, the Amber Warning Lamp (AWL) and the Red Stop Lamp (RSL), are supplied by the OEM. The functionality of each lamp along with the wiring requirements are covered separately in the following sections.

3.13.1 AMBER WARNING LAMP

The AWL is controlled by the DDEC ECU. The AWL remains ON:

- For approximately five (5) seconds at the start of every ignition cycle (a bulb check)
- When an electronic system fault occurs (This indicates the problem should be diagnosed as soon as possible.)

The AWL flashes:

- When the Diagnostic Request Switch is used to activate the AWL to flash inactive codes
- During last 90 seconds before Idle Shutdown if programmed for override
- When Idle Shutdown occurs or the Optimized Idle system shutdown occurs

AWL and Maintenance Intervals

AWL is active with the DDEC Reports Periodic Maintenance intervals. If a maintenance interval is within a specified percentage of expiration (default is 20%), the AWL flashes six times when the ignition is turned on. The ignition must have been off for less than 30 seconds prior to being turned on. If the off time has been greater than 30 seconds, no indication of maintenance interval status is given.

AWL and PasSmart

AWL is active with PasSmart. When the Passing Speed Duration time expires, the Amber Warning Lamp on the dashboard will begin to flash one minute prior to ramping the Vehicle Limit Speed (VLS) back down to the normal VLS limit. The rampdown event always takes 5 seconds regardless of the Passing Speed Increment programmed into the ECU. The rampdown alert can be distinguished from an engine fault warning in that the AWL flashes for the former and remains on constantly for the latter.

PasSmart still operates when there is an active engine fault. In this situation the Amber Warning Lamp goes from constant illumination to flashing one minute before the VLS limit ramps down. At the end of the passing event when PasSmart is deactivated, the Amber Warning Lamp will return to constant illumination if the engine fault is still active.

AWL and the Maintenance Alert System

AWL activity with the Maintenance Alert System (MAS) is set with DDDL, the Vehicle Electronic Programming System (VEPS), or the DDEC Reprogramming System (DRS). The four options for using the AWL with MAS are:

1. AWL and RSL will not illuminate or flash for MAS Warnings - sensor faults will still be logged (recommended for vehicles equipped with display modules).
2. AWL will illuminate continuously while the warning is active, i.e. low fluid levels (oil or coolant), filter restrictions.
3. The AWL and RSL flash for 15 seconds when the ignition is first turned ON and warnings have been present.
4. Both 2 and 3.

Amber Warning Lamp Requirements and Guidelines

The following requirements and guidelines apply to the AWL:

- □ The AWL must be supplied by the OEM.
- □ A 12 or 24 volt light of less than 2 A (DC) is required depending on the ignition source. Digital output circuits are designed to sink no more than 2 A (DC) current. A low-side digital output sinks 210 µA when OFF.
- □ The AWL must be integrated into the instrument panel or placed in clear view of the equipment operator.
- □ The lens color must be amber.
- □ The words CHECK ENGINE must appear on or near the AWL lamp.

Wiring Requirements

The AWL is connected to pin V-1 in the VIH connector.

See Figure 3-71 for the recommended AWL wiring.

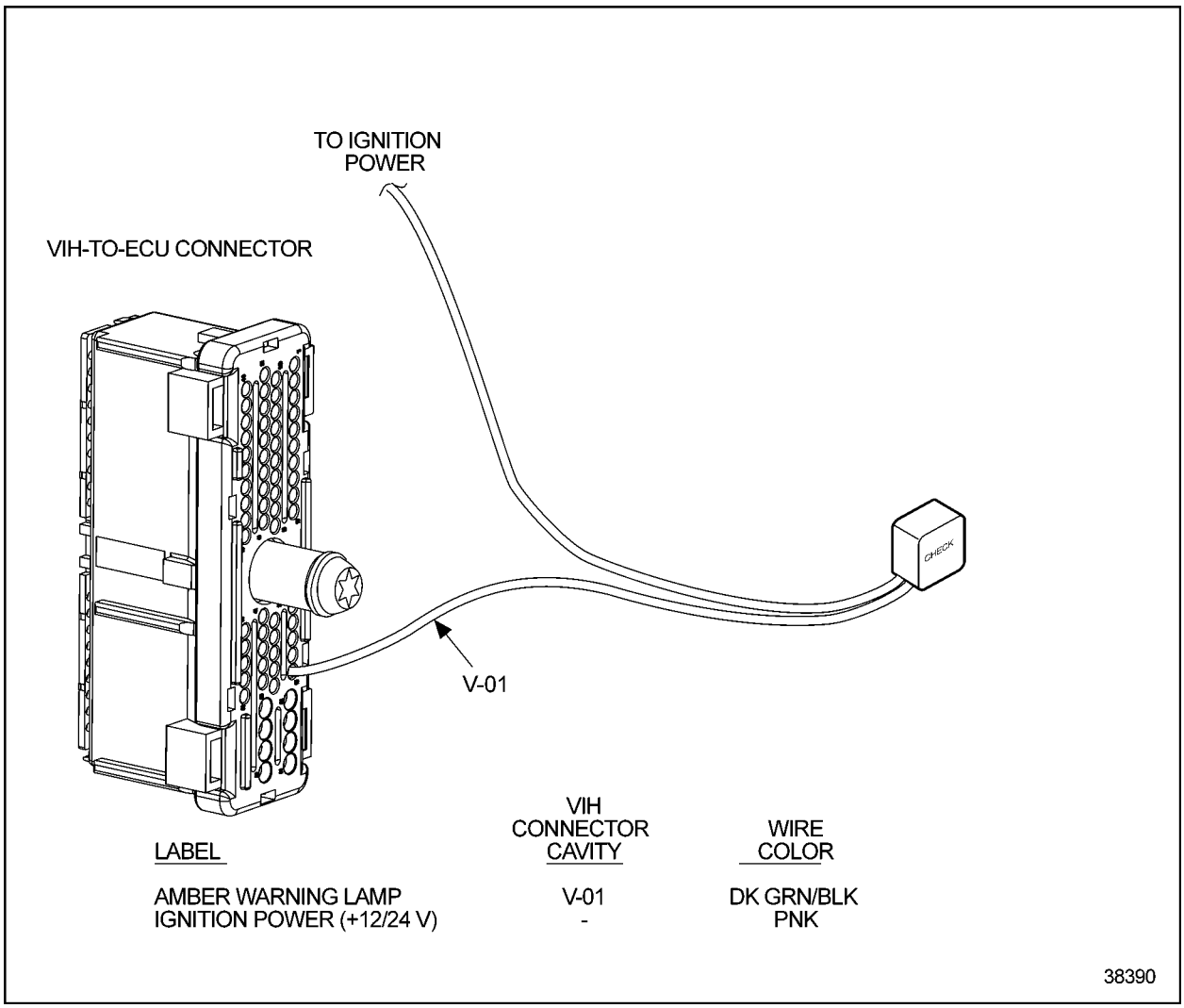

Figure 3-71 Amber Warning Lamp Wiring

3.13.2 RED STOP LAMP

The RSL is controlled by the DDEC ECU. The RSL remains ON:

- For approximately five (5) seconds at the start of every ignition cycle (a bulb check)
- When a potential engine damaging fault is detected

The RSL flashes:

- When Engine Protection Shutdown occurs
- When the Diagnostic Request Switch is used to activate the RSL to flash active codes

RSL activity with the MAS is set with DDDL, the Vehicle Electronic Programming System (VEPS), or the DDEC Reprogramming System (DRS). The two options for using the RSL with MAS are:

1. AWL and RSL will not illuminate or flash for MAS Warnings - sensor faults will still be logged (recommended for vehicles equipped with display modules).
2. The AWL and RSL flash for 15 seconds when the ignition is first turned ON and warnings have been present.

Red Stop Lamp Requirements and Guidelines

The following requirements and guidelines apply to the RSL:

- The RSL must be incorporated into the VIH by the OEM.
- A 12 or 24 volt light of less than 2 A (DC) is required depending on the ignition source. Digital output circuits are designed to sink no more than 2 A (DC) current. A low-side digital output sinks 210 µA when OFF.
- The RSL must be integrated into the instrument panel or placed in clear view of the equipment operator.
- The lens color must be red.
- The words STOP ENGINE must appear on or near the RSL lamp.

Red Stop Lamp Wiring

The RSL is connected to pin V-2 in the VIH connector.

See Figure 3-72 for the recommended RSL wiring.

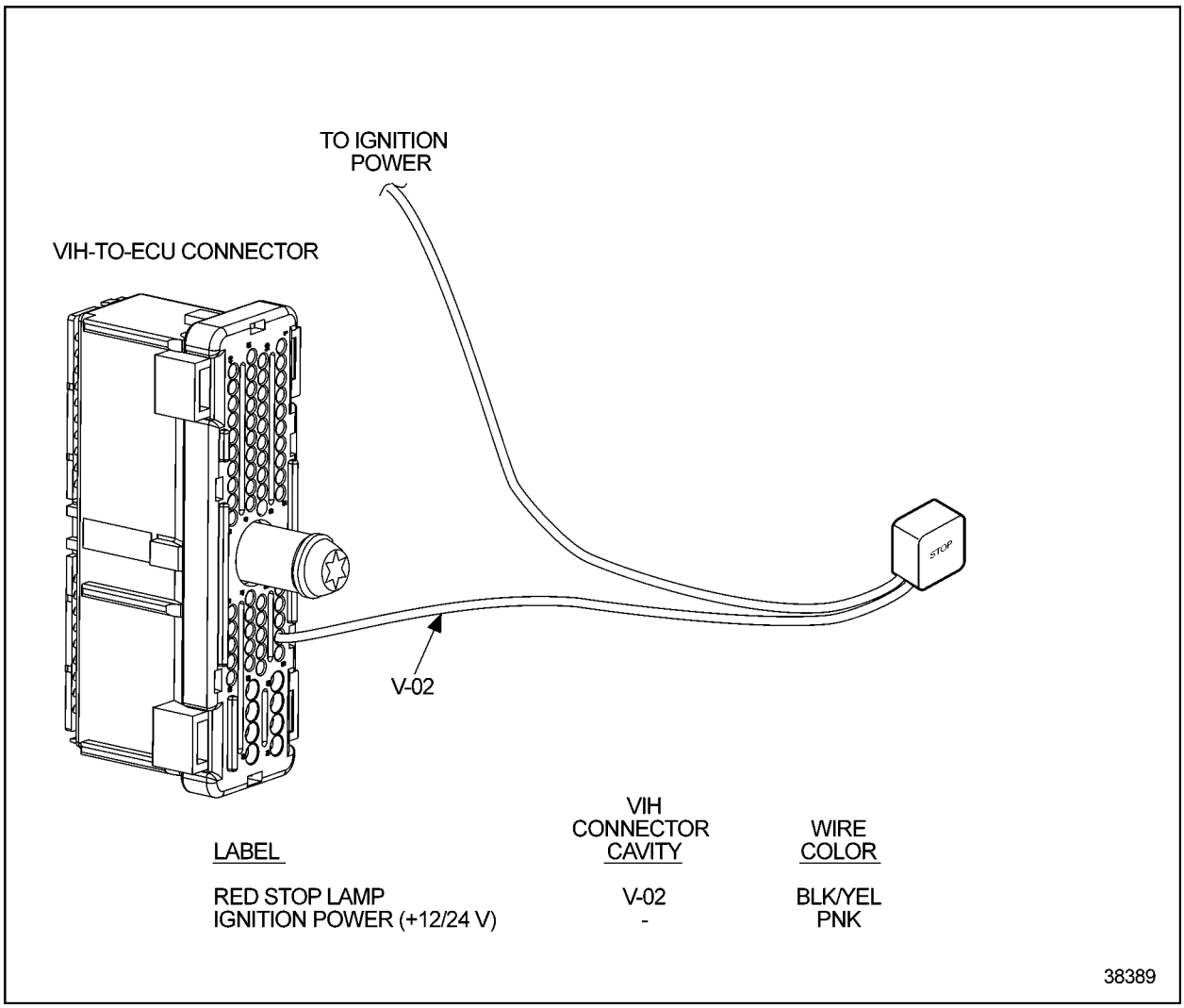

Figure 3-72 Red Stop Lamp Wiring

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