

# **DM**

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**DIAGNOSIS MANUAL  
ECM SYSTEM**

**WG1605-E3**

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**Kubota**

## **Record of Revisions**

For pdf, use search function {Search word} to find all the revised locations.

<b>Last digit of the Code No.</b>	<b>Issue month</b>	<b>Main Revised Point and Corrective Measures {Search word}</b>	<b>Reference Page</b>
<b>1</b>	2014.05	Added the models (WG1605-N-E3, WG1605-LN-E3, WG1605-GLN-E3)	–
<b>2</b>	2016.05	Updated the DTC(s)	–
<b>3</b>	2016.11	Added diagnostic procedure of DTC 87, 88 Correction the value of DTC list and Diagnostic procedure	–

# **I INFORMATION**

# INFORMATION

## CONTENTS

1. SAFETY FIRST ..... I-1



# 1. SAFETY FIRST

## SAFETY FIRST

- This symbol, the industry's "Safety Alert Symbol", is used throughout this manual and on labels on the machine itself to warn of the possibility of personal injury. Read these instructions carefully.
- It is essential that you read the instructions and safety regulations before you attempt to repair or use this unit.

### DANGER

- Indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.

### WARNING

- Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

### CAUTION

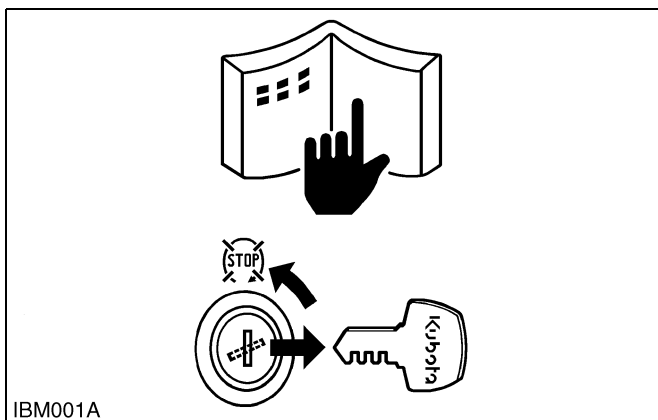
- Indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury.

### ■ IMPORTANT

- Indicates that equipment or property damage could result if instructions are not followed.

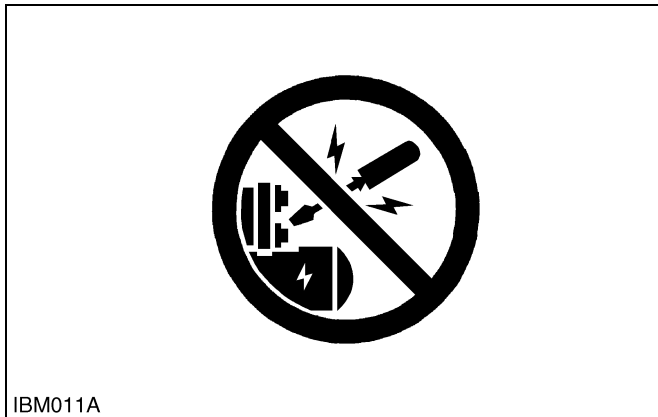
### ■ NOTE

- Gives helpful information.



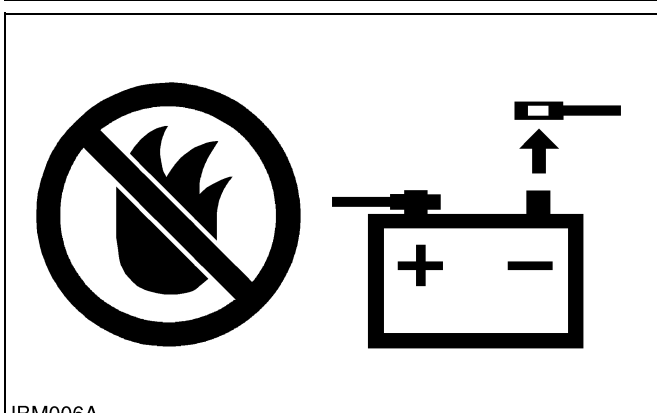
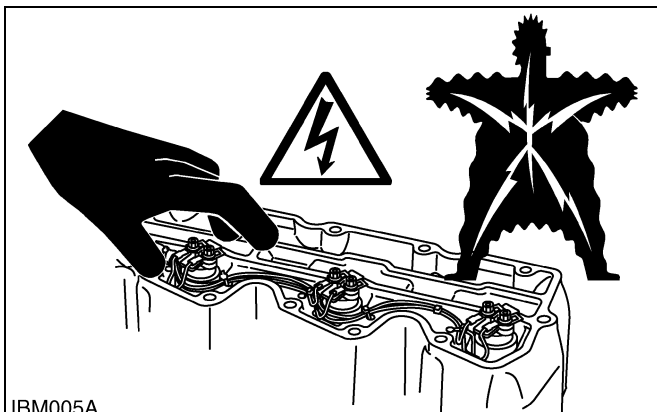
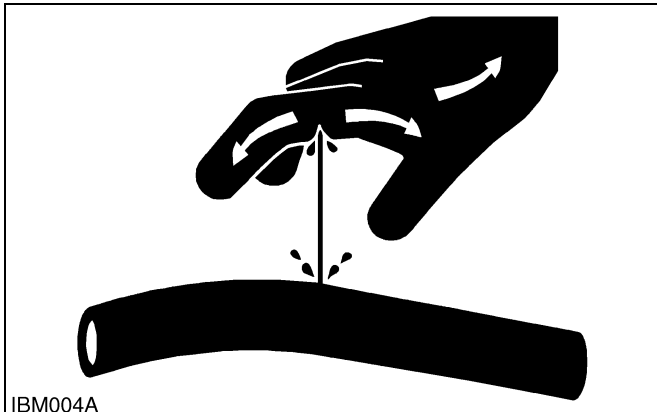
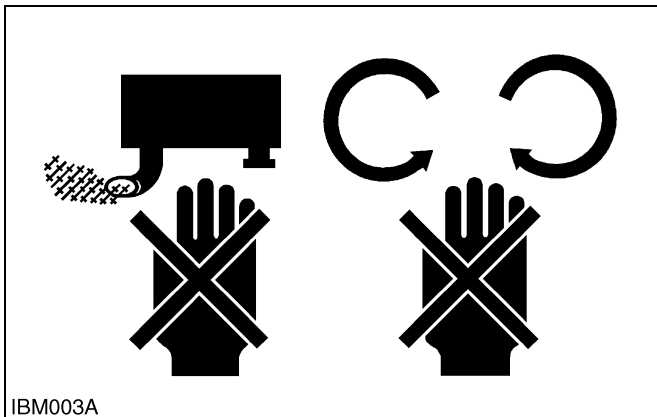
### BEFORE SERVICING AND REPAIRING

- Read all instructions and safety instructions in this manual and on your machine safety decals.
- Clean the work area and machine.
- Park the machine on a firm and level ground.
- Allow the engine to cool before proceeding.
- Stop the engine, and remove the key.
- Disconnect the battery negative cable.
- Hang a "DO NOT OPERATE" tag in operator station.



### SAFETY STARTING

- Do not start the engine by shorting across starter terminals or bypassing the safety start switch.
- Unauthorized modifications to the engine may impair the function and / or safety and affect engine life.

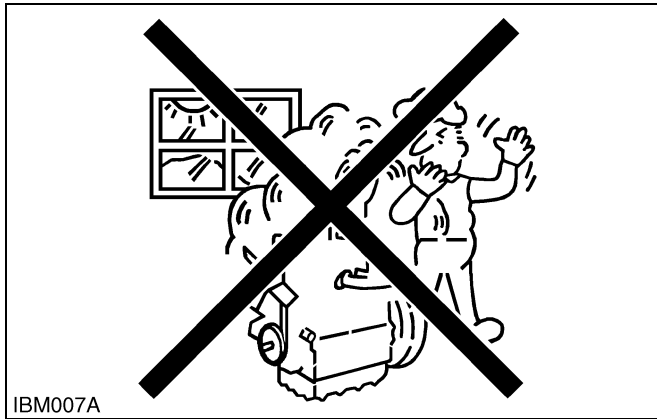


**SAFETY WORKING**

- Do not work on the machine while under the influence of alcohol, medication, or other substances or while fatigued.
- Wear close fitting clothing and safety equipment appropriate to the job.
- Use tools appropriate to the work. Makeshift tools, parts, and procedures are not recommended.
- When servicing is performed together by two or more persons, take care to perform all work safely.
- Do not touch the rotating or hot parts while the engine is running.
- Never remove the radiator cap while the engine is running, or immediately after stopping. Otherwise, hot water will spout out from radiator. Only remove radiator cap when cool enough to touch with bare hands. Slowly loosen the cap to first stop to relieve pressure before removing completely.
- Escaping fluid (fuel or hydraulic oil) under pressure can penetrate the skin causing serious injury. Relieve pressure before disconnecting hydraulic or fuel lines. Tighten all connections before applying pressure.
- Wear a suitable hearing protective device such as earmuffs or earplugs to protect against objectionable or uncomfortable loud noises.
- Do not open high-pressure fuel system. High-pressure fluid remaining in fuel lines can cause serious injury. Do not disconnect or attempt to repair fuel lines, sensors, or any other components between the high-pressure fuel pump and injectors on engines with high pressure common rail fuel system.
- High voltage exceeding 100 V is generated in the ECM and injector. Pay sufficient caution to electric shock when performing work activities.

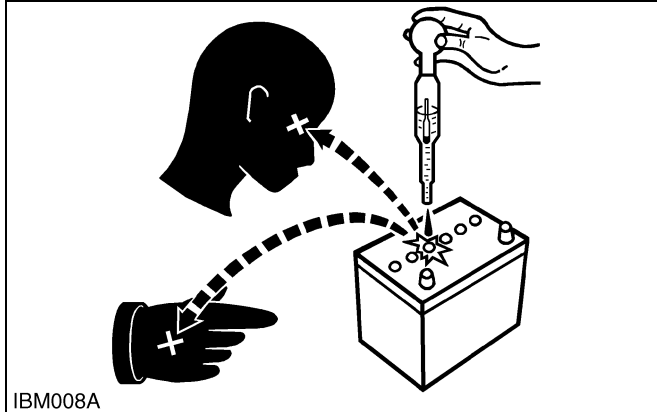
**AVOID FIRES**

- Fuel is extremely flammable and explosive under certain conditions. Do not smoke or allow flames or sparks in your working area.
- To avoid sparks from an accidental short circuit, always disconnect the battery negative cable first and connect it last.
- Battery gas can explode. Keep sparks and open flame away from the top of battery, especially when charging the battery.
- Make sure that no fuel has been spilled on the engine.



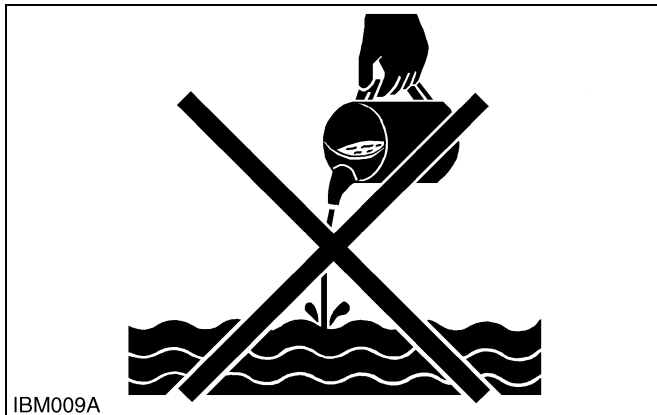
### VENTILATE WORK AREA

- If the engine must be running to do some work, make sure the area is well ventilated. Never run the engine in a closed area. The exhaust gas contains poisonous carbon monoxide.



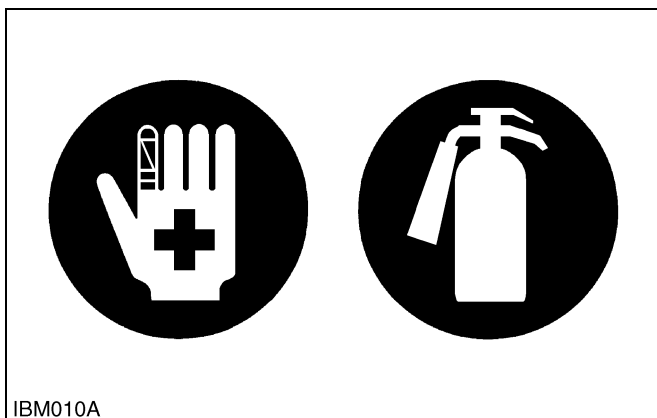
### PREVENT ACID BURNS

- Sulfuric acid in battery electrolyte is poisonous. It is strong enough to burn skin, clothing and cause blindness if splashed into eyes. Keep electrolyte away from eyes, hands and clothing. If you spill electrolyte on yourself, flush with water, and get medical attention immediately.



### DISPOSE OF FLUIDS PROPERLY

- Do not pour fluids into the ground, down a drain, or into a stream, pond, or lake. Observe relevant environmental protection regulations when disposing of oil, fuel, coolant, electrolyte and other harmful waste.



### PREPARE FOR EMERGENCIES

- Keep a first aid kit and fire extinguisher handy at all times.
- Keep emergency numbers for doctors, ambulance service, hospital and fire department near your telephone.

# **1 ECM SYSTEM**

# SERVICING

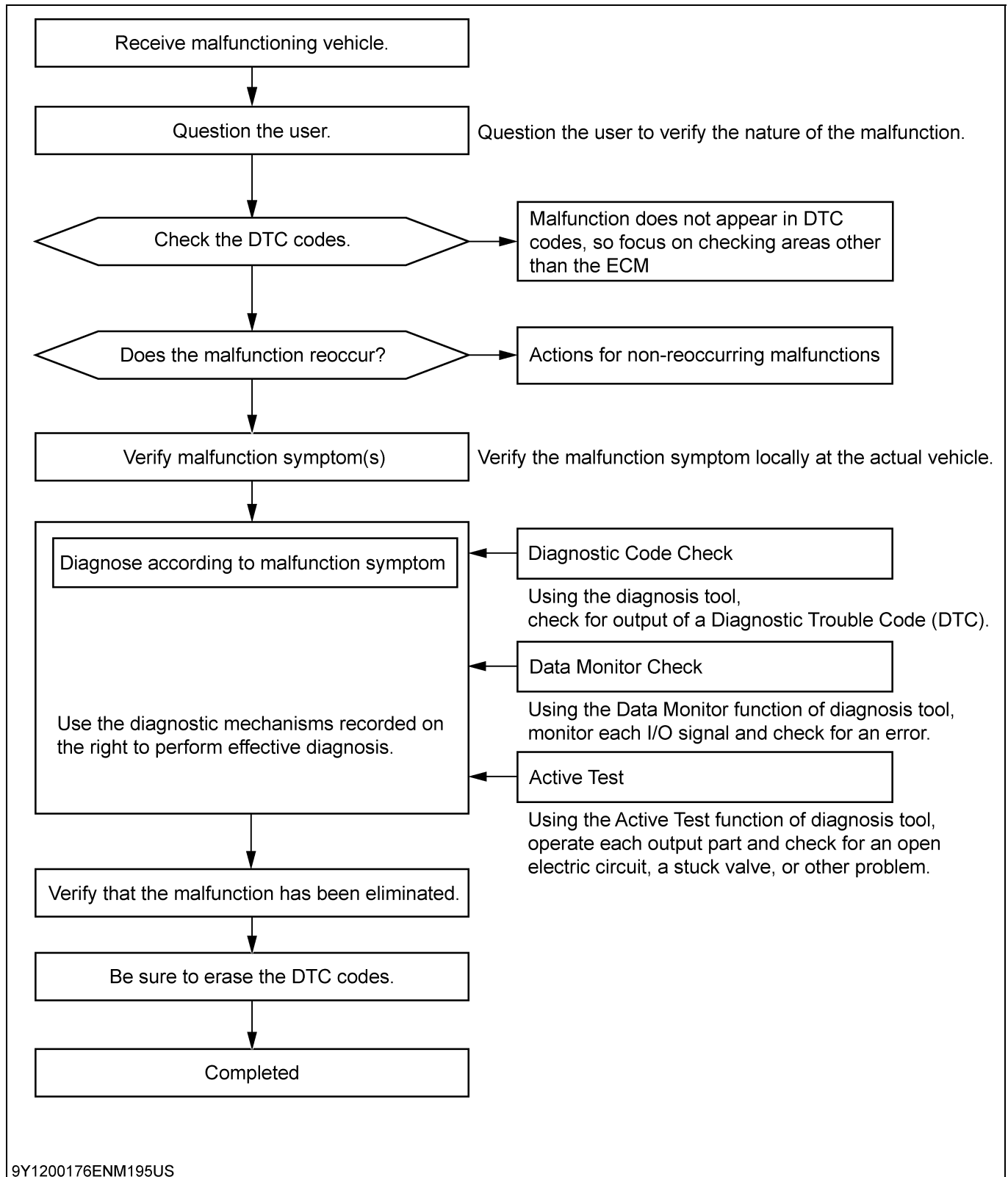
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# 1. OUTLINE

## [1] OVERALL DIAGNOSTIC PROCEDURE



## [2] QUESTIONING

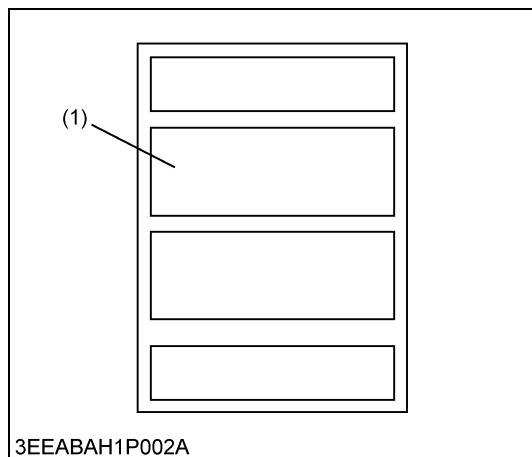
- Use the trouble check sheet to ensure that the customer's explanation is fully understood.
- Accurately judge information concerning the malfunction.  
Grasp the situation firmly, using five 5W1H (Who, What, When, Where, Why, How) as a basis.  
Ex: Low ambient temperature, starting, normal conditions, proximity to engine, metallic noise, etc.

**(Reference)**

Do not ask random questions. Ask questions that will aid in narrowing down the possible malfunctioning system while making educated guesses based on the malfunction symptoms.

**Questioning Points**

What?	Malfunction symptom
When?	Date, time, frequency of occurrence.
Where?	Field conditions
What were conditions like at the time of malfunction?	Driving conditions, operating conditions, weather.
What happened?	Type of malfunction.



**Trouble Check Sheet for WG Engines**

When the machine is received from the customer, it is necessary to verify the "malfunction symptoms" and the "generated malfunction data" with the customer. This is performed based on the trouble check sheet.

(1) Trouble Check Sheet

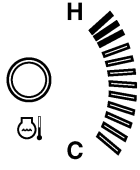
**Because:**

- The malfunction symptom may not be reproduced at the workshop.
- The customer's complaint does not always match the malfunction.
- If the person performing repairs is not working from the correct malfunction symptoms, man-hours will be wasted.

The question chart can aid the service person in diagnosing, repairing and verifying repair work.



<b>Trouble Check Sheet for WG Engines</b>				
<b>Machine details</b>				
Customer name				
Customer address				
Machine model		Machine serial number		
Engine serial number		Purchase date		
Repair date		Hourmeter indicator	hours	
<b>Warranty</b>				
Warranty Judgment	<input type="checkbox"/> Yes		<input type="checkbox"/> No	
Defective parts	<input type="checkbox"/> Injector		<input type="checkbox"/> Ignition Coil	
	<input type="checkbox"/> Fuel Filter			
	<input type="checkbox"/> Others ( )			
<b>Replace parts details</b>				
Injector	Quantity	Units	Part number	
	Serial number	Cylinder 1 ( )		Cylinder 2 ( )
		Cylinder 3 ( )		Cylinder 4 ( )
	Defective injector	<input type="checkbox"/> Injector 1		<input type="checkbox"/> Injector 2
<input type="checkbox"/> Injector 3		<input type="checkbox"/> Injector 4		
Actual part replacement	<input type="checkbox"/> Injector		<input type="checkbox"/> Ignition Coil	
	<input type="checkbox"/> Fuel Filter			
	<input type="checkbox"/> ECM		<input type="checkbox"/> Others ( )	
<b>Customer complaint</b>				
<input type="checkbox"/> 1. Engine no start	<input type="checkbox"/> a. No initial combustion		<input type="checkbox"/> b. No complete combustion	
	<input type="checkbox"/> c. No cranking			
<input type="checkbox"/> 2. Difficult to start	<input type="checkbox"/> a. Engine crank slowly			
	<input type="checkbox"/> b. Others ( )			
<input type="checkbox"/> 3. Poor idling	<input type="checkbox"/> a. Incorrect first idle		<input type="checkbox"/> b. Noise	
	<input type="checkbox"/> c. Hunting idle from ( ) to ( ) min <sup>-1</sup> (rpm)			
	<input type="checkbox"/> d. High idling ( ) min <sup>-1</sup> (rpm)			
	<input type="checkbox"/> e. Low idling ( ) min <sup>-1</sup> (rpm)			
	<input type="checkbox"/> f. Rough			
	<input type="checkbox"/> g. Others ( )			
<input type="checkbox"/> 4. Poor driveability	<input type="checkbox"/> a. Hesitation		<input type="checkbox"/> b. Surging	
	<input type="checkbox"/> c. Knocking		<input type="checkbox"/> d. Lack of power	
	<input type="checkbox"/> e. Others ( )			
<input type="checkbox"/> 5. Abnormal smoke	<input type="checkbox"/> a. Black		<input type="checkbox"/> b. White	
	<input type="checkbox"/> c. Others ( )			
<input type="checkbox"/> 6. Fuel leakage	<input type="checkbox"/> a. Large quantity		<input type="checkbox"/> b. Blurred	
	Leaking from:	<input type="checkbox"/> Injector		<input type="checkbox"/> Ignition Coil
		<input type="checkbox"/> Others ( )		
<input type="checkbox"/> 7. Engine not stop				
<input type="checkbox"/> 8. Engine stall				
<input type="checkbox"/> 9. Others				

Condition when problem occurs (Duplicated answers can be possible)		
1. Weather	<input type="checkbox"/> a. Fine	<input type="checkbox"/> b. Cloudy
	<input type="checkbox"/> c. Rainy	<input type="checkbox"/> d. Snow
	<input type="checkbox"/> e. Flood	
	<input type="checkbox"/> f. Others ( )	
2. Outdoor temperature	Approx. °C ( °F)	
3. Altitude	Approx. m	
4. Engine coolant	<input type="checkbox"/> a. Cold	Write the position of the indicator on coolant temperature gauge.  9Y1200058ENI031A
	<input type="checkbox"/> b. Warming up	
	<input type="checkbox"/> c. After warming up	
	<input type="checkbox"/> d. Any temperature	
	<input type="checkbox"/> e. Others ( )	
5. Engine operation	<input type="checkbox"/> a. Starting	<input type="checkbox"/> b. Just after starting
	<input type="checkbox"/> c. Idling	<input type="checkbox"/> d. Racing
	<input type="checkbox"/> e. Acceleration	<input type="checkbox"/> f. Deceleration
	<input type="checkbox"/> g. While at work	
	<input type="checkbox"/> h. Others ( )	
6. Problem frequency	<input type="checkbox"/> a. Constant	<input type="checkbox"/> b. Once only
	<input type="checkbox"/> c. Sometime ( Time per day/month)	
7. Engine warning light	<input type="checkbox"/> Turn on a light	<input type="checkbox"/> Turn off a light
8. Optional parts	Fill the parts in if you use optional parts or non-genuine parts for electrical, intake/exhaust and fuel system. ( )	
Dealer check		
1. Duplicate the problem	<input type="checkbox"/> a. Yes (Duplicate)	<input type="checkbox"/> b. No (Not occur)
2. Diagnosis trouble code	<input type="checkbox"/> a. Abnormal (What is code )	
	<input type="checkbox"/> b. Normal (No code)	
3. Appearance	<input type="checkbox"/> a. Normal	<input type="checkbox"/> b. Cracked
	<input type="checkbox"/> c. Discolored	
	<input type="checkbox"/> d. Others ( )	
4. Fuel condition	<input type="checkbox"/> a. Normal	
	<input type="checkbox"/> b. Abnormal ( )	

**[3] ABBREVIATIONS**

ACRONYM	DEFINITION
AC	Alternating Current
AF	Air Fuel Ratio
AL	Adaptive Learn
ATC	After Top Center
ATDC	After Top Dead Center
AVV	Air Valve Vacuum
BARO	Barometric Pressure
BAT	Battery
BHP	Brake Horse Power
BL	Block Learn
BP	Barometric Pressure
BTU	British Thermal Unit
°C	Celsius
CC	Cubic Centimeter
CAC	Charged Air Cooler
CAN	Controller Area Network
CARB	California Air Resources Board
CAT	Catalyst
CCP	CAN Calibration Protocol
CFM	Cubic Feet Per Minute
CHT	Cylinder Head Temperature
CID	Cubic Inch Displacement
CKP	Crankshaft Position Sensor
CL	Closed Loop
CMP	Camshaft Position Sensor
CNG	Compressed Natural Gas
CO	Carbon Monoxide
CO <sub>2</sub>	Carbon Dioxide
CPP	Clutch Pedal Position Sensor
CTP	Closed Throttle Position
DBW	Drive-By-Wire
DC	Direct Current
DFCO	Decel Fuel Cut Off
DFI	Direct Fuel Injection
DLC	Data Link Connector
DM	Diagnostic Message
DMM	Digital Multi-Meter (high impedance)
DST	Diagnostic Scan Tool
DTC	Diagnostic Trouble Code
DVOM	Digital Voltage and Ohm Meter (high imp.)
ECIPP	EControls Proprietary Protocol
ECM	Engine Control Module
ECT	Engine Coolant Temperature
EDIS	EControls Display and Interface Software
EGO	Exhaust Gas Oxygen Sensor
EGR	Exhaust Gas Recirculation
EI	Electronic Ignition

ACRONYM	DEFINITION
EMI	Electromagnetic Interference
EMWT	Exhaust Manifold Water Temperature
EOBD	Euro Onboard Diagnostic
EPR	Electronic Pressure Regulator
ERWT	Exhaust Manifold Riser Temperature
ETB	Electronic Throttle Body
ETC	Electronic Throttle Control
EVAP	Evaporative Emissions
°F	Fahrenheit
FC	Fan Control
FDR	Flight Data Recorder
FF	Flex Fuel
FMI	Failure Mode Indicator
FO	Firing Order
FP	Fuel Pressure
FPM	Fuel Pressure Module
FPP	Foot Pedal Position
FRP	Fuel Rail Pressure
FRT	Fuel Rail Temperature
FSS	Fault Snapshot
FT	Fuel Temperature
FT	Fuel Trim
ft. lb.	Foot Pounds
FTP	Federal Test Procedure
GCP	Global Control Platform
GEN	Generator
GND	Ground
GPM	Grams Per Mile
HC	Hydrocarbon
HVS	High Voltage Switch
HDGCP	Heavy-Duty Global Control Platform (On-Road Heavy-Duty)
HEGO	Heated Exhaust Gas Oxygen Sensor (same as HO <sub>2</sub> S)
HO <sub>2</sub> S	Heated Oxygen Sensor
HO <sub>2</sub> S1	Upstream Heated Oxygen Sensor (Pre CAT)
HO <sub>2</sub> S2	Downstream or Downstream Heated Oxygen Sensor (Pre CAT)
HP	Horsepower
IAC	Idle Air Control
IAT	Intake Air Temperature
IC	Ignition Control Circuit
ICM	Ignition Control Module
ICAV	Instant Crank Angle Velocity
ID	Inside Diameter
IFI	Indirect Fuel Injection
IGN	Ignition
IP	Instrument Panel
IPC	Instrument Panel Cluster
IVS	Idle Validation Switch
kHz	Kilohertz
Km	Kilometers

ACRONYM	DEFINITION
kPa	Kilopascals
KPH	Kilometers Per Hour
KOEC	Key On Engine Cranking
KOEO	Key On Engine Off
KOER	Key On Engine Running
KS	Knock Sensor
KV	Kilovolt
L.	Liter
lb.ft.	Pound Feet
LDGCP	Light-Duty Global Control Platform (Industrial, Smart/Logic Coil)
LED	Light Emitting Diode
LPG	Liquefied Propane Gas
LTFT	Long Term Fuel Trim
MAF	Mass Airflow Sensor
MAP	Manifold Absolute Pressure
MDGCP	Medium-Duty Global Control Platform (Industrial, Dumb Coil)
MDP	Manifold Differential Pressure
mP	Microprocessor
Mfg	Manufacture
MIL	Malfunction Indicator Lamp
mm	Millimeters
ms	Millisecond
mV	Millivolt
MPG	Miles Per Gallon
MPH	Miles Per Hour
NG	Natural Gas
Nm	Newton Meters
O <sub>2</sub>	Oxygen Sensor
OBD	On-Board Diagnostics
OBD I	On-Board Diagnostics generation one
OBD II	On-Board Diagnostics generation two
OBD III	On-Board Diagnostics generation three
OBD IV	On-Board Diagnostics generation four
OC	Oxidation Catalyst
OD	Outside Diameter
OEM	Original Equipment Manufacture
OHC	Overhead Cam
OL	Open Loop
PC	Personal Computer
PCM	Powertrain Control Module
PCU	Powertrain Control Unit
PCV	Positive Crankcase Ventilation
PFI	Port Fuel Injection
PGN	Parameter Group Number
PPM	Parts Per Million
PSA	Pressure Switch Assembly
psi	Pounds Per Square Inch
PWM	Pulse Width Modulated
RAM	Random Access Memory

ACRONYM	DEFINITION
RFI	Radio Frequency Interference
RPM	Revolutions Per Minute
Rx	Receive
SA	Source Address
SFI	Sequential Fuel Injection
SOHC	Single Overhead Cam
SPFI	Sequential Port Fuel Injection
SPN	Suspect Parameter Number
SRI	Service Reminder Indicator
SRT	System Readiness Test
Tach	Tachometer
TBI	Throttle Body Injection
TDC	Top Dead Center
TIP	Throttle Inlet Pressure
TPS1	Throttle Position Sensor One
TPS2	Throttle Position Sensor Two
TSC	Torque/Speed Control
TWC	Threeway Catalyst
TWC+OC	Threeway Catalyst + Oxidation Catalytic Converter
Tx	Transmit
UEGO	Universal Exhaust Gas Oxygen Sensor (also called wide-range EGO)
VBAT	Battery Voltage
VDC	Voltage, Direct Current
VIN	Vehicle Identification Number
VR	Variable Reluctance
VSS	Vehicle Speed Sensor
Vsw	Switched, Ignition Voltage
WGP	Waste-Gate Pressure
WOT	Wide Open Throttle

## 2. SYMPTOM CHARTS BY COMPONENTS

### [1] GASOLINE SYMPTOM CHARTS

	Important Preliminary Checks
Checks	Action
Before Using This Section	<p>Before using this section you should have performed On Board Diagnostic Checks and determined that:</p> <ul style="list-style-type: none"> <li>• The Control Module and MIL (Malfunction Indicator Lamp) are operating correctly.</li> <li>• There are no Diagnostic Trouble Codes (DTCs) stored or a DTC exists but without a MIL.</li> </ul> <p>Several of the following symptom procedures call for a careful visual and physical check. The visual and physical checks are very important. The checks can lead to correcting a problem, without further checks, that may save valuable time. Most importantly talk to the operator about the failure this may provide important information about the fault.</p>
Important Question to Ask the Operator	<ul style="list-style-type: none"> <li>• When and how did the operator first notice the fault condition</li> <li>• What engine speed and load condition did the fault occur at</li> <li>• Did the fault occur just after or before refueling</li> <li>• Did the fault occur at start up or shut down</li> <li>• Did the fault occur at a particular time of day or during the shift</li> <li>• Did the fault occur in a particular location</li> <li>• Has there been any recent repair to the engine or vehicle</li> <li>• Has the fault ever occurred before</li> <li>• Has there been any new external customer installed devices added to the vehicle and or engine</li> </ul>
Gasoline Fuel System Check	<p>Verify the customer complaint. Locate the correct symptoms table.</p> <ul style="list-style-type: none"> <li>• Check the items indicated under that symptom.</li> <li>• Operate the vehicle under the conditions the symptom occurs. Verify HEGO switching between lean and rich.</li> </ul> <p>■ <b>IMPORTANT</b></p> <ul style="list-style-type: none"> <li>• <b>Normal HEGO switching indicates the Gasoline fuel system is in closed loop and operating correctly at that time.</b></li> <li>• If a scan tool is available <b>take a snapshot</b> under the condition that the symptom occurs. Go to Engine Scan Tool Data. List to verify normal sensor values and parameters.</li> </ul>
Visual and Physical Checks	<ul style="list-style-type: none"> <li>• Check all ECM system fuses and circuit breakers.</li> <li>• Check the ECM ground for being clean, tight and in its proper location.</li> <li>• Check the vacuum hoses for splits, kinks and proper connections.</li> <li>• Check thoroughly for any type of fuel leak or restriction.</li> </ul>
	<ul style="list-style-type: none"> <li>• Check for air leaks at all the mounting areas of the intake manifold sealing surfaces.</li> <li>• Check for proper installation of the Throttle Body assembly.</li> </ul>
	<ul style="list-style-type: none"> <li>• Check for fuel leaks at the fuel rail and injectors.</li> <li>• Check the wiring for the following items:                             <ul style="list-style-type: none"> <li>– Proper connections, pinches or cuts.</li> </ul> </li> <li>• The following symptoms table contains groups of possible causes for each symptom. The order of these procedures is not important. If the scan tool readings do not indicate the problems, then proceed in a logical order easiest to check or most likely to cause first.</li> </ul>

	Intermittent
Checks	Action
DEFINITION: The problem may or may not turn ON the Malfunction Indicator Lamp (MIL), or store a Diagnostic Trouble Code (DTC).	
Preliminary Checks	<ul style="list-style-type: none"> <li>• Refer to Important Preliminary Checks.</li> <li>• Do not use the DTC tables. If a fault is an intermittent, the use of the DTC tables may result in the replacement of good parts.</li> </ul>
Faulty Electrical Connections or Wiring	<ul style="list-style-type: none"> <li>• Faulty electrical connections or wiring can cause most intermittent problems.</li> <li>• Check the suspected circuit for the following conditions: <ul style="list-style-type: none"> <li>– Check for faulty fuses or circuit breakers.</li> <li>– Check for poorly mated electrical connectors.</li> <li>– Check for connector pin and terminals not fully seated.</li> <li>– Check for terminal pin damaged or deformation.</li> <li>– Check poor soldering in the joints and connectors.</li> <li>– Check for excessive wire strain on the harness.</li> <li>– Check for burned or damaged wiring.</li> <li>– Check for recently added customer installed electrical options which may be improperly spliced into the harness assembly.</li> </ul> </li> <li>• Carefully remove all the connector terminals in the problem circuit in order to ensure the proper contact tension. If necessary, replace all the connector terminals in the problem circuit in order to ensure the proper contact tension.</li> <li>• Checking for poor terminal to wire connections requires removing the terminal from the connector body.</li> </ul>
Operational Test	If a visual and physical check does not locate the cause of the problem, drive the vehicle with a scan tool. When the problem occurs, an abnormal voltage or scan reading indicates the problem may be in that circuit.
Intermittent Malfunction Indicator Lamp (MIL)	<p>The following components can cause intermittent MIL and no DTC(s):</p> <ul style="list-style-type: none"> <li>• A defective relay Control Module driven solenoid, or a switch that can cause electrical system interference. Normally, the problem will occur when the faulty component is operating.</li> <li>• The improper installation of electrical devices, such as lights, 2-way radios, electric motors, etc.</li> <li>• The ignition secondary voltage, shorted to a ground.</li> <li>• The Malfunction Indicator Lamp (MIL) circuit or the Diagnostic Test Terminal intermittently shorted to ground.</li> <li>• The Control Module grounds.</li> </ul>
Loss of DTC Memory	<p>To check for the loss of the DTC Memory:</p> <ol style="list-style-type: none"> <li>1. Disconnect the TMAP sensor.</li> <li>2. Idle the engine until the Malfunction Indicator Lamp illuminates.</li> </ol> <p>The ECM should store a TMAP DTC. The TMAP DTC should remain in the memory, when the ignition is turned OFF. If the TMAP DTC does not store and remain, the ECM is faulty.</p>



	<b>No Start</b>
<b>Checks</b>	<b>Action</b>
DEFINITION: The engine cranks OK but does not start.	
Preliminary Checks	<ul style="list-style-type: none"> <li>• Refer to Important Preliminary Checks.</li> </ul>
Control Module Checks	<ul style="list-style-type: none"> <li>• Check the battery cranking voltage, voltage should not be less than 9.0 VDC.</li> <li>• Check the inline fuse in the ECM battery power circuit. Refer to Engine Controls Schematics.</li> <li>• Check battery power, ignition power and ground circuits to the ECM. Refer to Engine Control Schematics. Verify voltage and/or continuity for each circuit.</li> </ul>
Sensor Checks	<ul style="list-style-type: none"> <li>• Check the TMAP sensor.</li> <li>• Check the Camshaft position (CMP) and Crankshaft (CKP) position sensors.</li> <li>• Check the Gasoline pressure sensor.</li> </ul>
Fuel System Checks	<ul style="list-style-type: none"> <li>• Check for fuel pump electrical circuit.</li> <li>• Verify proper fuel pump pressure.</li> <li>• Verify proper Fuel rail pressure.</li> <li>• Refer to the Gasoline Fuel System Diagnosis.</li> <li>• Check Electrical connections at the injectors.</li> </ul>
Ignition System Checks	<ul style="list-style-type: none"> <li>• Check for the proper primary side ignition voltage output.</li> <li>• Verify that the spark plugs are correct.</li> <li>• Check the spark plugs for the following conditions:                             <ul style="list-style-type: none"> <li>– Wet plugs</li> <li>– Cracks</li> <li>– Wear</li> <li>– Improper gap</li> <li>– Burned electrodes</li> <li>– Heavy deposits</li> </ul> </li> <li>• Check for loose ignition coil connections at the coil.</li> </ul>
Engine Mechanical Checks	<ul style="list-style-type: none"> <li>• Check for the following:                             <ul style="list-style-type: none"> <li>– Vacuum leaks</li> <li>– Improper valve timing</li> <li>– Low compression</li> <li>– Bent pushrods</li> <li>– Worn rocker arms</li> <li>– Broken or weak valve springs</li> <li>– Worn camshaft lobes</li> </ul> </li> </ul>
Exhaust System Checks	<ul style="list-style-type: none"> <li>• Check the exhaust system for a possible restriction:                             <ul style="list-style-type: none"> <li>– Inspect the exhaust system for damaged or collapsed pipes.</li> <li>– Inspect the muffler for signs of heat distress, or for possible internal failure.</li> </ul> </li> <li>• Check for possible plugged catalytic converter. Refer to Restricted Exhaust System Diagnosis.</li> </ul>

	<b>Hard Start</b>
<b>Checks</b>	<b>Action</b>
DEFINITION: The engine cranks OK, but does not start for a long time. The engine does eventually run, or may start but immediately dies.	
Preliminary Checks	<ul style="list-style-type: none"> <li>• Refer to Important Preliminary Checks.</li> <li>• Make sure the vehicle's operator is using the correct starting procedure.</li> </ul>
Sensor Checks	<ul style="list-style-type: none"> <li>• Check the Throttle position (TPS) sensor.</li> <li>• Check the Camshaft position (CMP) and Crankshaft (CKP) position sensors.</li> </ul>
Fuel System Checks	<ul style="list-style-type: none"> <li>• Check for fuel pump electrical circuit.</li> <li>• Verify proper fuel pump pressure.</li> <li>• Verify proper fuel rail pressure.</li> <li>• Refer to the Gasoline Fuel System Diagnosis.</li> <li>• Check Electrical connections at the injectors.</li> </ul>
Ignition System Checks	<ul style="list-style-type: none"> <li>• Check for the proper ignition voltage output.</li> <li>• Verify that the spark plugs are correct.</li> <li>• Check the spark plugs for the following conditions: <ul style="list-style-type: none"> <li>– Wet plugs</li> <li>– Cracks</li> <li>– Wear</li> <li>– Improper gap</li> <li>– Burned electrodes</li> <li>– Heavy deposits</li> </ul> </li> <li>• Check for loose ignition, coil connections.</li> </ul> <p>■ <b>IMPORTANT</b></p> <ol style="list-style-type: none"> <li>1. <b>If the engine starts but then immediately stalls. Check the Crankshaft Position (CKP) sensor.</b></li> <li>2. <b>Check for improper gap, debris or faulty connections.</b></li> </ol>
Engine Mechanical Checks	<ul style="list-style-type: none"> <li>• Check for the following: <ul style="list-style-type: none"> <li>– Vacuum leaks</li> <li>– Improper valve timing</li> <li>– Low compression</li> <li>– Bent pushrods</li> <li>– Worn rocker arms</li> <li>– Broken or weak valve springs</li> </ul> </li> <li>• Check the intake and exhaust manifolds, for casting flash.</li> </ul>
Exhaust System Checks	<ul style="list-style-type: none"> <li>• Check the exhaust system for a possible restriction: <ul style="list-style-type: none"> <li>– Inspect the exhaust system for damaged or collapsed pipes.</li> <li>– Inspect the muffler for signs of heat distress, or for possible internal failure.</li> </ul> </li> <li>• Check for possible plugged catalytic converter. Refer to Restricted Exhaust System Diagnosis.</li> </ul>

<b>Cuts Out, Misses</b>	
<b>Checks</b>	<b>Action</b>
DEFINITION: A surging or jerking that follows engine speed, usually more pronounced as the engine load increases, which is not normally felt above 1500 RPM. The exhaust has a steady spitting sound at idle, low speed, or hard acceleration for the fuel starvation that can cause the engine to cut-out.	
Preliminary Checks	<ul style="list-style-type: none"> <li>Refer to Important Preliminary Checks.</li> </ul>
Ignition System Checks	<ul style="list-style-type: none"> <li>Start the engine.</li> <li>Wet down the secondary ignition system with water from a spray bottle and look/listen for arcing or misfiring as you apply water.</li> <li>Check for proper ignition output voltage with spark tester.</li> <li>Check for a cylinder misfire.</li> <li>Verify that the spark plugs are correct.</li> <li>Remove the spark plugs in these cylinders and check for the following conditions:                             <ul style="list-style-type: none"> <li>Insulation cracks</li> <li>Wear</li> <li>Improper gap</li> <li>Burned electrodes</li> <li>Heavy deposits</li> </ul> </li> <li>Visually/Physically inspect the secondary ignition for the following:                             <ul style="list-style-type: none"> <li>Ignition coil for cracks or carbon tracking.</li> </ul> </li> </ul>
Engine Mechanical Checks	<ul style="list-style-type: none"> <li>Perform a cylinder compression check.</li> <li>Check the engine for the following:                             <ul style="list-style-type: none"> <li>Improper valve timing</li> <li>Bent pushrods</li> <li>Worn rocker arms</li> <li>Worn camshaft lobes.</li> <li>Broken or weak valve springs.</li> </ul> </li> <li>Check the intake and exhaust manifold passages, for casting flash.</li> </ul>
Fuel System Checks	<ul style="list-style-type: none"> <li>Check the fuel system-plugged fuel filter, low fuel pressure, etc. Refer to Gasoline Fuel System Diagnosis.</li> <li>Check the condition of the wiring to the fuel pump and injectors.</li> </ul>
Additional Check	<p>Check for Electromagnetic Interference (EMI).</p> <ul style="list-style-type: none"> <li>EMI on the reference circuit can cause a missing condition.</li> <li>Monitoring the engine RPM with a scan tool, can detect an EMI.</li> <li>A sudden increase in the RPM with little change in the actual engine RPM, indicates EMI is present.</li> <li>If the problem exists, check the routing of the secondary wires and the ground circuit.</li> </ul>

<b>Hesitation, Sag, Stumble</b>	
<b>Checks</b>	<b>Action</b>
DEFINITION: The vehicle has a momentary lack of response, when depressing the accelerator. The condition can occur at any vehicle speed. The condition may cause the engine to stall, if it's severe enough.	
Preliminary Checks	Refer to Important Preliminary Checks.
Fuel System Checks	<ul style="list-style-type: none"> <li>Check the fuel pump electrical circuit.</li> <li>Verify proper fuel pump pressure.</li> <li>Verify proper fuel rail pressure.</li> <li>Refer to the Gasoline Fuel System Diagnosis.</li> <li>Check Electrical connections at the injectors.</li> </ul>
Ignition System Checks	<ul style="list-style-type: none"> <li>Check for the proper ignition voltage output.</li> <li>Verify that the spark plugs are correct.</li> <li>Check for fouled spark plugs.</li> </ul>
Additional Check	<ul style="list-style-type: none"> <li>Check for manifold vacuum or air induction system leaks.</li> <li>Check the generator output voltage.</li> </ul>

<b>Backfire</b>	
<b>Checks</b>	<b>Action</b>
<p>DEFINITION: The fuel ignites in the intake manifold, or in the exhaust system, making a loud popping noise. A backfire which is heard in the intake manifold and air stream indicates that the fuel is being ignited in the intake manifold and is a result of a spark igniting the fuel air mixture. A backfire heard in the exhaust system indicates that there is an over fueling condition or a late spark event which ignites unburned fuel in the exhaust.</p>	
Preliminary Check	<ul style="list-style-type: none"> <li>• Refer to Important Preliminary Checks.</li> </ul>
Ignition System Checks	<ul style="list-style-type: none"> <li>• Check for the proper ignition coil output voltage using a spark tester.</li> <li>• Check the connection at each ignition coil.</li> <li>• Check the spark plugs.</li> <li>• Remove the plugs and inspect them for the following conditions:                             <ul style="list-style-type: none"> <li>– Wet plugs</li> <li>– Cracks</li> <li>– Wear</li> <li>– Improper gap</li> <li>– Burned electrodes</li> <li>– Heavy deposits</li> </ul> </li> </ul>
Engine Mechanical Check	<ul style="list-style-type: none"> <li>• Check the engine for the following:                             <ul style="list-style-type: none"> <li>– Improper valve timing</li> <li>– Engine compression</li> <li>– Manifold vacuum leaks</li> <li>– Intake manifold gaskets</li> <li>– Sticking or leaking valves</li> <li>– Exhaust system leakage</li> </ul> </li> <li>• Check the intake and exhaust system for casting flash or other restrictions.</li> </ul>
Fuel System Checks	<ul style="list-style-type: none"> <li>• Perform a fuel system diagnosis. Refer to Gasoline Fuel System Diagnosis.</li> </ul>

<b>Lack of Power, Sluggishness, or Sponginess</b>	
<b>Checks</b>	<b>Action</b>
<p>DEFINITION: The engine delivers less than expected power. There is little or no increase in speed when partially applying the accelerator pedal.</p>	
Preliminary Checks	<ul style="list-style-type: none"> <li>• Refer to Important Preliminary Checks.</li> <li>• Refer to the Gasoline Fuel system OBD System Check.</li> <li>• Compare the customer's vehicle with a similar unit. Make sure the customer has an actual problem.</li> <li>• Remove the air filter and check for dirt or restriction.</li> <li>• Check the vehicle transmission. Refer to the OEM transmission diagnostics.</li> </ul>
Fuel System Checks	<ul style="list-style-type: none"> <li>• Check for a restricted fuel filter, contaminated fuel, or improper fuel pressure. Refer to Gasoline Fuel System Diagnosis.</li> <li>• Check for the proper ignition output voltage, with the spark tester.</li> <li>• Check the fuel pump electrical circuit.</li> <li>• Verify proper fuel pump pressure.</li> <li>• Verify proper fuel rail pressure.</li> <li>• Refer to the Gasoline Fuel System Diagnosis.</li> <li>• Check electrical connections at the injectors.</li> </ul>
Sensor Checks	<ul style="list-style-type: none"> <li>• Check the Heated Exhaust Gas Oxygen Sensor (HEGO) for contamination and performance.</li> <li>• Check for proper operation of the MAP sensor.</li> <li>• Check for proper operation of the TPS sensor.</li> </ul>
Exhaust System Checks	<ul style="list-style-type: none"> <li>• Check the exhaust system for a possible restriction:                             <ul style="list-style-type: none"> <li>– Inspect the exhaust system for damaged or collapsed pipes.</li> <li>– Inspect the muffler for signs of heat distress or for possible internal failure.</li> <li>– Check for possible plugged catalytic converter.</li> </ul> </li> </ul>
Engine Mechanical Check	<ul style="list-style-type: none"> <li>• Check the engine for the following:                             <ul style="list-style-type: none"> <li>– Engine compression</li> <li>– Valve timing</li> <li>– Improper or worn camshaft. Refer to Engine Mechanical.</li> </ul> </li> </ul>
Additional Check	<ul style="list-style-type: none"> <li>• Check the ECM grounds for being clean, tight, and in their proper locations.</li> <li>• Check the generator output voltage.</li> <li>• If all procedures have been completed, and no malfunction has been found, review and inspect the following items:                             <ul style="list-style-type: none"> <li>– Visually and physically inspect all electrical connections within the suspected circuit and/or systems.</li> <li>– Check the brake system for sticking or dragging brakes.</li> </ul> </li> </ul>

<b>Poor Fuel Economy</b>	
<b>Checks</b>	<b>Action</b>
DEFINITION: Fuel economy, as measured by refueling records is noticeably lower than expected. Also, the economy is noticeably lower, than it was on this vehicle at one time as previously shown by refueling records.	
Preliminary Checks	<ul style="list-style-type: none"> <li>• Refer to Important Preliminary Checks.</li> <li>• Check the air cleaner element (filter) for dirt or being plugged.</li> <li>• Visually (Physically) check the vacuum hoses for splits, kinks and proper connections.</li> <li>• Check the operators driving habits for the following items:               <ul style="list-style-type: none"> <li>– Is there excessive idling or stop and go driving</li> <li>– Are the tires at the correct air pressure</li> <li>– Are excessively heavy loads being carried</li> <li>– Is there often rapid acceleration</li> </ul> </li> <li>• Suggest to the owner to fill the fuel tank and to recheck the fuel economy.</li> <li>• Suggest that a different operator use the equipment and record the results.</li> </ul>
Fuel System Checks	<ul style="list-style-type: none"> <li>• Check the fuel Rail pressure. Refer to Gasoline Fuel System Diagnosis.</li> <li>• Check the fuel system for leakage.</li> </ul>
Sensor Checks	<ul style="list-style-type: none"> <li>• Check the Temperature Manifold Absolute Pressure (TMAP) sensor.</li> </ul>
Ignition System Checks	<ul style="list-style-type: none"> <li>• Verify that the spark plugs are correct.</li> <li>• Check the spark plugs. Remove the plugs and inspect them for the following conditions:               <ul style="list-style-type: none"> <li>– Wet plugs</li> <li>– Cracks</li> <li>– Wear</li> <li>– Improper gap</li> <li>– Burned electrodes</li> <li>– Heavy deposits</li> </ul> </li> </ul>
Cooling System Checks	<ul style="list-style-type: none"> <li>• Check the engine thermostat for always being open or for the wrong heat range.</li> </ul>
Engine Mechanical Check	<ul style="list-style-type: none"> <li>• Check the engine for the following:               <ul style="list-style-type: none"> <li>– Engine compression</li> <li>– Valve timing</li> <li>– Improper or worn camshaft. Refer to Engine Mechanical, in the Service Manual.</li> </ul> </li> </ul>
Additional Check	<ul style="list-style-type: none"> <li>• Check the transmission shift pattern. Refer to the OEM Transmission Controls section in their Service Manual.</li> <li>• Check for dragging brakes.</li> </ul>

<b>Rough, Unstable or Incorrect Idle or Stalling</b>	
<b>Checks</b>	<b>Action</b>
DEFINITION: The engine runs unevenly at idle. If severe enough, the engine or vehicle may shake. The engine idle speed may vary in RPMs. Either condition may be severe enough to stall the engine.	
Preliminary Check	<ul style="list-style-type: none"> <li>• Refer to Important Preliminary Checks.</li> </ul>
Sensor Checks	<ul style="list-style-type: none"> <li>• Check for silicon contamination from fuel or improperly used sealant. The sensor will have a white powdery coating. The sensor will result in a high but false, signal voltage (rich exhaust indication). The ECM will reduce the amount of fuel delivered to the engine causing a severe drivability problem.</li> <li>• Check the Heated Exhaust Gas Oxygen Sensor (HEGO) performance.</li> <li>• Check the Temperature Manifold Absolute Pressure (TMAP) sensor response and accuracy.</li> </ul>
Fuel System Checks	<ul style="list-style-type: none"> <li>• Check for rich or lean symptoms that causes the condition. Drive the vehicle at the speed of the complaint. Monitoring the oxygen sensors will help identify the problem.</li> <li>• Verify proper operation of the injectors.</li> <li>• Perform a cylinder compression test. Refer to Engine Mechanical in the Service Manual.</li> <li>• Check the fuel Rail pressure. Refer to the Gasoline Fuel System Diagnosis.</li> <li>• Check injector electrical connections.</li> </ul>
Ignition System Checks	<ul style="list-style-type: none"> <li>• Check for the proper ignition output voltage using the spark tester.</li> <li>• Verify that the spark plugs are correct.</li> <li>• Check the spark plugs. Remove the plugs and inspect them for the following conditions: <ul style="list-style-type: none"> <li>– Wet plugs</li> <li>– Cracks</li> <li>– Wear</li> <li>– Improper gap</li> <li>– Burned electrodes</li> <li>– Blistered insulators</li> <li>– Heavy deposits</li> </ul> </li> </ul>
Additional Checks	<ul style="list-style-type: none"> <li>• Check the ECM grounds for being clean, tight and in their proper locations.</li> <li>• Check the battery cables and ground straps. They should be clean and secure. Erratic voltage may cause all sensor readings to be skewed, resulting in poor idle quality.</li> </ul>
Engine Mechanical Check	<ul style="list-style-type: none"> <li>• Check the engine for the following: <ul style="list-style-type: none"> <li>– Broken motor mounts</li> <li>– Improper valve timing</li> <li>– Low compression</li> <li>– Bent pushrods</li> <li>– Worn rocker arms</li> <li>– Broken or weak valve springs</li> <li>– Worn camshaft lobes</li> </ul> </li> </ul>

<b>Surges/Chuggles</b>	
<b>Checks</b>	<b>Action</b>
DEFINITION: The engine has a power variation under a steady throttle or cruise. The vehicle feels as if it speeds up and slows down with no change in the accelerator pedal.	
Preliminary Checks	<ul style="list-style-type: none"> <li>• Refer to Important Preliminary Checks.</li> <li>• Be sure the driver understands "the Torque Converter Clutch operation"</li> </ul>
Sensor Checks	Check the Heated Exhaust Gas Oxygen Sensor (HEGO), performance.
Fuel System Checks	<ul style="list-style-type: none"> <li>• Check for Rich or Lean symptom that causes the condition. Drive the vehicle at the speed of the complaint. Monitoring the oxygen sensors will help identify the problem.</li> <li>• Check the fuel rail pressure while the condition exists. Refer to Gasoline Fuel System Diagnosis.</li> <li>• Verify check injector electrical connections.</li> <li>• Check the in-line fuel filter for restrictions.</li> </ul>
Ignition System Checks	<ul style="list-style-type: none"> <li>• Check for the proper ignition output voltage using the spark tester.</li> <li>• Verify that the spark plugs are correct.</li> <li>• Check the spark plugs. Remove the plugs and inspect them for the following conditions:                             <ul style="list-style-type: none"> <li>– Wet plugs</li> <li>– Cracks</li> <li>– Wear</li> <li>– Improper gap</li> <li>– Burned electrodes</li> <li>– Heavy deposits</li> </ul> </li> <li>• Check the Crankshaft Position (CKP) sensor.</li> </ul>
Additional Check	<ul style="list-style-type: none"> <li>• Check the ECM grounds for being clean, tight and in their proper locations.</li> <li>• Check the generator output voltage.</li> <li>• Check the vacuum hoses for kinks or leaks.</li> <li>• Check Transmission.</li> </ul>

## [2] LPG / NATURAL GAS SYMPTOM CHARTS

	<b>Important Preliminary Checks</b>
<b>Checks</b>	<b>Action</b>
<p>Before Using This Section</p>	<p>Before using this section, you should have performed On Board Diagnostic Check and determined that:</p> <ul style="list-style-type: none"> <li>• The Control Module and MIL (Malfunction Indicator Lamp) are operating correctly.</li> <li>• There are no Diagnostic Trouble Codes (DTCs) stored, or a DTC exists, but without a MIL.</li> </ul> <p>Several of the following symptom procedures call for a careful visual and physical check. The visual and physical checks are very important. The checks can lead to correcting a problem, without further checks, that may save valuable time. Most importantly talk to the operator about the failure this may provide important information about the fault.</p>
<p>Important Question to Ask the Operator</p>	<ul style="list-style-type: none"> <li>• When and how did the operator first notice the fault condition</li> <li>• What engine speed and load condition did the fault occur at</li> <li>• Did the fault occur just after or before refueling</li> <li>• Did the fault occur at start up or shut down</li> <li>• Did the fault occur at a particular time of day or during the shift</li> <li>• Did the fault occur in a particular location</li> <li>• Has there been any recent repair to the engine or vehicle</li> <li>• Has the fault ever occurred before</li> <li>• Has there been any new external customer installed devices added to the vehicle and or engine</li> </ul>
<p>LPG / Natural Gas Fuel System Check</p>	<ul style="list-style-type: none"> <li>• Verify the customer complaint.</li> <li>• Locate the correct symptom table.</li> <li>• Check the items indicated, under that symptom.</li> <li>• Operate the vehicle, under the condition the symptoms occurs. Verify HEGO is switching between lean and rich.</li> </ul> <p>■ <b>IMPORTANT</b></p> <ul style="list-style-type: none"> <li>• <b>Normal HEGO switching, indicates the LPG / natural gas fuel system is in closed loop, and operating correctly at that time.</b></li> <li>• If a scan tool is available, <b>take a snapshot</b>, under the condition that the symptom occurs. Go to Engine Scan Tool Data List, to verify normal sensor values and parameters.</li> </ul>
<p>Visual and Physical Checks</p>	<ul style="list-style-type: none"> <li>• Check all ECM system fuses and/or circuit breakers.</li> <li>• Check the ECM ground for being clean, tight, and in its proper location.</li> <li>• Check the vacuum hoses for splits, kinks, and proper connections.</li> <li>• Check thoroughly for any type of leak or restriction.</li> <li>• Check for air leaks, at all the mounting areas, of the intake manifold sealing surfaces.</li> <li>• Check for proper installation of the mixer module assembly.</li> <li>• Check for air leaks, at the mixer assembly.</li> <li>• Check the wiring, for the following items:                         <ul style="list-style-type: none"> <li>– Proper connections, pinches, or cuts.</li> </ul> </li> <li>• Check the fuel level and fuel delivery system for leaks</li> <li>• Check the battery condition</li> </ul> <p>The following symptom tables contain groups of possible causes, for each symptom. The order of these procedures is not important. If the scan tool readings do not indicate the problems, then proceed in a logical order, easiest to check, or most likely to occur first.</p>



	Intermittent
Checks	Action
DEFINITION: The problem may or may not turn ON the Malfunction Indicator Lamp (MIL), or store a Diagnostic Trouble Code (DTC).	
Preliminary Checks	<ul style="list-style-type: none"> <li>• Refer to Important Preliminary Checks.</li> <li>• Do not use the DTC tables, if a fault is an intermittent, the use of the DTC tables may result in the replacement of good parts.</li> </ul>
Faulty Electrical Connections, or Wiring	<ul style="list-style-type: none"> <li>• Faulty electrical connections, or wiring, can cause most intermittent problems.</li> <li>• Check the suspected circuit for the following conditions:                             <ul style="list-style-type: none"> <li>– Faulty fuse, or circuit breaker</li> <li>– Connectors poorly mated</li> <li>– Corrosion or loose pins in the connectors</li> <li>– Terminals not fully seated, in the connector (backed out)</li> <li>– Terminals not properly formed, or damaged</li> <li>– Terminal to wire joints poorly connected</li> <li>– Terminal tension, insufficient</li> <li>– Wire strain from improper wire routing</li> <li>– Burned or damaged wires from contacting hot surfaces or rotating devices</li> </ul> </li> <li>• Improper splicing method used when optional equipment is installed to the vehicle.</li> <li>• Carefully remove all the connector terminals in the problem circuit, in order to ensure the proper contact tension. If necessary, replace all the connector terminals in the problem circuit, in order to ensure the proper contact tension.</li> <li>• Checking for poor terminal, to wire connections, requires removing the terminal from the connector body.</li> </ul>
Operational Test	If a visual and physical check does not locate the cause of the problem, drive the vehicle with a scan tool. When the problem occurs, an abnormal voltage or scan reading indicates the problem may be in that circuit.
Intermittent Malfunction Indicator Lamp (MIL)	<p>The following components can cause intermittent MIL, and no DTC(s):</p> <ul style="list-style-type: none"> <li>• A defective relay Control Module driven solenoid, or a switch that can cause electrical system interference. Normally, the problem will occur when the faulty component is operating.</li> <li>• The improper installation of electrical devices, such as lights, 2-way radios, electric motors, etc.</li> <li>• The ignition, secondary voltage, is shorted to a ground.</li> <li>• The Malfunction Indicator Lamp (MIL) circuit, or the Diagnostic Test Terminal, is intermittently shorted to ground.</li> <li>• The Control Module grounds.</li> </ul>
Loss of DTC Memory	<p>To check for the loss of the DTC Memory:</p> <ol style="list-style-type: none"> <li>1. Disconnect the TMAP sensor.</li> <li>2. Idle the engine, until the Malfunction Indicator Lamp illuminates.</li> </ol> <p>The ECM should store a TMAP DTC. The TMAP DTC should remain in the memory, when the ignition is turned OFF. If the TMAP DTC does not store and remains, the ECM is faulty.</p>
Additional Checks	

	<b>No Start</b>
<b>Checks</b>	<b>Action</b>
DEFINITION: The engine cranks OK, but does not start.	
Preliminary Checks	<ul style="list-style-type: none"> <li>• Refer to Important Preliminary Checks.</li> </ul>
Battery and Voltage Check	<ul style="list-style-type: none"> <li>• Check the battery charge condition.</li> <li>• Check the battery cranking voltage, voltage less the 9.00 V are outside the parameters of operation.</li> <li>• Check Battery positive and negative cable ends for corrosion build up.</li> </ul>
Control Module Checks	<ul style="list-style-type: none"> <li>• Check the inline fuse in the ECM battery power circuit. Refer to Engine Controls Schematics.</li> <li>• Check battery power, ignition power, and ground circuits, to the ECM. Refer to Engine Control Schematics. Verify voltage and/or continuity, for each circuit.</li> </ul>
Sensor Checks	<ul style="list-style-type: none"> <li>• Crank sensor.</li> <li>• Cam sensor.</li> </ul>
Fuel System Checks	<ul style="list-style-type: none"> <li>■ <b>IMPORTANT</b></li> <li>• <b>A closed LPG / natural gas manual fuel shut off valve, will create a no start condition. Check the fuel supply line connection to ensure the Excess flow check valve has not set</b></li> <li>• Check for air intake system leakage, between the mixer and the throttle body.</li> <li>• Verify proper operation, of the low pressure lock-off solenoids.</li> <li>• Fuel filter plugging.</li> <li>• Check the fuel system pressures. Refer to the LPG / Natural Gas Fuel System Diagnosis.</li> <li>• Check the low pressure fuel supply hose for restrictions and or blockage.</li> <li>• Check for restrictions in the air intake system.</li> <li>• Check for large vacuum leaks in the intake system.</li> <li>• Check for proper mixer air valve operation.</li> <li>• Check for exhaust pipe or catalyst restrictions.</li> </ul>
Ignition System Checks	<ul style="list-style-type: none"> <li>■ <b>NOTE</b></li> <li>• <b>LPG / natural gas, being a gaseous fuel, requires higher secondary ignition system voltages, for the equivalent gasoline operating conditions.</b></li> <li>• Check for the proper ignition voltage output.</li> <li>• Verify that the spark plugs are correct, for use with LPG / natural gas.</li> <li>• Check the spark plugs, for the following conditions:                             <ul style="list-style-type: none"> <li>– Wet plugs</li> <li>– Cracks</li> <li>– Wear</li> <li>– Improper gap</li> <li>– Burned electrodes</li> <li>– Heavy deposits</li> </ul> </li> <li>• Check for loose ignition, coil connections, at the coil.</li> </ul>
Engine Mechanical Checks	<ul style="list-style-type: none"> <li>■ <b>IMPORTANT</b></li> <li>• <b>The LPG / Natural Gas Fuel system works on a fumigation principle, of fuel introduction, and is more sensitive, to intake manifold leakage, than the gasoline fuel supply system.</b></li> <li>• Check for the following:                             <ul style="list-style-type: none"> <li>– Vacuum leaks</li> <li>– Improper valve timing</li> <li>– Low compression</li> <li>– Bent pushrods</li> <li>– Worn rocker arms</li> <li>– Broken, or weak valve springs</li> <li>– Worn camshaft lobes</li> </ul> </li> </ul>
Exhaust System Checks	<ul style="list-style-type: none"> <li>• Check the exhaust system, for a possible restriction:</li> <li>• Inspect the exhaust system, for damaged or collapsed pipes.</li> <li>• Inspect the muffler, for signs of heat distress, or for possible internal failure.</li> <li>• Check for, possible, plugged catalytic converter. Refer to Restricted Exhaust System Diagnosis.</li> </ul>

	Hard Start
Checks	Action
DEFINITION: The engine cranks OK, but does not start for a long time. The engine does eventually run, or may start, but immediately dies.	
Preliminary Checks	<ul style="list-style-type: none"> <li>• Refer to Important Preliminary Checks.</li> <li>• Make sure the vehicle's operator is using the correct starting procedure.</li> <li>• Be sure that there is fuel in the fuel tank.</li> <li>• Check to make sure the manual tank valve is fully open.</li> </ul>
Sensor Checks	<ul style="list-style-type: none"> <li>• Check the Crankshaft Position (CKP) sensor.</li> <li>• Check the Camshaft sensor.</li> </ul>
Fuel System Checks	<ul style="list-style-type: none"> <li>■ <b>IMPORTANT</b></li> <li>• <b>A closed LPG / natural gas manual fuel shut off valve will create an extended crank, OR no start condition.</b></li> <li>• Verify the excess flow valve, in the LPG / natural gas manual shut-off valve, is not tripped.</li> <li>• Check mixer module assembly, for proper installation and leakage.</li> <li>• Verify proper operation, of the low pressure lock-off solenoids.</li> <li>• Check for air intake system leakage, between the mixer and the throttle body.</li> <li>• Check the fuel system pressures. Refer to the Fuel System Diagnosis.</li> </ul>
Ignition System Checks	<ul style="list-style-type: none"> <li>■ <b>NOTE</b></li> <li>• <b>LPG / natural gas, being a gaseous fuel, requires higher, secondary ignition system voltages, for the equivalent gasoline operating conditions.</b></li> <li>• Check for the proper ignition voltage output</li> <li>• Verify that the spark plugs are correct, for use with LPG / natural gas.</li> <li>• Check the spark plugs, for the following conditions:                         <ul style="list-style-type: none"> <li>– Wet plugs</li> <li>– Cracks</li> <li>– Wear</li> <li>– Improper gap</li> <li>– Burned electrodes</li> <li>– Heavy deposits</li> </ul> </li> <li>• Check for loose ignition coil connections.</li> <li>■ <b>IMPORTANT</b></li> <li>1. <b>If the engine starts, but then immediately stalls, check Crankshaft Position (CKP).</b></li> <li>2. <b>Check for improper gap, debris, or faulty connections.</b></li> </ul>
Engine Mechanical Checks	<ul style="list-style-type: none"> <li>■ <b>IMPORTANT</b></li> <li>• <b>The LPG / Natural Gas Fuel system, works on a fumigation principle of fuel introduction, and is more sensitive to intake manifold leakage, than the gasoline fuel supply system.</b></li> <li>• Check for the following:                         <ul style="list-style-type: none"> <li>– Vacuum leaks</li> <li>– Improper valve timing</li> <li>– Low compression</li> <li>– Bent pushrods</li> <li>– Worn rocker arms</li> <li>– Broken or weak valve springs</li> <li>– Worn camshaft lobes. Refer to Workshop Manual</li> </ul> </li> <li>• Check the intake and exhaust manifolds, for casting flash.</li> </ul>
Exhaust System Checks	<ul style="list-style-type: none"> <li>• Check the exhaust system for a possible restriction:</li> <li>• Inspect the exhaust system, for damaged or collapsed pipes.</li> <li>• Inspect the muffler, for signs of heat distress, or for possible internal failure.</li> <li>• Check for possible, plugged, catalytic converter. Refer to Restricted Exhaust System Diagnosis.</li> </ul>
Additional Checks	

	<b>Cuts Out, Misses</b>
<b>Checks</b>	<b>Action</b>
DEFINITION: A surging or jerking, that follows engine speed, usually more pronounced as the engine load increases, which is not normally felt, above 1500 RPM. The exhaust has a steady spitting sound at idle, low speed, or hard acceleration, for the fuel starvation, that can cause the engine to cut-out.	
Preliminary Checks	<ul style="list-style-type: none"> <li>• Refer to Important Preliminary Checks.</li> <li>• Check the battery condition.</li> <li>• Check the positive and negative cable connections.</li> <li>• Check the ECM and system grounds for corrosion at the connectors.</li> <li>• Check the coil electrical connections.</li> <li>• Check the air filter for restriction.</li> </ul>
Ignition System Checks	<ul style="list-style-type: none"> <li>• Start the engine.</li> <li>• Check for proper ignition output voltage, with spark tester.</li> <li>• Check for a cylinder misfire.</li> <li>• Verify that the spark plugs are correct for use, with LPG / natural gas.</li> <li>• Remove the spark plugs and check for the following conditions: <ul style="list-style-type: none"> <li>– Insulation cracks</li> <li>– Wear</li> <li>– Improper gap</li> <li>– Burned electrodes</li> <li>– Heavy deposits</li> </ul> </li> <li>• Visually/Physically inspect the secondary ignition, for the following: <ul style="list-style-type: none"> <li>– Ignition coils, for cracks or carbon tracking.</li> </ul> </li> <li>• Wet down the secondary ignition system with water from a spray bottle and look / listen for arcing or misfiring as you apply water.</li> </ul>
Engine Mechanical Checks	<ul style="list-style-type: none"> <li>• Perform a cylinder compression check.</li> <li>• Check the engine for the following: <ul style="list-style-type: none"> <li>– Improper valve timing</li> <li>– Bent pushrods</li> <li>– Worn rocker arms</li> <li>– Worn camshaft lobes.</li> <li>– Broken or weak valve springs.</li> </ul> </li> <li>• Check the intake and exhaust manifold passages, for casting flash.</li> </ul>
Fuel System Checks	<ul style="list-style-type: none"> <li>• Check the fuel system-plugged fuel filter, low fuel pressure, etc. Refer to LPG / Natural Gas Fuel System Diagnosis.</li> <li>• Check the condition of the wiring, to the low pressure lock-off solenoid.</li> <li>• Check the DEPR wire harness connection at the DEPR.</li> <li>• Check the VSW electrical connection to make sure it is fully seated and locked.</li> </ul>
Additional Check	<p>Check for Electromagnetic Interference (EMI).</p> <ul style="list-style-type: none"> <li>• EMI on the reference circuit can cause a missing condition.</li> <li>• Monitoring the engine RPM, with a scan tool, can detect an EMI.</li> <li>• A sudden increase, in the RPM, with little change in the actual engine RPM, indicates EMI is present.</li> <li>• If the problem exists, check the routing of the secondary wires, and the ground circuit.</li> <li>• Check for secondary electrical equipment improperly spliced into the engine electrical system.</li> </ul>

<b>Hesitation, Sag, Stumble</b>	
<b>Checks</b>	<b>Action</b>
DEFINITION: The vehicle has a momentary lack of response when depressing the accelerator. The condition can occur at any vehicle speed. The condition may cause the engine to stall if it's severe enough.	
Preliminary Checks	<ul style="list-style-type: none"> <li>• Refer to Important Preliminary Checks.</li> <li>• Check the battery condition.</li> <li>• Check the positive and negative cable connections.</li> <li>• Check the ECM and system grounds for corrosion at the connectors.</li> <li>• Check the coil electrical connections.</li> <li>• Check the air filter for restriction.</li> </ul>
Fuel System Checks	<ul style="list-style-type: none"> <li>• Check the fuel pressure. Refer to LPG / Natural Gas Fuel System Diagnosis.</li> <li>• Check for low fuel pressure, during a moderate, or full throttle acceleration. If the fuel pressure drops below specification, there is a possibility of a faulty low pressure regulator, or a restriction, in the fuel system.</li> <li>• Check the Manifold Absolute Pressure (MAP) sensor response and accuracy.</li> <li>• Check LPL electrical connection.</li> <li>• Check the mixer air valve for sticking or binding.</li> <li>• Check the mixer module assembly, for proper installation and leakage.</li> </ul>
Ignition System Checks	<p>■ <b>NOTE</b></p> <ul style="list-style-type: none"> <li>• <b>LPG / natural gas, being a gaseous fuel, requires higher secondary ignition system voltages, for the equivalent gasoline operating conditions. If a problem is reported on LPG / natural gas, and not gasoline, do not discount the possibility of a LPG / natural gas only, ignition system failure, and test the system accordingly.</b></li> <li>• Check for proper ignition output voltage, with spark tester.</li> <li>• Verify that the spark plugs are correct, for use with LPG / natural gas.</li> <li>• Check for fouled spark plugs.</li> </ul>
Additional Check	<ul style="list-style-type: none"> <li>• Check for manifold vacuum, or air induction, system leaks.</li> <li>• Check the generator, output voltage.</li> </ul>

<b>Backfire</b>	
<b>Checks</b>	<b>Action</b>
DEFINITION: The fuel ignites in the intake manifold, or in the exhaust system, making a loud popping noise.	
Preliminary Check	<ul style="list-style-type: none"> <li>• Refer to Important Preliminary Checks.</li> </ul>
Ignition System Checks	<p>■ <b>IMPORTANT</b></p> <ul style="list-style-type: none"> <li>• <b>LPG / natural gas, being a gaseous fuel, requires higher secondary ignition system voltages, for the equivalent gasoline operating conditions. The ignition system must be maintained in peak condition, to prevent backfire.</b></li> <li>• Check for the proper ignition coil output voltage, using the spark tester.</li> <li>• Check the connection, at each ignition coil.</li> <li>• Check the spark plugs.</li> <li>• Remove the plugs, and inspect them, for the following conditions:                         <ul style="list-style-type: none"> <li>– Wet plugs</li> <li>– Cracks</li> <li>– Wear</li> <li>– Improper gap</li> <li>– Burned electrodes</li> <li>– Heavy deposits</li> </ul> </li> </ul>
Engine Mechanical Check	<p>■ <b>IMPORTANT</b></p> <ul style="list-style-type: none"> <li>• <b>The LPG / Natural Gas Fuel system, works on a fumigation principle, of fuel introduction, and is more sensitive to intake manifold leakage, than a gasoline fuel supply system.</b></li> <li>• Check the engine for the following:                         <ul style="list-style-type: none"> <li>– Improper valve timing</li> <li>– Engine compression</li> <li>– Manifold vacuum leaks</li> <li>– Intake manifold gaskets</li> <li>– Sticking or leaking valves</li> <li>– Exhaust system leakage</li> </ul> </li> <li>• Check the intake and exhaust system, for casting flash or other restrictions.</li> </ul>
Fuel System Checks	<ul style="list-style-type: none"> <li>• Perform a fuel system diagnosis. Refer to LPG / Natural Gas Fuel System Diagnosis.</li> </ul>

<b>Lack of Power, Sluggishness, or Sponginess</b>	
<b>Checks</b>	<b>Action</b>
DEFINITION: The engine delivers less than expected power. There is little or no increase in speed, when partially applying the accelerator pedal.	
Preliminary Checks	<ul style="list-style-type: none"> <li>• Refer to Important Preliminary Checks.</li> <li>• Refer to the LPG / Natural Gas Fuel system, OBD System Check.</li> <li>• Compare the customer's vehicle, with a similar unit. Make sure the customer has an actual problem. Do not compare the power output, of the vehicle operating on LPG / natural gas, to a vehicle operating on gasoline, as the fuels do have different drive feel characteristics.</li> <li>• Remove the air filter, and check for dirt or restriction.</li> <li>• Check the vehicle transmission. Refer to the OEM transmission diagnostics.</li> <li>• Verify the fuel tank has fuel.</li> </ul>
Fuel System Checks	<ul style="list-style-type: none"> <li>• Check for a restricted fuel filter, contaminated fuel, or improper fuel pressure. Refer to LPG / Natural Gas Fuel System Diagnosis.</li> <li>• Check for the proper ignition output voltage, with the spark tester.</li> <li>• Check for proper installation, of the mixer module assembly.</li> <li>• Check all air inlet ducts, for condition and proper installation.</li> <li>• Check for fuel leaks, between the DSR, and the mixer.</li> <li>• Verify that the LPG / natural gas tank manual shut-off valve is fully open.</li> <li>• Verify that liquid fuel (not vapor) is being delivered to the DSR.</li> </ul>
Sensor Checks	<ul style="list-style-type: none"> <li>• Check the Heated Exhaust Gas Oxygen Sensor (HEGO), for contamination and performance.</li> <li>• Check for proper operation of the MAP sensor.</li> <li>• Check for proper operation of the TPS sensor.</li> </ul>
Exhaust System Checks	<ul style="list-style-type: none"> <li>• Check the exhaust system, for a possible restriction:</li> <li>• Inspect the exhaust system, for damaged or collapsed pipes.</li> <li>• Inspect the muffler, for signs of heat distress, or for possible internal failure.</li> <li>• Check for possible plugged catalytic converter.</li> </ul>
Engine Mechanical Check	<ul style="list-style-type: none"> <li>• Check the engine for the following: <ul style="list-style-type: none"> <li>– Engine compression</li> <li>– Valve timing</li> </ul> </li> <li>• Improper or worn camshaft. Refer to Engine Mechanical, in the Service Manual.</li> </ul>
Additional Check	<ul style="list-style-type: none"> <li>• Check the ECM grounds, for being clean, tight, and in their proper locations.</li> <li>• Check the generator output voltage.</li> <li>• Visually and physically, inspect all electrical connections, within the suspected circuit and/or systems.</li> <li>• Check the scan tool data.</li> </ul>

<b>Poor Fuel Economy</b>	
<b>Checks</b>	<b>Action</b>
DEFINITION: Fuel economy, as measured by refueling records, is noticeably lower than expected. Also, the economy is noticeably lower, than it was on this vehicle at one time, as previously shown by refueling records.	
Preliminary Checks	<ul style="list-style-type: none"> <li>• Refer to Important Preliminary Checks.</li> <li>• Check the air cleaner element (filter), for dirt or being plugged.</li> <li>• Visually (Physically) check the vacuum hoses, for splits, kinks, and proper connections.</li> <li>• Check the operators driving habits, for the following items:                             <ul style="list-style-type: none"> <li>– Is there excessive idling, or stop and go driving?</li> <li>– Are the tires at the correct air pressure?</li> <li>– Are excessively heavy loads being carried?</li> <li>– Is their often rapid acceleration?</li> </ul> </li> <li>• Suggest to the owner, to fill the fuel tank, and to recheck the fuel economy.</li> <li>• Suggest that a different operator, use the equipment and record the results.</li> </ul>
Fuel System Checks	<ul style="list-style-type: none"> <li>• Check the DSR fuel pressure. Refer to LPG / Natural Gas Fuel System Diagnosis.</li> <li>• Check the fuel system for leakage.</li> </ul>
Sensor Checks	<ul style="list-style-type: none"> <li>• Check the Temperature Manifold Absolute Pressure (TMAP) sensor.</li> </ul>
Ignition System Checks	<ul style="list-style-type: none"> <li>• Verify that the spark plugs are correct, for use with LPG / natural gas. Check the spark plugs. Remove the plugs, and inspect them, for the following conditions:                             <ul style="list-style-type: none"> <li>– Wet plugs</li> <li>– Cracks</li> <li>– Wear</li> <li>– Improper gap</li> <li>– Burned electrodes</li> <li>– Heavy deposits</li> </ul> </li> </ul>
Cooling System Checks	<ul style="list-style-type: none"> <li>• Check the engine thermostat, for always being open, or for the wrong heat range.</li> </ul>
Engine Mechanical Check	<ul style="list-style-type: none"> <li>• Check the engine for the following:                             <ul style="list-style-type: none"> <li>– Engine compression</li> <li>– Valve timing</li> </ul> </li> <li>• Improper or worn camshaft. Refer to Engine Mechanical, in the Service Manual.</li> </ul>
Additional Check	<ul style="list-style-type: none"> <li>• Check the transmission shift pattern. Refer to the OEM Transmission Controls section of the Service Manual.</li> <li>• Check for dragging brakes.</li> </ul>





	<b>Surges/Chuggles</b>
<b>Checks</b>	<b>Action</b>
DEFINITION: The engine has a power variation, under a steady throttle or cruise. The vehicle feels as if it speeds up and slows down, with no change in the accelerator pedal.	
Preliminary Checks	<ul style="list-style-type: none"> <li>• Refer to Important Preliminary Checks.</li> <li>• Be sure the driver understands the Torque Converter Clutch operation.</li> </ul>
Sensor Checks	Check the Heated Exhaust Gas Oxygen Sensor (HEGO) performance.
Fuel System Checks	<ul style="list-style-type: none"> <li>• Check for Rich or Lean symptom that causes the condition. Drive the vehicle at the speed of the complaint. Monitoring the oxygen sensors will help identify the problem.</li> <li>• Check the fuel pressure, while the condition exists. Refer to LPG / Natural Gas Fuel System Diagnosis.</li> <li>• Verify proper fuel control solenoid operation.</li> <li>• Verify that the LPG / natural gas manual shut-off valve is fully open.</li> <li>• Check the in-line fuel filter for restrictions.</li> </ul>
Ignition System Checks	<ul style="list-style-type: none"> <li>• Check for the proper ignition output voltage, using a spark tester.</li> <li>• Verify that the spark plugs are correct, for use with LPG / natural gas.</li> <li>• Check the spark plugs. Remove the plugs, and inspect them for the following conditions:                             <ul style="list-style-type: none"> <li>– Wet plugs</li> <li>– Cracks</li> <li>– Wear</li> <li>– Improper gap</li> <li>– Burned electrodes</li> <li>– Heavy deposits</li> </ul> </li> <li>• Check the Crankshaft Position (CKP) sensor.</li> </ul>
Additional Check	<ul style="list-style-type: none"> <li>• Check the ECM grounds, for being clean, tight, and in their proper locations.</li> <li>• Check the generator output voltage.</li> <li>• Check the vacuum hoses, for kinks or leaks.</li> <li>• Check Transmission.</li> </ul>

### 3. SET UP AND PROCEDURE DIAGNOSTIC TOOL

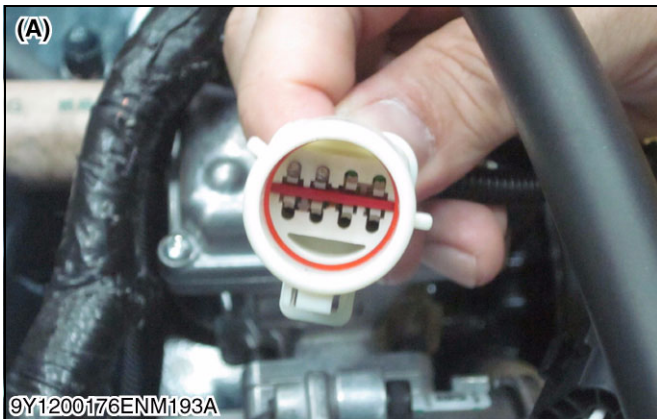
#### [1] DIAGNOSTIC CONNECTOR POSITION

The connector for connecting the diagnostic tool is in the position shown in the figure.

(A) Diagnostic Tool Connector



9Y1200176ENM191A

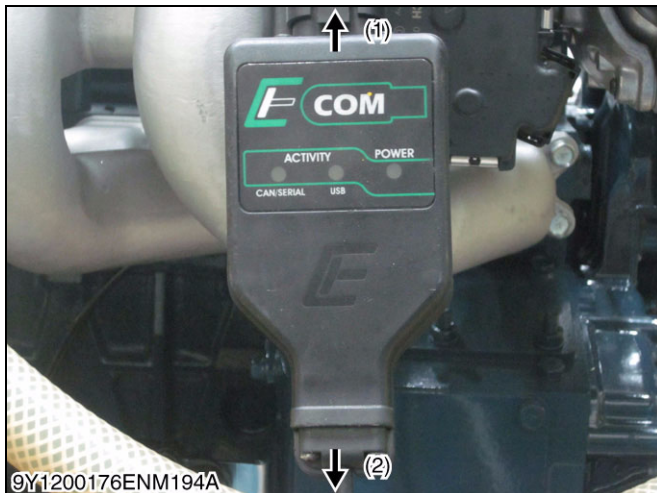
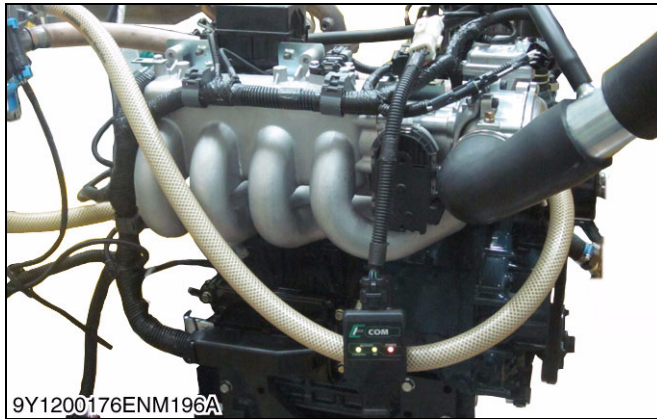
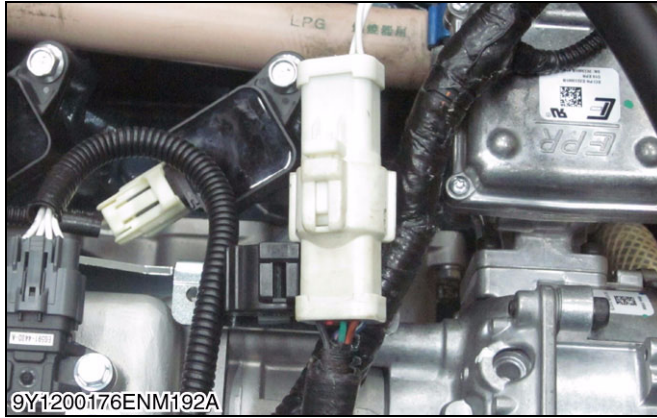


9Y1200176ENM193A

## [2] DIAGNOSTIC TOOL CONNECTION PROCEDURE

### ■ IMPORTANT

- At first time usage, it is necessary to install the software with administrator user account.
- Prepare a PC on which the diagnostic software has been installed.
- When connecting the diagnosis cable, don't have to switch off the key of the vehicle.



1. Start up a PC on which diagnosis software has been installed with administrator user account.
2. Connect the vehicle-side connector to the interface (to vehicle) with administrator user account.
3. Connect the cable (USB) to the interface (to PC) and then connect the USB connector to the USB port on PC.
4. Start the diagnostic software.

### ■ NOTE

- The power of diagnostic tool is supplied by the USB port.
- After installed the software, all USB ports can be used to connect the diagnosis cable.
- Connecting orders of diagnosis cables are not important.

- (1) Interface (To Vehicle)      (2) Interface (To PC)

## [3] SET UP AND PROCEDURE

### (1) Overview

This manual is intended to be used as an aid for KUBOTA LSI engine customers. Certain portions of this manual are only intended for use by the KUBOTA LSI engine customers to understand the fault detection system. This section of the manual defines the diagnostics and recommended troubleshooting procedures associated with an EControls Global Control Platform (GCP) engine control module (ECM) for use on industrial and heavy-duty gas engines.

**Kubota LSI engines use EControls diagnostic software to make the diagnosis of failure.**

### (2) Using the GCP Diagnostic Display Tool

#### Fault Code Broadcast

All diagnostic trouble codes are broadcast through EDIS for display on a PC. EDIS can acquire the data from the ECM through a protocol; CAN using the EControls Inc. Proprietary Protocol (ECIPP).

Faults may also be acquired over the CAN1 network through CAN J1939-based scan tools or multi-function display units.

#### Diagnostic Trouble Codes

The numeric diagnostic trouble codes assigned to the faults in this manual are cross-referenced to SAE's "Recommended Practice for Diagnostic Trouble Code Definitions" (SAE J2012). While these codes are recommended, customers may define their own codes by assigning a new number to the flash code in the diagnostic calibration. This will assign both the DTC as displayed in EDIS as well as the flash code output on the MIL output pin. EDIS may be used to connect to the GCP using either RS232 (serial) or Controller Area Network (CAN) communication protocols.

#### Serial Network

Fault code information can only be acquired through a PC tool compatible with ECIPP.

#### CAN

The GCP supports SAE J1939 CAN based diagnostic support. This includes:

- DM1: Active Diagnostic Trouble Codes
- DM2: Previously Active Diagnostic Trouble Codes
- DM3: Diagnostic Data Clear/Reset of Previously Active DTCs
- DM4: Freeze Frame Parameters
- DM5: Diagnostic Readiness (bytes 1, 2, and 3 are supported)
- DM11: Diagnostic Data Clear/Reset For Active DTCs
- DM12: Emissions-Related Active Diagnostic Trouble Codes
- DM19: Calibration Information

All diagnostic trouble codes broadcast over CAN1 will be according to SAE J1939 DM1 and DM2. MY08 MGCP ECUs are compliant with J1939 OBD-M, supporting the Diagnostic Messages above as well as user indicators and CAN data defined in the OBD-M protocol.

Faults available for broadcast and their respective SPN/FMI numbers are dependent on the application and engine calibration. There are 4 CAN SPN/FMI lists available in the GCP software set, contact EControls for a list of CAN SPN/FMIs.

The data capture at the occurrence of a fault, known in the ECM as fault snapshot (FSS), is available upon DM4 request. The following bytes are supported for DM4 if configured in the ECM software:

- Byte 1: Freeze Frame Length
- Byte 2-6: SPN, FMI, SPN Conversion Method, and Occurrence
- Byte 7: Manifold Absolute Pressure
- Byte 8-9: Engine Speed
- Byte 10: Engine Load (MAP based estimate)
- Byte 11: Engine Coolant Temperature
- Byte 14: # of starts since fault was last
- Byte 15: Index into FSS\_storage table for Fault Snap Shot retrieval.

Resetting active and previously active DTCs is handled through DM11 and DM3, respectively. DM1 and DM2 lamp indicators are assigned to each fault based on the fault's diagnostic action as defined in the calibration. The lamps are assigned based on the configuration outlined in Table 1.

**Table 1: J1939 Diagnostic Lamp Configuration**

ECM Diagnostic Action	J1939 Lamp
MIL	MIL
Soft Warning	Amber
Hard Warning, Low Rev Limit, Shutdown	Red Stop
Power Derate 1 & 2	Protect
Forced Idle	None (use in combination with other action)

## Diagnostic Calibration Configuration and Corrective Actions

Each fault within the GCP is capable of being uniquely configured in the engine's diagnostic calibration to cause one or more corrective actions while a given fault is active.

Table 2 identifies the configuration options and corrective actions available for configuration of each fault. The desired action is set by KUBOTA.

**Table 2: Diagnostic Corrective Actions**

Corrective Action	Description
Enable	Enables the fault for fault detection.
Shutdown	Cause an engine shutdown when fault becomes active.
Never Forget	Retain fault as historic/previously active until cleared by a technician and does not allow historic fault to be "auto-cleared".
Turn on MIL	Turn on MIL output when fault becomes active.
CL Disable	Disable closed-loop while the fault is active.
CL Disable Key-Cyc	Disable closed-loop while the fault is active and for the remainder of the key cycle.
AL Disable	Disable adaptive learn while the fault is active.
AL Disable Key-Cyc	Disable adaptive learn while the fault is active and for the remainder of the key cycle.
Power Derate 1	Limit TPS to the Power Derate 1 % set in the diagnostic calibration while the fault is active. The Power Derate 1 TPS % should be set higher than Power Derate 2 as Power Derate 2 adds a higher level of protection.
Power Derate 2	Limit TPS to the Power Derate 2 % set in the diagnostic calibration while the fault is active. If the calibration is set to "Latched for Key-Cycle" Power Derate 2 remains active until engine speed and FPP conditions are satisfied. The Power Derate 2 TPS % should be set lower than Power Derate 1 as Power Derate 2 adds a higher level of protection.
Low Rev Limit	Limit RPM to the Low Rev Limit speed set in the diagnostic calibration while the fault is active. If the calibration is set to "Latched for Key-Cycle" Low Rev Limit remains active until engine speed and FPP conditions are satisfied.
Forced Idle	Limit RPM to the Forced Idle speed set in the diagnostic calibration while the fault is active and for the remainder of the key cycle.
Soft Warning	Turn on the soft warning output when the fault becomes active.
Hard Warning	Turn on the hard warning output when the fault becomes active.
Stopped Check	Run fault detection/checking while the engine is in a key-on, engine-off condition. <b>■ NOTE</b> <ul style="list-style-type: none"> <li>It is recommended that this feature only be used for general sensor faults (high/low voltage) and some output drivers.</li> </ul>

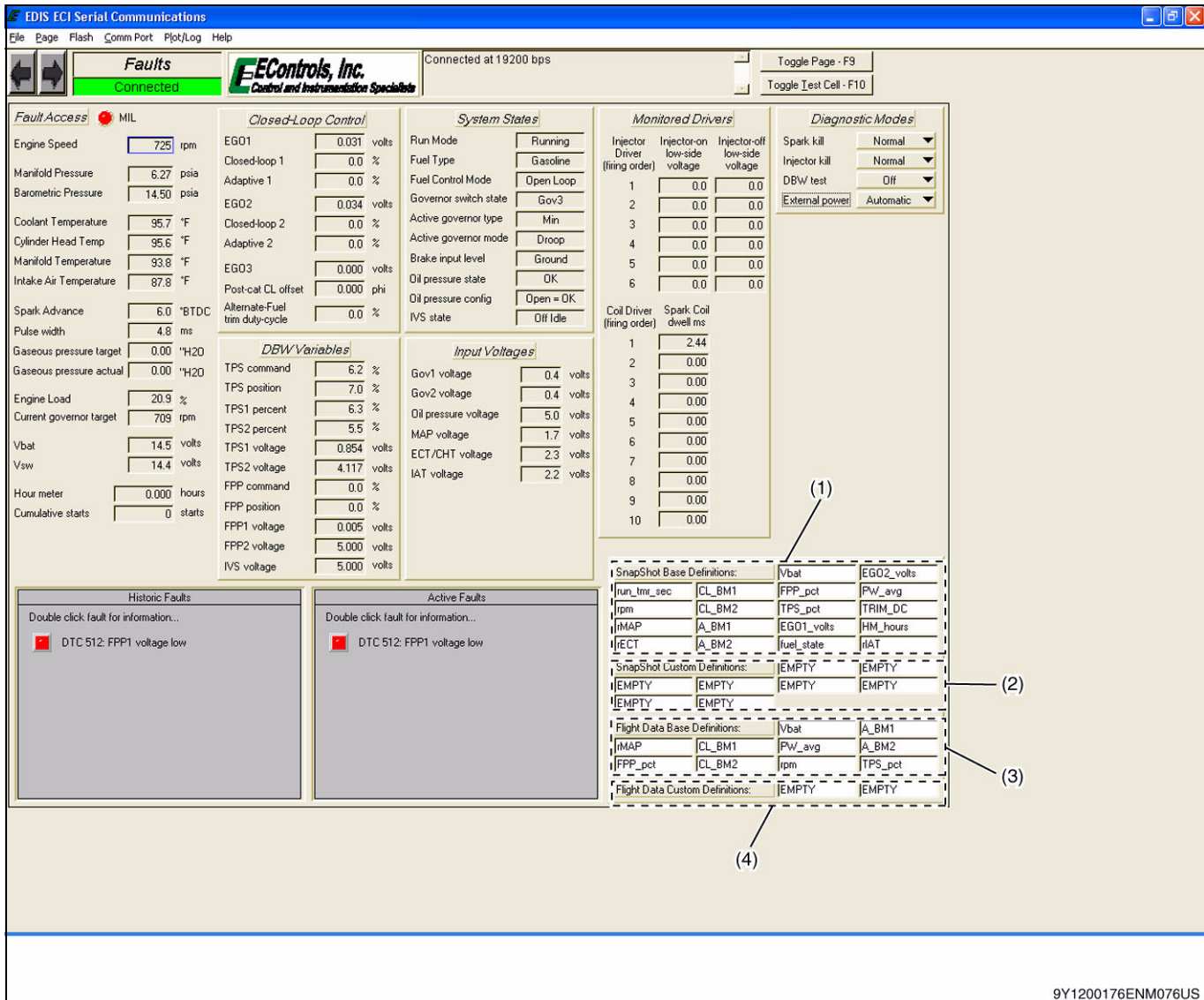
### Fault/Diagnostic Trouble Code Interaction

All fault and diagnostic information is managed through the Faults page. Interaction includes viewing fault messages, downloading fault data (fault snapshot and flight data recorder), erasing faults from memory, and defining variables for fault data logging.

Faults are separated into two categories, Active and Historic. Active faults are active in real-time and historic faults have been generated at some instance in time that may or may not be active in real-time. Once a fault has become active, it is immediately logged as historic and a snapshot and flight data log is saved.

Figure 1 shows an example of the fault page when an active fault has been generated. Notice that the fault is present in both the active and historic lists and the malfunction indicator lamp (MIL) has been illuminated.

Figure 2 shows an example of the fault page with a historic fault stored in memory.



**Figure 1:** Custom Flight Data Recorder variable definitions (User Defined)

- (1) Base Fault snapshot variable definitions (CAN NOT be altered)
- (2) Custom Fault Snapshot variable definitions (User Defined)
- (3) Base Flight Data Recorder variable definitions (CAN NOT be altered)
- (4) Custom Flight Data Recorder variable definitions (User Defined)



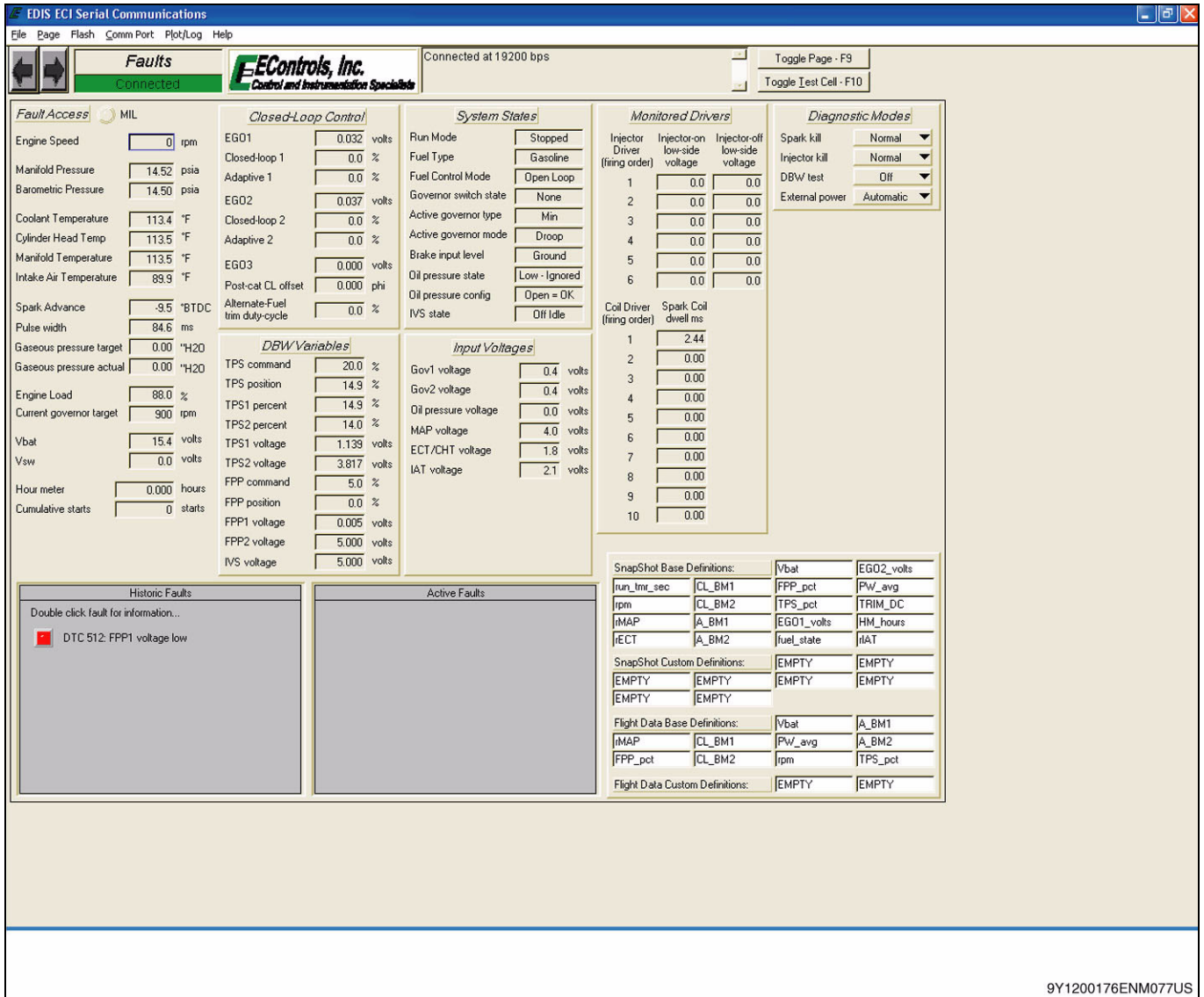


Figure 2: Faults Page with Historic Fault Message

Once an active fault has occurred two sets of data are recorded, fault snapshot and flight data recorder. The fault snapshot (FSS) is a sample of data taken at the instance the fault triggered. Variables included in the FSS are defined in the Snapshot Base and Snapshot Custom Definition fields found on the Faults Page. A FSS is saved with each of the first eight (8) faults for the first time the fault becomes active. Conversely, the flight data recorder (FDR) is a ten-second stream of data that includes eight-seconds prior and two-seconds after triggering the fault. An FDR is saved for each of the first two (2) faults for the first time the fault becomes active. Variables included in the FDR are defined in the Flight Data Base and Flight Data Custom Definition fields found on the Faults Page.

The memory location of the FDR is RAM, therefore this data is only available if the ECM has not lost battery power. In addition, if there is a "Dirty Flash Page" in the ECM, the FDR data will not be available. The memory location of the FSS data is EEPROM and is retained when the ECM loses battery power.

Both sets of data are accessed from the Historic Fault Information interface and can be saved to the PC upon retrieval. Base variables for FSS and FDR are generally defined by the Kubota to include variables most often referenced during fault diagnosis. The base definitions are not fault dependent. Additional variables may be selected for capture during a fault occurrence through a single, left-click of the custom table and selecting the desired variables from a list. An example of custom fault variable definitions is shown in Figure 3.

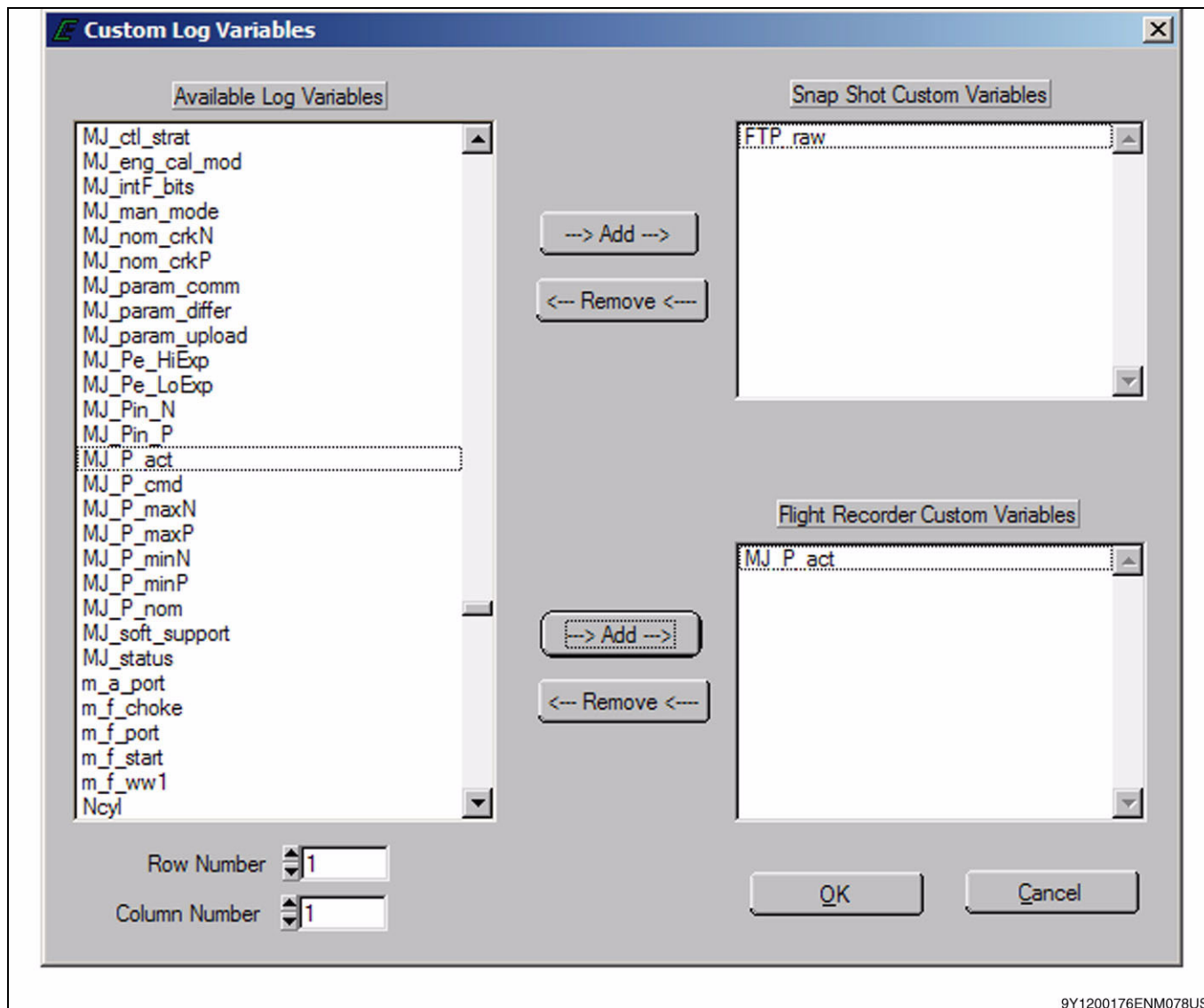
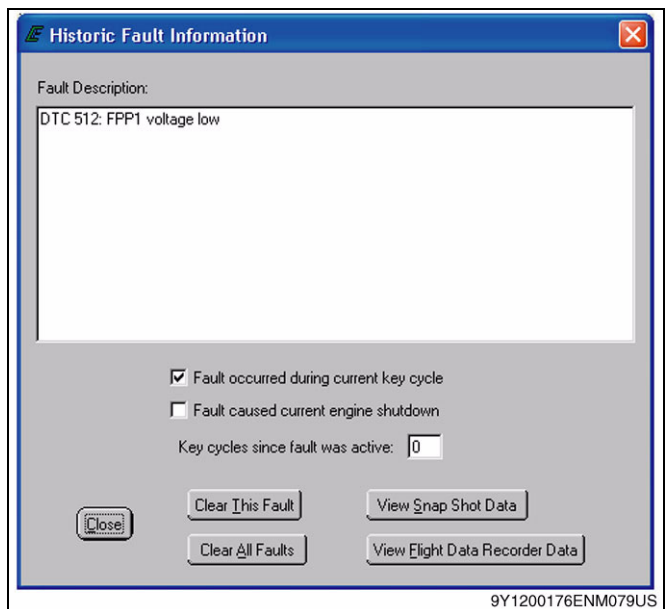


Figure 3: Custom Fault Variable Interface



Accessing fault information is accomplished through a double left-click of the fault LED in the historic fault list. This produces the Historic Fault Information interface shown in Figure 4. From this interface the user can interpret a diagnostic trouble code (DTC) message, identify whether or not the fault occurred during the current key cycle, identify if the fault caused the engine to shutdown, determine how many key cycles have occurred since the fault was last active, clear selected or all historic faults, and view snapshot and flight data.

Table 3 outlines the options displayed in the Historic Fault Information screen. Historic faults are not overwritten if the same fault becomes active, storing data from the original active fault.



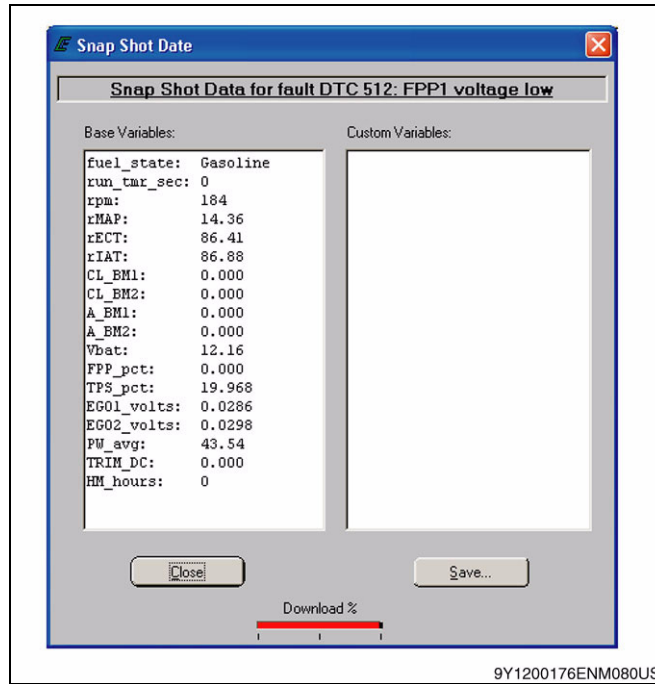
**Figure 4:** Historic Fault Information Interface

**Historic Fault Information Interface Functions**

Fault Description Message Box	Customized text that references the DTC flash code and describes the fault.
Fault During Key Cycle Checkbox	Informs that the fault occurred during the current key-on event.
Fault Caused Engine Shutdown Checkbox	Informs that the fault caused the engine to shutdown.
Key Cycles Since Fault Active Indicator	Displays the amount of key-on events since the fault was last active.
Clear This Fault Button*	Erases the selected historic fault from the ECM.
Clear All Faults Button*	Erases all historic faults from the ECM.
View Snap Shot Data Button	Retrieves a data "snap shot" from the ECM for variables defined in the base and custom snapshot variable definition lists. An example of a fault snap shot is shown in Figure 5.
View Flight Data Recorder Data Button	Retrieves a 10-second data strip chart (8 seconds prior, 2 seconds after fault trigger) from the ECM for variables defined in the base and custom flight data recorder definition lists. An example of a fault snap shot is shown in Figure 6.
Close Button	Exits the Historic Fault Information interface. DOES NOT cancel or clear any faults.
* Snapshot and flight data recorder data for historic faults is erased after the prompt shown in Figure 7 is satisfied.	

Figure 5 is an example of a fault snapshot after View Fault Snapshot is selected. Data is presented in two columns, base and custom variables.

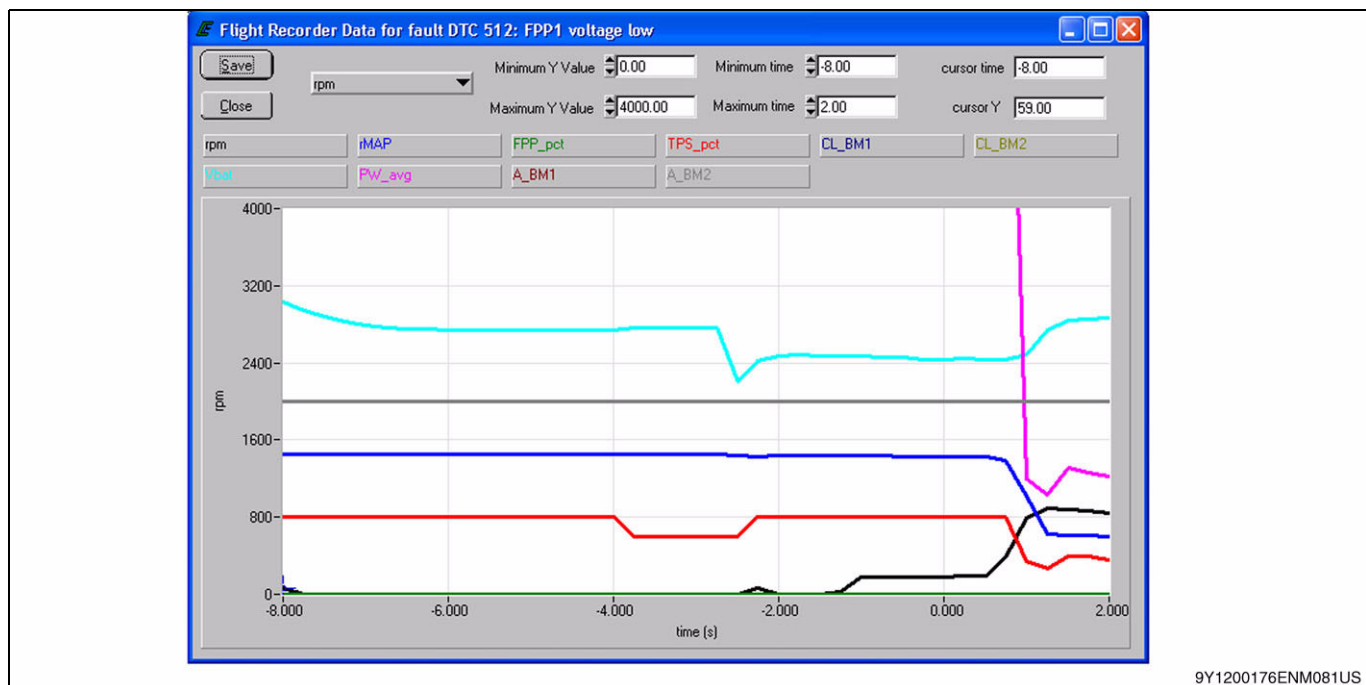
Once retrieved, the FSS data may be saved to the PC in text format with an .fss extension. A FSS saved to a PC may be reviewed in any ASCII based software program.



**Figure 5:** Snapshot Data Interface

Figure 6 shows the Flight Data Recorder interface after View Flight Data Recorder is selected. The FDR captures a ten second (eight seconds prior and two seconds after generating the fault) strip of data for base and custom variables. FDR data is presented in an interface similar to the Plot interface for a quick graphical presentation.

From this interface, the FDR data may be saved to the PC in text, tab-delimited format with an .fdr file extension. Once saved to PC, FDR data may be reviewed using any graphical post-processing software capable of handling tab-delimited formatting.



**Figure 6:** Flight Data Recorder Interface

Fault information may be manually erased using the "Clear" button functions. Once a "Clear" function has been selected, the dialog prompt shown in Figure 7 will be displayed. Choosing YES deletes all fault information from the ECM.



**Figure 7:** Clear Faults Prompt

## [4] DIAGNOSTIC TESTS

The GCP engine control module for spark-ignited engine applications incorporates a set of four (4) diagnostic tests that perform specific functions used as an aid for verifying proper engine control. This section describes the tests supported, test states, and operating criteria for each test.

Diagnostic tests is software which can be initiated via CAN using CCP.

### **Spark Kill Test**

"Coil X" disables individual cylinders at any operating condition for the duration defined in calibration or until released through software. 'Spark Kill' may be used in conjunction with 'Injector Kill' to disable two cylinders at any given time. Upon a state change from one cylinder to another, the test sequence will automatically re-enable the first coil prior to disabling the selected coil. This test reverts to normal operation if "Normal" state is selected, ignition voltage is cycled from high to low, or the calibrated time-out expires.

#### ■ NOTE

- **This test should not be initiated prior to the "Injector Kill" test when the engine is attached with a catalyst. If performed while the injector for the selected cylinder is firing, raw-unburned fuel and air will be present in the exhaust and will react in the catalyst resulting in extremely high catalyst substrate temperatures which can cause wash coat or substrate damage and failure.**

#### States

- 1) Normal: State of normal operation
- 2) Coil 1: Disables coil or spark for cylinder 1 in block order
- 3) Coil 2: Disables coil or spark for cylinder 2 in block order
- 4) Coil 3: Disables coil or spark for cylinder 3 in block order
- 5) Coil 4: Disables coil or spark for cylinder 4 in block order

#### Monitored Status

- 1) Test not started
- 2) Test is running
- 3) Test finished (time-out achieved)
- 8) Cannot start test

### **Injector Kill Test**

"Inj X" disables individual cylinders at any operating condition for the duration defined in calibration or until released through software. 'Injector Kill' may be used in conjunction with 'Spark Kill' to disable two cylinders at any given time. Upon a state change from one cylinder to another, the test sequence will automatically re-enable the first injector prior to disabling the selected injector. Reverts to normal operation if "Normal" state is selected, ignition voltage is cycled from high to low, or the calibrated time-out expires.

#### ■ NOTE

- **This test should not be initiated at high loads or for more than five (5) seconds if the engine is attached with a catalyst. If done so, a large quantity of oxygen will fuel undesirable reactions in the catalyst resulting in extremely high catalyst substrate temperatures which can cause wash coat or substrate damage and failure.**

#### States

- 1) Normal: State of normal operation
- 2) Inj 1: Disables injector 1 in block order
- 3) Inj 2: Disables injector 2 in block order
- 4) Inj 3: Disables injector 3 in block order
- 5) Inj 4: Disables injector 4 in block order

#### Monitored Status

- 1) Test not started
- 2) Test is running
- 3) Test finished (time-out achieved)
- 8) Cannot start test

### **DBW Test**

Permits full-authority operation of an electronic throttle via the throttle command input while the engine is in the "Stopped" state only. Reverts to normal operation if "Off" state is selected, ignition voltage is lost, or engine speed is sensed.

#### ■ NOTE

- **Ensure that the foot pedal position sensor/electronic throttle control input is at 0 % or idle prior to starting/operating the engine. While this test mode will revert to disabled when engine speed is sensed, the throttle command will follow the FPP % commanded by the sensor causing the engine to accelerate.**

#### States

- 1) Off: State of normal operation
- 2) Enabled: Enables full authority control of an electronic throttle

#### Monitored Status

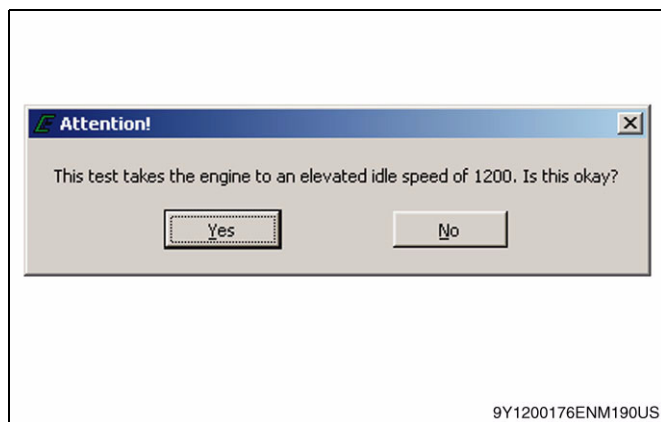
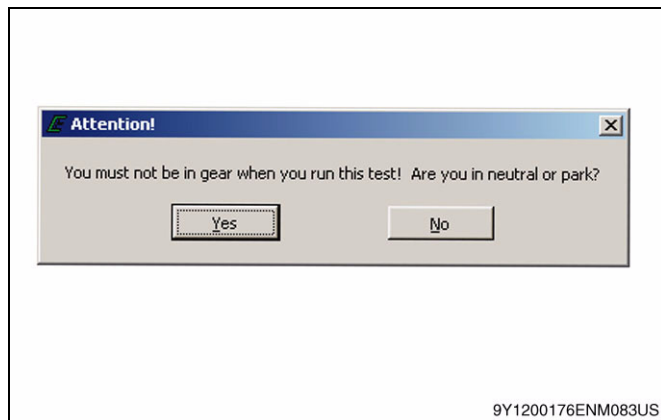
- 1) Test not started
- 2) Test is running
- 3) Test finished
- 8) Cannot start test (speed is sensed)

**Closed-Loop Test**

Tests the closed-loop fueling feedback system to verify that exhaust gas oxygen sensors are properly functioning and are providing reliable information. The test runs in the order defined below and aborts if at any time an error/fault is identified, the throttle input is elevated, or the operator requests the test to STOP. Aborting the test due to identification of an error/fault requires that the service technician addresses the identified error and then repeats the test to fully validate the system.

**1. Enable Strategy and HEGO Sensors (CL Test State= Pre-cat init test)**

- a. The test mode is entered by selecting START from EDIS. Once initiated, the user must acknowledge two prompts prior to the test running. These prompts require that the vehicle be in neutral or park and notify the user that the engine speed will increase to run the test. Answering YES to both of these prompts will initiate the test.



- a. Govern engine to × RPM as defined in the calibration.

**NOTE**

- **Test disables if FPP % exceeds the % used in Idle Speed Command Test (Tidlsprd\_FPP\_max)**

- b. Turn all configured EGO heaters on according to ‘EGOZ Heater-Control Target Impedance / Voltage Limit Schedule’.

**NOTE**

- **EGO heater control during this phase uses the run time and heater impedance target schedule, including the heater voltage limits, until the**

**heaters are operating at the final impedance target.**

- c. CL pre-cat test status will indicate “Test Running” through steps 2-3.

**2. Pre-Catalyst EGO Heater Diagnosis (CL Test State= Pre-cat heater & pre-cat power test)**

- The purpose of this portion of the test is:
  1. To validate that the pre-catalyst EGO heater element(s) are capable of heating the sense element(s) to a useable state.
  2. To validate that the pre-catalyst sense element(s) are operating at the desired temperature.
    - a) Monitor EGO impedance feedback and verify impedance ≤ ‘EGO impedance active threshold’; this stage runs up to the maximum run time in the ‘EGOZ Heater-Control Target Impedance / Voltage Limit Schedule’ + ‘EGO Heater Additional Wait Time’. If this check fails for any of the pre-catalyst sensors the CL pre-cat test status will indicate “Pre or Post-cat EGO Lazy” and the appropriate EGO Lazy fault for the sensor(s) is set.
    - b) In addition, the system monitors EGO impedance feedback and verifies that impedance is equal to the fully warm ‘EGOZ Impedance Target’ + ‘EGO Heater Impedance Max Error’. If any EGO impedance fails to reach the final target plus the impedance error tolerance the heater power is deemed low, the CL pre-cat test status "Pre-cat EGO Power Low" is generated, and the appropriate EGO Lazy fault for the sensor(s) is set. Once all pre-catalyst EGOs have reached the active threshold (‘Pre-cat EGO impedance active threshold’) the closed-loop system is activated and fueling perturbation begins at the nominal fueling target defined in the test setup parameters.

**(To be continued)**

(Continued)

### 3. Pre-Catalyst EGO Sensor Check (CL Test State= Pre-cat voltage test & Pre-cat BM test)

- The purpose of this portion of the test is:
  1. To validate that the pre-catalyst EGO sensor feedback is perturbing and providing feedback that correlates to commanded fueling excursions.
  2. Attempt to identify leaks within the pre-catalyst sensor assembly and/or the exhaust system and/or identify significant fuel delivery problems.
    - a) Once all pre-catalyst EGOs have reached the active threshold ('Pre-cat EGO impedance active threshold') closed-loop is activated and fueling perturbation begins at the nominal fueling target defined in the test setup parameters. During this time, adaptive learn is disabled and the fueling error is monitored (CL\_BM). Once the closed-loop system validates a certain number of EGO switches, the total fueling correction (CL\_BM+A\_BM) is compared to allowable fueling correction limit for the test ('CL+ adapt multiplier max value').
    - b) If the fueling correction is within the limits defined in the calibration, the CL pre-cat test status will indicate "Test Finished: Passed".
    - c) This portion of the test will fail if the EGO fails to generate the required number of switching cycles or if the fueling correction is outside of the acceptable limits. The CL pre-cat test status will indicate "Pre-cat EGO non-responsive" or "Pre-cat EGO fueling error" status, respectively. In addition, the appropriate "Closed-Loop High/Low" fault will be generated if this check fails.

### 4. Post-Catalyst EGO Heater Diagnosis (CL Test State= Post-cat heater test & post-cat power test)

- The purpose of this portion of the test is:
  1. To validate that the post-catalyst EGO heater element(s) are capable of heating the sense element(s) to a useable state.
  2. To validate that the post-catalyst sense element(s) are operating at the desired temperature.
    - a) Upon successful completion of the pre-catalyst EGO test checks, the system begins to monitor the post-catalyst sensor(s). The first check is to monitor EGO impedance feedback and verify impedance  $\leq$  'EGO impedance active threshold'; this stage runs up to the maximum run time in the 'EGOZ Heater-Control Target Impedance / Voltage Limit Schedule' + 'EGO Heater Additional Wait Time'. If this check fails for any of the post-catalyst sensors the CL post-cat test status will indicate "Post-cat EGO Lazy" and the appropriate EGO Lazy fault for the sensor(s) is set.
    - b) In addition, the system monitors EGO impedance feedback and verifies that impedance is equal to the fully warm 'EGOZ Impedance Target' + 'EGO Heater Impedance Max Error'. If any EGO impedance fails to reach

the final target plus the impedance error tolerance the heater power is deemed low, the CL post-cat test status "Post-cat EGO Power Low" is generated, and the appropriate EGO Lazy fault for the sensor(s) is set. Once all post-catalyst EGOs have reached the active threshold ('Post-cat EGO impedance active threshold) the rich/lean test is run on the post-catalyst sensors.

### 5. Post-Catalyst EGO Sensor Check (CL Test State= Post-cat rich test & Post-cat lean test)

- The purpose of this portion of the test is:
  1. To validate that the post-catalyst EGO sensor feedback is changing as a result of significant changes in pre-catalyst fueling.
    - a) Command nominal fueling while applying the fueling multiplier(s) generated during the 'CL pre-cat voltage test' mode (step 3a).
    - b) Command a rich open-loop fueling command as defined in the calibration and monitor the post-catalyst EGO voltage feedback to verify that the sensor's rich feedback is within tolerance.
    - c) Command a lean open-loop fueling command as defined in the calibration and monitor the post-catalyst EGO voltage feedback to verify that the sensor's lean feedback is within tolerance.
    - d) If the post-catalyst EGO voltage feedback is within the limits defined in the calibration, the CL post-cat test status will indicate "Test Finished: Passed" and the CL Test State will indicate "Finished". If post-cat voltage(s) fall outside of the rich/lean limits, CL post-cat test status will indicate "Post-cat EGO Rich Failure" or "Post-cat EGO Lean Failure" and the EGO Lazy fault will be set for the appropriate sensor, respectively.

The engine will return to idle upon completion or abortion of the of the closed-loop diagnostic test.

#### ■ NOTE

- **Be sure to check CL Test State, CL pre-cat test status, and CL post-cat test status to determine if the test was successful. If the test failed for ANY reason, faults will be displayed and configured system alarm(s) (soft warning, hard warning, or MIL) will be generated. Technicians should clear faults after running the Closed-Loop Test.**

(To be continued)

**(Continued)****States (CL Test State)**

- 1) Inactive
- 2) Pre-cat init test
- 3) Pre-cat heater test
- 4) Pre-cat power test
- 5) Pre-cat voltage test
- 6) Pre-cat BM test
- 7) Post-cat heater test
- 8) Post-cat power test
- 9) Post-cat rich test
- 10) Post-cat lean test
- 11) Finished
- 12) Invalid

**Pre-Catalyst Monitored Status (CL Pre-Cat Test Status)**

- 1) Test Not Started
- 2) Test Running
- 3) Test Finished: Passed
- 4) Pre-cat EGO Lazy (generates appropriate EGO Lazy fault)
- 5) Pre-cat EGO Power Low
- 6) Pre-cat EGO non-responsive
- 7) Pre-cat EGO fueling error
- 8) Cannot start test (FPP or TCP % above limit is detected)

**Post-Catalyst Monitored Status (CL Post-Cat Test Status)**

- 1) Test Not Started
- 2) Test Running
- 3) Test Finished: Passed
- 4) Post-cat EGO Lazy (generates appropriate EGO Lazy fault)
- 5) Post-cat EGO Power Low
- 6) Post-cat EGO Rich Failure
- 7) Post-cat EGO Lean Failure
- 8) Cannot start test (FPP or TCP % above limit is detected)

## 4. BASIC SYSTEM INFORMATION

### [1] FUEL SYSTEM

#### KUBOTA FUEL SYSTEMS

Kubota LSI engines use EControls fuel system. In this section of the manual, Kubota fuel system will be explained further to provide the technician the ability to understand how each system operates and the general layout of each system. A typical installation schematic has been included to identify where in the system the components are located, and how the component communicates to other fuel system components, and the EControls ECM.

#### FUEL METERING SYSTEMS

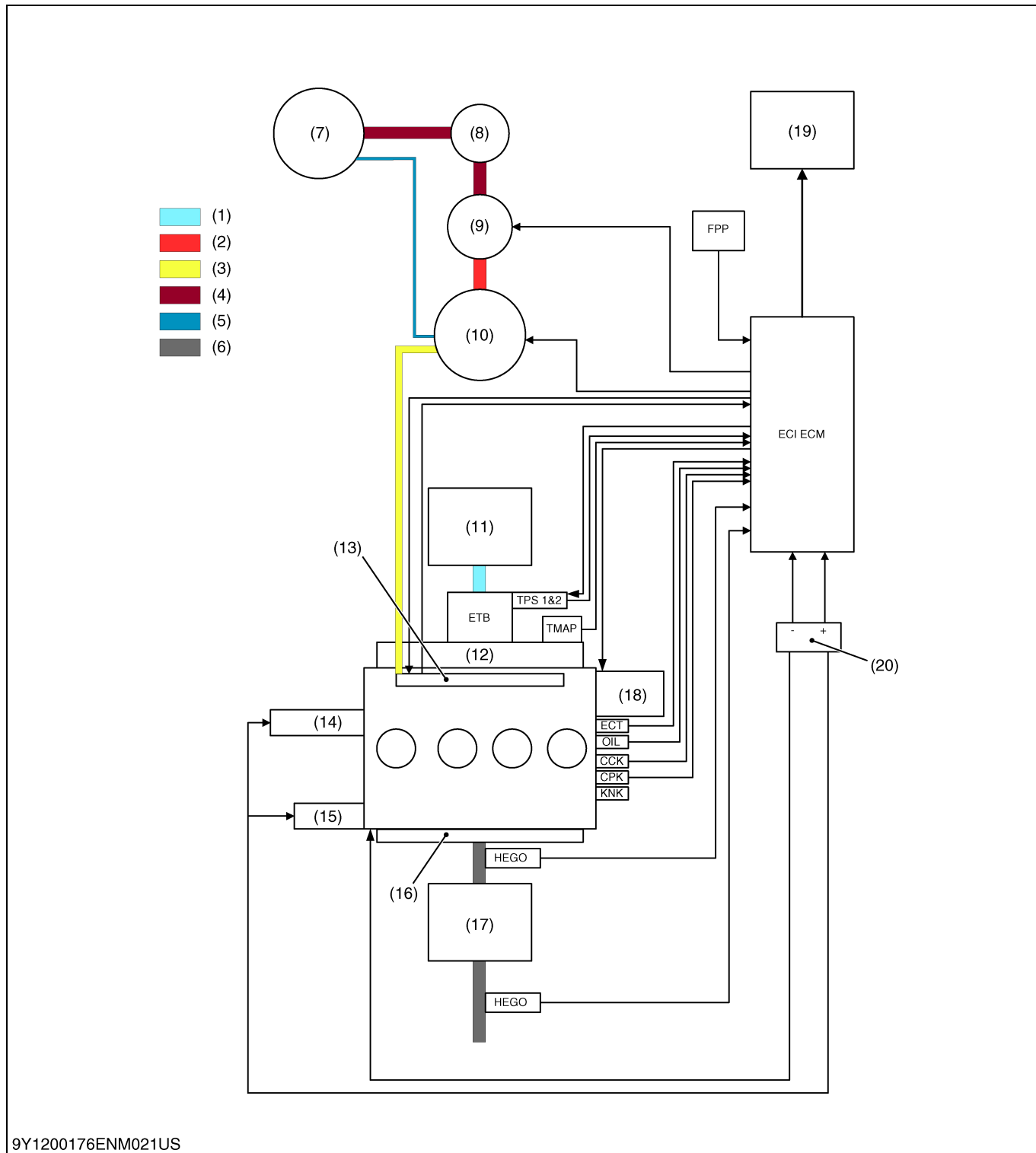
In all cases where EControls has supplied the fuel metering system for Kubota, EControls has designed the system for peak engine performance, durability, precise fuel metering and control of the exhaust emission. Each design has been tested and developed in conjunction with Kubota. When servicing an EControls system, you should always follow the prescribed service instructions and procedures, to repair the engine fuel system. When replacing parts within the fuel metering system you should use only Kubota replacement parts. Failure to do so may result in improper performance, an unsafe conditions, and lack of emissions control.

#### ENGINE CONTROL MODULE

Kubota fuel system will utilize an EControls Engine Control Module (ECM), to control fueling and control emissions output, in the exhaust. In some cases the ECM provides signal output to the vehicle instrument panel. The ECM will utilize signal inputs, from the engine sensors, to control the fuel metering and speed control, while the engine is running. As well, the ECM will provide diagnostic control, over the fuel system.

The diagnostics within the ECM, continually monitor the fuel system performance, by measuring sensor voltage, and if the ECM determines that a sensor value has exceeded the high or low threshold value, the ECM will make changes in the fuel metering system operation, to protect the engine fuel system. These changes were developed during the EControls calibration activities, and during the design of the system. To assist the technician, in determining the fault condition, in the EControls fuel system, Diagnostic Trouble Codes (DTC), are used, to identify the fault conditions. These fault codes can be identified, by using the EControls Global Control Platform laptop diagnostic tool (GCP). To determine fault codes and corrective action to be taken, the technician will use the GCP and the Diagnostic Trouble Code section, of this manual, to determine the root cause of the failure, the effective changes in the EControls fuel system, as well as what repairs must be made, to correct the fault in the fuel system.

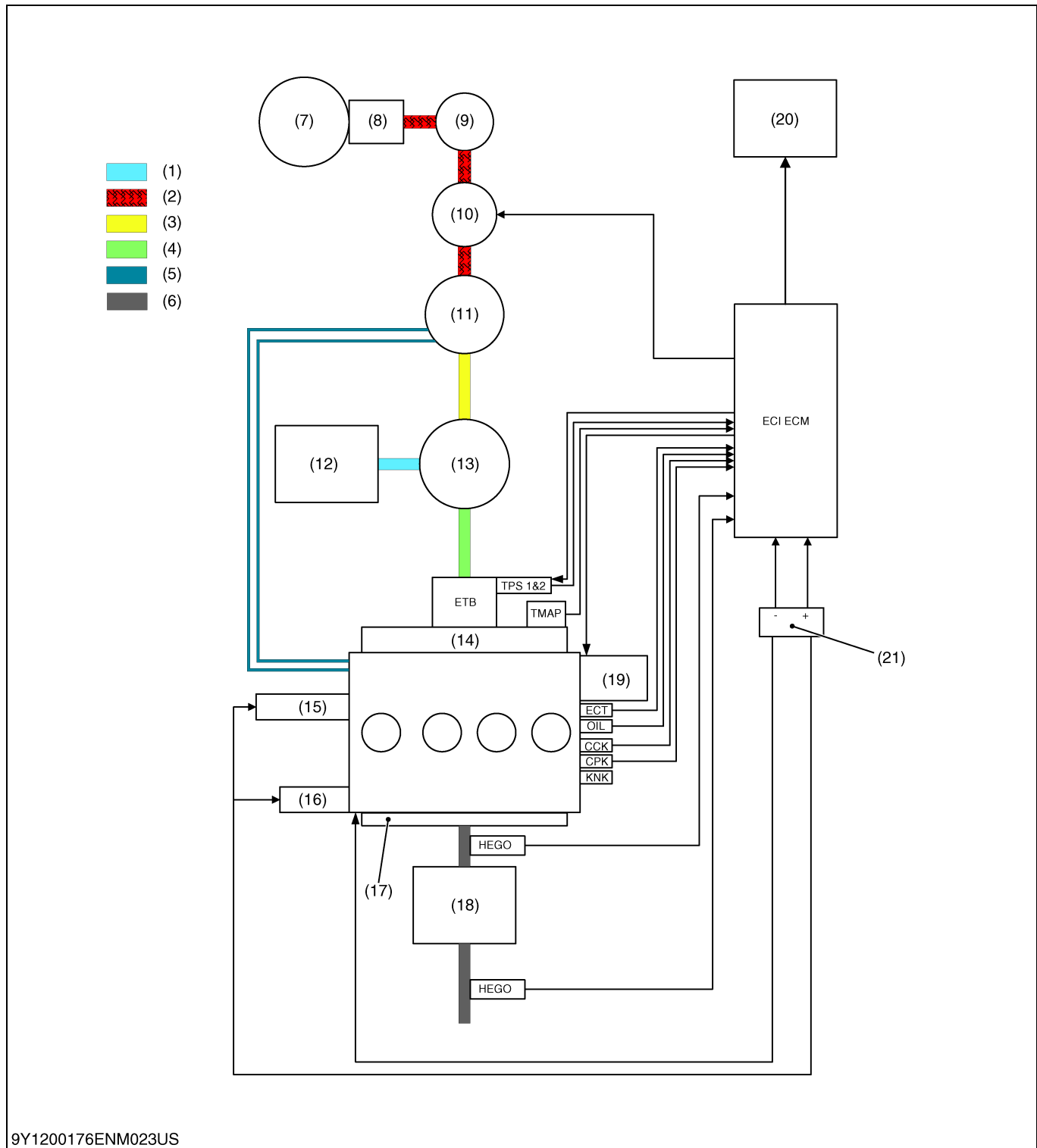




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**Figure 8:** Gasoline Schematic

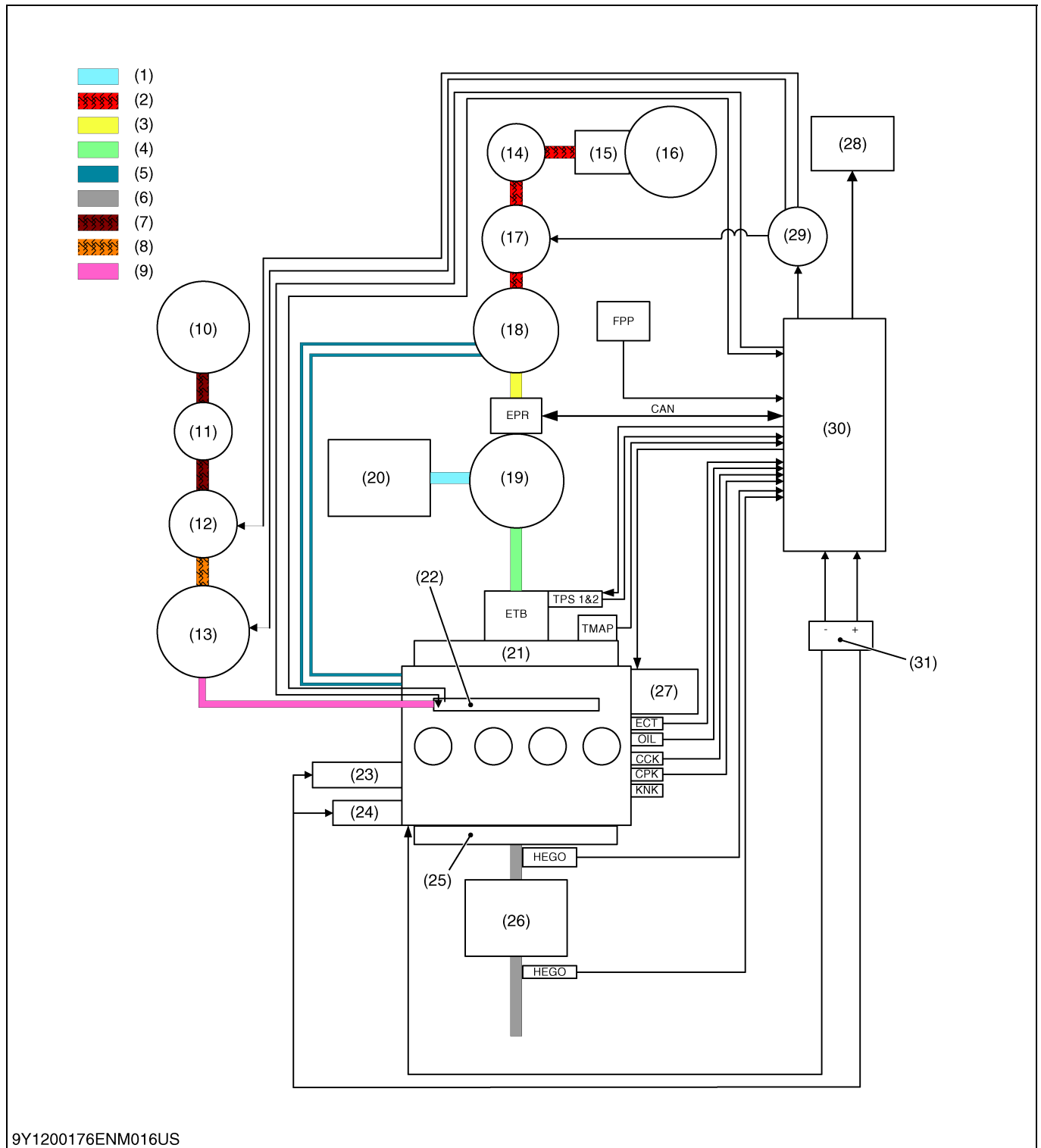
- |                               |   |                            |                         |
|-------------------------------|---|----------------------------|-------------------------|
| (1) FRESH AIR                 | (6) EXHAUST GASES                       | (11) AIR FILTRATION SYSTEM | (16) EXHAUST MANIFOLD   |
| (2) LIQUID FUEL HIGH PRESSURE | (7) GASOLINE TANK                       | (12) INTAKE MANIFOLD       | (17) MUFFLER            |
| (3) REGULATED PRESSURE FUEL   | (8) FUEL FILTER                         | (13) GASOLINE FUEL RAIL    | (18) IGNITION COIL PACK |
| (4) SUCTION FUEL              | (9) ELECTRIC FUEL PUMP                  | (14) ALTERNATOR            | (19) INSTRUMENT PANEL   |
| (5) RETURN FUEL               | (10) RETURNLESS FUEL PRESSURE REGULATOR | (15) STARTER               | (20) BATTERY            |



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**Figure 9:** LPG / Natural Gas Schematic

- |                               |                            |                            |                         |
|-------------------------------|----------------------------|----------------------------|-------------------------|
| (1) FRESH AIR                 | (7) LPG / NATURAL GAS TANK | (12) AIR FILTRATION SYSTEM | (17) EXHAUST MANIFOLD   |
| (2) LIQUID FUEL HIGH PRESSURE | (8) MANUAL VALVE           | (13) MIXER                 | (18) MUFFLER            |
| (3) LOW PRESSURE FUEL         | (9) FUEL FILTER            | (14) INTAKE MANIFOLD       | (19) IGNITION COIL PACK |
| (4) AIR FUEL MIXTURE          | (10) ELECTRIC LOCK OFF     | (15) ALTERNATOR            | (20) INSTRUMENT PANEL   |
| (5) ENGINE COOLANT            | (11) DUAL STAGE REGULATOR  | (16) STARTER               | (21) BATTERY            |
| (6) EXHAUST GASES             |                            |                            |                         |



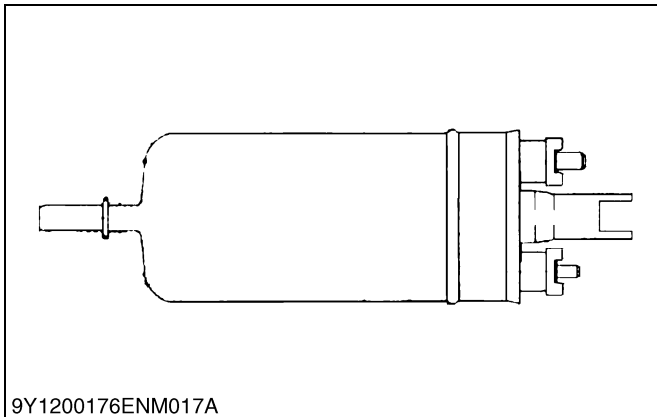
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**Figure 10: Bi-fuel Schematic**

- |  |   |                             |                         |
|--|---|-----------------------------|-------------------------|
| (1) FRESH AIR                            | (8) GASOLINE PRESSURE                   | (16) LPG / NATURAL GAS TANK | (24) STARTER            |
| (2) LPG / NATURAL GAS FUEL HIGH PRESSURE | (9) GASOLINE REGULATED                  | (17) ELECTRIC LOCK OFF      | (25) EXHAUST MANIFOLD   |
| (3) LPG / NATURAL GAS LOW PRESSURE FUEL  | (10) GASOLINE TANK                      | (18) DUAL STAGE REGULATOR   | (26) CATALYST           |
| (4) LPG / NATURAL GAS AIR FUEL MIXTURE   | (11) FUEL FILTER                        | (19) MIXER                  | (27) IGNITION COIL PACK |
| (5) ENGINE COOLANT                       | (12) ELECTRIC FUEL PUMP                 | (20) AIR FILTRATION SYSTEM  | (28) INSTRUMENT PANEL   |
| (6) EXHAUST GASES                        | (13) RETURNLESS FUEL PRESSURE REGULATOR | (21) INTAKE MANIFOLD        | (29) SELECT SWITCH      |
| (7) GASOLINE SUCTION                     | (14) FUEL FILTER                        | (22) GASOLINE FUEL RAIL     | (30) ECI ECM            |
|  | (15) MANUAL VALVE                       | (23) ALTERNATOR             | (31) BATTERY            |

**ELECTRIC GASOLINE FUEL PUMP (G, GL, GLN)**

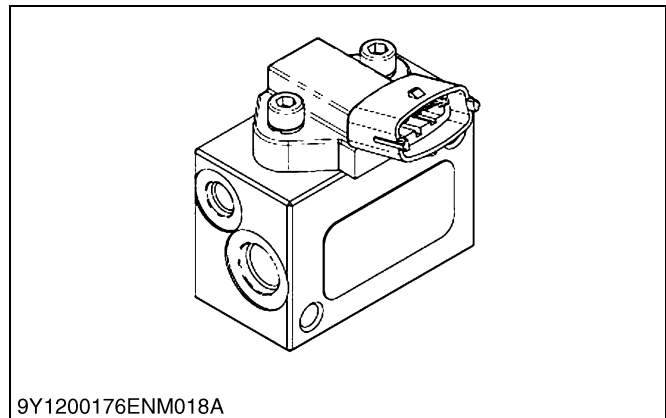
To supply gasoline to the fuel system, the Kubota bi-fuel system will utilize an external electric gasoline fuel pump. The pump will be mounted in the chassis of the vehicle, or equipment near the fuel tank. Gasoline rated fuel hose and securing devices supplied by Kubota, will be used to transfer the pumped fuel to the Gasoline Fuel Pressure Manifold assembly. Kubota have installed a fuel filtration device ahead of the electric pump, which may be located in the tank or an external filter. Most industrial equipment will be exposed to dusty and dirty environments, therefore use caution when opening the gasoline tank, to prevent dirt and debris from falling in the tank. For filter maintenance, refer to the Recommended Maintenance Chart.



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**Figure 11:** Electric Gasoline Fuel Pump**GASOLINE FUEL PRESSURE MANIFOLD (G, GL, GLN)**

The Kubota gasoline fuel system, utilizes a Fuel Pressure Manifold assembly, to control the delivery pressure to the gasoline injector rail. The manifold is mounted to the chassis, between the electric fuel pump and the gasoline injector rail. The manifold is attached with a sensor, which provides the ECM with the gasoline fuel temperature, and pressure being regulated to the gasoline injector rail. The ECM uses the fuel temperature and pressure, to calculate the precise amount of gasoline, to be injected to the engine during operation. The manifold is designed into the system, to control pressure, as well as the amount of gasoline, to be returned to the fuel tank. In normal gasoline delivery systems, the electric fuel pump, delivers a constant pressure to the injector rails, and allows a significant amount of fuel to be recycled to the tank, thus causing the gas to heat and vaporize, and requiring the use of a vapor recovery system to control the excess vapor. The Kubota system manages the fuel pressure at the manifold and minimizes the amount of returned fuel, thus reducing the vapor fuel in the tank.




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**Figure 12:** Gasoline Fuel Pressure Manifold

**GASOLINE INJECTORS AND INJECTOR RAIL (G, GL, GLN)**

Kubota gasoline fuel delivery system, utilizes a fuel rail, mounted with injectors, for each cylinder. The fuel rail and injectors, are attached by Kubota. During the design and calibration phase, the ECM gasoline fuel delivery calibrations are developed. The EControls ECM will utilize these calibrations, to pulse width modulate each injector, to deliver the correct amount of gasoline, for optimized performance, and reduced tail pipe emissions. The injector pulsing or "firing", is accomplished by supplying a 12.0 V supply to the positive side of the injector coil, and switching the ground circuit side, using the injector drivers, internal to the ECM.

Because Kubota gasoline fuel system, utilizes the Fuel Pressure Manifold, to control fuel delivery to the rail, Kubota fuel system does not use a separate return line, from the fuel rail assembly. Gasoline injectors are an emissions control device, and do not require periodic adjustment. When serving or placing injectors, use only Kubota replacement injectors, to insure the fuel system operates as designed.

 <b>WARNING</b>
NEVER CUT OR WELD ON EITHER THE LPG / NATURAL GAS OR GASOLINE FUEL TANK. REPAIRS TO THE FUEL TANK SHOULD ONLY BE MADE BY A CERTIFIED TANK REPAIR FACILITY. FAILURE TO OBSERVE THIS WARNING COULD RESULT IN SERIOUS BODILY INJURY AND OR DEATH AND COULD RESULT IN SERIOUS PROPERTY DAMEGE.

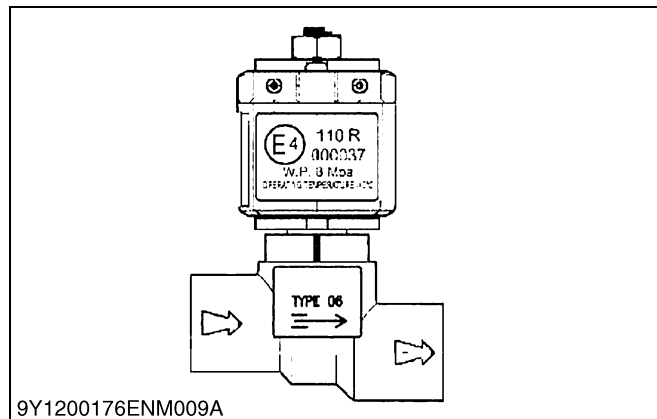
 <b>WARNING</b>
ALWAYS WEAR PROTECTIVE EYEWESR AND GLOVES WHEN PERFORMING MAINTENANCE ON THE LPG / NATURAL GAS OR GASOLINE FUEL SYSTEMS, TO PREVENT SERIOUS INJURY. ALWAYS PERFORM MAINTENACE PROCEDURES IN A WELL VENTILATED AREA AND INSURE THAT THERE ARE NO EXTERNAL SOURSES OF IGNITION.

**SERVICE LINE (L, N, GL, LN, GLN)**

LPG / Natural Gas flows from the fuel tank to the electric lock, via the service line. The service line is most commonly connected to the tank, utilizing a quick coupler. The other end of the service line is connected to a "bulkhead connector" which is used to allow the service line, to pass through the metal enclosure, vehicle body panels, or hoods. This hose is made of special material, which protects the inner core of the hose, from chemicals contained within the LPG / natural gas, which could result in a failure of the hose. The hose should never be kinked or allowed to come into contact with the chassis, or other engine components, and electrical connection or wiring. When replacing the fuel line, use care as there may be fuel retained in the line between the tank manual valve connection, and the electric lock off device.

**LPG / NATURAL GAS FUEL LOCK OFF (L, N, GL, LN, GLN)**

The LPG / Natural Gas Fuel Lock Off device is an integrated assembly. The electric lock assembly is a 12.0 V, normally closed valve. The solenoid is mounted to the valve body. When energized the solenoid opens the pilot valve, within the lock off, which uses the tank pressure, to assist in opening the valve. By using the pilot valve, to help open the valve, the service life of the valve, is extended, and requires less electrical energy, to open the valve. The valve opens, during cranking, and remains open, during the run cycles of the engine. The lock off supply voltage is controlled by the Engine Control Module (ECM), or may be energized by a relay, which supplies battery voltage, when energized.



**Figure 13:** Typical In-line LPG / Natural Gas Fuel Lock Off device

## **DUAL STAGE REGULATOR (DSR) (L, N, GL, LN, GLN)**

The DSR is a combination vaporizer, pressure regulating device. The DSR is a two stage regulator that is normally closed, when the engine is not running. When the engine is cranking or running, a partial vacuum is created in the fuel line, which connects the regulator to the Direct Electronic Pressure Regulators (DEPR), and mixer. This partial vacuum opens the second stage regulator, permitting fuel to flow to the DEPR, and mixer.

LPG / natural gas fuel enters the primary port of the DSR, and passes through the primary jet, and into the primary/exchanger chamber. As the LPG / natural gas passes through the heat exchanger, the fuel expands, and creates pressure inside the chamber. The pressure rises as the fuel expands, when the pressure rises above 10 kPa (0.11 kgf/cm<sup>2</sup>, 1.5 psi); sufficient pressure is exerted on the primary diaphragm, to cause the diaphragm plate to pivot, and press against the primary valve pin, thus closing off the flow of fuel. This action causes the flow of fuel, into the regulator to be regulated. When the engine is cranking, sufficient vacuum will be introduced into the secondary chamber, from the EPR/mixer, drawing the secondary diaphragm down onto the spring loaded lever, and opening the secondary valve, allowing vaporized fuel, to pass to the mixer. Increased vacuum, in the secondary chamber, increases the downward action on the secondary lever, causing it to open wider, allowing more fuel to flow to the mixer.

The DSR requires a connection to the engine coolant, to prevent freezing in the regulator, during the pressure reduction phase, within the regulator. Coolant connections on the DSR are fitted with "Push In" fittings. These fittings are designed with an o-ring seal, which allows the fitting to be pushed into the water connection on the DSR, and are then locked by spring locks, and retained by screws.

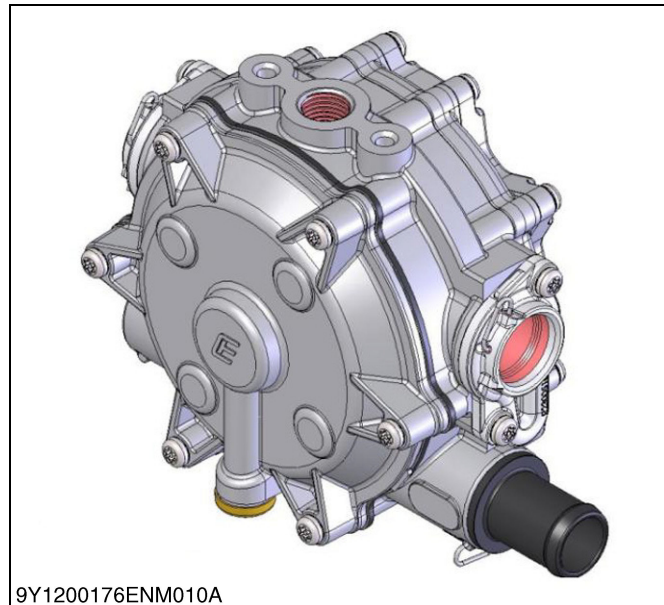
The DSR is connected to the DEPR, by a low pressure flexible hose. Like the other fuel hoses used in the fuel system, the low pressure hose is designed with a special inner core, and is usually wire reinforced, to prevent collapse of the hose, during high demand fueling operations. The low pressure hose should only be replaced, with the recommended Kubota hose replacement.

The packaging of the regulator, into the engine and chassis, must be approved by Kubota, to insure continued long term operation, of the fuel delivery and emission control system. You should never relocate the regulator, or any of the fuel system components, as doing so, may cause excess build up of oil in the regulator, improper coolant flow, or improper fuel delivery.

In certain regions, fuel supplies may be made up of much different chemicals and during the heating of the fuel, in the heat exchange section of the regulator, "heavy end" or petroleum oils, may accumulate over time. To drain the DSR, remove the fuel outlet hose and pour the oils out of the regulator. To determine the frequency, for draining the regulators, refer to the

Recommended Maintenance Schedule.

The regulator utilized on USA emission certified engines, are a critical part of the certified emissions system, and does not require any periodic adjustment.



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**Figure 14:** Dual Stage Regulator (DSR)

## **DIRECT ELECTRONIC PRESSURE REGULATOR (DEPR) (L, N, LN, GL, GLN)**

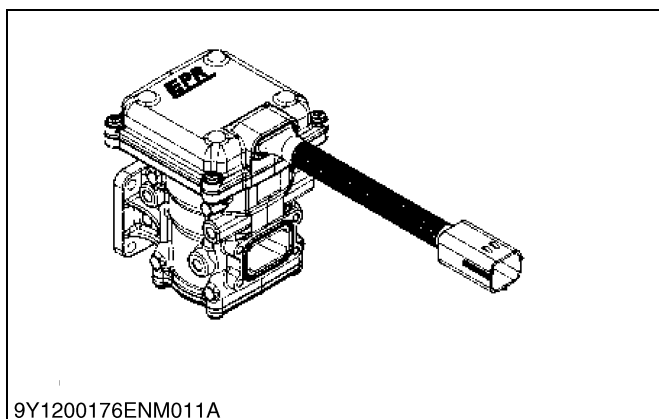
The Direct Electronic Pressure Regulator (DEPR) is the primary fuel control device, used to maintain both performance and emissions control. The DEPR contains an internal computer, which communicates to the EControls Engine Control Module (ECM), via a Communications Area Network (CAN), high speed connection.

The DEPR precisely controls the fuel flow required to insure Stoichiometric (correct air/fuel mixture for complete burn) fuel delivery to the engine combustion chambers. The DEPR also contains internally mounted fuel pressure and temperature sensors, which provide input across the CAN link, to the ECM, for fuel calculation. The ECM will process this information and command changes back across the CAN link, to the DEPR, to adjust fueling.

The DEPR internal computer also maintains certain levels of diagnostics within the system, to ensure emissions control is always maintained. If the DEPR detects a fault within the regulator or fuel delivery system, the DEPR will send that fault information across the CAN link to the ECM. The ECM will then activate the Malfunction Indicator Light (MIL), in the operator control panel. Depending on the type of fault, and its effect on fuel control, or engine performance, the ECM may command the DEPR to change fueling, limit fuel delivery, or in some cases shut down the engine.

The DEPR is connected directly to the mixer on all certified engines. A special designed inlet fitting, is mounted to the DEPR, which allows for the connection, to the DSR. The outlet connection is bolted directly to the mixer.

The DEPR utilized on USA emission certified engines is a critical part of the certified emissions system, and do not require any periodic adjustment.



**Figure 15:** Direct Electronic Pressure Regulator (DEPR)

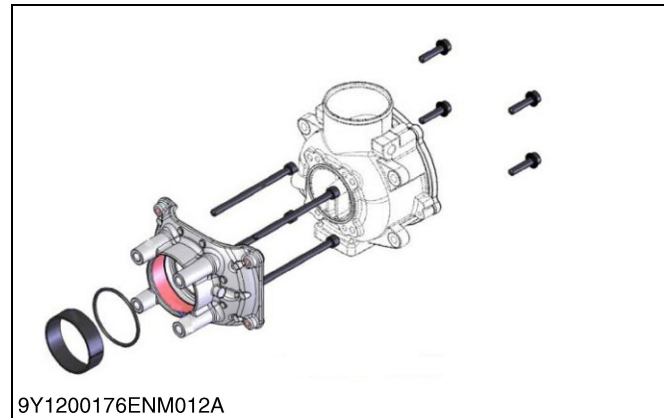
### **MIXER ASSEMBLY (L, N, LN, GL, GLN)**

The air valve mixer is an air-fuel metering device, and is completely self-contained. The mixer is an air valve design, utilizing a relatively constant pressure drop, to draw fuel into the mixer from cranking, to full load. The mixer is mounted in the air stream, ahead of the throttle control device.

When the engine begins to crank, it draws in air, with the air valve covering the inlet, negative pressure begins to build. This negative pressure signal is communicated to the top of the air valve chamber, through 4 vacuum ports, in the air valve assembly. A pressure/force imbalance begins to build, across the air valve diaphragm, between the air valve vacuum chamber, and the atmospheric pressure, below the diaphragm. The air valve vacuum spring is calibrated, to generate from 101.6 mm (4.0 inches) of water column at start, to as high as 355.60 mm (14.0 inches) of water column, at full throttle. The vacuum being created is referred to as Air Valve Vacuum (AVV). As the air valve vacuum reaches 101.6 mm (4.0 inches) of water column, the air valve begins to lift against the air valve spring. The amount of AVV generated is a direct result of the throttle position. At low engine speed, the air valve vacuum is low and the air valve position is low, thus creating a small venturi, for the fuel to flow. As the engine speed increases, the AVV increases, and the air valve is lifted higher, thus creating a much larger venturi. This air valve vacuum is communicated from the mixer venture, to the DSR secondary chamber, via DEPR and the low pressure fuel supply hose. As the AVV increases in the secondary chamber, the secondary diaphragm is drawn further down, forcing the secondary valve lever to open wider.

The DEPR maintains the precise fuel control to the mixer, despite the air valve position, and AVV being sent to the DSR secondary chamber. The mixer acts as the secondary fuel metering device, and delivery device, in the EControls emission control systems. The mixer is attached to the Electronic Throttle Body (ETB), via an adapter. The adapter is fitted with specific spacers and o-rings, to insure a seal tight fit, with the ETB.

The Mixer is designed such that the air valve diaphragm assembly can be replaced, should the diaphragm be damaged, during operation, from fuel contaminants. Refer to Mixer Diaphragm Replacement section in this manual. The Mixer utilized on USA emission certified engines are a critical part of the certified emissions system, and do not require any periodic adjustment. The mixer does not have any external nor internal adjustments.



**Figure 16:** Mixer and ETB Adapter



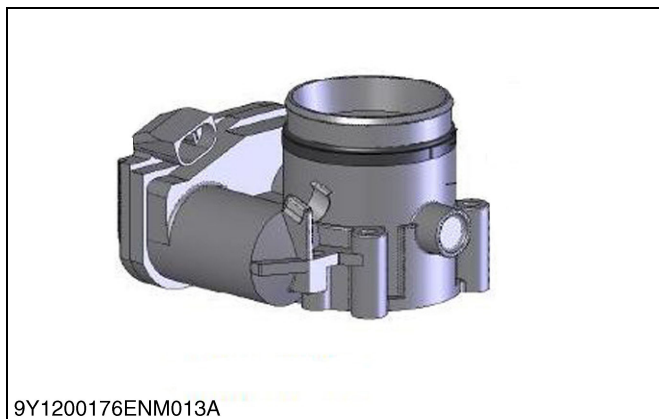
**ELECTRONIC THROTTLE BODY (ETB) (ALL)**

The Kubota fuel systems utilize Drive By Wire (DBW), to control engine speed, in this type of application. There is no direct connection between the operator pedal, and the throttle shaft. Speed and load control are determined by the ECM. Defaults programmed into the ECM software, and throttle position sensors, allow the ECM, to maintain safe operating control, over the engine.

In a drive by wire application, the Electronic Throttle Body (ETB) device, or "throttle body assembly", is connected to the intake manifold of the engine. The electronic throttle control device, utilizes an electric motor, connected to the throttle shaft. In addition, a Foot Pedal Position Sensor (FPP) is located in the operator's compartment. When the engine is running, electrical signals are sent from the foot pedal position sensor, to the engine ECM, when the operator depresses or release the foot pedal. The ECM then sends an electrical signal to the motor, on the electronic throttle control, to increase or decrease the angle of the throttle blade, thus increasing or decreasing the air flow to the engine.

The electronic throttle control device also incorporates two internal Throttle Position Sensors (TPS), which provide output signals to the ECM, as to the location of the throttle shaft and blade. The TPS information is used by the ECM, to correct for speed and load control, as well as emission control, and engine protection.

The ETB utilized on USA emission certified engines do not require any periodic adjustment.



**Figure 17:** Electronic Throttle Body ETB

**THREE WAY CATALYST (ALL)**

The emission certified engine has been designed and calibrated, to meet the emission standards in effect for 2010. To help meet the emission requirements, the vehicle has been attached with a Three Way Catalyst (TWC). Kubota has designed and supplied the catalyst in a separate unit. The catalyst function is the final treatment, of the exhaust gases, which are created from the combustion process. The three-way catalyst consists of a honeycomb, coated with a mixture of platinum, palladium, and rhodium. As the hot gases flow through the catalyst section, an oxidation and reduction reactions takes place. This chemical reaction reduces the amount of CO, HC and NOx, in the engines exhaust. The Exhaust gas then flows through the outlet.

## **HEATED EXHAUST GAS OXYGEN SENSOR (HEGO) (ALL)**

The Heated Exhaust Gas Oxygen Sensor (HEGO) is mounted in the exhaust system, downstream of the engine, but before the catalyst, referred to as the "Pre Catalyst" sensor. The ECM continuously monitors the HEGO sensor output if a rich or lean condition is present for an extended period of time, and if the ECM cannot correct the condition, the ECM will set a diagnostic code, and turn on the MIL light in the dash.

The HEGO is used to measure the amount of oxygen, present in the exhaust stream, and communicate that to the ECM, via an electrical signal. The amount of oxygen, present in the exhaust stream, indicates whether the fuel air ratio is too rich or too lean. If the HEGO sensor signal indicates that the exhaust stream is too rich, the ECM will decrease or lean the fuel mixture, during engine operation. If the mixture is too lean, the ECM will richen the mixture.

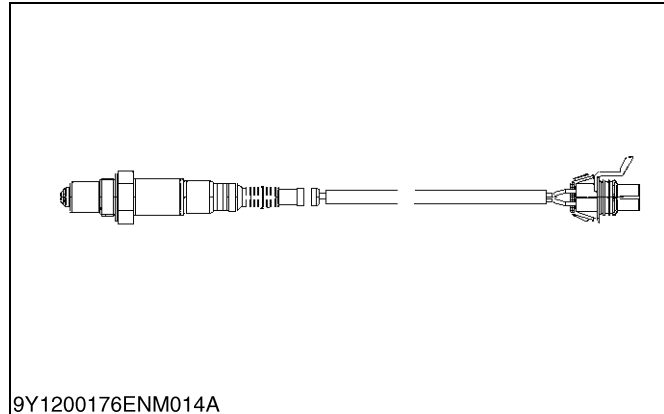
When the air/fuel mixture is rich, and there is little oxygen in the exhaust, the difference in oxygen levels, across the sensing element, generates a voltage through the sensor's electrodes: typically 0.800 to 0.900 V. When the air/fuel mixture is lean and there is more oxygen in the exhaust, the sensor's voltage drops to 0.100 to 0.300 V. When the air/fuel mixture is perfectly balanced and combustion is cleanest, the sensor's output voltage is around 0.450 V.

The oxygen sensor's voltage signal is monitored by the EControls ECM, to regulate the fuel mixture. When the ECM sees a rich signal (high voltage), from the O<sub>2</sub> sensor, it commands the fuel mixture to go lean. When the computer receives a lean signal (low voltage) from the O<sub>2</sub> sensor, it commands the fuel mixture to go rich. The continued cycling, back and forth from rich to lean, averages out the overall air/fuel mixture, to minimize emissions, and to help the catalytic converter operate at peak efficiency, which is often referred to as the "duty cycle".

The speed with which the oxygen sensor reacts to oxygen changes in the exhaust is very important for accurate fuel control, peak fuel economy, and low emissions. Aging of the sensor due to exposure to contaminants in the fuel, will occur over time, and may cause the sensor to slow down.

On all USA Emission certified engines, the exhaust system is attached with a second HEGO, located after the catalyst, referred to as the "Post Catalyst" sensor. The function of the second HEGO is to monitor the efficiency of the catalyst and fuel control. The operation of the HEGO is the same as the Pre Catalyst sensor; it provides an output voltage to the ECM, to determine the level of oxygen, in the exhaust stream after the catalyst. This type of monitoring is referred to as the On Board Diagnostic, in which additional sensors are installed in the system, to monitor the fuel control systems.

The ECM continuously monitors the HEGO sensors output, if a rich or lean condition is present for an extended period of time and the ECM cannot correct the condition, the ECM will set a diagnostic code and turn on the MIL light in the dash.



**Figure 18:** Heated Exhaust Gas Oxygen Sensor (HEGO)

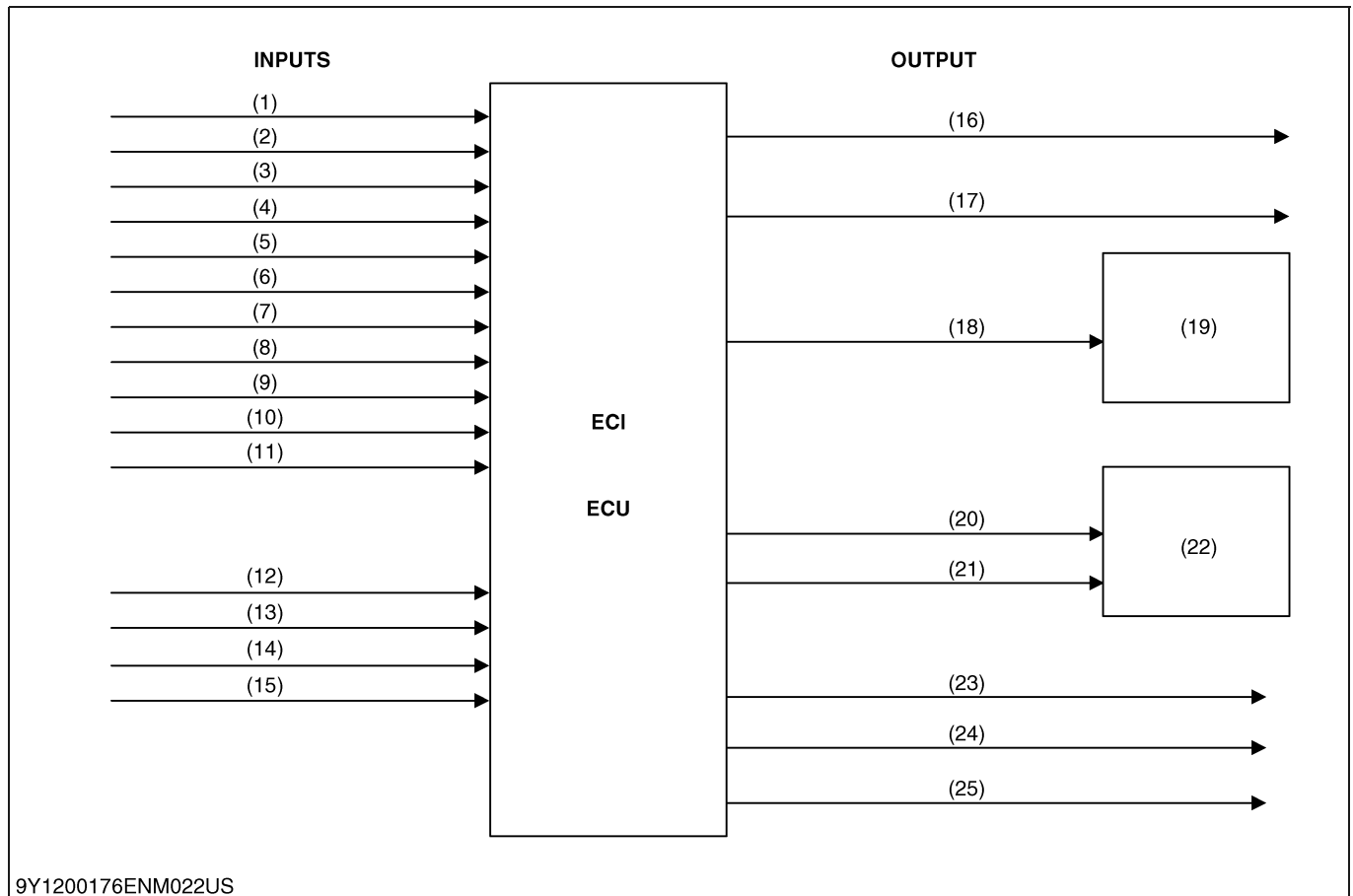
### **CAUTION**

The Heated Exhaust Gas Oxygen Sensor is an emissions control component. If the HEGO fails to operate, replace only with Kubota replacement part. The HEGO sensor is sensitive to silicone based products and can become contaminated. Avoid using silicone sealers or hoses, treated with silicone lubricant, in the air stream or fuel supply lines.

## **FUEL SYSTEM SELECT SWITCH (GL, GLN)**

As explained earlier, there are two complete fuel systems, included in Kubota bi-fuel system. To adequately protect the engine from damage caused by introducing two fuels simultaneously, the Kubota has designed a Fuel System Select switch which signals the ECM to change fuels. The switch is typically either a two position, or three positioned switch. When using a three position switch in the center position neither the gasoline fuel pump nor the electric lock off, can be energized. Rotating the switch in one direction or the other will activate the fuel system, the operator has chosen.

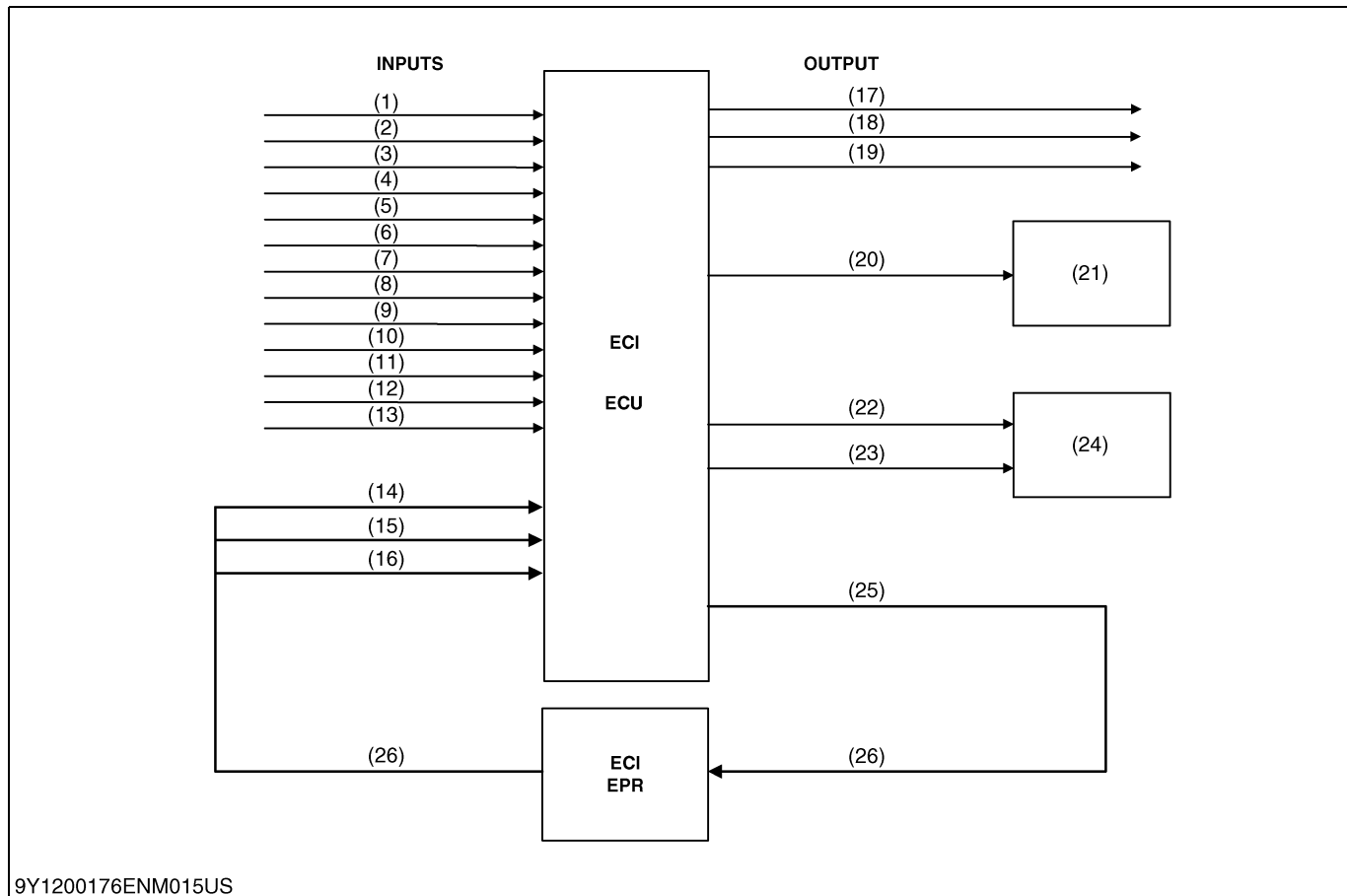
**ENGINE CONTROL MODULE (ECM)**



**Figure 19: Gasoline ECM Input and Outputs**

- |                        |                          |                           |                          |
|------------------------|--------------------------|---------------------------|--------------------------|
| (1) BATTERY PLUS       | (9) THROTTLE POSITION 1  | (16) SPARK CONTROL TO     | (21) GAGE OUTPUT         |
| (2) BATTERY MINUS      | (10) THROTTLE POSITION 2 | IGNITION COILS            | (22) INSTURMENT PANEL    |
| (3) ENGINE RPM         | (11) FOOT PEDAL POSITION | (17) THROTTLE SPEED       | (23) GASOLINE FUELPUMP   |
| (4) ENGINE COOLANT     | (12) KNOCK SENSOR        | CONTROL                   | CONTROL                  |
| (5) ENGINE OIL         | (13) PRE CAT HEGO        | (18) DATA LINK CONNECTION | (24) GASOLINE RETURNLESS |
| (6) CRANK SHAFT SENSOR | (14) POST CAT HEGO       | (19) DIAGNOSTIC TOOL      | RAIL                     |
| (7) INTAKE AIR TEMP    | (15) GASOLINE RETURNLESS | (20) MIL LIGHT            | (25) GASOLINE INJECTORS  |
| (8) MANIFOLD PRESSURE  | RAIL                     |                           |                          |

**ENGINE CONTROL MODULE (ECM)**

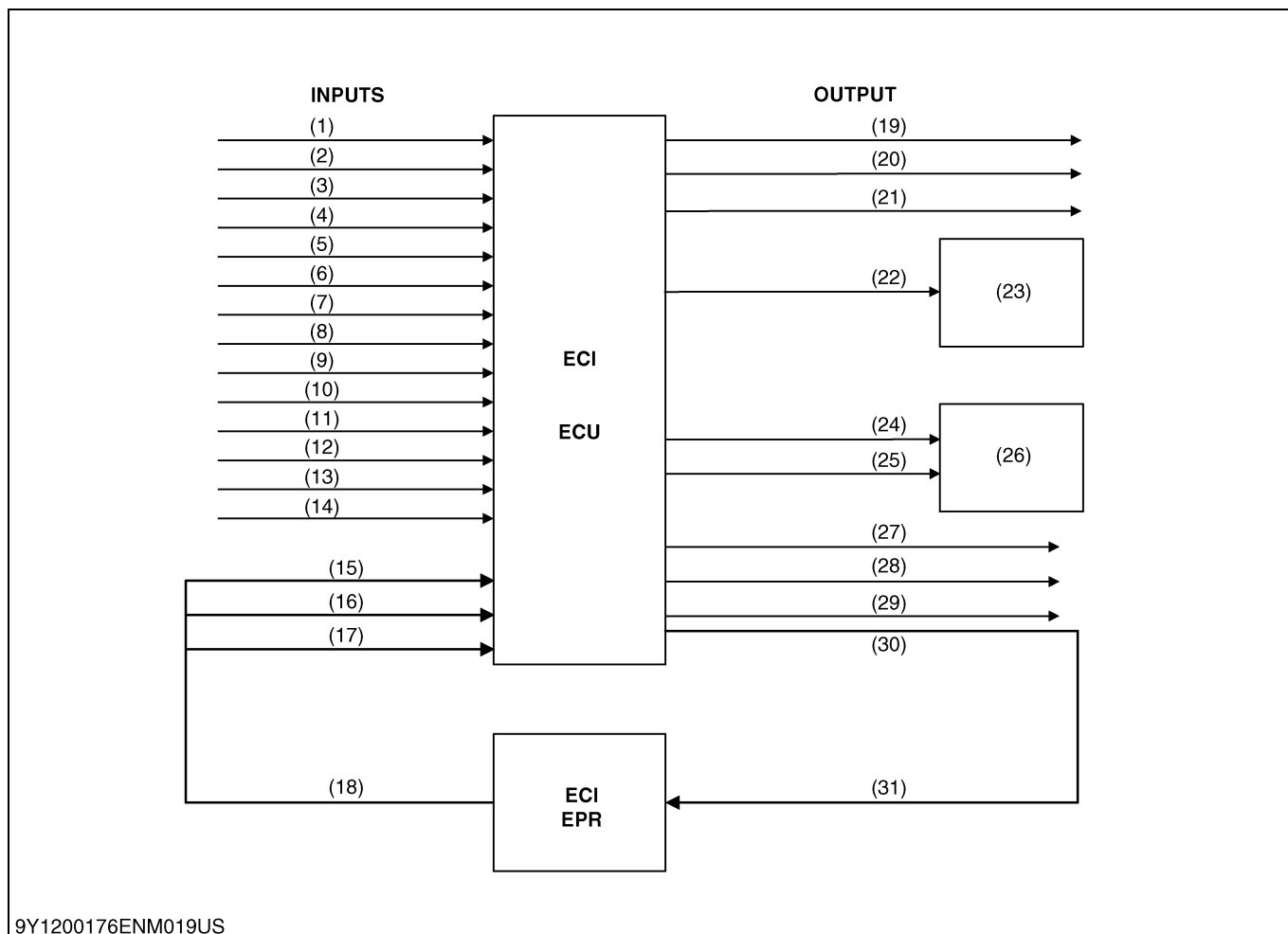


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**Figure 20: LPG / Natural Gas ECM Input and Outputs**

- |                        |                          |                             |                          |
|------------------------|--------------------------|-----------------------------|--------------------------|
| (1) BATTERY PLUS       | (9) THROTTLE POSITION 1  | (16) FUEL CONTROL LOCATION  | (21) DIAGNOSTIC TOOL     |
| (2) BATTERY MINUS      | (10) THROTTLE POSITION 2 | (17) SPARK CONTROL TO       | (22) MIL LIGHT           |
| (3) ENGINE RPM         | (11) FOOT PEDAL POSITION | IGNITION COILS              | (23) GAGE OUTPUT         |
| (4) ENGINE COOLANT     | (12) PRE CAT HEGO        | (18) LPG / NATURAL GAS LOCK | (24) INSTRUMENT PANEL    |
| (5) ENGINE OIL         | (13) POST CAT HEGO       | OFF CONTROL                 | (25) FUEL METERING       |
| (6) CRANK SHAFT SENSOR | (14) FUEL PRESSURE       | (19) THROTTLE SPEED         | CORRECTION               |
| (7) INTAKE AIR TEMP    | (15) FUEL TEMP           | CONTROL                     | (26) HIGH SPEED CAN LINK |
| (8) MANIFOLD PRESSURE  |                          | (20) DATA LINK CONNECTION   |                          |

**ENGINE CONTROL MODULE (ECM)**



9Y1200176ENM019US

**Figure 21: Bi-Fuel ECM Input and Outputs**

- |                        |                                      |   |                                |
|------------------------|--------------------------------------|---|--------------------------------|
| (1) BATTERY PLUS       | (11) FOOT PEDAL POSITION             | (18) HIGH SPEED CAN LINK                | (25) GAGE OUTPUT               |
| (2) BATTERY MINUS      | (12) PRE CAT HEGO                    | (19) SPARK CONTROL TO IGNITION COILS    | (26) INSTRUMENT PANEL          |
| (3) ENGINE RPM         | (13) POST CAT HEGO                   | (20) LPG / NATURAL GAS LOCK OFF CONTROL | (27) GASOLINE FUELPUMP CONTROL |
| (4) ENGINE COOLANT     | (14) GASOLINE RETURNLESS RAIL        | (21) THROTTLE SPEED CONTROL             | (28) GASOLINE RETURNLESS RAIL  |
| (5) ENGINE OIL         | (15) LPG / NATURAL GAS FUEL PRESSURE | (22) DATA LINK CONNECTION               | (29) GASOLINE INJECTORS        |
| (6) CRANK SHAFT SENSOR | (16) LPG / NATURAL GAS FUEL TEMP     | (23) DIAGNOSTIC TOOL                    | (30) FUEL METERING CORRECTION  |
| (7) INTAKE AIR TEMP    | (17) FUEL CONTROL LOCATION           | (24) MIL LIGHT                          | (31) HIGH SPEED CAN LINK       |

In Kubota fuel systems, the Engine Control Module (ECM) provides total control, of the engine, fuel control, ignition spark control, and auxiliary features. The ECM depends on Kubota designed wire harness, to receive the required input data, from sensors, and sends the appropriate outputs. The harness is specifically designed to provide the necessary electrical supply, to the engine, through the life of the equipment. All electrical connectors utilize sealed connectors, to prevent damage from moisture intrusion, necessary shielding, when required, and protective covering, to protect the wiring.

To obtain maximum effect from the catalyst and accurate control of the air fuel ratio, the emissions certified engine is attached with an onboard computer known as the ECM. The ECM is a 32 bit controller, which

receives input data from sensors, fitted to the engine and fuel system, and then outputs various signals, to control engine operation.

Engine sensors are used for fuel calculation and control, and are also used for the gasoline diagnostics. Those sensors are defined in the sensor group, in this section.

## **ENGINE SENSOR GROUP**

To maintain fuel control, and insure the system provides the optimum performance, the ECM depends on sensors installed in the engine and fuel system, to provide input to the ECM, for calculating fuel delivery, as well as fuel system diagnostics. This section will provide the technician, with the understanding of the function of each sensor.

### **TEMPERATURE MANIFOLD ABSOLUTE PRESSURE (TMAP)**

The TMAP sensor is a combination sensor, and provides the ECM with the Intake Air Temperature (IAT), and the Manifold Absolute Pressure (MAP). The ECM uses the intake air temperature to correct fueling based on the density of the air.

The MAP portion of the TMAP sensor provides the ECM with a measurement of the pressure in the intake manifold. During the start up, the MAP provides the ECM with the barometric pressure, to allow the ECM to adjust fueling, based on barometric pressure. Once the engine has started, the ECM uses the MAP to measure the load on the engine, and make fuel and RPM corrections, to compensate for changing load conditions.

In Kubota fuel system design, the TMAP is mounted to the intake manifold, The TMAP is a 5.00 V reference signal sensor, which operates by the resistance change in the sensor, to output a reference voltage for the ECM to use. The sensor can be a 0 to 5.00 V which is supplied by the engine. During the development phase of the system, the minimum and maximum thresholds of operation are determined, and are part of the fuel calibration and diagnostics, programmed into the ECM. These thresholds are used to establish the point at which the ECM will set the MIL light, to indicate that a fault has been detected in the fuel system.

### **ENGINE COOLANT TEMPERATURE (ECT)**

The ECM monitors the engine coolant temperature, through the ECT sensor mounted in the engine. The ECM uses this sensor input to make corrections in fueling, and to protect the engine from overheating during normal operation.

In Kubota fuel system designs, the ECT is mounted in the water flange, and is usually supplied by Kubota. The ECT is a 5.00 V reference signal sensor, which operates by the resistance change in the sensor, to output a reference voltage for the ECM to use. The sensor can be a 0 to 5.00 V which is supplied by the engine. During the development phase of the system, the minimum and maximum threshold of engine temperature, during normal operation, are determined and are part of the fuel calibration and diagnostics, programmed into the ECM. These thresholds are used to establish the point at which the ECM will set the MIL light, to indicate that a fault has been detected in the fuel system. Should the temperature be exceeded, the ECM will first reduce the engine performance capabilities, often referred to as "limp home", which allows the

operator to move the equipment to a facility for repair, or safely shut down the system. In the event the temperature continues to rise, the ECM will shut down the engine in a specified period of time, after the "limp home" strategy has been activated.

### **ENGINE OIL PRESSURE (EOP)**

The ECM monitors the engine oil pressure, through the EOP sensor, mounted in the engine. The ECM uses this sensor input, to protect the engine from damage, from the lack of oil in the crank case.

In Kubota fuel system designs, the EOP is mounted in the cylinder block, and is supplied by Kubota. The EOP is a 5.00 V reference signal sensor, which operates by the resistance change in the sensor, to output a reference voltage for the ECM to use. The sensor can be a 0 to 5.00 V which is supplied by the engine. During the development phase of the system, the minimum and maximum threshold of engine temperature, during normal operation are determined, and are part of the fuel calibration and diagnostics, programmed into the ECM. These thresholds are used to establish the point, at which the ECM will set the MIL light, to indicate that a fault has been detected in the engine. Should the pressure be exceeded or fall below the minimum pressure, the ECM will shut down the engine in a specified period of time.

### **THROTTLE POSITION SENSORS 1 & 2 (TPS 1&2)**

Kubota fuel systems use an Electronic Throttle Body (ETB) for speed and load control. Internal to the ETB, are two Throttle Position Sensors (TPS), which provide an "actual position" of the throttle plate. During the calibration development, the throttle blade variation, from actual to command, is defined. A maximum variation threshold is determined and included in the calibration, this threshold insures that the variation between actual and command do not vary above this threshold. In the event the variation exceeds the threshold, the ECM will command the ETB to idle, or shutdown the engine. The ECM will also set a diagnostic code, and turn on the MIL light

### **FOOT PEDAL POSITION SENSORS (FPP)**

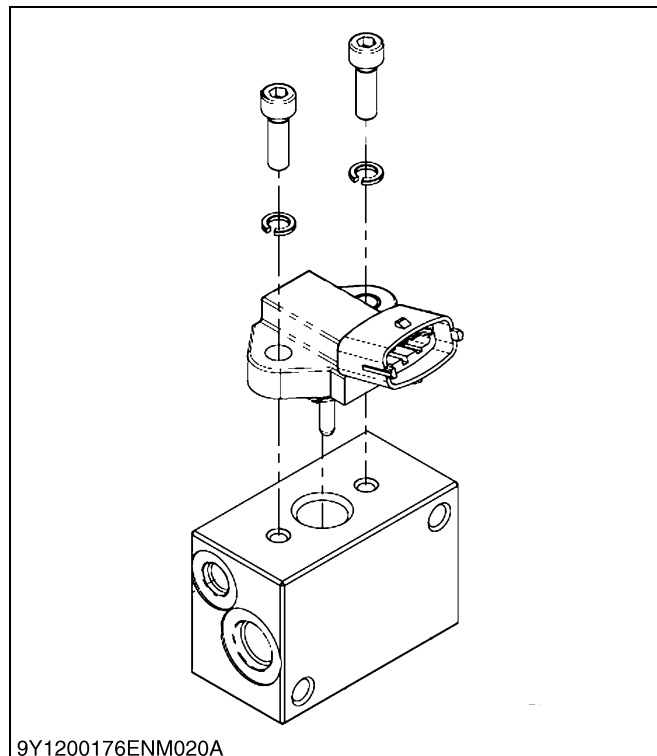
Kubota fuel systems, utilize a "drive by wire" technique, to allow the operator to accelerate the engine. This type of technique does not use a physical connection, between the operator foot pedal and the throttle body. Therefore control of the engine is managed by electrical signals, using a Foot Pedal Position Sensor (FPP), to determine the location, or how much the pedal is being depressed or released, which is relative to the command, that the operator desires. The FPP is a reference voltage sensor, therefore changing the voltage output level up or down, indicates a different desired position to the ECM. The ECM then changes the output signal, to the ETB, thus changing the throttle blade position, to correspond to the desired foot pedal command. The FPP is generally integrated, in the foot pedal mechanism, mounted in the operator's platform.

### **GASOLINE PRESSURE SENSORS (GPS)**

The Gasoline Pressure Sensor (GPS) provides a reference voltage signal to the ECM. The ECM reads the voltage signal and determines the pressure of the gasoline in the Fuel Pressure Manifold. The ECM uses this value to maintain the precise amount of gasoline pressure for injection, to maintain engine performance and emission control. Thresholds of operation are determined during the development of the calibrations; these thresholds are used to provide diagnostics, of the fuel delivery system. If the GPS output voltage is outside the threshold, either high or low, the ECM will detect the condition and either correct the fuel delivery, or set an engine code, and utilize a "limp home" strategy, or shut down the engine. The sensor is located in the Fuel Pressure Manifold, and is serviceable as a separate part.

### **GAS TEMPERATURE SENSORS (GTS)**

The EControls ECM adjusts gasoline fuel delivery to the engine, by utilizing a Gasoline Temperature Sensor (GTS), which provides a reference voltage signal, to the ECM. The ECM reads the voltage signal, and determines the temperature of the gasoline, in the Fuel Pressure Manifold, and uses this value, to correct the precise amount of gasoline, required for injection, to maintain engine performance, and emissions control. Thresholds of operation are determined during the development of the calibrations; these thresholds are used to provide diagnostics, of the fuel delivery system. If the GTS output voltage is outside the threshold, either high or low, the ECM will detect the condition, and either correct the fuel delivery, or set an engine code, and utilize a "limp home" strategy, or shut down the engine. The sensor is located in the Fuel Pressure Manifold, and is serviceable as a separate part.



**Figure 22:** Gasoline Temperature and Pressure Sensor

### **CRANKSHAFT POSITION SENSOR (CKP)**

To determine the engine RPM and piston position of number one cylinder, the ECM receives this information from the Crankshaft Sensor. The CKP is located near the flywheel at the rear of the engine, and is supplied by the engine. CKPs vary in design, depending on the signal that the sensor produces. Induction sensors produce a sine wave signal, where as the pick-up crank position sensor, which reads a notched metal "interrupter" ring, on the back of the harmonic balancer, creates a square wave pattern.

### **CAMSHAFT POSITION SENSOR (CMP)**

The cam shaft sensor is used to determine which stroke of the engine cycle the engine is running on for control of the fuel and spark. The sensor is mounted at the front of the engine (gear case side) and reads a pick up wheel mounted internally within the engine. The pick up wheel can be of vary design and number of pulses.

**KNOCK SENSOR (KCS)**

To prevent engine "knock", which occurs when the fuel air mixture does not burn smoothly, during this condition timing is generally decreased, to assist with the fuel burn process. Kubota gasoline fuel system, utilizes a Knock Sensor, which is installed to the engine block, and attached by Kubota. The Knock Sensor is a 5 volt reference signal sensor, which operates by the resistance change in the sensor, to output a reference voltage for the ECM to use. The knock sensor sends a base or "no knock" signal to the EControls ECM, when knocking does occur the sensor detects the increased vibration, and increases the voltage output to the ECM. When the ECM receives the voltage change, the ECM will slightly retard the timing, until such time, the knocking no longer exists.



## [2] Electrical System

### INTRODUCTION

This section of the Kubota's manual has been designed to allow the technician to be able to select the section of the electrical system which is applicable to the fuel system being used. EControls systems are designed such that variation in fuel, engine size and auxiliary control feature are controlled by only several variations of Engine Control Modules (ECM). During the design of each of Kubota fuel systems Kubota defines the components that will interface with the EControls ECM and what options and auxiliary system are to be controlled by the ECM. Kubota fuel system wire harness varies slightly not only in circuits but in length and connector end. However each of the EControls ECM has identical 90 pin connectors. Variations in each ECM will dictate what the individual pin function is however there are many of the pins which have the same function regardless of fuel system or engine size. Some pins may not be used in certain Kubota fuel system and are blanked in the connector.

### SYSTEM WIRING DIAGRAM

This section has shown the detail specific wire harness diagram for Kubota fuel system and electrical circuit. It is shown a connection to the vehicle side and engine side each for each specification.

### CONNECTOR VIEWS

For those circuits which are not likely to vary, the individual circuits are documented in the harness section of this manual. Also included are the standard connector mating views which define the pin location in each connection. The view display is from mating connector perspective. Each connector in the overall wire harness has a connector number which begins with the prefix **CO-** followed by a three (3) digit number.

### CIRCUIT IDENTIFICATION

Circuit numbers are not identified and wire colors may vary slightly as Kubota request specific wire colors for certain circuits. Standard circuit descriptions are used to identify each circuit. (example: Injector #1+)

### WIRE DESCRIPTION

Each of the individual circuit diagrams contains the wiring information necessary for the technician to make repairs to that circuit without causing future damage to any electrical component or the wiring harness itself. All components use a crimped connector unless otherwise defined.

### REPAIR OF WIRING HARNESS

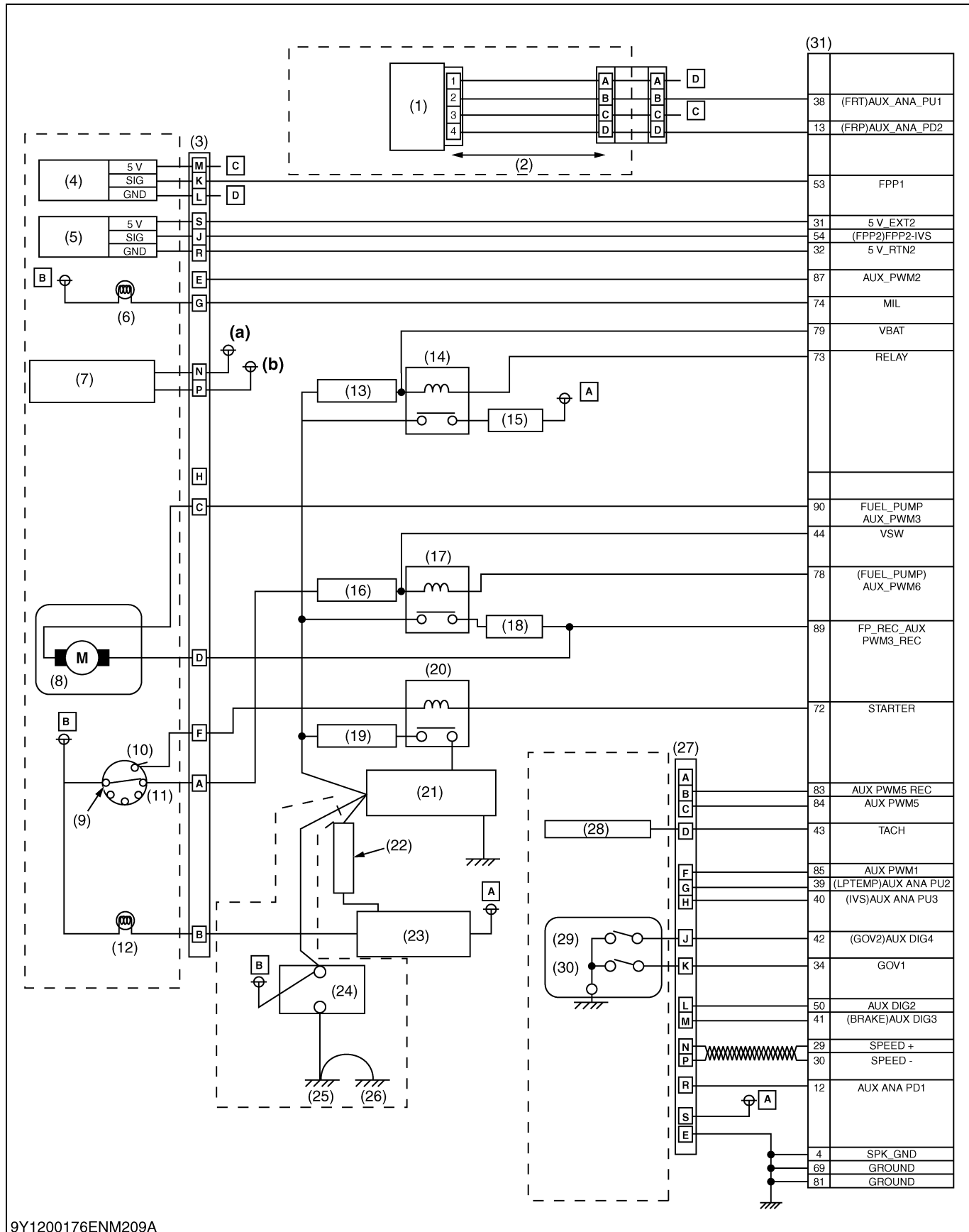
EControls recognizes that through normal wear or improper handling of the main wire harness damage can occur over time. Wires, connector ends, and pins may become damaged and require replacement or repair. EControls has provided in this manual a section which described the proper repair procedures when making repairs to any wire harness. Use this section and the proper tools when making splices or repairs to the harness.

#### ■ **NOTE**

- **BEFORE DIAGNOSING ANY ELECTRICAL PROBLEM CHECK THE MAIN ECM CONNECTOR TO IDENTIFY WHAT PINS ARE BLANKED.**
- **BEFORE MAKING HARNESS REPAIRS BE SURE TO USE THE CORRECT WIRE HARNESS REPAIR TOOLS SUCH AS CRIMPING TOOLS, WIRE STRIPPING TOOLS, AND ELECTRICAL DIAGNOSTIC TOOLS**
- **BEFORE ADDING ANY OPTIONAL ELECTRICAL EQUIPMENT TO THE VEHICLE FITTED WITH AN ECONTROLS SYSTEM CONSULT WITH KUBOTA OF THE EQUIPMENT TO VERIFY THAT THE ELECTRICAL SYSTEM CAN SUSTAIN THE NEW ELECTRICAL LOADS AND WHERE TO CONNECT THE ADDITIONAL LOAD.**
- **WHEN ADDING OPTIONAL ELECTRICAL EQUIPMENT BE SURE TO USE A IN-LINE FUSE OF THE PROPER ELECTRICAL LOAD TO PROTECT THE VEHICLE ELECTRICAL SYSTEM.**

# (1) System Wiring Diagram

## [A] VEHICLE SIDE OF SYSTEM WIREING DIAGRAM (WG1605-G)



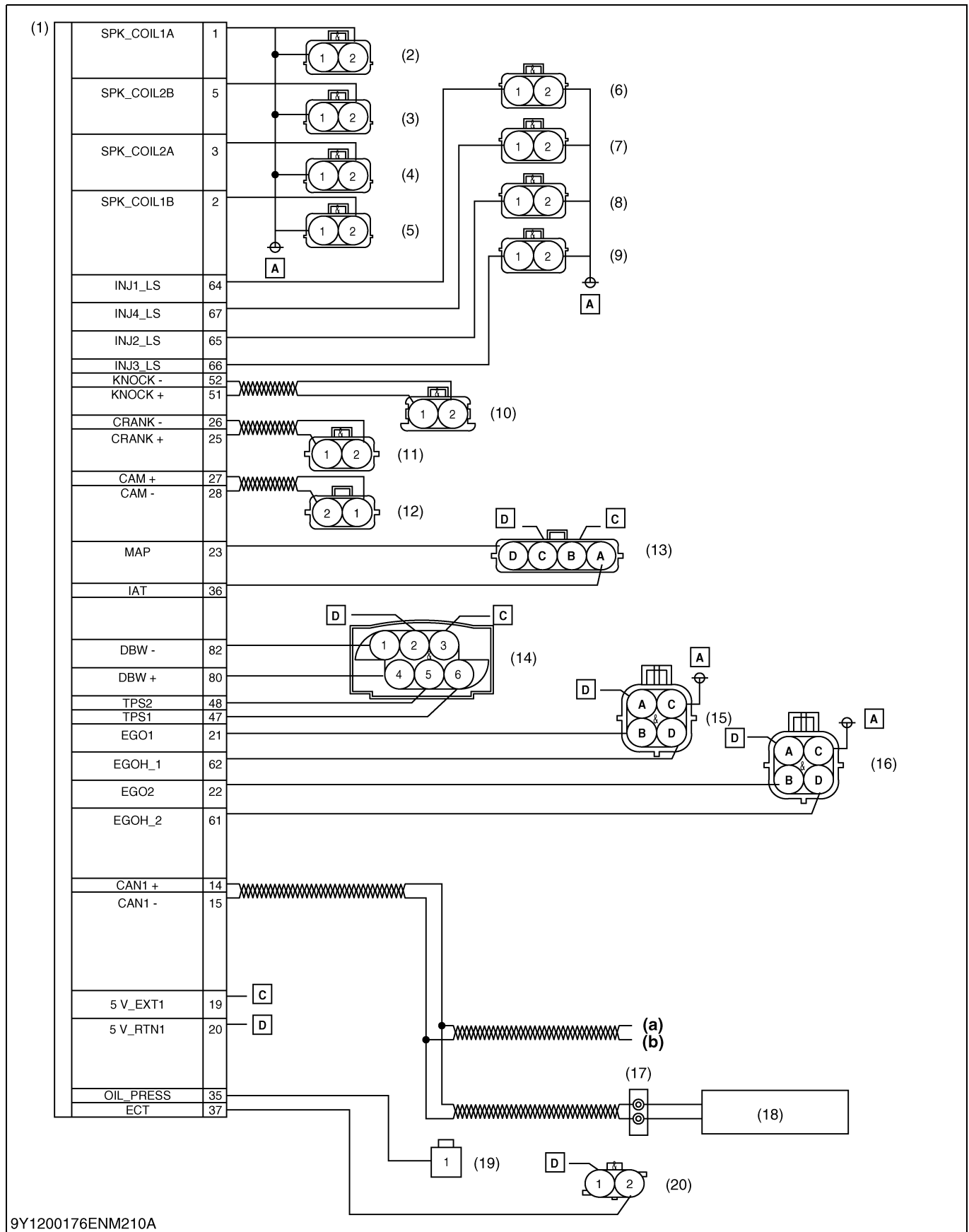
9Y1200176ENM209A

**JOINT POINTS (A, B, C, D)**

- **A: The points below are joined.**  
 IGNITION\_FUSE (15A)  
 ALTERNATOR\_PIN\_2  
 VIC2\_PIN\_S  
 COIL\_CYL\_#1,2,3,4\_PIN\_1  
 INJ\_CYL\_#1,2,3,4\_PIN\_2  
 O2\_SENSOR\_PRE\_CATALYST\_PIN\_C  
 O2\_SENSOR\_POST\_CATALYST\_PIN\_C
- **B: The points below are joined.**  
 BATTERY +  
 KEY\_SWITCH\_PIN\_OFF  
 ALTERNATOR\_CHARGE\_INDICATION\_LAMP  
 FUEL\_SEL\_PIN\_NG  
 MIL\_LAMP
- **C: The points below are joined.**  
 ECM\_PIN\_19 (5 V\_EXT1)  
 THROTTLE\_ACTUATOR\_PIN\_3  
 TMAP (BOOST) PIN\_B  
 FPM\_PIN\_C  
 VIC1\_PIN\_M
- **D: The points below are joined.**  
 ECM\_PIN\_20 (5 V\_RTN1)  
 COOLANT\_TEMPERATURE\_SENSOR\_PIN\_1  
 O2\_SENSOR\_PRE\_CATALYST\_PIN\_A  
 O2\_SENSOR\_POST\_CATALYST\_PIN\_A  
 THROTTLE\_ACTUATOR\_PIN\_2  
 TMAP (BOOST)\_PIN\_C  
 FPM\_PIN\_A  
 VIC1\_PIN\_L

- |                              |                        |                         |                                   |
|------------------------------|------------------------|-------------------------|-----------------------------------|
| (1) FPM                      | (10) KEY ST            | (18) FUEL_PUMP 15A FUSE | (26) ENG. BODY                    |
| (2) FPM Intermediate Harness | (11) KEY IG            | (19) STARTER 15A FUSE   | (27) VIC2 Connector               |
| (3) VIC1 Connector           | (12) Charge Indication | (20) Starter Relay      | (28) SPEED_METER                  |
| (4) ACCEL SENSOR1            | (13) ECM 10A FUSE      | (21) STARTER            | (29) GOV_SEL2                     |
| (5) ACCEL SENSOR2            | (14) Power Relay       | (22) 60A FUSE           | (30) GOV_SEL1                     |
| (6) MIL                      | (15) IGNITION 15A FUSE | (23) ALTERNATOR         | (31) ECM (1/2)                    |
| (7) CAN for Vehicle          | (16) VSW 5A FUSE       | (24) BATTERY            | <b>(a) to ECM_PIN_14 (CAN1 +)</b> |
| (8) FEED_PUMP                | (17) Fuel_pump Relay   | (25) BODY EARTH         | <b>(b) to ECM_PIN_15 (CAN1 -)</b> |
| (9) KEY OFF                  |                        |                         |                                   |

**[B] ENGINE SIDE OF SYSTEM WIRING DIAGRAM (WG1605-G)**



9Y1200176ENM210A

**JOINT POINTS (A, B, C, D)**

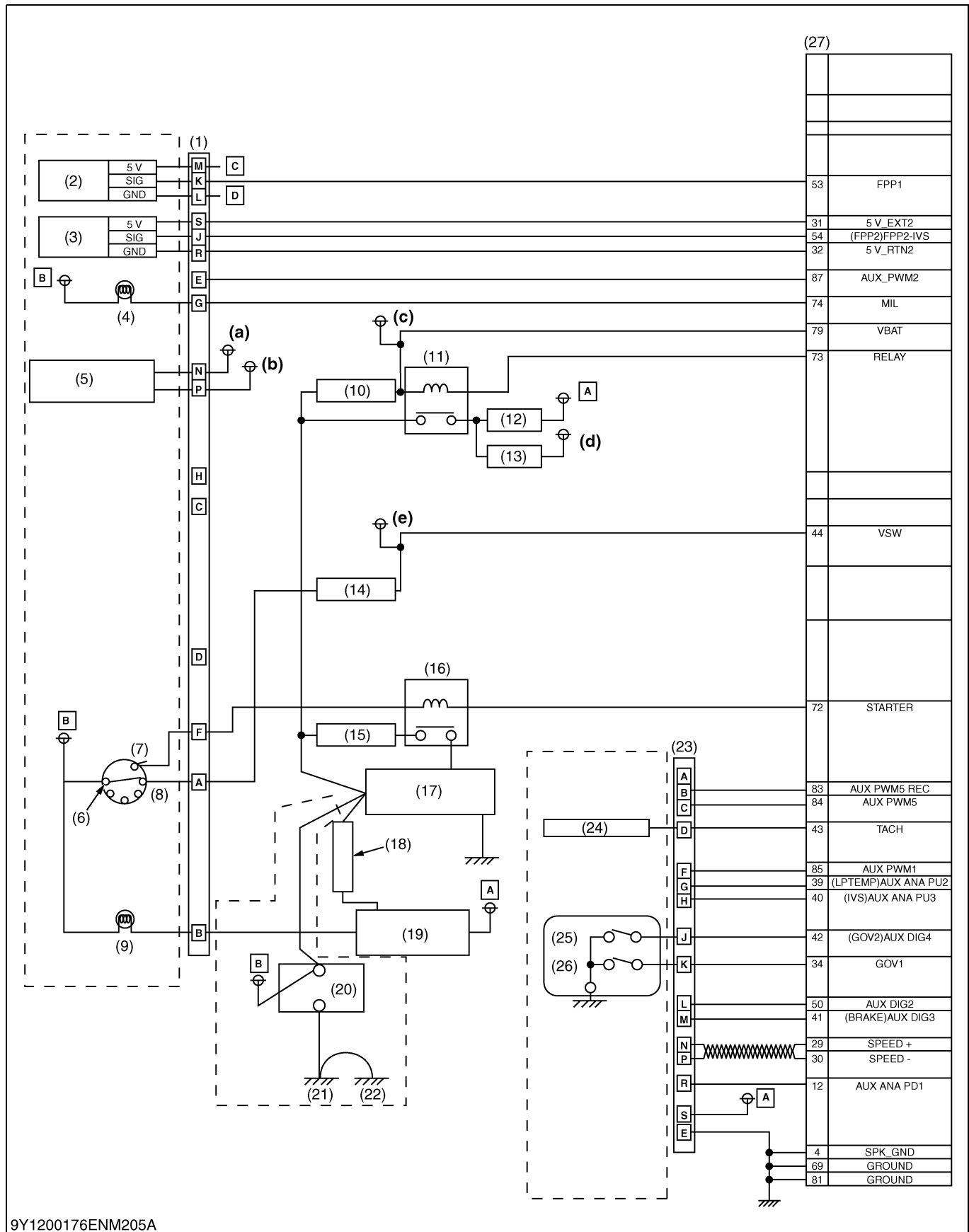
- **A: The points below are jointed.**  
IGNITION\_FUSE (15A)  
ALTERNATOR\_PIN\_2  
VIC2\_PIN\_S  
COIL\_CYL\_#1,2,3,4\_PIN\_1  
INJ\_CYL\_#1,2,3,4\_PIN\_2  
O<sub>2</sub>\_SENSOR\_PRE\_CATALYST\_PIN\_C  
O<sub>2</sub>\_SENSOR\_POST\_CATALYST\_PIN\_C
- **B: The points below are jointed.**  
BATTERY +  
KEY\_SWITCH\_PIN\_OFF  
ALTERNATOR\_CHARGE\_INDICATION\_LAMP  
FUEL\_SEL\_PIN\_NG  
MIL\_LAMP
- **C: The points below are jointed.**  
ECM\_PIN\_19 (5 V\_EXT1)  
THROTTLE\_ACTUATOR\_PIN\_3  
TMAP (BOOST) PIN\_B  
FPM\_PIN\_C  
VIC1\_PIN\_M
- **D: The points below are jointed.**  
ECM\_PIN\_20 (5 V\_RTN1)  
COOLANT\_TEMPERATURE\_SENSOR\_PIN\_1  
O<sub>2</sub>\_SENSOR\_PRE\_CATALYST\_PIN\_A  
O<sub>2</sub>\_SENSOR\_POST\_CATALYST\_PIN\_A  
THROTTLE\_ACTUATOR\_PIN\_2  
TMAP (BOOST)\_PIN\_C  
FPM\_PIN\_A  
VIC1\_PIN\_L

**NOTE**

- **The picture shows the pin arrangement of the connector housing viewed from the harness connector mating side.**

(1) ECM (2/2)	(7) INJ_SYL_#2	(13) TMAP (BOOST)	(18) CAN Tool
(2) COIL_CYL_#1	(8) INJ_SYL_#3	(14) Throttle Actuator	(19) Oil SW
(3) COIL_CYL_#2	(9) INJ_SYL_#4	(15) O <sub>2</sub> sensor Pre Catalyst	(20) Coolant temperature sensor
(4) COIL_CYL_#3	(10) Knock sensor	(16) O <sub>2</sub> sensor Post Catalyst	<b>(a) to VIC1_PIN_N</b>
(5) COIL_CYL_#4	(11) Crank sensor	(17) DIAG_TOOL Connector	<b>(b) to VIC1_PIN_P</b>
(6) INJ_SYL_#1	(12) Cam sensor		

[C] VEHICLE SIDE OF SYSTEM WIRING DIAGRAM (WG1605-L, WG1605-N, WG1605-LN)



9Y1200176ENM205A

**JOINT POINTS (A, B, C, D)**

- **A: The points below are joined.**  
 IGNITION\_FUSE (15A)  
 ALTERNATOR\_PIN\_2  
 VIC2\_PIN\_S  
 COIL\_CYL\_#1,2,3,4\_PIN\_1  
 INJ\_CYL\_#1,2,3,4\_PIN\_2  
 O2\_SENSOR\_PRE\_CATALYST\_PIN\_C  
 O2\_SENSOR\_POST\_CATALYST\_PIN\_C
- **B: The points below are joined.**  
 BATTERY +  
 KEY\_SWITCH\_PIN\_OFF  
 ALTERNATOR\_CHARGE\_INDICATION\_LAMP  
 FUEL\_SEL\_PIN\_NG  
 MIL\_LAMP
- **C: The points below are joined.**  
 ECM\_PIN\_19 (5 V\_EXT1)  
 THROTTLE\_ACTUATOR\_PIN\_3  
 TMAP (BOOST) PIN\_B  
 FPM\_PIN\_C  
 VIC1\_PIN\_M
- **D: The points below are joined.**  
 ECM\_PIN\_20 (5 V\_RTN1)  
 COOLANT\_TEMPERATURE\_SENSOR\_PIN\_1  
 O2\_SENSOR\_PRE\_CATALYST\_PIN\_A  
 O2\_SENSOR\_POST\_CATALYST\_PIN\_A  
 THROTTLE\_ACTUATOR\_PIN\_2  
 TMAP (BOOST)\_PIN\_C  
 FPM\_PIN\_A  
 VIC1\_PIN\_L

- |                     |                        |                     |                                   |
|---------------------|------------------------|---------------------|-----------------------------------|
| (1) VIC1 Connector  | (9) Charge Indication  | (17) STARTER        | (25) GOV_SEL2                     |
| (2) ACCEL SENSOR1   | (10) ECM 10A FUSE      | (18) 60A FUSE       | (26) GOV_SEL1                     |
| (3) ACCEL SENSOR2   | (11) Power Relay       | (19) ALTERNATOR     | (27) ECM (1/2)                    |
| (4) MIL             | (12) IGNITION 15A FUSE | (20) BATTERY        | <b>(a) to ECM_PIN_14 (CAN1 +)</b> |
| (5) CAN for Vehicle | (13) DEPR 5A FUSE      | (21) BODY EARTH     | <b>(b) to ECM_PIN_15 (CAN1 -)</b> |
| (6) KEY OFF         | (14) VSW 5A FUSE       | (22) ENG. BODY      | <b>(c) to DEPR_PIN_6</b>          |
| (7) KEY ST          | (15) STARTER 15A FUSE  | (23) VIC2 Connector | <b>(d) to DEPR_PIN_3</b>          |
| (8) KEY IG          | (16) Starter Relay     | (24) SPEED_METER    | <b>(e) to LOCKOFF VALVE_PIN_B</b> |





**JOINT POINTS (A, B, C, D)**

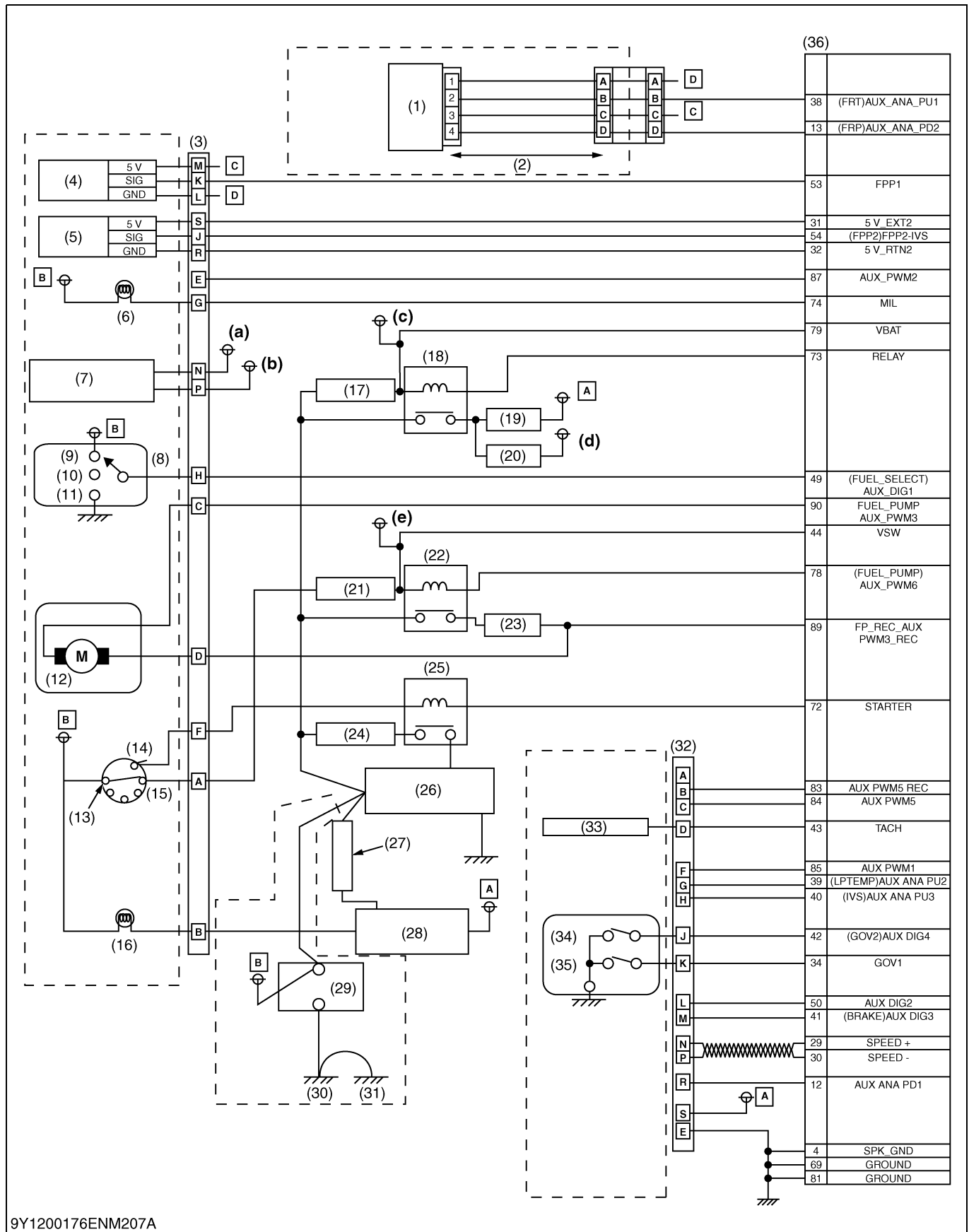
- **A: The points below are jointed.**  
 IGNITION\_FUSE (15A)  
 ALTERNATOR\_PIN\_2  
 VIC2\_PIN\_S  
 COIL\_CYL\_#1,2,3,4\_PIN\_1  
 INJ\_CYL\_#1,2,3,4\_PIN\_2  
 O2\_SENSOR\_PRE\_CATALYST\_PIN\_C  
 O2\_SENSOR\_POST\_CATALYST\_PIN\_C
- **B: The points below are jointed.**  
 BATTERY +  
 KEY\_SWITCH\_PIN\_OFF  
 ALTERNATOR\_CHARGE\_INDICATION\_LAMP  
 FUEL\_SEL\_PIN\_NG  
 MIL\_LAMP
- **C: The points below are jointed.**  
 ECM\_PIN\_19 (5 V\_EXT1)  
 THROTTLE\_ACTUATOR\_PIN\_3  
 TMAP (BOOST) PIN\_B  
 FPM\_PIN\_C  
 VIC1\_PIN\_M
- **D: The points below are jointed.**  
 ECM\_PIN\_20 (5 V\_RTN1)  
 COOLANT\_TEMPERATURE\_SENSOR\_PIN\_1  
 O2\_SENSOR\_PRE\_CATALYST\_PIN\_A  
 O2\_SENSOR\_POST\_CATALYST\_PIN\_A  
 THROTTLE\_ACTUATOR\_PIN\_2  
 TMAP (BOOST)\_PIN\_C  
 FPM\_PIN\_A  
 VIC1\_PIN\_L

■ **NOTE**

- **The picture shows the pin arrangement of the connector housing viewed from the harness connector mating side.**

- |                  |                             |                                |                                 |
|------------------|-----------------------------|--------------------------------|---------------------------------|
| (1) ECM (2/2)    | (7) Crank sensor            | (13) O2 sensor Post Catalyst   | (19) Coolant temperature sensor |
| (2) COIL_CYL_#1  | (8) Cam sensor              | (14) Can termination Connector | <b>(a) to VSW_FUSE (5A)</b>     |
| (3) COIL_CYL_#2  | (9) TMAP (BOOST)            | Open: termination OFF          | <b>(b) to DEPR_FUSE (5A)</b>    |
| (4) COIL_CYL_#3  | (10) Lockoff Valve          | Close: termination ON          | <b>(c) to ECM_FUSE (10A)</b>    |
| (5) COIL_CYL_#4  | (11) Throttle Actuator      | (15) DEPR                      | <b>(d) to VIC1_PIN_N</b>        |
| (6) Knock sensor | (12) O2 sensor Pre Catalyst | (16) DIAG_TOOL Connector       | <b>(e) to VIC1_PIN_P</b>        |
|                  |                             | (17) CAN Tool                  |                                 |
|                  |                             | (18) Oil SW                    |                                 |

[E] VEHICLE SIDE OF SYSTEM WIRING DIAGRAM (WG1605-GL, WG1605-GLN)



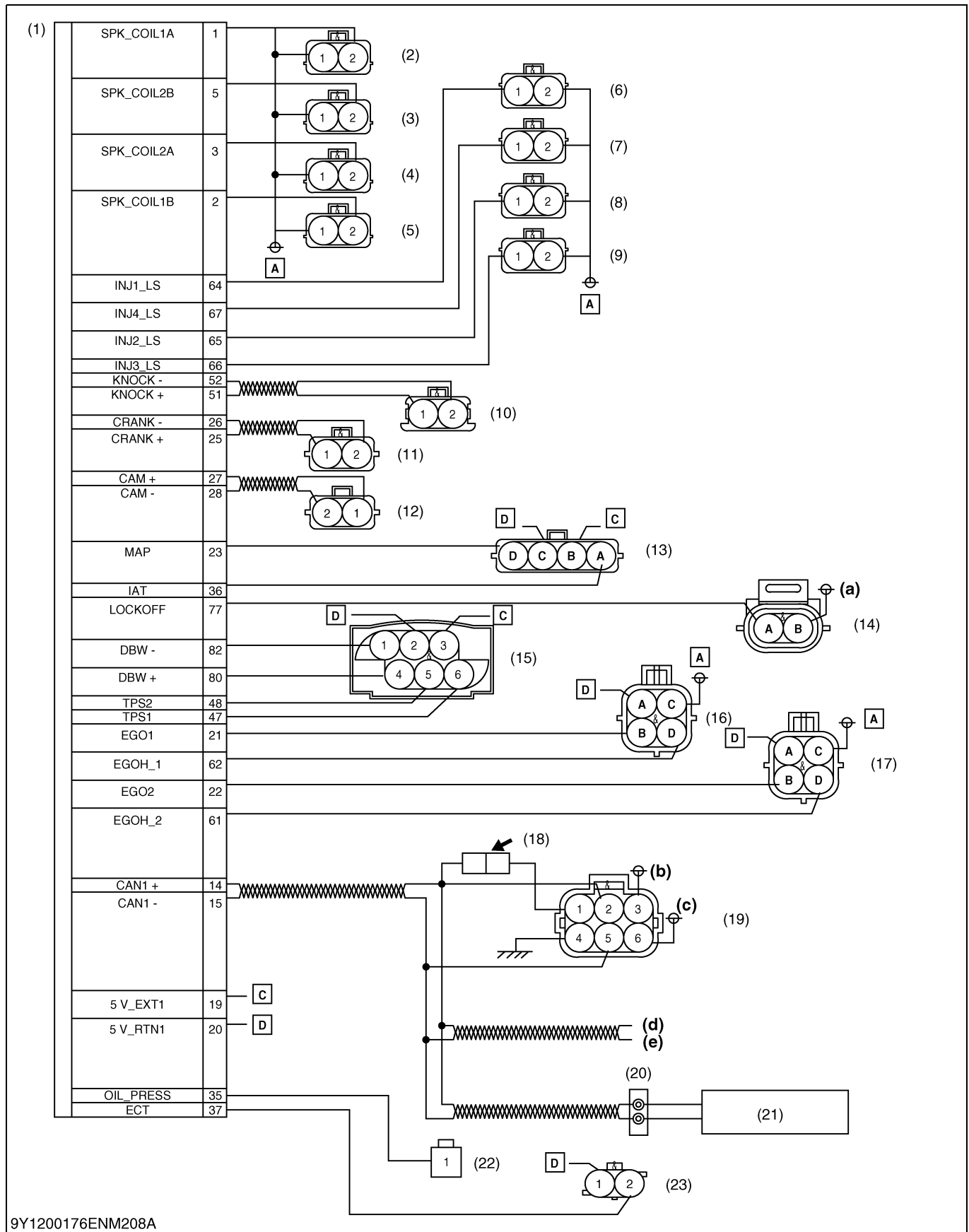
9Y1200176ENM207A

**JOINT POINTS (A, B, C, D)**

- **A: The points below are joined.**  
 IGNITION\_FUSE (15A)  
 ALTERNATOR\_PIN\_2  
 VIC2\_PIN\_S  
 COIL\_CYL\_#1,2,3,4\_PIN\_1  
 INJ\_CYL\_#1,2,3,4\_PIN\_2  
 O2\_SENSOR\_PRE\_CATALYST\_PIN\_C  
 O2\_SENSOR\_POST\_CATALYST\_PIN\_C
- **B: The points below are joined.**  
 BATTERY +  
 KEY\_SWITCH\_PIN\_OFF  
 ALTERNATOR\_CHARGE\_INDICATION\_LAMP  
 FUEL\_SEL\_PIN\_NG  
 MIL\_LAMP
- **C: The points below are joined.**  
 ECM\_PIN\_19 (5 V\_EXT1)  
 THROTTLE\_ACTUATOR\_PIN\_3  
 TMAP (BOOST) PIN\_B  
 FPM\_PIN\_C  
 VIC1\_PIN\_M
- **D: The points below are joined.**  
 ECM\_PIN\_20 (5 V\_RTN1)  
 COOLANT\_TEMPERATURE\_SENSOR\_PIN\_1  
 O2\_SENSOR\_PRE\_CATALYST\_PIN\_A  
 O2\_SENSOR\_POST\_CATALYST\_PIN\_A  
 THROTTLE\_ACTUATOR\_PIN\_2  
 TMAP (BOOST)\_PIN\_C  
 FPM\_PIN\_A  
 VIC1\_PIN\_L

- |                              |                        |                         |                                   |
|------------------------------|------------------------|-------------------------|-----------------------------------|
| (1) FPM                      | (12) FEED_PUMP         | (22) Fuel_pump Relay    | (32) VIC2 Connector               |
| (2) FPM Intermediate Harness | (13) KEY OFF           | (23) FUEL_PUMP 15A FUSE | (33) SPEED_METER                  |
| (3) VIC1 Connector           | (14) KEY ST            | (24) STARTER 15A FUSE   | (34) GOV_SEL2                     |
| (4) ACCEL SENSOR1            | (15) KEY IG            | (25) Starter Relay      | (35) GOV_SEL1                     |
| (5) ACCEL SENSOR2            | (16) Charge Indication | (26) STARTER            | (36) ECM (1/2)                    |
| (6) MIL                      | (17) ECM 10A FUSE      | (27) 60A FUSE           | <b>(a) to ECM_PIN_14 (CAN1 +)</b> |
| (7) CAN for Vehicle          | (18) Power Relay       | (28) ALTERNATOR         | <b>(b) to ECM_PIN_15 (CAN1 -)</b> |
| (8) FUEL_SEL                 | (19) IGNITION 15A FUSE | (29) BATTERY            | <b>(c) to DEPR_PIN_6</b>          |
| (9) NG                       | (20) DEPR 5A FUSE      | (30) BODY EARTH         | <b>(d) to DEPR_PIN_3</b>          |
| (10) Gasoline                | (21) VSW 5A FUSE       | (31) ENG. BODY          | <b>(e) to LOCKOFF VALVE_PIN_B</b> |
| (11) LPG                     |                        |                         |                                   |

**[F] ENGINE SIDE OF SYSTEM WIRING DIAGRAM (WG1605-GL, WG1605-GLN)**



9Y1200176ENM208A

**JOINT POINTS (A, B, C, D)**

- **A: The points below are jointed.**  
 IGNITION\_FUSE (15A)  
 ALTERNATOR\_PIN\_2  
 VIC2\_PIN\_S  
 COIL\_CYL\_#1,2,3,4\_PIN\_1  
 INJ\_CYL\_#1,2,3,4\_PIN\_2  
 O2\_SENSOR\_PRE\_CATALYST\_PIN\_C  
 O2\_SENSOR\_POST\_CATALYST\_PIN\_C
- **B: The points below are jointed.**  
 BATTERY +  
 KEY\_SWITCH\_PIN\_OFF  
 ALTERNATOR\_CHARGE\_INDICATION\_LAMP  
 FUEL\_SEL\_PIN\_NG  
 MIL\_LAMP
- **C: The points below are jointed.**  
 ECM\_PIN\_19 (5 V\_EXT1)  
 THROTTLE\_ACTUATOR\_PIN\_3  
 TMAP (BOOST) PIN\_B  
 FPM\_PIN\_C  
 VIC1\_PIN\_M
- **D: The points below are jointed.**  
 ECM\_PIN\_20 (5 V\_RTN1)  
 COOLANT\_TEMPERATURE\_SENSOR\_PIN\_1  
 O2\_SENSOR\_PRE\_CATALYST\_PIN\_A  
 O2\_SENSOR\_POST\_CATALYST\_PIN\_A  
 THROTTLE\_ACTUATOR\_PIN\_2  
 TMAP (BOOST)\_PIN\_C  
 FPM\_PIN\_A  
 VIC1\_PIN\_L

■ **NOTE**

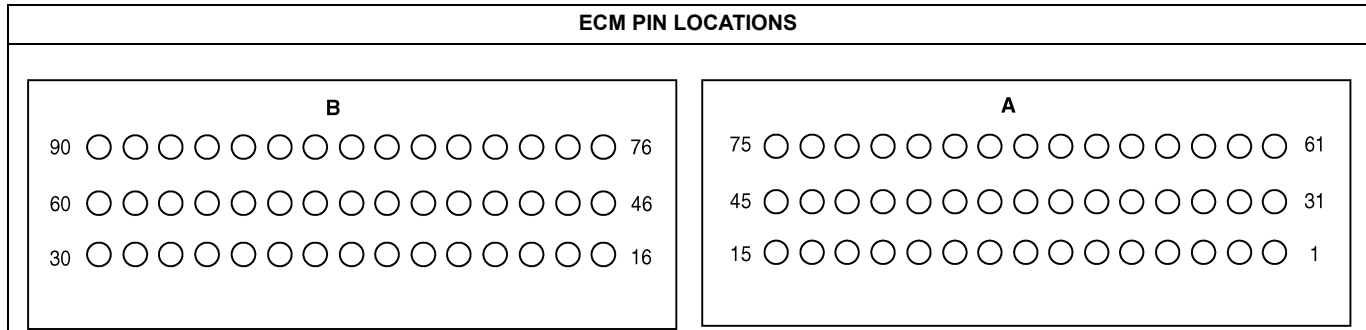
- **The picture shows the pin arrangement of the connector housing viewed from the harness connector mating side.**

- |                 |                    |                                |                                 |
|-----------------|--------------------|--------------------------------|---------------------------------|
| (1) ECM (2/2)   | (8) INJ_SYL_#3     | (15) Throttle Actuator         | (22) Oil SW                     |
| (2) COIL_CYL_#1 | (9) INJ_SYL_#4     | (16) O2 sensor Pre Catalyst    | (23) Coolant temperature sensor |
| (3) COIL_CYL_#2 | (10) Knock sensor  | (17) O2 sensor Post Catalyst   | <b>(a) to VSW_FUSE (5A)</b>     |
| (4) COIL_CYL_#3 | (11) Crank sensor  | (18) Can termination Connector | <b>(b) to DEPR_FUSE (5A)</b>    |
| (5) COIL_CYL_#4 | (12) Cam sensor    | Open: termination OFF          | <b>(c) to ECM_FUSE (10A)</b>    |
| (6) INJ_SYL_#1  | (13) TMAP (BOOST)  | Close: termination ON          | <b>(d) to VIC1_PIN_N</b>        |
| (7) INJ_SYL_#2  | (14) Lockoff Valve | (19) DEPR                      | <b>(e) to VIC1_PIN_P</b>        |
|                 |                    | (20) DIAG_TOOL Connector       |                                 |
|                 |                    | (21) CAN Tool                  |                                 |

## (2) ECU Terminal Layout

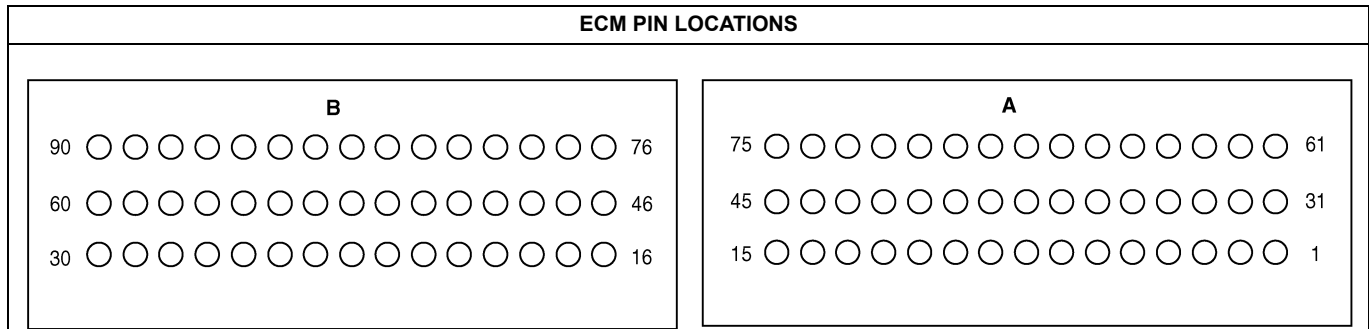
Connector Number: C001

Name: ECM CONNECTOR



9Y1200176ENM047A

PIN		DISCRIPTION		PIN		DISCRIPTION		PIN		DISCRIPTION	
1	SPK_COIL1A	YELLOW 18	31	5 V EXT 2	LT_GREEN/ PURPLE 18	61	EGOH 2	BLACK/ YELLOW 18			
2	SPK_COIL1B	YELLOW/ BLACK 18	32	5 V RTN 2	LT_GREEN/ BLACK 18	62	EGOH 1	BLACK/ WHITE 18			
3	SPK_COIL2A	YELLOW/ RED 18	33	PULSE_IN	BLANK	63	INJ HS	BLANK			
4	SPK_GRND	BLACK 16	34	GOV 1	GRAY/ DK_BLUE 18	64	INJ1 LS	BROWN/ LT_BLUE 18			
5	SPK_COIL2B	YELLOW/ WHITE 18	35	OIL PRESSURE	LT_BLUE 18	65	INJ2 LS	BROWN/ LT_GREEN 18			
6	SPK_COIL3A	BLANK	36	IAT	YELLOW/ GRAY 18	66	INJ3 LS	BROWN/ YELLOW 18			
7	SPK_COIL3B	BLANK	37	ECT	TAN/WHITE 18	67	INJ4 LS	BROWN/ WHITE 18			
8	UEGOS	BLANK	38	(FRP) AUX ANA PU1	LT_GREEN/ WHITE 18	68	INJ5 LS	BLANK			
9	UEGOC	BLANK	39	(LPTMP) AUX ANA PU2	YELLOW/ DK_BLUE 18	69	GROUND	BLACK 16			
10	UEGOP	BLANK	40	(IVS) AUX ANA PU3	DK_BLUE/ YELLOW 18	70	INJ6 LS	BLANK			
11	UEGPR	BLANK	41	BRAKE AUX DIG 3	TAN/ DK_GREEN 18	71	AUX PWM8	BLANK			
12	AUX ANA PD1	ORANGE/ YELLOW 18	42	(GOV2) AUX DIG 4	GRAY/RED 18	72	STARTER	PINK/BLACK 18			
13	(FRP) AUX ANA PDI	WHITE/ LT_GREEN 18	43	TACH	GRAY 18	73	RELAY	WHITE/ LT_BLUE 18			
14	CAN 1 +	Dk Blue/Pink 18	44	VSW	PINK/TAN 18	74	MIL	GREEN/ YELLOW 18			
15	CAN 1 -	BULE/WHITE 18	45	AUX ANA PUD 2	BLANK	75	UEGO H	BLANK			
16	CAN 2 +	BLANK	46	AUX ANA PUD 1	BLANK	76	AUX PWM7	BLANK			
17	CAN 2 -	BLANK	47	TPS 1	PURPLE/ LT_BLUE 18	77	LOCK OFF	WHITE/ BLACK 18			
18	AUX ANA PUD3	BLANK	48	TPS 2	LT_BLUE/ DK_BLUE 18	78	FUEL PUMP AUX PWM6	TAN/BLACK 18			
19	5 V EXT 1	LT_GREEN/ RED 18	49	FUEL SELECT AUX DIG 1	DK_GREEN/ PURPLE 18	79	VBAT	RED/TAN 16			
20	5 V RTN 1	BLACK/ LT_GREEN 18	50	AUX DIG 2	TAN/RED 18	80	DBW +	PINK/WHITE 18			
21	EGO 1	DK_GREEN/ ORANGE 18	51	KNOCK +	BLACK/ YELLOW 18	81	GROUND	BLACK 16			
22	EGO 2	DK_GREEN/ WHITE 18	52	KNOCK -	BLACK 18	82	DBW -	TAN/ ORANGE 18			



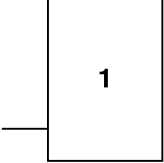
9Y1200176ENM047A

PIN	DISCRIPTION		PIN	DISCRIPTION		PIN	DISCRIPTION	
23	MAP	LT_GREEN 18	53	FPP1	DK_BLUE/ ORANGE 18	83	AUX PWM5 REC	WHITE/ BROWN 16
24	AUX ANA PUD3	BLANK	54	(FPP2) FPP2 IVS	PURPLE/ YELLOW 18	84	AUX PWM5	BROWN/ WHITE 16
25	CRANK +	PURPLE/ WHITE 18	55	PC TX	BLANK	85	AUX PWM1	TAN 16
26	CRANK -	WHITE/ PURPLE 18	56	PC RX	BLANK	86	AUX PWM4	BLANK
27	CAM +	GRAY/ BROWN 18	57	KNOCK 2 +	BLANK	87	AUX PWM2	DK_BLUE 18
28	CAM -	PURPLE/ ORANGE 18	58	KNOCK 2 -	BLANK	88	AUX PWM4 REC	BLANK
29	SPEED +	RED/WHITE 18	59	VBAT PROT	BLANK	89	FP REC AUX PWM3 REC	PINK/ YELLOW 16
30	SPEED -	RED/BLACK 18	60	VBAT	RED/TAN 16	90	FUEL PUMP AUX PWM3	BLACK/RED 16

### (3) Connector Views

Connector Number: C002\*<sup>1</sup>

Name: Starter Solenoid

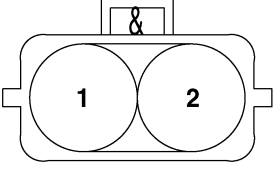


9Y1200176ENM049A

Pin Number	Description	Wire Color
1	Starter Solenoid	WHITE

Connector Number: C003\*<sup>1</sup>

Name: Crankshaft Sensor

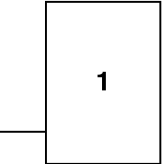


9Y1200176ENM197A

Pin Number	Description	Wire Color
1	CRANK +	PURPLE/WHITE
2	CRANK -	WHITE/PURPLE

Connector Number: C004\*<sup>1</sup>

Name: Oil Pressure Switch



9Y1200176ENM049A

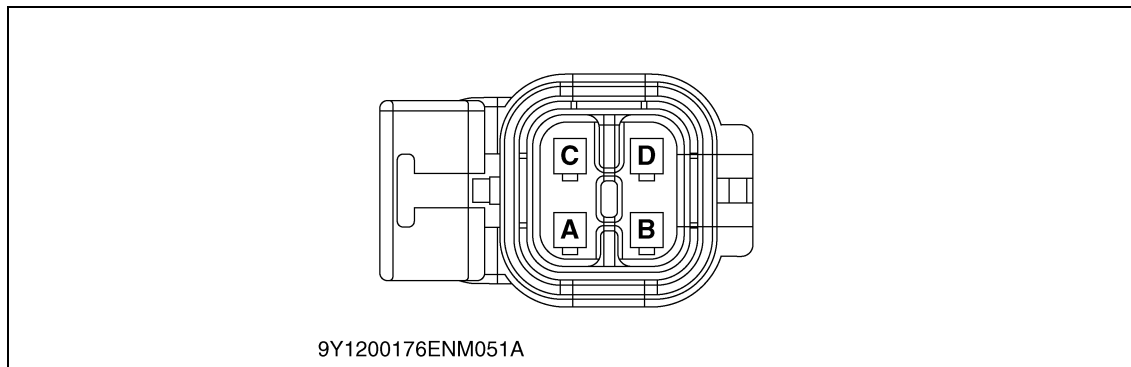
Pin Number	Description	Wire Color
1	Oil Pressure	LT_BLUE

■ **NOTE**

- \*1: All connector views are the mating connector view.

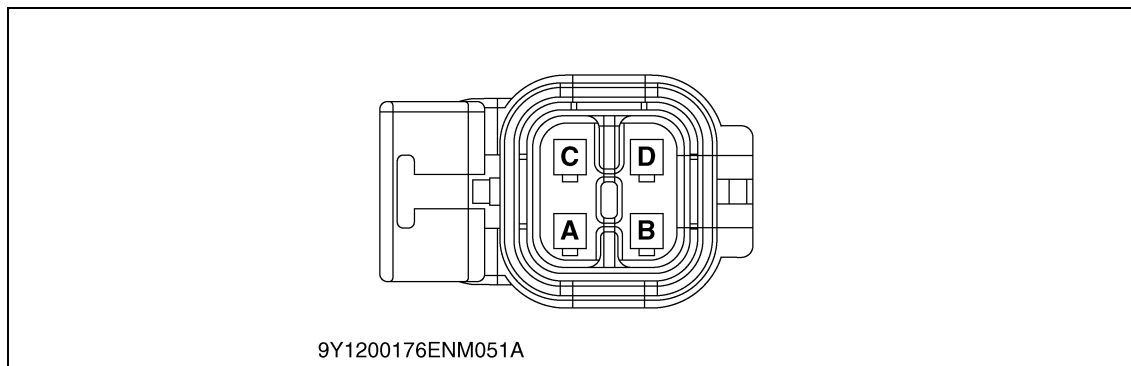


**Connector Number: C005\*1**  
**Name: Heated O<sub>2</sub> Sensor (Pre-Cat)**



Pin Number	Description	Wire Color
A	5 V_RTN 1	BLACK/LT_GREEN
B	EGO 1	DK_GREEN/ORANGE
C	12 V_RELAYED_POWER	PINK/DK_GREEN
D	EGOH 1	BLACK/WHITE

**Connector Number: C006\*1**  
**Name: Heated O<sub>2</sub> Sensor (Post-Cat)**



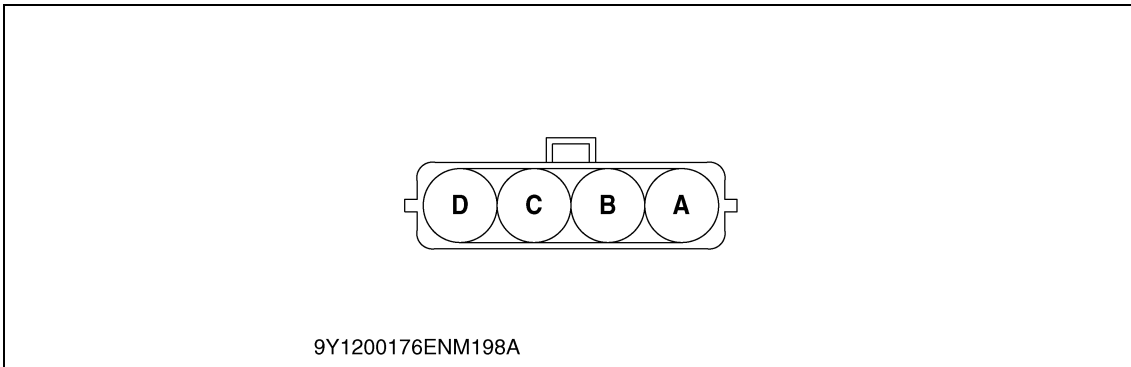
Pin Number	Description	Wire Color
A	5 V_RTN 1	BLACK/LT_GREEN
B	EGO 2	DK_GREEN/WHITE
C	12 V_RELAYED_POWER	PINK/DK_GREEN
D	EGOH 2	BLACK/YELLOW

■ **NOTE**

- \*1: All connector views are the mating connector view.

**Connector Number: C007\*1**

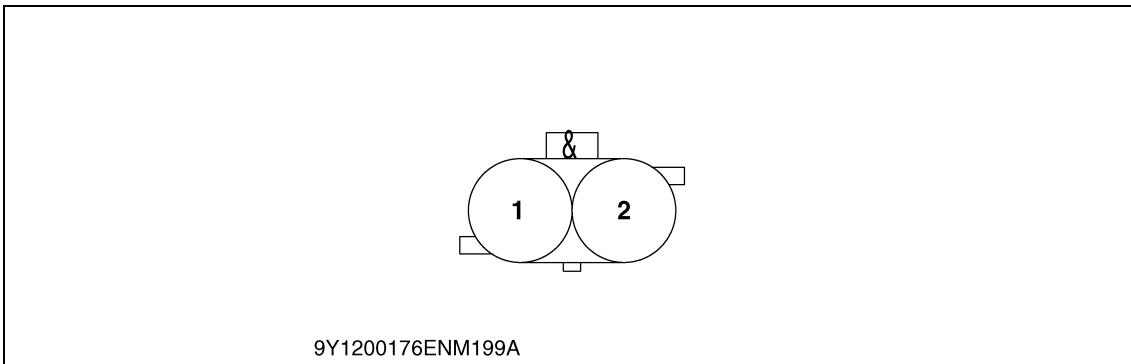
**Name: TMAP**



Pin Number	Description	Wire Color
A	MAP	LT_GREEN
B	5 V_RTN 1	BLACK/LT_GREEN
C	5 V_EXT 1	LT_GREEN/RED
D	IAT	YELLOW/GRAY

**Connector Number: C008\*1**

**Name: Engine Coolant Temperature**

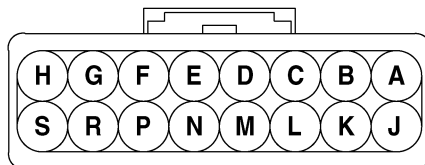


Pin Number	Description	Wire Color
1	5 V_RTN 1	BLACK/LT_GREEN
2	ECT	TAN/WHITE

■ **NOTE**

- \*1: All connector views are the mating connector view.

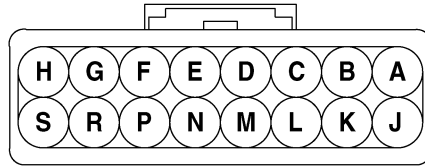
**Connector Number: C009\*1**  
**Name: Vehicle Interface Connector1**



9Y1200176ENM200A

Pin Number	Description	Wire Color
A	VSW	PINK 18
B	CHARGE_INDICATION	PURPLE 18
C	FUEL_PUMP -	BLACK/RED 16
D	FUEL_PUMP +	PINK/YELLOW 16
E	AUX_PWM2	DK_BLUE 18
F	START_COMMAND	LT_BLUE/PINK 18
G	MIL	GREEN/YELLOW 18
H	AUX_DIG1 (FUEL_SELECT)	DK_GREEN/PURPLE 18
J	(FPP 2) FPP 2_IVS	PURPLE/YELLOW 18
K	FPP1	DK_BLUE/ORANGE 18
L	5 V_RTN	BLACK/LT_GREEN 18
M	5 V_EXT	LT_GREEN/RED 18
N	CAN1 +	BLUE/PINK 18
P	CAN1 -	BULE/WHITE 18
R	5 V_RTN2	LT_GREEN/BLACK 18
S	5 V_EXT2	LT_GREEN/PURPLE 18

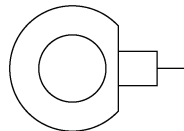
**Connector Number: C010\*1**  
**Name: Vehicle Interface Connector2**



9Y1200176ENM200A

Pin Number	Description	Wire Color
A	NOT_USE	
B	AUX_PWM5_RECIRC	WHITE/BROWN 16
C	AUX_PWM5	BROWN/WHITE 16
D	TACH	GRAY 18
E	GROUND	BLACK 16
F	AUX_PWM1	TAN 16
G	AUX_ANA_PU3	YELLOW/DK_BLUE 18
H	AUX_ANA_PU1	DK_BLUE/YELLOW 18
J	GOV_SELECT2	GRAY/RED 18
K	GOV_SELECT1	GRAY/DK_BLUE 18
L	AUX_DIG2	TAN/RED 18
M	AUX_DIG3	TAN/DK_GREEN 18
N	VS +	RED/WHITE 18
P	VS -	RED/BLACK 18
R	AUX_ANA_PD1	ORANGE/YELLOW 18
S	12 V_RELAYED_POWER	PINK/DK_GREEN 16

**Connector Number: C011**  
**Name: System Ground Connection**

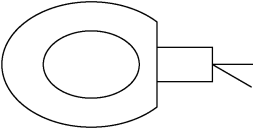


9Y1200176ENM055A

Pin Number	Description	Wire Color
1	Sys Ground	BLACK

- **NOTE**
- \*1: All connector views are the mating connector view.

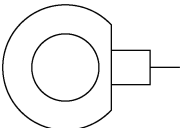
**Connector Number: C012**  
**Name: 12 Volt Battery + Connection**



9Y1200176ENM056A

Pin Number	Description	Wire Color
1	Battery 12 V +	RED

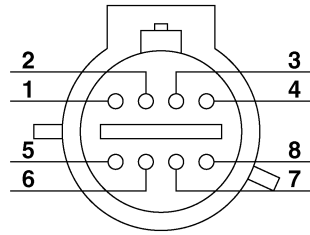
**Connector Number: C013**  
**Name: Alternator Battery +**



9Y1200176ENM055A

Pin Number	Description	Wire Color
1	Battery 12 V +	RED

**Connector Number: C014\*1**  
**Name: Diagnostic Tool Connector**



9Y1200176ENM057A

Pin Number	Description	Wire Color
1	ANA_RTN	
2	5 V_REF	
3	PC TX	
4	PC RX	
5	VBAT	
6		
7	CAN 1 +	BLUE/PINK
8	CAN 1 -	BLUE/WHITE

**Connector Number: C015\*1**  
**Name: Alternator Connector**



9Y1200176ENM058A

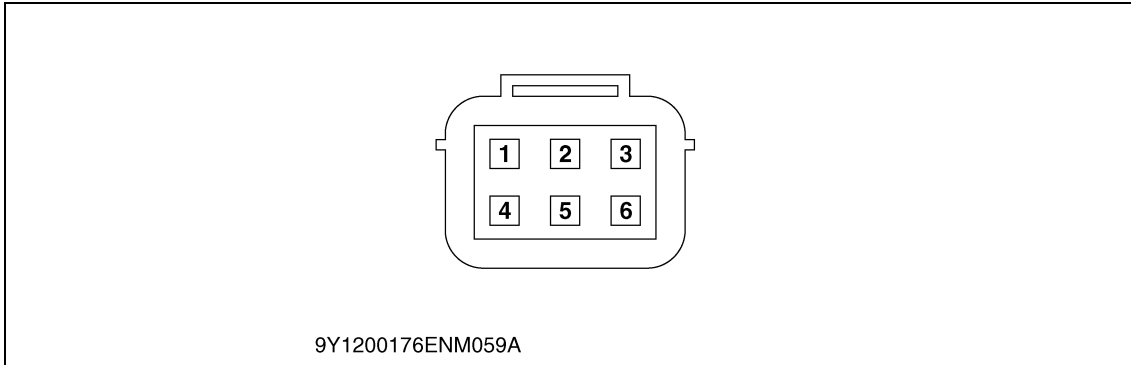
Pin Number	Description	Wire Color
1	Not Used	
2	12 V_RELAYED_POWER	PINK/DK_GREEN
3	Charge Indication	PURPLE

■ **NOTE**

- \*1: All connector views are the mating connector view.

**Connector Number: C016\*1**

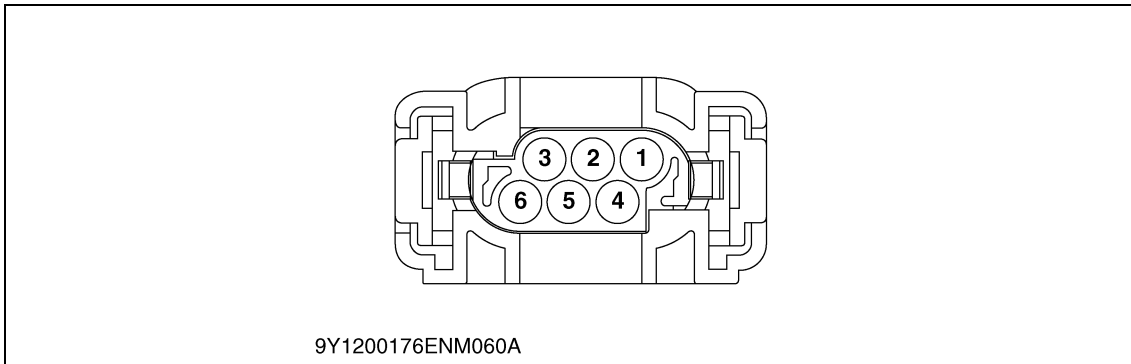
**Name: DEPR Connector**



Pin Number	Description	Wire Color
1	CAN Termination	WHITE
2	CAN 1 +	DK_BLUE/PINK
3	VRELAY	PINK/DK_GREEN
4	Ground	BLACK
5	CAN -	DK_BLUE/WHITE
6	VBAT (12 V)	RED/TAN

**Connector Number: C017\*1**

**Name: Bosch Throttle Connector**



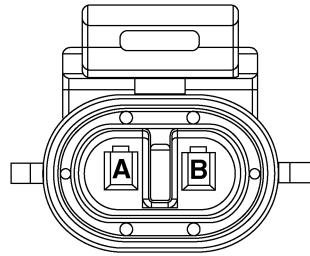
Pin Number	Description	Wire Color
1	DBW -	TAN/ORANGE
2	5 V_RTN 1	BLACK/LT_GREEN
3	5 V_EXT 1	LT_GREEN/RED
4	DBW +	PINK/WHITE
5	TPS 2	LT_BLUE/DK_BLUE
6	TPS 1	PURPLE/LT_BLUE

■ **NOTE**

- \*1: All connector views are the mating connector view.

**Connector Number: C018\*1**

**Name: LPG / Natural Gas Fuel Lock Off Connector**

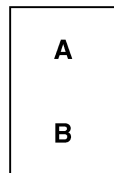


9Y1200176ENM062A

Pin Number	Description	Wire Color
A	Lock Off	WHITE/BLACK
B	12 V	PINK/TAN

**Connector Number: C019\*1**

**Name: Knock Sensor Connector**

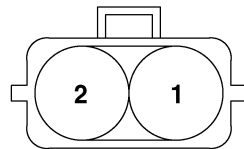


9Y1200176ENM063A

Pin Number	Description	Wire Color
1	Knock +	BLACK/YELLOW
2	Knock -	BLACK

**Connector Number C020\*1**

**Name: Camshaft Position Sensor Connector**



9Y1200176ENM201A

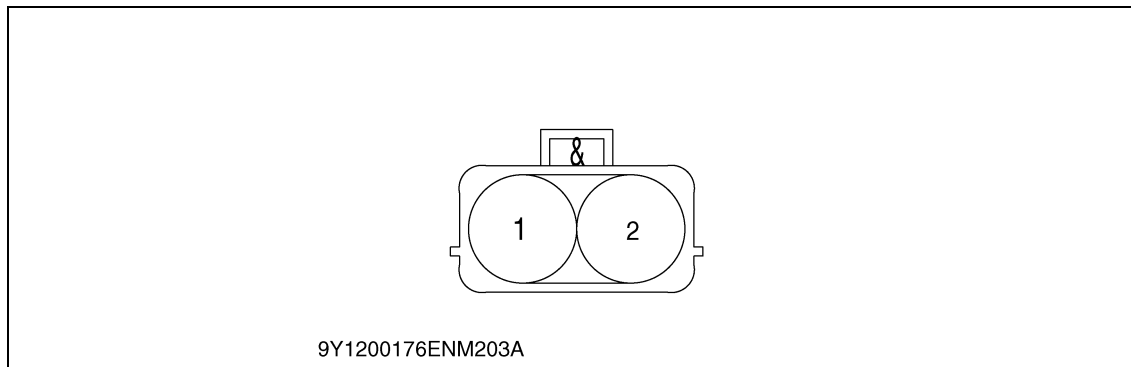
Pin Number	Description	Wire Color
1	CAM +	GRAY/BROWN
2	CAM -	PURPLE/ORANGE

■ **NOTE**

- \*1: All connector views are the mating connector view.

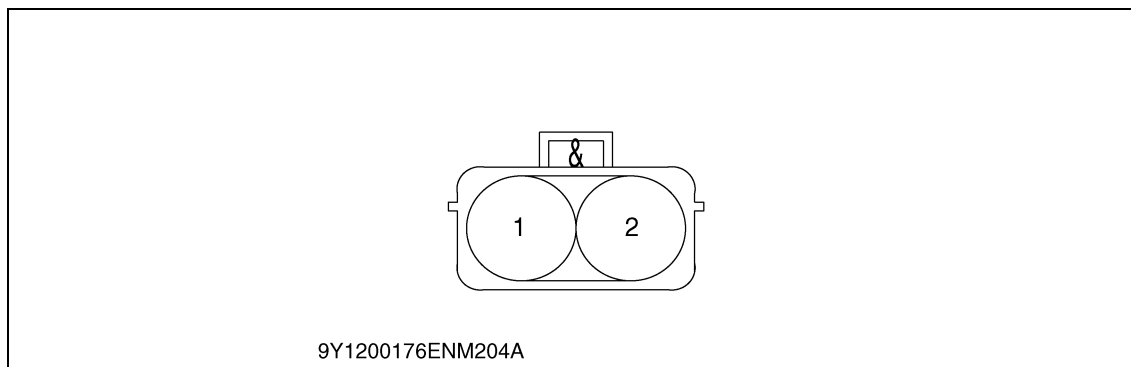


**Connector Number C021\*1**  
**Name: Ignition Coil Connector**



Cylinder Number	Pin Number	Description	Wire Color
1 to 4 (All)	1	12 V_RELAYED_POWER	PINK/DK_GREEN
1	2	SPK_COIL1A	YELLOW
2	2	SPK_COIL2B	YELLOW/WHITE
3	2	SPK_COIL2A	YELLOW/RED
4	2	SPK_COIL1B	YELLOW/BLACK

**Connector Number C022\*1**  
**Name: Injector Connector**



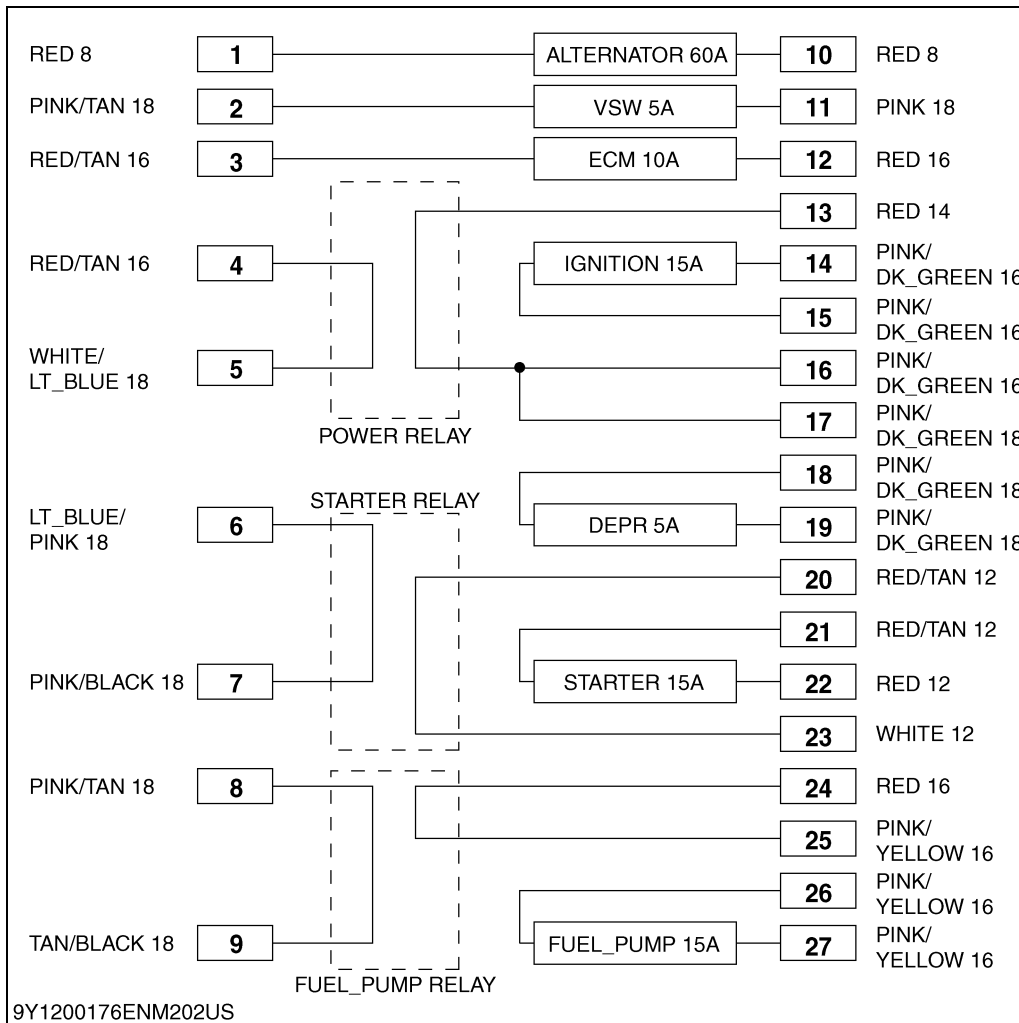
Cylinder Number	Pin Number	Description	Wire Color
1	1	INJ1_LS	BROWN/LT_BLUE
2	1	INJ4_LS	BROWN/WHITE
3	1	INJ2_LS	BROWN/LT_GREEN
4	1	INJ3_LS	BROWN/YELLOW
1 to 4 (All)	2	12 V_RELAYED_POWER	PINK/DK_GREEN

■ **NOTE**

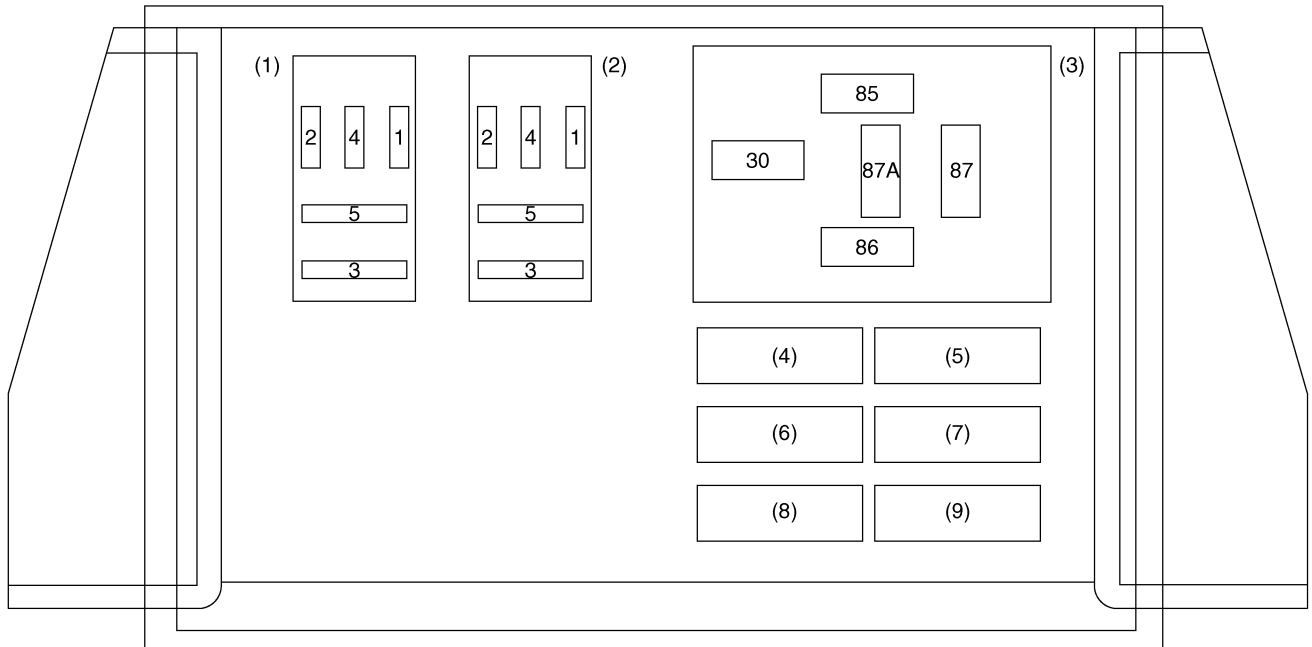
- \*1: All connector views are the mating connector view.

**Connector Number C023**

**Name: FUSE BOX**



**Connector Number C024**  
**Name: FUSE BOX (LAYOUT)**



9Y1200176ENM211A

• **WG1605-G**

- |                     |               |               |               |
|---------------------|---------------|---------------|---------------|
| (1) Fuel Pump Relay | (4) 15 A FUSE | (6) 15 A FUSE | (8) 10 A FUSE |
| (2) Power Relay     | (5) 15 A FUSE | (7) BLANK     | (9) 5 A FUSE  |
| (3) Starter Relay   |               |               |               |

• **WG1605-L, WG1605-N, WG1605-LN**

- |                   |               |               |               |
|-------------------|---------------|---------------|---------------|
| (1) BLANK         | (4) 15 A FUSE | (6) 15 A FUSE | (8) 10 A FUSE |
| (2) Power Relay   | (5) BLANK     | (7) 5 A FUSE  | (9) 5 A FUSE  |
| (3) Starter Relay |               |               |               |

• **WG1605-GL, WG1605-GLN**

- |                     |               |               |               |
|---------------------|---------------|---------------|---------------|
| (1) Fuel Pump Relay | (4) 15 A FUSE | (6) 15 A FUSE | (8) 10 A FUSE |
| (2) Power Relay     | (5) 15 A FUSE | (7) 5 A FUSE  | (9) 5 A FUSE  |
| (3) Starter Relay   |               |               |               |

## (4) Repair of Wiring Harness

### INTRODUCTION

The EControls ECM for both certified and non-certified fuel system relies on precise voltage input and outputs to maintain precise fuel control during normal operation. The ECM utilizes reference voltage signals to calculate fuel control, command throttle and engine speed and provide data to the operator through the instrument cluster.

When diagnosing faults in the system often the technician is required to disconnect the electrical connectors in the wire harness. Technicians should always use care when working on the wire harness. Special care should be given to the following items:

- When disconnecting connectors always grasp the connector at its base **DO NOT PULL ON THE WIRES** this make cause extreme stress on the crimped or solder joints
- Always depress or unlatch the connector **DO NOT USE A SCREW DRIVER TO PRY THE CONNECTOR APART** as damage to the connector or mating electrical device can occur
- When disconnecting a electrical connector always check the connector for corrosion in the connector pins, moisture in the connector, missing or damage water seals.
- **DO NOT PUSH THE ELECTRICAL PROBES INTO THE PINS WHEN TESTING CIRCUITS** as this will cause the pin to become enlarged and result in intermittent electrical problems
- When reconnecting an electrical connector "PUSH" the connector together until you here the "CLICK" then "PULL" on the connector base to make sure it is seated and locked.
- Make sure to route the harness in the original fashion and secure the harness using straps, wire ties or clips to prevent the harness from contact with hot surfaces, rotating devices or damage for external elements

Because the critical sensor control circuits operate at low voltage it is always best to use solder to make joints and replace connector pins. Refer to next page "REPAIR OF WIRING HARNESS". If a connector is the "Molded" type and requires repair the complete connector must be replaced using a "pig tail" replacement.

### CONNECTORS AND TERMINALS

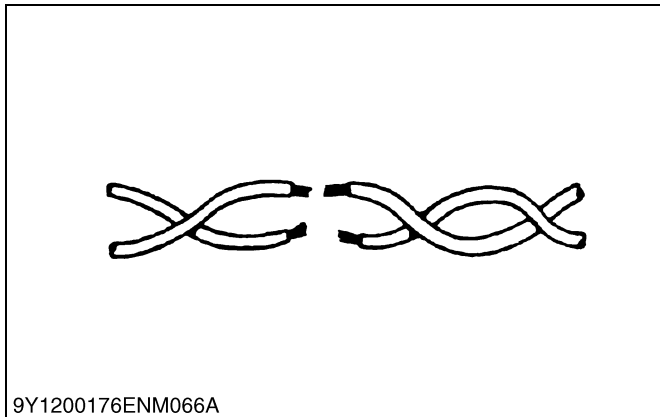
As stated earlier always use care when probing a connector or replacing terminals in a connector housing. Improper repair of a connector can resulting in shorts at the connector and can damage critical electrical components. Always use a jumper wire between the terminal when checking circuits. **NEVER USE A SHARP POINTED OBJECT TO PROBE THROUGH THE WEATHER TIGHT SEALS**, doing so will allow water to intrude into the circuit and will result in future electrical faults in the system or may deter system performance.

Using the proper tools when working on the wire harness is essential to making proper and durable repairs. Use of an improper tool may result in damaging other electrical components and will result in needless repair costs. When working with the use proper wire stripping and cutting tools, use a fuse removal tool when replacing or check fuses, use a small screw driver to unlock connector latches, use electrical probes when testing wires, it is often best to find mating connectors to the EControls wire harness connectors for testing circuits as this will ensure a positive connection when reading ohms or voltage. Use the proper "Pin Removal Tool" when removing a connector terminal from its housing.

When diagnosing intermittent shorts in the electrical system is often easy to find the fault by wiggling the wires in a connector while the engine is operating as this may cause the misalignment, or corrosion to negatively affect the connection. Corrosion is a primary cause of electrical faults within the system, always look for visible signs of corrosion when diagnosing an electrical fault.

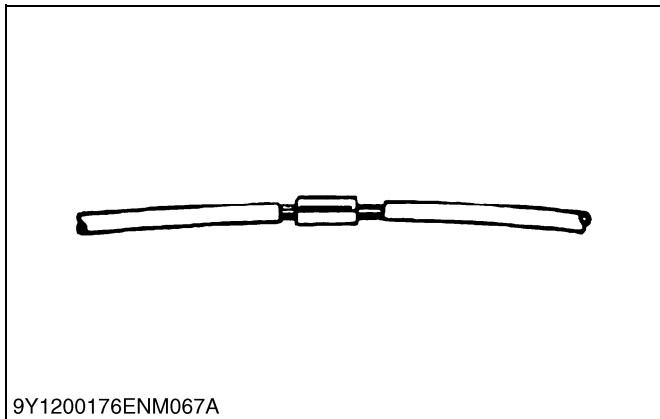
**REPAIR OF WIRING HARNESS**

**TWISTED LEADS**



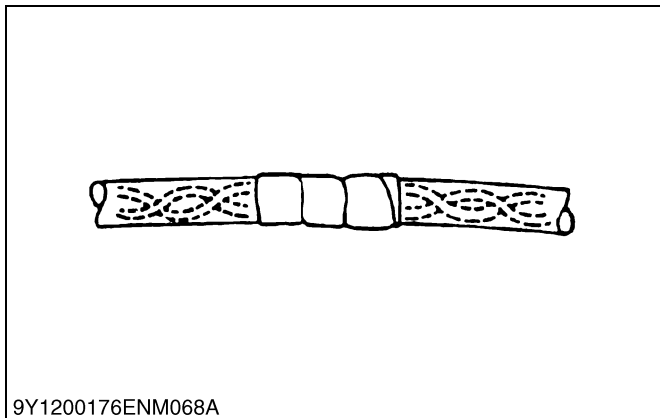
9Y1200176ENM066A

1. Locate the damaged wire remove only sufficient insulation to allow for a complete sealing of the wire in the connector splice.



9Y1200176ENM067A

2. Place a proper sized heat shrink tube over one of the cut end and slide back from the splice area.
3. position each of the stripped wire ends into the splice and ensure there is no bare wire exposed.
4. Solder the connection using a Rosin Core solder
5. Slide the heat shrink tube over the splice and use heat to shrink the tube over the connection to create a water tight seal.



9Y1200176ENM068A

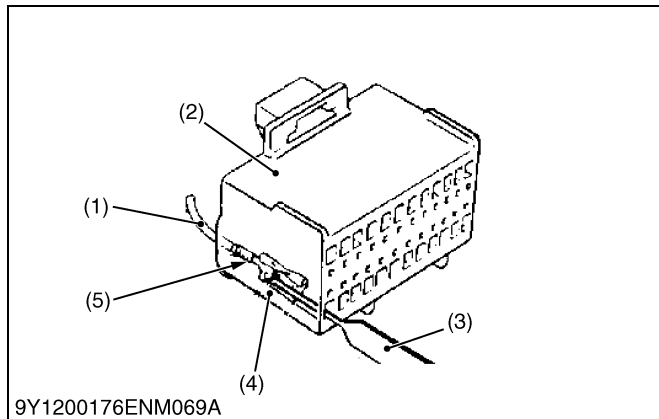
6. Re-twist the wire and secure the splice are with electrical tape to tightly seal the area.

**CONNECTOR END REPAIR OR REPLACEMENT**

Before making a connector repair, be certain of the type of connector for example Weather-Pack connectors and Compact Three connectors look very similar but are service differently.

**MICRO-PACK CONNECTOR**

Refer to Figure 2 for the repair procedure for the repair of a MICRO-PACK connector



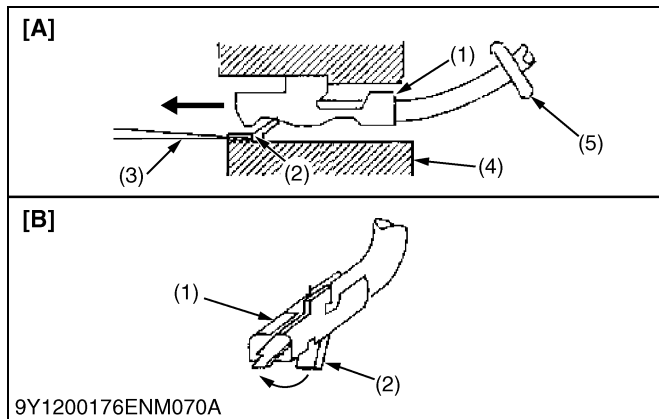
9Y1200176ENM069A

**Figure 23: MICRO PACK CONNECTOR REPAIR**

- |                                       |                  |
|---------------------------------------|------------------|
| (1) Connector Housing                 | (4) Locking Tang |
| (2) Cable                             | (5) Terminal     |
| (3) Pin Removal Tool J33095, BTB234-A |                  |

**METRI-PACK CONNECTORS**

Some electrical connectors on the harness may utilize a METRI-PACK connector. Refer to Figure 3 for removal and repair of the terminal.



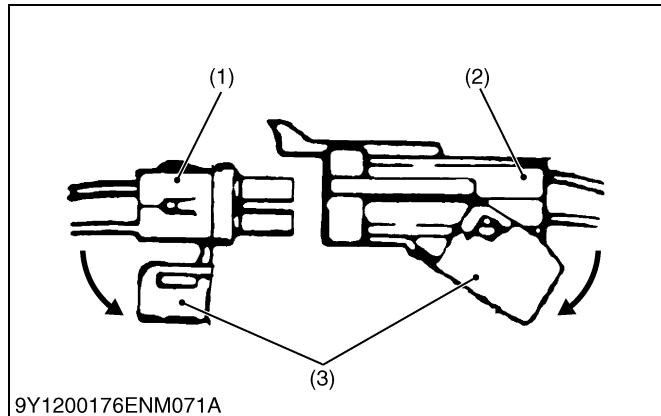
9Y1200176ENM070A

**Figure 24: METRI-PACK Terminal Repair**

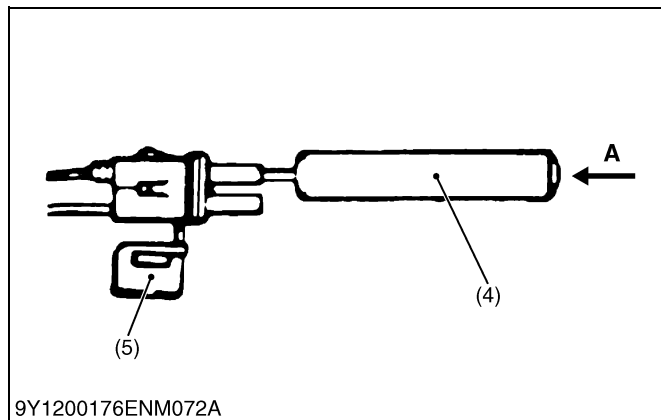
- |   |                                   |
|---|-----------------------------------|
| (1) METRI-PACK Series 150 Female Terminal | <b>[A] Cut image of connector</b> |
| (2) Locking Tang                          | <b>[B] End of Wire harness</b>    |
| (3) Tool J35689, or Bt-8446               |                                   |
| (4) Connector Body                        |                                   |
| (5) Seal                                  |                                   |

**WEATHER PACK CONNECTOR**

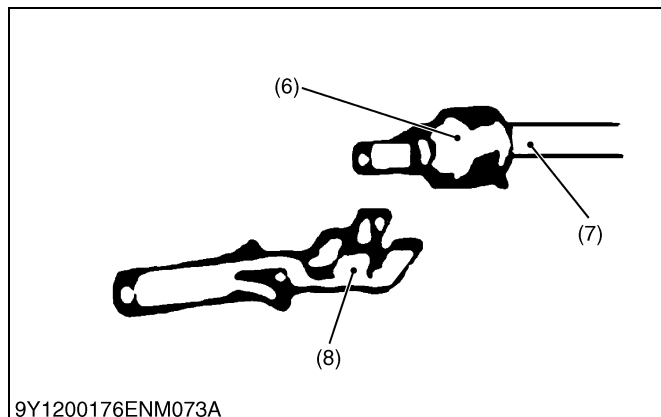
A Weather-Pack connector can be identified by a rubber seal installed to the wire at the rear of the connector. This type of connector is use in the engine compartment to protect against moisture intrusion into the connector. Refer to Figure 4 for terminal removal and repair.



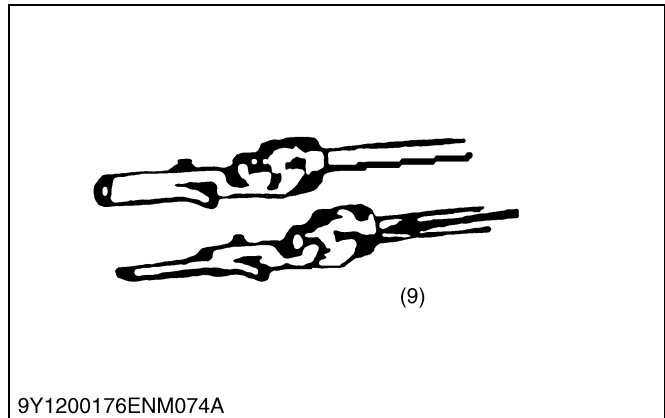
1. Open the secondary lock hinge to the female connector and separate the connectors.



2. Remove the terminal using the pin tool.



3. Cut the wire immediately behind the cable seal.



4. Replace the terminal
  - a) Slip the new seal onto the wire.
  - b) Strip 5 mm (0.2 in.) of insulation from the wire.
  - c) Crimp the terminal over the wire and seal.
5. Push the terminal back into the connector until the locking tangs are seated.
6. Connect the male and female terminals.
7. Close the secondary locks.

- |                             |                           |
|-----------------------------|---------------------------|
| (1) Male Connector          | (6) Seal                  |
| (2) Female Connector        | (7) Wire                  |
| (3) Secondary Lock Hinge    | (8) Terminal              |
| (4) Tool J-28742 / BT8234-A | (9) Wire harness terminal |
| (5) Terminal                |                           |

## 5. DIAGNOSIS

### [1] FUEL SYSTEM CHECKS

#### INTRODUCTION

The maintenance of the engine fitted with Kubota LPG / Natural Gas and Gasoline fuel systems, and its related components, is critical to the life of the engine and optimum performance, during its useful life. All engines require a certain amount of maintenance. The suggested maintenance requirements are contained in this section. Industrial engines operate in various environmental conditions, and various temperature ranges.

#### ■ NOTE

- **This is a recommended guide line only; each user must assess the daily operational usage and environmental conditions, and determine an appropriate schedule.**

In addition, the owner may have installed additional equipment to the vehicle, which may also increase the requirements for service on certain components. Therefore, the owner and the service agent, should review the operating condition of the equipment, and determine if more frequent inspections, and maintenance cycles maybe required.

This section of the service manual supplement, covers the maintenance items of both the LPG / Natural Gas and Gasoline fuel systems, which are designed and supplied by EControls, and general information on those items which are supplied by Kubota, and requires regularly scheduled maintenance. For maintenance of the base engine and or chassis, refer to the Kubota manual which covers the maintenance of the equipment.

#### GENERAL LPG / NATURAL GAS FUEL TANK MAINTENANCE

##### **LPG / NATURAL GAS TANKS**

The typical LPG / Natural Gas fuel storage cylinder should be inspected daily or at the beginning of each shift for any of the following.

- External leaks, external damage
- Manual service valve is fully open
- Securely mounted; inspect the securing straps for damage, and that the securing devices are closed and locked.
- Insure that the fuel storage cylinder is properly positioned in the locating pin, in the tank collar, on all horizontally mounted tanks. This will insure that the tank pressure relief device will always be in the correct position, to function if required.

When refueling or exchanging a cylinder, check the following:

- Quick fill valve for thread damage
- Insure that the o-ring seal is in place
- Check the o-ring for cracks, separation or chunking;
- Replace the o-ring if necessary before refueling
- Check the service line quick coupler for any thread damage
- Check the coupler o-ring for cracks, separation, or chunking
- Replace the o-ring if necessary, before refueling.

#### ■ IMPORTANT

- **When refueling the cylinder, clean both the fill hose and the tank connector with a clean cloth to remove any dust, dirt or debris to prevent contamination of the fuel system.**



#### **WARNING**

**NEVER CUT OR WELLD ON EITHER THE LPG / NATURAL GAS OR GASOLINE FUEL TANK. REPAIRS TO THE FUEL TANL SHOULD ONLY BE MADE BY A CREATIFIED TANK REPAIR FACILITY. FAILURE TO OBSERVE THIS WARNING COULD RESULT IN SERIOUS BODILY INJURY AND OR DEATH AND COULD RESULT IN SERIOUS PROPERETY DAMAGE.**

## **FUEL FILTER MAINTENANCE**

Kubota fuel systems will be designed with a specification, which requires filtration of the system. With the EControls designed fuel system; the filter have been attached with additional filtration, (Refer to Kubota Base engine section).

To determine the recommended maintenance intervals, refer to the EControls Recommended Maintenance Schedule at the end of this section. However, engines which operate in extremely dirty environment will require more frequent maintenance.

When inspecting the fuel filtration systems, check the following:

- Check for any fuel leaks at the inlet and outlet fittings.
- Check to make sure the filter is securely mounted.
- Check for any external damage or distortion; if damaged replace the filter element.

To replace the filters use the following steps:

1. Move the equipment to a well ventilated area and insure there are no external ignition sources.
2. On LPG / Natural Gas systems start the engine and close the manual valve on the cylinder, and run the engine until the engine runs out of fuel.
3. Remove and replace the fuel filter.
4. Leak check the connections with a soapy solution, or electronic leak detector.
5. On Gasoline fuel pumps with integrated fuel filters or screens located in the tank, follow the procedures for pump removal.
6. On externally mounted filters, close the manual valve at the gasoline tank to prevent fuel from draining from the tank.
7. Drain any excess fuel into an approved container and replace the filter.
8. After replacing the filter, start the engine and leak check all connections.



### **WARNING**

**ALWAYS WEAR PROTECTIVE EYEWEAR AND GLOVES WHEN PERFORMING MAINTENANCE ON THE LPG / NATURAL GAS OR GASOLINE FUEL SYSTEMS, TO PREVENT SERIOUS INJURY. ALWAYS PERFORM MAINTENANCE PROCEDURES IN A WELL VENTILATED AREA AND INSURE THAT THERE ARE NO EXTERNAL SOURCES OF IGNITION**

## **FUEL SUPPLY AND RETURN LINE MAINTENANCE**

Kubota LPG / Natural Gas and Gasoline fuel system utilize fuel supply and return lines that are attached by Kubota. These lines are made of special rubber or metal material, which meet the design working pressures, regional requirements, and provide the proper protection from chemicals found in the fuels. It is recommended that all the fuel line connections be leak checked annually at a minimum, or anytime the lines have been removed. The routing of the lines should also be inspected annually, to insure that the lines have not come into contact with any rotating devices, hot surfaces, or are located in a position in which they may be impacted by debris.



**LPG / NATURAL GAS PRESSURE REGULATORS****LPG / NATURAL GAS DUAL STAGE REGULATOR (DSR)**

The EControls LPG / Natural Gas DSR is a two stage mechanical regulator with an integral vaporizer which reduces the fuel inlet or tank pressure to a specific lower pressure and adds heat to the fuel for vaporization. You should check the following items at a minimum of once per year:

- Check for any fuel leaks at the inlet and outlet fittings.
- Check for any fuel leaks at the connecting seams of the regulator body.
- Check the inlet and outlet coolant fittings at the regulator body.
- Check the inlet and outlet coolant lines for hardening, cracking, chaffing or splits. If any of these conditions exist replace the coolant lines.
- Check the inlet and outlet coolant line hose clamps at each connection, tighten if necessary.
- Check the mounting bracket to insure the regulator is securely mounted, tighten if necessary.
- Check any of the rubber isolators used for mounting for cracking, hardening or separation.
- Check the regulator for a buildup of oil in the second stage chamber of the regulator. Drain the oil by opening the drain plug located at the bottom of the secondary chamber.

**■ NOTE**

- **Certain Kubota LPG / Natural Gas systems may be fitted with a Direct Electronic Pressure Regulator (DEPR) which is downstream of the DSR. Check these items when inspecting the DEPR:**
- Check the harness connection on the electronic control section, to insure it is seated and locked.
- Check to make sure the DEPR assembly is securely mounted.

**■ NOTE**

- **All EControls LPG / Natural Gas systems are fitted with an LPG / Natural Gas Fuel Lock Off device which is typically mounted to the inlet of the DSR. These are the additional items when inspecting the regulator:**
- Check for any fuel leaks at the inlet and outlet fittings.
- Check the Lock Off electrical connector, to insure it is seated and locked.
- Check to insure the solenoid retaining nut is tightened and fully seated.

**GASOLINE FUEL PRESSURE MANIFOLD**

On Bi-fuel and dedicated gasoline engines, fuel is delivered to the gasoline injector rails via an electric fuel pump. The ECM controls fuel delivery pressure via a PWM low side drive circuit connected to the ground terminal of the pump. The ECM increases or decreases the fuel pump's voltage to achieve the desired pressure using pressure feedback information from the gasoline fuel pressure manifold assembly. This manifold assembly also measures the gasoline fuel temperature and provides this information to the ECM. This manifold, along with the electric fuel pump, will be located on the chassis. By closely maintaining the target fuel pressure using minimum pump current flow, a minimal amount of fuel is returned to the tank. The fuel pressure manifold and fuel pump do not require adjustment. The following items must be inspected once per year.

- Check the mounting bracket for the fuel pressure manifold and fuel pump, for cracks or breakage.
- Check the securing method for the fuel pressure manifold and fuel pump to insure the devices are firmly attached.
- Check the electrical connection at both the fuel pressure manifold and fuel pump.

**INJECTOR RAIL AND INJECTORS**

The injector rail and injectors require no periodic adjustment. You should annually inspect the following items on the fuel rails and injectors.

- Check to make sure the rail bracket is securely attached to the engine.
- Check to make sure the rail brackets have no cracking or breaking.
- Check to make sure that each injector is securely attached to the rail bracket.
- Check each injector electrical connection to insure the connector is securely attached.
- Leak check all the connections on the manifold at each injector connector, and the inlet and outlet fitting at the rail, using an electronic leak detector or a soapy solution.
- Check the injector delivery hose (if used) for any cracking, kinky, cuts, or deformation, and replace if necessary.

**ELECTRICAL SYSTEM CHECKS**

The electrical system, sensors, wiring harness, and ECM do not require any periodic adjustments. You should annually inspect the following items.

**BATTERY**

- Check and clean the battery terminal connections and insure the connections are tight.
- Check the battery for any cracks or damage to the case.
- Check the Positive and Negative battery cables for any corrosion build up, rubbing or chaffing, and check ground connections on chassis, to insure they are tight.

**ECM CHECKS**

- Check the mounting bracket for the EControls ECM, for cracks or breaking.
- Check the controller mounting bracket, securing bolts to insure they are securely fastened.
- Check the rubber isolators for cracks or deterioration.
- Check the electrical connector and insure the connector is securely attached, locked and the secondary lock is in position. Check the connector for any corrosion in the connector, or on the pins. Clean if observed.

**WIRE HARNESS CHECKS**

- Check the wire harness routing, under the hood, to insure the main harness and injector harness have not come into contact with any rotating devices, hot surfaces, or have come loose from their securing points, and are hanging in an unsafe location.
- Check all wire ties and / or clamps used to secure the harness for cracking, splitting, or breakage, replace if necessary.
- Check the harness routing and insure the harness is securely attached to the frame and protected from any hot surfaces, rotating devices or road debris, repair any unsafe condition.

**SENSORS**

- While inspecting the wire harness connector for each sensor, check for any damage to the sensor.
- If the sensor is retained by threads or by fasteners, insure the retaining device is fully secured.

**IGNITION SYSTEM**

- Check ignition coil and spark plug cables for hardening, cracking, chaffing, separation, split boot covers and properly fitted.
- Replace spark plugs at the proper intervals, as prescribed in the recommended maintenance.
- Check to make sure all electrical components are fitted securely.

**MISCELLANEOUS ELECTRICAL**

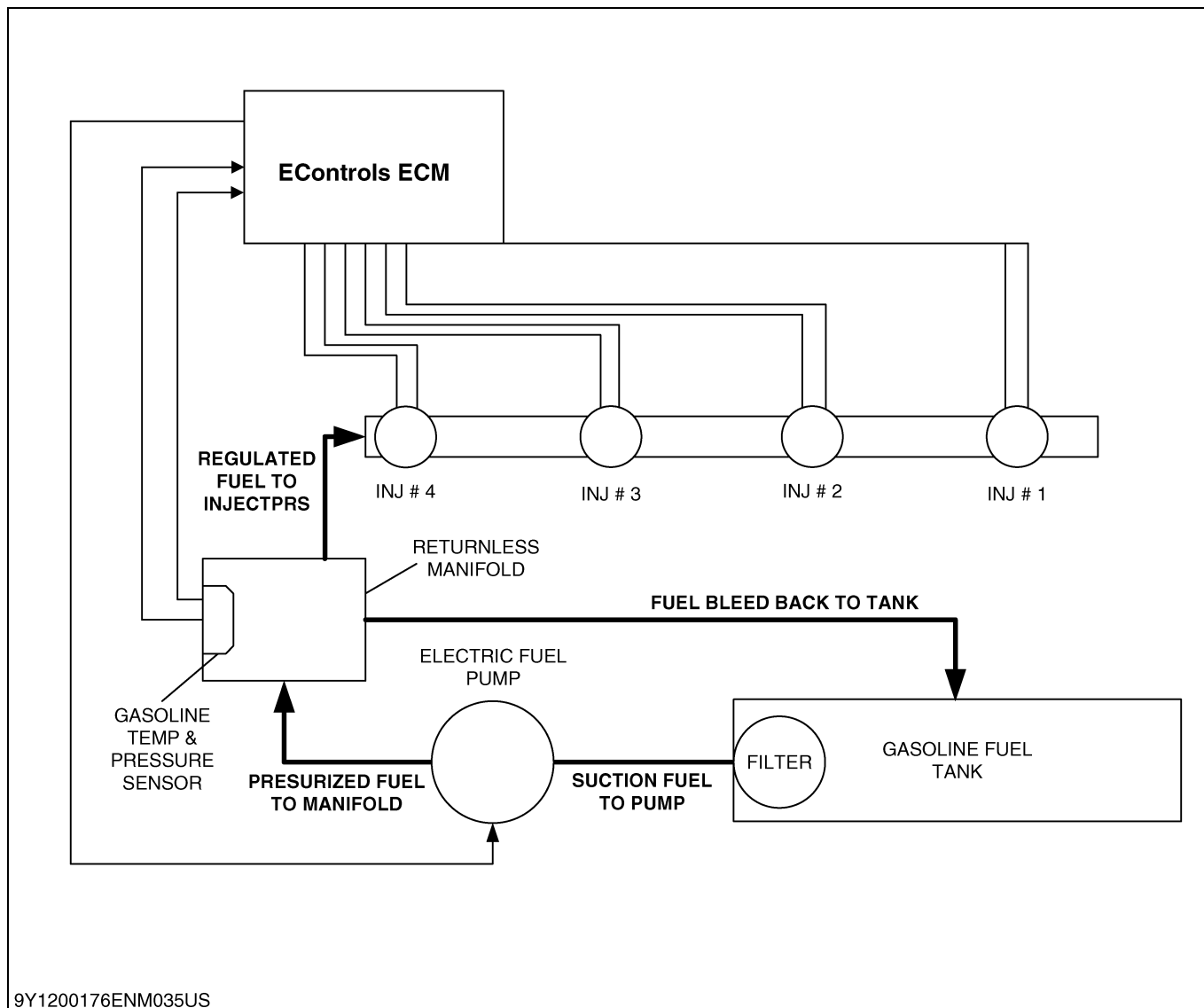
- Check the instrument panel to insure all warning lights are functioning, MIL, oil pressure and temperature gauges are registering
- Check the ignition switch and electrical connectors to insure the connections are fully seated and locked and the tumbler mechanism is working properly

**RECOMMENDED MAINTENANCE**

The maintenance schedule represents manufacturers recommended maintenance intervals to maintain proper engine/equipment function. Specific state and federal regulations may require equipment operators to conduct comprehensive engine/equipment inspections at more periodic intervals than those specified above.

## [2] FUEL SYSTEM DIAGNOSIS

### Gasoline Fuel System Diagnosis



### Fuel System Description

Engines which use the EControls gasoline fuel injection system will utilize a gasoline fuel tank which is either part of the chassis or a standalone vessel for the storage of the gasoline. On EControls USA emissions certified engines fuel tanks will not have a vented gasoline tank as the design of the system does not require the use of any vapor recovery from the fuel tank.

When the engine is operating the fuel is being drawn from the tank by the suction created from the fuel pump. An inline fuel filter will be installed either in-line or in the tank to filter out the small contaminants which may be in the fuel prior to reaching the fuel pump.

The EControls ECM controls the fuel pump by varying the supplied voltage to control the outlet pressure. The pump subsequently "pulses", sending pressurized fuel to the Fuel Pressure Manifold.

A fuel temperature and pressure sensor mounted in the manifold measures the gasoline temperature and pressure for feedback to the ECM. By controlling the fuel pump outlet pressure, excess fuel is not being sent to the injector rail and therefore the rail does not have a return line back to the tank. Any excess pressure is allowed to "bleed back" to the tank from the Fuel Pressure Manifold. This method of fuel delivery prevents large amounts of hot fuel from being returned to the tank from the injector rail which would normally cause a vapor build up in the fuel tank and subsequently requiring the need for a vapor recovery system on the engine.

The fuel pressure is controlled by the ECM and therefore to properly measure the pressure, the EControls GCP Display SW is required. On engines where a test port in the fuel rail has been installed, a gauge method can be used to measure pressure.

**Diagnostic Aids**

This procedure is intended to diagnose a vehicle operating on Gasoline. If the vehicle will not continue to run on Gasoline, refer to Hard Start for preliminary checks. Before proceeding with this procedure, verify that the vehicle has a sufficient quantity of fuel.

**Tools Required:****Diagnostic Scan Tool**

- EControls GCP Display SW tool.

**CAUTION**

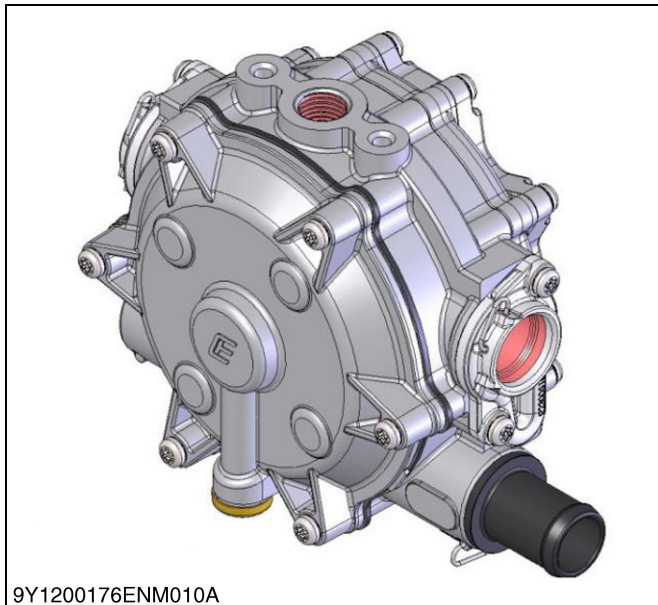
- **To reduce the risk of fire or personal injury that may result from fuel spray on the engine, make sure fuel rails is positioned over injector port and injector retaining clips are intact.**

**Gasoline Fuel System Diagnosis**

Step	Action	Value(s)	Yes	No
G1	Were you referred to this procedure by a DTC diagnostic chart?	–	Go to Step G3	Go to Step G2
G2	Connect the EControls GCP Display SW tool Perform the On Board Diagnostic (OBD) System Check. Key On Engine Off. System Stopped Mode. Check for DTC 87, 88, 91, 92, 627, 628, 629.  Are any fuel pump DTCs present in the ECM? If codes are present follow those procedures first.	–	Go to the applicable DTC Table	Go to Step G3
G3	Verify that the Gasoline fuel tank has a minimum of 1/4 tank of fuel.  Does the vehicle have fuel?	–	Go to Step G4	Put fuel into the fuel tank
G4	Check the fuel supply line from the tank to the fuel pump for leakage, crimping, kinks or restriction.  Was there a problem found?	–	Go to Step G2	Go to Step G5
G5	Check the electrical connections at the fuel pump and insure they are secured and tightened.  Was there a problem found?	–	Go to Step G2	Go to Step G6
G6	Check the Fuel Temperature and Pressure electrical connectors at the Fuel Pressure Manifold.  Was there a problem found?	–	Go to Step G2	Go to Step G7
G7	Check the fuel delivery lines, to and from, the Fuel Pressure Manifold for kinks, crimps or blockage of fuel flow.  Was there a problem found?	–	Go to Step G2	Go to Step G8
G8	Key Off Engine Off. Remove the fuel inlet hose to the injector rail. Place the hose end into a container Key On Engine Off.  Did fuel flow from the hose during the prime sequence?	–	Go to Step G2	Go to Step G9
G9	Key Off Engine Off. Using a volt meter place one probe on the VBAT connector to the fuel pump and ground Key On. Engine Off.  Was the voltage > 80 % of VBAT?	> 80 % of VBAT	Go to Step G16	Go to Step G10
G10	Check the 10 Amp fuel pump fuse.  Was there a problem found?	–	Go to Step G2	Go to Step G11
G11	Check the fuel pump relay power supply. Key off Engine Off. Using a DVOM place the positive probe on Pin 5 at the fuel pump relay and battery ground Key On. Engine Off.  Was the voltage > 80 % of VBAT?	> 80 % of VBAT	Go to Step G16	Go to Step G12
G12	Check the supply voltage to the relay. Using a DVOM place the positive lead on Pin 3 at the relay and battery ground.  Was the voltage > 80 % of VBAT?	> 80 % of VBAT	Go to Step G13	Repair Supply voltage wiring

Step	Action	Value(s)	Yes	No
G13	Check the fuel pump signal circuit at the ECM. Using DVOM place the Positive probe at the relay and ground. Key On Engine Off.  Was the voltage present?	-	Go to Step G14	Go to Step G15
G14	Replace fuel pump relay.  Is this action Complete?	-	Go to Step G2	-
G15	Replace the ECM.  Is this action Complete?	-	Go to Step G2	-
G16	Check for restricted fuel pump strainer. Check for plugged fuel filter.  Was a problem found?	-	Go to Step G2	-
G17	Replace fuel pump.  Is this action Complete?	-	Go to Step G2	-

## **LPG / Natural Gas Fuel System Diagnosis (Open & Closed Loop Systems)**



### **DUAL STAGE REGULATOR (DSR)**

This section of the manual has been prepared to allow the technician to check the mechanical functions, of the regulator and fuel delivery devices, of the EControls "closed loop" fuel control delivery system. The design of the EControls closed loop system is such that, Diagnostic Trouble Codes (DTC) are employed to monitor the fuel delivery system. To properly diagnose fuel delivery system faults, you should first install the EControls GCP diagnostic laptop tool to check for any DTC present in the ECM first, and refer to the proper DTC chart, prior to utilizing this diagnostic section.

The DSR is a combination vaporizer, pressure regulating device. The DSR is a two stage regulator that is a positive pressure regulator that is normally open in the secondary chamber, when the engine is not running. When the engine is cranking or running, pressure from the secondary chamber passes from the regulator to Direct Electronic Pressure Regulators (DEPR), and mixer.

LPG / natural gas fuel enters the primary port of the DSR, and passes through the primary jet, and into the primary/exchanger chamber. As the LPG / natural gas passes through the heat exchanger, the fuel expands and creates pressure inside the chamber. The pressure rises as the fuel expands. When the pressure rises above 10 kPa (0.11 kgf/cm<sup>2</sup>, 1.5 psi), sufficient pressure is exerted on the primary diaphragm, to cause the diaphragm plate, to pivot and press against the primary valve pin, thus closing off the flow of fuel. This action causes the flow of fuel into the regulator, to be regulated. The secondary diaphragm is spring loaded on top of the secondary diaphragm, causing the secondary lever to be pressed down, which opens the secondary seat. When the pressure in the primary chamber enters the secondary chamber, the diaphragm is forced in an upward motion, thus closing the secondary lever against

the valve seat. When commanded by the ECM, the DEPR will open, which causes a pressure drop in the secondary seat, and allows the secondary seat to open, and allow fuel to flow to the DEPR. The DEPR regulates the fuel delivery to the mixer, based on the calibration required, for the specific engine load and speed, determined during engine fuel system development.

The DSR requires a connection to the engine coolant, to prevent freezing in the regulator, during the pressure reduction phase, within the regulator. Coolant connections on the DSR are fitted with "Push In" fittings. These fitting are designed with an o-ring seal, which allows the fitting to be pushed into the water connection on the DSR, and are then locked by spring locks, and retained by screws.

The DSR is connected to the DEPR, by a low pressure flexible hose. Like the other fuel hoses used in the fuel system, the low pressure hose is designed with a special inner core and may also be wire reinforced, to prevent collapse of the hose, during high demand fueling operations. The low pressure hose should only be replaced with the recommended Kubota hose replacement.

The packaging of the regulator, into the engine and chassis, has been approved by EControls, to insure continued long term operation, of the fuel delivery and emissions control system.

#### **■ NOTE**

- **You should never relocate the regulator or any of the fuel system components, as doing so may cause excess build up of oil in the regulator, improper coolant flow, or improper fuel delivery.**

In certain regions, fuel supplies may contain different chemicals and may employ different manufacturing processes to make the LPG / natural gas, which during the heating of the fuel in the heat exchange section of the regulator, may cause "heavy ends", to accumulate over time. The DSR is attached with a drain plug, to allow the technician to drain excess oil and other contaminants from the regulator. To determine the frequency for draining the regulators, refer to the Recommended Maintenance Schedule.

The regulator utilized on USA emissions certified engines, are a critical part of the certified emissions system, and do not require any periodic adjustment.

**(To be continued)**

**(Continued)****Tools Required:**

- 7/16 Open end wrench (for test port plugs)
- Straight Blade screw driver
- DVOM

**Diagnostic Scan Tool**

- GCP Display Software (laptop)

**Pressure Gauges**

- 0 to 69 kPa (0 to 0.70 kgf/cm<sup>2</sup>, 0 to 10 psi) Gauge

**Test Description**

The numbers below refer to step numbers, on the diagnostic table which identify faulty components.

1. This step will determine if the DSR primary fuel pressure regulation is correct.
2. This step determines if the LPG / Natural Gas Fuel Lock Off is functioning properly
3. This step checks for Plugged filters if attached
4. This step determines if fuel is available, from the fuel tank & supply system.



**LPG / Natural Gas Fuel System Diagnosis**

Step	Action	Value(s)	Yes	No
L1	Were you referred to this procedure by a DTC diagnostic chart?	-	Go to Step L3	Go to Step L2
L2	Connect the EControls GCP display SW (EDIS). Key On Engine Off System Mode Stopped  Are any DTCs present in the ECM?	-	Go to the applicable DTC Table	Go to Step L3
L3	Verify that the LPG / Natural Gas fuel tank has a minimum 1/4 tank of fuel, and that the manual valve is open.  Is the tank valve open and fuel in the tank?	-	Go to Step L4	Refuel tank and Open Valve
L4	Connect a 0 to 69 kPa (0 to 0.70 kgf/cm <sup>2</sup> , 0 to 10 psi) gauge to the primary test port of the dual stage regulator (DSR). Key On Engine Running System Running Mode Observe the pressure reading, for the DSR primary pressure.  Is the fuel pressure <b>ABOVE</b> the specified value?	14 to 24 kPa (0.14 to 0.24 kgf/cm <sup>2</sup> , 2.0 to 3.5 psi)	Go to Step L13	Go to Step L5
L5	Turn OFF the ignition. Disconnect the LPG / Natural Gas Fuel lock Off electrical connector. Install a test light between the 12 V supply pin of the LPG / natural gas Fuel lock-off connector and battery ground, or connect a DVOM between the two pins. Crank the engine. The test light should illuminate or 12 V should be present.  Does the test light illuminate?	12 V	Go to Step L6	Go to Step L12
L6	Using a DVOM, check the resistance of the LPG / natural gas fuel lock-off.  Is the resistance within the specified range?	12 to 24 W	Go to Step L7	Go to Step L14
L7	Turn the ignition OFF. Close the manual shut-off valve on the LPG / natural gas tank.  <b>⚠ CAUTION</b> • <b>When disconnecting LPG / natural gas fuel lines, liquid LPG / natural gas may be present. Perform this step in a well ventilated area.</b> Slowly loosen the fuel inlet hose fitting, at the inlet of the LPL.  Was fuel present, when the fitting was loosened?	-	Go to Step L8B	Go to Step L8A
L8A	Engines fitted with a LPG / natural gas in-line fuel filter:  Slowly loosen the inlet to the fuel filter.  Was fuel present, when the fitting was loosened?	-	Go to Step L11	Go to Step L9
L8B	Engines fitted with a integrated filter to the LPL. Remove the filter from the LPL. Empty the contents, of the inlet side of the LPG / natural gas fuel filter, onto a clean surface. Inspect the contents of the LPG / natural gas fuel filter, for an excessive amount of foreign material or water. If necessary, locate and repair the source of contamination. Verify if the LPG / natural gas fuel filter is not restricted or plugged.  Was a problem found?	-	Go to Step L11	Go to Step L9

Step	Action	Value(s)	Yes	No
L9	With the fuel line loose at the fuel filter inlet (in-line filter) or at the LPL inlet. Slowly open and close the manual valve.  Did fuel begin to flow when the manual valve was opened?	-	Go to Step L14	Go to Step L10
L10	Check the fuel supply system, the hoses are plugged or restricted or the tank valve is not opening. Locate and repair the problem.  Is the action complete?	-	Go to Step L16	-
L11	Replace the fuel filter. Refer to Fuel Filter Replacement.  Is the action complete?	-	Go to Step L16	-
L12	Repair the open or short, in the lock-off circuit.  Is the action complete?	-	Go to Step L16	-
L13	Replace the dual stage regulator (DSR). Refer to Dual Stage Regulator Replacement.  Is the action complete?	-	Go to Step L16	-
L14	Replace the lock-off. Refer to Low Pressure Lock-off (LPL) Replacement.  Is the action complete?	-	Go to Step L16	-
L15	The fuel supply system is operating normally.  Install the test plug, in the DSR secondary chamber. If you were sent to this routine by another diagnostic chart, return to the previous diagnostic procedure.  Is the action complete?	-	System OK	-
L16	Disconnect all test equipment. Install the primary and secondary test port plugs, if removed. Start the engine. Using SNOOP® ? or equivalent, leak check the test port plugs, if removed.  Is the action complete?	-	System OK	-

## (1) Restricted Exhaust System Diagnosis

### Exhaust System Description

The emission certified engine has been designed and calibrated to meet the emission standards in effect for 2010. To help meet the emission requirements the vehicle has been attached with a three way catalyst. The catalyst is a three way catalyst, sound damping and spark arresting unit. Besides controlling the noise created from the combustion process, and preventing sparks from escaping from the exhaust system the most important function is treating the exhaust gases which are created from the combustion process. The three-way catalyst consists of a honeycomb core coated with a mixture of precious metals. The hot gases flow through the catalyst honeycomb core where an oxidation and reduction reactions take place. These chemical reactions reduce the amount of CO, HC and NOX in the engines exhaust. The Exhaust gas then flows through the tailpipe outlet.

During normal operation the exhaust system could become damaged. Damage which reduces the flow of the exhaust gas will create increased back pressure in the engine. Reduction in exhaust flow can result from crushed muffler outlets or melted catalyst brick inside the converter.

It may be necessary to measure the back pressure in the exhaust system. To determine if the back pressure in the engine is correct use the following procedure.

### Diagnostic Aids

#### Tools Required:

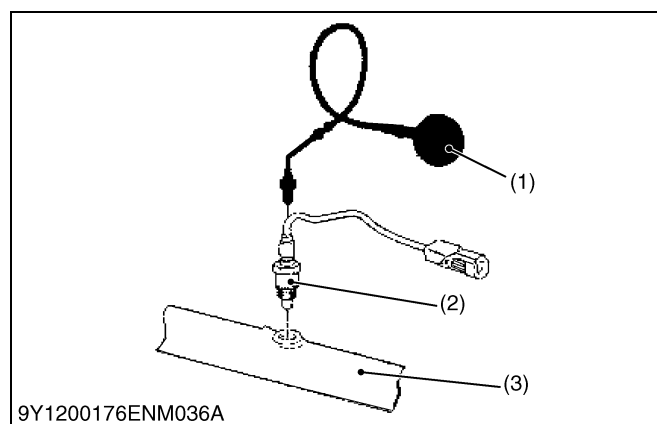
- Back pressure gage 0 to 69 kPa (0 to 0.70 kgf/cm<sup>2</sup>, 0 to 10 psi)

#### Diagnostic Scan Tool:

- EControls GCP Display SW Tool

### Check at Heated Exhaust Gas Oxygen Sensor (HEGO)

1. Carefully remove the HEGO.
2. Install exhaust back pressure gage in place of the HEGO Refer to Figure 1.
3. With the engine idling at normal operating temperature, observe the exhaust system back pressure reading on the gage. Reading should not exceed 8.6 kPa (0.088 kgf/cm<sup>2</sup>, 1.25 psi).
4. Increase engine speed to 2000 RPM and observe gage. Reading should not exceed 20.7 kPa (0.21 kgf/cm<sup>2</sup>, 3 psi).
5. If the back pressure at either speed exceeds specification, a restricted exhaust system is indicated.
6. Inspect the entire exhaust system for a collapsed pipe, heat distress or possible internal muffler failure.
7. If there are no obvious reasons for the excessive back pressure, the catalytic converter is suspected to be restricted and should be replaced using the recommended procedures.



9Y1200176ENM036A

- (1) Back Pressure Gage                      (3) Exhaust Manifold  
 (2) Oxygen Sensor (O<sub>2</sub>S)

**[3] DTC LIST**

DTC		16	87	88
<b>Name</b>		Cam/Crank Sensors	FP	FP
<b>DTC Name</b>		Crank and/or Cam Could Not Synchronize During Start	Fuel pressure low	Fuel pressure high
J1939	SPN	636	94	94
	FMI	8	1	0
<b>MIL</b>		ON	ON	ON
<b>Detected Item</b>		<ul style="list-style-type: none"> <li>Mechanical misalignment between cam and crank</li> </ul>	<ul style="list-style-type: none"> <li>Fuel pressure abnormality (Low side)</li> </ul>	<ul style="list-style-type: none"> <li>Fuel pressure abnormality (High side)</li> </ul>
<b>DTC Set Preconditions</b>		<ul style="list-style-type: none"> <li>Engine Cranking or Running</li> </ul>	<ul style="list-style-type: none"> <li>Engine Running</li> </ul>	<ul style="list-style-type: none"> <li>Engine Running</li> </ul>
<b>DTC Set Conditions</b>		<ul style="list-style-type: none"> <li>Cranking revs without sysnc &gt; 4.0 revs</li> <li>and RPM &gt; 90 min<sup>-1</sup> (rpm)</li> </ul>	<ul style="list-style-type: none"> <li>FP fault mode Gasoline only</li> <li>run time wait for fuel pressure low faults 5.0 sec</li> <li>FP pressure &lt; 345 kPa [abs] (3.52 kgf/cm<sup>2</sup>, 50.0 psia)</li> </ul>	<ul style="list-style-type: none"> <li>FP fault mode Gasoline only</li> <li>run time wait for fuel pressure high faults 5.0 sec</li> <li>FP pressure &gt; 448 kPa [abs] (4.57 kgf/cm<sup>2</sup>, 65.0 psia)</li> </ul>
<b>Period for Judgment or Number of Occurrence for Judgment</b>		<ul style="list-style-type: none"> <li>2 sec</li> </ul>	<ul style="list-style-type: none"> <li>2 sec</li> </ul>	<ul style="list-style-type: none"> <li>2 sec</li> </ul>
<b>System Action</b>		<ul style="list-style-type: none"> <li>None</li> </ul>	<ul style="list-style-type: none"> <li>AL Disable KC</li> <li>Low Rev Limit</li> </ul>	<ul style="list-style-type: none"> <li>AL Disable KC</li> <li>Low Rev Limit</li> </ul>
<b>Engine Warning Light</b>		ON	ON	ON

DTC		91	92	107
<b>Name</b>		FP	FP	MAP
<b>DTC Name</b>		FP Low Voltage	FP High Voltage	MAP Low Voltage
J1939	SPN	94	94	106
	FMI	4	3	4
<b>MIL</b>		ON	ON	ON
<b>Detected Item</b>		<ul style="list-style-type: none"> <li>Sensor/wiring harness open/short to ground</li> <li>Sensor malfunction</li> </ul>	<ul style="list-style-type: none"> <li>Sensor/wiring harness short to power</li> <li>Sensor malfunction</li> </ul>	<ul style="list-style-type: none"> <li>Sensor/wiring harness open/short to ground</li> <li>Sensor malfunction</li> </ul>
<b>DTC Set Preconditions</b>		<ul style="list-style-type: none"> <li>Key ON</li> </ul>	<ul style="list-style-type: none"> <li>Key ON</li> </ul>	<ul style="list-style-type: none"> <li>Engine Cranking or Running</li> </ul>
<b>DTC Set Conditions</b>		<ul style="list-style-type: none"> <li>FP voltage &lt; 0.100 V</li> </ul>	<ul style="list-style-type: none"> <li>FP voltage &gt; 4.90 V</li> </ul>	<ul style="list-style-type: none"> <li>MAP voltage &lt; 0.050 V</li> <li>and TPS &gt; 5.0 %</li> <li>and RPM &lt; 4000 min<sup>-1</sup> (rpm)</li> </ul>
<b>Period for Judgment or Number of Occurrence for Judgment</b>		<ul style="list-style-type: none"> <li>1 sec</li> </ul>	<ul style="list-style-type: none"> <li>5 sec</li> </ul>	<ul style="list-style-type: none"> <li>1 sec</li> </ul>
<b>System Action</b>		<ul style="list-style-type: none"> <li>AL Disable KC</li> <li>Low Rev Limit</li> </ul>	<ul style="list-style-type: none"> <li>AL Disable KC</li> <li>Low Rev Limit</li> </ul>	<ul style="list-style-type: none"> <li>AL Disable KC</li> <li>Power derate 1</li> </ul>
<b>Engine Warning Light</b>		ON	ON	ON

DTC		108	111	112
Name		MAP	IAT	IAT
DTC Name		MAP high pressure	IAT Higher Than Expected Stage 1	IAT Low Voltage
J1939	SPN	106	105	105
	FMI	16	15	4
MIL		ON	OFF	OFF
Detected Item		<ul style="list-style-type: none"> <li>• Sensor/wiring harness short to power</li> <li>• Sensor malfunction</li> </ul>	<ul style="list-style-type: none"> <li>• Intake air temperature abnormality (High side stage 1)</li> </ul>	<ul style="list-style-type: none"> <li>• Sensor/wiring harness short to ground</li> <li>• Sensor malfunction</li> </ul>
DTC Set Preconditions		<ul style="list-style-type: none"> <li>• Engine Cranking or Running</li> </ul>	<ul style="list-style-type: none"> <li>• Engine Running</li> </ul>	<ul style="list-style-type: none"> <li>• Engine Running</li> </ul>
DTC Set Conditions		<ul style="list-style-type: none"> <li>• MAP pressure &gt; 110.3 kPa [abs] (1.125 kgf/cm<sup>2</sup>, 16.00 psia)</li> <li>• and TPS &lt; 3.0 %</li> <li>• and RPM &gt; 1000 min<sup>-1</sup> (rpm)</li> </ul>	<ul style="list-style-type: none"> <li>• run-time wait for all IAT HiExp faults 0.0 sec</li> <li>• IAT &gt; 71 degC (160 degF)</li> <li>• and RPM &gt; 1000 min<sup>-1</sup> (rpm)</li> </ul>	<ul style="list-style-type: none"> <li>• IAT voltage &lt; 0.100 V</li> </ul>
Period for Judgment or Number of Occurrence for Judgment		<ul style="list-style-type: none"> <li>• 2 sec</li> </ul>	<ul style="list-style-type: none"> <li>• 60 sec</li> </ul>	<ul style="list-style-type: none"> <li>• 1 sec</li> </ul>
System Action		<ul style="list-style-type: none"> <li>• AL Disable KC</li> <li>• Power derate 1</li> </ul>	<ul style="list-style-type: none"> <li>• AL Disable</li> <li>• Power derate 1</li> </ul>	<ul style="list-style-type: none"> <li>• AL Disable</li> <li>• Power derate 1</li> </ul>
Engine Warning Light		ON	ON	ON

DTC		113	116	117
Name		IAT	ECT/CHT	ECT/CHT
DTC Name		IAT High Voltage	ECT Higher Than Expected Stage 1	ECT/CHT Low Voltage
J1939	SPN	105	110	110
	FMI	3	15	4
MIL		OFF	OFF	OFF
Detected Item		<ul style="list-style-type: none"> <li>• Sensor/wiring harness open/short to power</li> <li>• Sensor malfunction</li> </ul>	<ul style="list-style-type: none"> <li>• Engine coolant temperature abnormality (High side stage 1)</li> </ul>	<ul style="list-style-type: none"> <li>• Sensor/wiring harness short to ground</li> <li>• Sensor malfunction</li> </ul>
DTC Set Preconditions		<ul style="list-style-type: none"> <li>• Engine Running</li> </ul>	<ul style="list-style-type: none"> <li>• Engine Running</li> </ul>	<ul style="list-style-type: none"> <li>• Engine Running</li> </ul>
DTC Set Conditions		<ul style="list-style-type: none"> <li>• IAT voltage &gt; 4.90 V</li> </ul>	<ul style="list-style-type: none"> <li>• run time wait for ECT HiExp faults 30.0 sec</li> <li>• ECT &gt; 110 degC (230 degF)</li> <li>• and RPM &gt; 600 min<sup>-1</sup> (rpm)</li> </ul>	<ul style="list-style-type: none"> <li>• ECT voltage &lt; 0.100 V</li> </ul>
Period for Judgment or Number of Occurrence for Judgment		<ul style="list-style-type: none"> <li>• 1 sec</li> </ul>	<ul style="list-style-type: none"> <li>• 20 sec</li> </ul>	<ul style="list-style-type: none"> <li>• 1 sec</li> </ul>
System Action		<ul style="list-style-type: none"> <li>• AL Disable</li> <li>• Power derate 1</li> </ul>	<ul style="list-style-type: none"> <li>• AL Disable</li> <li>• Power derate 1</li> </ul>	<ul style="list-style-type: none"> <li>• AL Disable</li> <li>• Power derate 1</li> </ul>
Engine Warning Light		ON	ON	ON

DTC		118	121	122
Name		ECT/CHT	TPS	TPS
DTC Name		ECT/CHT High Voltage	TPS1 % Lower Than TPS2 %	TPS1 Signal Voltage Low
J1939	SPN	110	51	51
	FMI	3	1	4
MIL		OFF	ON	ON
Detected Item		<ul style="list-style-type: none"> <li>• Sensor/wiring harness open/short to power</li> <li>• Sensor malfunction</li> </ul>	<ul style="list-style-type: none"> <li>• TPS malfunction</li> </ul>	<ul style="list-style-type: none"> <li>• TPS circuit in the harness short to ground</li> <li>• TPS malfunction</li> </ul>
DTC Set Preconditions		<ul style="list-style-type: none"> <li>• Engine Running</li> </ul>	<ul style="list-style-type: none"> <li>• Key-On, Engine Cranking, or Running</li> </ul>	<ul style="list-style-type: none"> <li>• Key-On, Engine Cranking, or Running</li> </ul>
DTC Set Conditions		<ul style="list-style-type: none"> <li>• ECT voltage &gt; 4.90 V</li> </ul>	<ul style="list-style-type: none"> <li>• (TPS1 % – TPS2 %) &lt; –20.0 %</li> </ul>	<ul style="list-style-type: none"> <li>• TPS1 voltage &lt; 0.200 V</li> </ul>
Period for Judgment or Number of Occurrence for Judgment		<ul style="list-style-type: none"> <li>• 1 sec</li> </ul>	<ul style="list-style-type: none"> <li>• 1 sec</li> </ul>	<ul style="list-style-type: none"> <li>• 0.5 sec</li> </ul>
System Action		<ul style="list-style-type: none"> <li>• AL Disable</li> <li>• Power derate 1</li> </ul>	<ul style="list-style-type: none"> <li>• Shutdown</li> </ul>	<ul style="list-style-type: none"> <li>• Shutdown</li> </ul>
Engine Warning Light		ON	ON	ON

DTC		123	127	129
Name		TPS	IAT	IAT
DTC Name		TPS1 Signal Voltage High	IAT Higher Than Expected Stage 2	BP Low Pressure
J1939	SPN	51	105	108
	FMI	3	0	1
MIL		ON	OFF	ON
Detected Item		<ul style="list-style-type: none"> <li>• TPS circuit in the harness short to power</li> <li>• TPS malfunction</li> </ul>	<ul style="list-style-type: none"> <li>• Intake air temperature abnormality (High side stage 2)</li> </ul>	<ul style="list-style-type: none"> <li>• Sensor out of calibration</li> <li>• Loss for 5V reference feed (5V_ext1) to MAP</li> <li>• Signal wire open or shorted to ground</li> </ul>
DTC Set Preconditions		<ul style="list-style-type: none"> <li>• Key-On, Engine Cranking, or Running</li> </ul>	<ul style="list-style-type: none"> <li>• Engine Running</li> </ul>	<ul style="list-style-type: none"> <li>• Engine Running</li> </ul>
DTC Set Conditions		<ul style="list-style-type: none"> <li>• TPS1 voltage &gt; 4.80 V</li> </ul>	<ul style="list-style-type: none"> <li>• run-time wait for all IAT HiExp faults 0.0 sec</li> <li>• IAT &gt; 93 degC (200 degF)</li> <li>• and RPM &gt; 1000 min<sup>-1</sup> (rpm)</li> </ul>	<ul style="list-style-type: none"> <li>• BP &lt; 57.2 kPa [abs] (0.584 kgf/cm<sup>2</sup>, 8.30 psia)</li> </ul>
Period for Judgment or Number of Occurrence for Judgment		<ul style="list-style-type: none"> <li>• 0.5 sec</li> </ul>	<ul style="list-style-type: none"> <li>• 120 sec</li> </ul>	<ul style="list-style-type: none"> <li>• 1 sec</li> </ul>
System Action		<ul style="list-style-type: none"> <li>• Shutdown</li> </ul>	<ul style="list-style-type: none"> <li>• AL Disable</li> <li>• Force idle</li> </ul>	<ul style="list-style-type: none"> <li>• AL Disable KC</li> </ul>
Engine Warning Light		ON	ON	ON

DTC		134	154	171
<b>Name</b>		EGO Sensors	EGO Sensors	Adaptive Learn
<b>DTC Name</b>		EGO1 Open/Lazy (HO2S1)	EGO2 Open/Lazy (HO2S2)	Adaptive Learn Bank 1 High (Gasoline)
<b>J1939</b>	<b>SPN</b>	3217	3227	4237
	<b>FMI</b>	5	5	0
<b>MIL</b>		ON	ON	ON
<b>Detected Item</b>		<ul style="list-style-type: none"> <li>• Open feed circuit to O<sub>2</sub> heater</li> <li>• Open heater ground circuit</li> <li>• Open or shorted to ground O<sub>2</sub> signal wire</li> <li>• open sensor ground (5Vrtn1)</li> <li>• inoperative sensor</li> </ul>	<ul style="list-style-type: none"> <li>• Open feed circuit to O<sub>2</sub> heater</li> <li>• Open heater ground circuit</li> <li>• Open or shorted to ground O<sub>2</sub> signal wire</li> <li>• open sensor ground (5Vrtn1)</li> <li>• inoperative sensor</li> </ul>	<ul style="list-style-type: none"> <li>• exhaust leaks upstream or near the HEGO sensor</li> <li>• reduced fuel supply pressure to the fuel injection system</li> <li>• a inoperative sensor</li> <li>• an injector that is stuck closed or dirty</li> <li>• weak spark or lack of spark to a cylinder</li> <li>• a MAP sensor that indicates pressure that is lower than ture pressure</li> </ul>
<b>DTC Set Preconditions</b>		<ul style="list-style-type: none"> <li>• Engine Running</li> </ul>	<ul style="list-style-type: none"> <li>• Engine Running</li> </ul>	<ul style="list-style-type: none"> <li>• Engine Running, Adaptive Mode</li> </ul>
<b>DTC Set Conditions</b>		<ul style="list-style-type: none"> <li>• EGO cold persistently &gt; 120.0 sec</li> </ul>	<ul style="list-style-type: none"> <li>• EGO cold persistently &gt; 120.0 sec</li> </ul>	<ul style="list-style-type: none"> <li>• AL_BM &gt; 30 %</li> <li>• and RPM &gt;= 0 min<sup>-1</sup> (rpm)</li> <li>• and RPM &lt;= 9999 min<sup>-1</sup> (rpm)</li> <li>• and MAP &gt;= 0.0 kPa [abs] (0.0 kgf/cm<sup>2</sup>, 0.0 psia)</li> <li>• and MAP &lt;= 682 kPa [abs] (6.96 kgf/cm<sup>2</sup>, 99.0 psia)</li> </ul>
<b>Period for Judgment or Number of Occurrence for Judgment</b>		<ul style="list-style-type: none"> <li>• 5 sec</li> </ul>	<ul style="list-style-type: none"> <li>• 5 sec</li> </ul>	<ul style="list-style-type: none"> <li>• 3 updates</li> </ul>
<b>System Action</b>		<ul style="list-style-type: none"> <li>• CL Disable</li> <li>• AL Disable KC</li> </ul>	<ul style="list-style-type: none"> <li>• CL Disable</li> <li>• AL Disable KC</li> </ul>	<ul style="list-style-type: none"> <li>• CL Disable</li> <li>• AL Disable KC</li> </ul>
<b>Engine Warning Light</b>		ON	ON	ON

DTC		172	182	183
<b>Name</b>		Adaptive Learn	FT	FT
<b>DTC Name</b>		Adaptive Learn Bank1 Low (Gasoline)	FT gasoline low	FT gasoline high
<b>J1939</b>	<b>SPN</b>	4237	174	174
	<b>FMI</b>	1	4	3
<b>MIL</b>		ON	ON	ON
<b>Detected Item</b>		<ul style="list-style-type: none"> <li>• an inoperative O<sub>2</sub> sensor</li> <li>• high fuel supply pressure or temperature</li> <li>• internal mechanical engine damage</li> <li>• an injector that is stuck open or leaking</li> </ul>	<ul style="list-style-type: none"> <li>• Operating in a frigid atmosphere</li> <li>• Sensor out of calibration</li> </ul>	<ul style="list-style-type: none"> <li>• Operating in a hot environment</li> <li>• Sensor out of calibration</li> </ul>
<b>DTC Set Preconditions</b>		<ul style="list-style-type: none"> <li>• Engine Running, Adaptive Mode</li> </ul>	<ul style="list-style-type: none"> <li>• Engine Running</li> </ul>	<ul style="list-style-type: none"> <li>• Engine Running</li> </ul>
<b>DTC Set Conditions</b>		<ul style="list-style-type: none"> <li>• AL_BM &lt; -30 %</li> <li>• and RPM &gt;= 0 min<sup>-1</sup> (rpm)</li> <li>• and RPM &lt;= 9999 min<sup>-1</sup> (rpm)</li> <li>• and MAP &gt;= 0.0 kPa [abs] (0.0 kgf/cm<sup>2</sup>, 0.0 psia)</li> <li>• and MAP &lt;= 682 kPa [abs] (6.96 kgf/cm<sup>2</sup>, 99.0 psia)</li> </ul>	<ul style="list-style-type: none"> <li>• FT fault mode Temp only</li> <li>• fuel temp &lt; -37.0 degC (-35.0 degF)</li> </ul>	<ul style="list-style-type: none"> <li>• FT fault mode Temp only</li> <li>• fuel temp &gt; 60.0 degC (140.0 degF)</li> </ul>
<b>Period for Judgment or Number of Occurrence for Judgment</b>		<ul style="list-style-type: none"> <li>• 3 updates</li> </ul>	<ul style="list-style-type: none"> <li>• 1 sec</li> </ul>	<ul style="list-style-type: none"> <li>• 1 sec</li> </ul>
<b>System Action</b>		<ul style="list-style-type: none"> <li>• CL Disable</li> <li>• AL Disable KC</li> </ul>	<ul style="list-style-type: none"> <li>• None</li> </ul>	<ul style="list-style-type: none"> <li>• Power derate 2</li> </ul>
<b>Engine Warning Light</b>		ON	ON	ON



DTC		187	217	219
Name		FT	ECT/CHT	Engine Speed
DTC Name		FT Gaseous Fuel Extremery Low	ECT Higher Than Expected 2	RPM Higher Than Max Allowed Governed Speed
J1939	SPN	3468	110	515
	FMI	1	0	15
MIL		ON	OFF	OFF
Detected Item		<ul style="list-style-type: none"> <li>Not vaporized completely</li> </ul>	<ul style="list-style-type: none"> <li>Engine coolant temperature abnormality (High side stage 2)</li> </ul>	<ul style="list-style-type: none"> <li>Engine over speed condition, stuck throttle, large vacuum leak into intake manifold after throttle blade</li> </ul>
DTC Set Preconditions		<ul style="list-style-type: none"> <li>Engine Running</li> </ul>	<ul style="list-style-type: none"> <li>Engine Running</li> </ul>	<ul style="list-style-type: none"> <li>Engine Running</li> </ul>
DTC Set Conditions		<ul style="list-style-type: none"> <li>Fuel temp &lt; -40 °C (-40 °F)</li> </ul>	<ul style="list-style-type: none"> <li>run time wait for ECT HiExp faults 30.0 sec</li> <li>ECT &gt; 116 degC (240 degF)</li> <li>and RPM &gt; 600 min<sup>-1</sup> (rpm)</li> </ul>	<ul style="list-style-type: none"> <li>RPM &gt; 3800 min<sup>-1</sup> (rpm)</li> </ul>
Period for Judgment or Number of Occurrence for Judgment		<ul style="list-style-type: none"> <li>1 sec</li> </ul>	<ul style="list-style-type: none"> <li>30 sec</li> </ul>	<ul style="list-style-type: none"> <li>1 sec</li> </ul>
System Action		<ul style="list-style-type: none"> <li>None</li> </ul>	<ul style="list-style-type: none"> <li>Power derate 2</li> </ul>	<ul style="list-style-type: none"> <li>reduce throttle to limit speed</li> </ul>
Engine Warning Light		ON	ON	ON

DTC		221	222	223
Name		TPS	TPS	TPS
DTC Name		TPS1 % Higher Than TPS2 %	TPS2 Signal Voltage Low	TPS2 Signal Voltage High
J1939	SPN	51	3673	3673
	FMI	0	4	3
MIL		ON	ON	ON
Detected Item		<ul style="list-style-type: none"> <li>TPS malfunction</li> </ul>	<ul style="list-style-type: none"> <li>TPS circuit in the harness short to ground</li> <li>TPS malfunction</li> </ul>	<ul style="list-style-type: none"> <li>TPS circuit in the harness short to power</li> <li>TPS malfunction</li> </ul>
DTC Set Preconditions		<ul style="list-style-type: none"> <li>Key-On, Engine Cranking, or Running</li> </ul>	<ul style="list-style-type: none"> <li>Key-On, Engine Cranking, or Running</li> </ul>	<ul style="list-style-type: none"> <li>Key-On, Engine Cranking, or Running</li> </ul>
DTC Set Conditions		<ul style="list-style-type: none"> <li>(TPS1 % – TPS2 %) &gt; 20.0 %</li> </ul>	<ul style="list-style-type: none"> <li>TPS2 voltage &lt; 0.200 V</li> </ul>	<ul style="list-style-type: none"> <li>TPS2 voltage &gt; 4.80 V</li> </ul>
Period for Judgment or Number of Occurrence for Judgment		<ul style="list-style-type: none"> <li>1 sec</li> </ul>	<ul style="list-style-type: none"> <li>0.5 sec</li> </ul>	<ul style="list-style-type: none"> <li>0.5 sec</li> </ul>
System Action		<ul style="list-style-type: none"> <li>Shutdown</li> </ul>	<ul style="list-style-type: none"> <li>Shutdown</li> </ul>	<ul style="list-style-type: none"> <li>Shutdown</li> </ul>
Engine Warning Light		ON	ON	ON

DTC		261	262	264
<b>Name</b>		Injectors	Injectors	Injectors
<b>DTC Name</b>		Injector Driver #1 Open/Short-To-Ground	Injector Driver #1 Short-To-Power	Injector Driver #2 Open/Short-To-Ground
J1939	SPN	651	651	652
	FMI	5	6	5
<b>MIL</b>		ON	ON	ON
<b>Detected Item</b>		<ul style="list-style-type: none"> <li>Loss of 12.0 V feed to injector</li> <li>open injector coil</li> <li>open or shorted to ground injector driver circuit in engine harness</li> </ul>	<ul style="list-style-type: none"> <li>Injector coil shorted internally</li> <li>Injector driver circuit shorted to voltage between injector and ECM</li> </ul>	<ul style="list-style-type: none"> <li>Loss of 12.0 V feed to injector</li> <li>open injector coil</li> <li>open or shorted to ground injector driver circuit in engine harness</li> </ul>
<b>DTC Set Preconditions</b>		<ul style="list-style-type: none"> <li>Key-On, Engine Running</li> </ul>	<ul style="list-style-type: none"> <li>Key-On, Engine Running</li> </ul>	<ul style="list-style-type: none"> <li>Key-On, Engine Running</li> </ul>
<b>DTC Set Conditions</b>		<ul style="list-style-type: none"> <li>Injector1 off-state low-side &lt; 4.00 V</li> <li>and battery voltage &gt; 9.00 V</li> </ul>	<ul style="list-style-type: none"> <li>Injector1 on-state low-side &gt; 4.00 V</li> <li>and battery voltage &lt; 16.0 V</li> </ul>	<ul style="list-style-type: none"> <li>Injector2 off-state low-side &lt; 4.00 V</li> <li>and battery voltage &gt; 9.00 V</li> </ul>
<b>Period for Judgment or Number of Occurrence for Judgment</b>		<ul style="list-style-type: none"> <li>10 samples</li> </ul>	<ul style="list-style-type: none"> <li>10 samples</li> </ul>	<ul style="list-style-type: none"> <li>10 samples</li> </ul>
<b>System Action</b>		<ul style="list-style-type: none"> <li>CL Disable</li> <li>AL Disable KC</li> <li>Low Rev Limit</li> </ul>	<ul style="list-style-type: none"> <li>CL Disable</li> <li>AL Disable KC</li> <li>Low Rev Limit</li> </ul>	<ul style="list-style-type: none"> <li>CL Disable</li> <li>AL Disable KC</li> <li>Low Rev Limit</li> </ul>
<b>Engine Warning Light</b>		ON	ON	ON

DTC		265	267	268
<b>Name</b>		Injectors	Injectors	Injectors
<b>DTC Name</b>		Injector Driver #2 Short-To-Power	Injector Driver #3 Open/Short-To-Ground	Injector Driver #3 Short-To-Power
J1939	SPN	652	653	653
	FMI	6	5	6
<b>MIL</b>		ON	ON	ON
<b>Detected Item</b>		<ul style="list-style-type: none"> <li>Injector coil shorted internally</li> <li>Injector driver circuit shorted to voltage between injector and ECM</li> </ul>	<ul style="list-style-type: none"> <li>Loss of 12.0 V feed to injector</li> <li>open injector coil</li> <li>open or shorted to ground injector driver circuit in engine harness</li> </ul>	<ul style="list-style-type: none"> <li>Injector coil shorted internally</li> <li>Injector driver circuit shorted to voltage between injector and ECM</li> </ul>
<b>DTC Set Preconditions</b>		<ul style="list-style-type: none"> <li>Key-On, Engine Running</li> </ul>	<ul style="list-style-type: none"> <li>Key-On, Engine Running</li> </ul>	<ul style="list-style-type: none"> <li>Key-On, Engine Running</li> </ul>
<b>DTC Set Conditions</b>		<ul style="list-style-type: none"> <li>Injector2 on-state low-side &gt; 4.00 V</li> <li>and battery voltage &lt; 16.0 V</li> </ul>	<ul style="list-style-type: none"> <li>Injector3 off-state low-side &lt; 4.00 V</li> <li>and battery voltage &gt; 9.00 V</li> </ul>	<ul style="list-style-type: none"> <li>Injector3 on-state low-side &gt; 4.00 V</li> <li>and battery voltage &lt; 16.0 V</li> </ul>
<b>Period for Judgment or Number of Occurrence for Judgment</b>		<ul style="list-style-type: none"> <li>10 samples</li> </ul>	<ul style="list-style-type: none"> <li>10 samples</li> </ul>	<ul style="list-style-type: none"> <li>10 samples</li> </ul>
<b>System Action</b>		<ul style="list-style-type: none"> <li>CL Disable</li> <li>AL Disable KC</li> <li>Low Rev Limit</li> </ul>	<ul style="list-style-type: none"> <li>CL Disable</li> <li>AL Disable KC</li> <li>Low Rev Limit</li> </ul>	<ul style="list-style-type: none"> <li>CL Disable</li> <li>AL Disable KC</li> <li>Low Rev Limit</li> </ul>
<b>Engine Warning Light</b>		ON	ON	ON

DTC		270	271	326
<b>Name</b>		Injectors	Injectors	Knock
<b>DTC Name</b>		Injector Driver #4 Open/Short-To-Ground	Injector Driver #4 Short-To-Power	Knock 1 Excessive or Erratic Signal
J1939	SPN	654	654	731
	FMI	5	6	2
<b>MIL</b>		ON	ON	ON
<b>Detected Item</b>		<ul style="list-style-type: none"> <li>Loss of 12.0 V feed to injector</li> <li>open injector coil</li> <li>open or shorted to ground injector driver circuit in engine harness</li> </ul>	<ul style="list-style-type: none"> <li>Injector coil shorted internally</li> <li>Injector driver circuit shorted to voltage between injector and ECM</li> </ul>	<ul style="list-style-type: none"> <li>Knock signal abnormality (High side)</li> <li>Sensor malfunction</li> </ul>
<b>DTC Set Preconditions</b>		<ul style="list-style-type: none"> <li>Key-On, Engine Running</li> </ul>	<ul style="list-style-type: none"> <li>Key-On, Engine Running</li> </ul>	<ul style="list-style-type: none"> <li>Key On, Engine On</li> </ul>
<b>DTC Set Conditions</b>		<ul style="list-style-type: none"> <li>Injector4 off-state low-side &lt; 4.00 V</li> <li>and battery voltage &gt; 9.00 V</li> </ul>	<ul style="list-style-type: none"> <li>Injector4 on-state low-side &gt; 4.00 V</li> <li>and battery voltage &lt; 16.0 V</li> </ul>	<ul style="list-style-type: none"> <li>KNK1 sensor input &gt; 0.500 V</li> <li>MAP &lt; 55.2 kPa [abs] (0.562 kgf/cm<sup>2</sup>, 8.00 psia)</li> </ul>
<b>Period for Judgment or Number of Occurrence for Judgment</b>		<ul style="list-style-type: none"> <li>10 samples</li> </ul>	<ul style="list-style-type: none"> <li>10 samples</li> </ul>	<ul style="list-style-type: none"> <li>3 sec</li> </ul>
<b>System Action</b>		<ul style="list-style-type: none"> <li>CL Disable</li> <li>AL Disable KC</li> <li>Low Rev Limit</li> </ul>	<ul style="list-style-type: none"> <li>CL Disable</li> <li>AL Disable KC</li> <li>Low Rev Limit</li> </ul>	<ul style="list-style-type: none"> <li>Power derate 1</li> <li>Retard Fault KNK</li> </ul>
<b>Engine Warning Light</b>		ON	ON	ON

DTC		327	336	337
<b>Name</b>		Knock	Cam/Crank Sensors	Cam/Crank Sensors
<b>DTC Name</b>		Knock 1 Sensor Open or Not Present	Crank Input Signal Noise	Loss of Crankshaft Input Signal
J1939	SPN	731	636	636
	FMI	4	2	4
<b>MIL</b>		ON	ON	ON
<b>Detected Item</b>		<ul style="list-style-type: none"> <li>Sensor/wiring harness open/short to power</li> <li>Sensor malfunction</li> </ul>	<ul style="list-style-type: none"> <li>Crank+ or Crank- circuits in wrong connector terminal slot</li> </ul>	<ul style="list-style-type: none"> <li>Loss of sensor feed</li> <li>open sensor ground</li> <li>open or shorted to ground signal wire</li> </ul>
<b>DTC Set Preconditions</b>		<ul style="list-style-type: none"> <li>Key On, Engine On</li> </ul>	<ul style="list-style-type: none"> <li>Key On, Engine On</li> </ul>	<ul style="list-style-type: none"> <li>Key On, Engine On</li> </ul>
<b>DTC Set Conditions</b>		<ul style="list-style-type: none"> <li>KNK1 sensor input &lt; 0.005 V</li> <li>and RPM &gt; 2000 min<sup>-1</sup> (rpm)</li> <li>and MAP &gt; 82.7 kPa [abs] (0.844 kgf/cm<sup>2</sup>, 12.00 psia)</li> </ul>	<ul style="list-style-type: none"> <li>Number of invalid cam re-syncs 3 re-syncs</li> <li>within a time window of &lt;= 800 ms</li> </ul>	<ul style="list-style-type: none"> <li>Cam pulsed without crank activity &gt; 3 cam pulses</li> </ul>
<b>Period for Judgment or Number of Occurrence for Judgment</b>		<ul style="list-style-type: none"> <li>10 sec</li> </ul>	<ul style="list-style-type: none"> <li>1 sec</li> </ul>	<ul style="list-style-type: none"> <li>1 sec</li> </ul>
<b>System Action</b>		<ul style="list-style-type: none"> <li>Power derate 1</li> <li>Retard Fault KNK</li> </ul>	<ul style="list-style-type: none"> <li>AL Disable KC</li> </ul>	<ul style="list-style-type: none"> <li>None</li> </ul>
<b>Engine Warning Light</b>		ON	ON	ON

DTC		341	342	359
<b>Name</b>		Cam/Crank Sensors	Cam/Crank Sensors	Lockoff/Fuel Diagnostics
<b>DTC Name</b>		Camshaft Input Signal Noise	Loss of Camshaft Input Signal	Fuel run-out longer than expected
J1939	<b>SPN</b>	723	723	632
	<b>FMI</b>	2	4	31
<b>MIL</b>		ON	ON	ON
<b>Detected Item</b>		<ul style="list-style-type: none"> <li>Cam+ or Cam- circuits in wrong connector terminal slot</li> </ul>	<ul style="list-style-type: none"> <li>Loss of feed voltage to Cam sensor</li> <li>loss of signal or ground circuits</li> <li>faulty sensor</li> </ul>	
<b>DTC Set Preconditions</b>		<ul style="list-style-type: none"> <li>Key On, Engine On</li> </ul>	<ul style="list-style-type: none"> <li>Key On, Engine On</li> </ul>	<ul style="list-style-type: none"> <li>Key Off, Engine On</li> </ul>
<b>DTC Set Conditions</b>		<ul style="list-style-type: none"> <li>Number of invalid cam re-syncs 3 re-syncs</li> <li>within a time window of &lt;= 700 ms</li> </ul>	<ul style="list-style-type: none"> <li>No cam pulse in 2.0 cycles</li> <li>and RPM &gt; 150 min<sup>-1</sup> (rpm)</li> </ul>	<ul style="list-style-type: none"> <li>Fuel run-out engine run time &gt; 20000 ms</li> </ul>
<b>Period for Judgment or Number of Occurrence for Judgment</b>		<ul style="list-style-type: none"> <li>1 sec</li> </ul>	<ul style="list-style-type: none"> <li>1 sec</li> </ul>	<ul style="list-style-type: none"> <li>N/A</li> </ul>
<b>System Action</b>		<ul style="list-style-type: none"> <li>AL Disable KC</li> </ul>	<ul style="list-style-type: none"> <li>AL Disable KC</li> </ul>	<ul style="list-style-type: none"> <li>Shutdown</li> </ul>
<b>Engine Warning Light</b>		ON	ON	OFF

DTC		420	524	562
<b>Name</b>		Catalyst	Oil Pressure	Battery Voltage
<b>DTC Name</b>		Catalyst Monitor	Oil Pressure Low	Battery Voltage (VBAT) Low
J1939	<b>SPN</b>	3050	100	168
	<b>FMI</b>	11	1	17
<b>MIL</b>		OFF	ON	ON
<b>Detected Item</b>			<ul style="list-style-type: none"> <li>Low Oil Pressure</li> </ul>	<ul style="list-style-type: none"> <li>Wiring harness open/short/damage</li> <li>Battery abnormality</li> </ul>
<b>DTC Set Preconditions</b>		<ul style="list-style-type: none"> <li>Engine Running</li> </ul>	<ul style="list-style-type: none"> <li>Key On, Engine On</li> </ul>	<ul style="list-style-type: none"> <li>Key On, Engine On</li> </ul>
<b>DTC Set Conditions</b>		<ul style="list-style-type: none"> <li>EGO3/4 RMS &gt; 0.008 phi</li> <li>and EGO3/4 RMS &gt; EGO1/2 RMS 50 %</li> <li>and EGO3/4 RMS &gt; CL waveform RMS 50 %</li> <li>and mass flow at ports &gt;= 10.0 g/sec and &lt;= CBT -CBT_ss +/- 50.0 degF</li> </ul>	<ul style="list-style-type: none"> <li>run time wait for oil pressure low faults 4.0 sec</li> <li>RPM lower limit for oil pressure low faults 300 min<sup>-1</sup> (rpm)</li> <li>Oil pressure pulled-up input less than a threshold voltage of 2.50 V</li> </ul>	<ul style="list-style-type: none"> <li>Voltage &lt; 9.00 V</li> <li>and RPM &gt; 1000 min<sup>-1</sup> (rpm)</li> </ul>
<b>Period for Judgment or Number of Occurrence for Judgment</b>		<ul style="list-style-type: none"> <li>100 updates</li> </ul>	<ul style="list-style-type: none"> <li>1 sec</li> </ul>	<ul style="list-style-type: none"> <li>5 sec</li> </ul>
<b>System Action</b>		<ul style="list-style-type: none"> <li>Shutdown</li> <li>CL Disable</li> <li>AL Disable</li> <li>Hard Warning</li> </ul>	<ul style="list-style-type: none"> <li>Shutdown</li> </ul>	<ul style="list-style-type: none"> <li>AL Disable KC</li> <li>Power derate 2</li> </ul>
<b>Engine Warning Light</b>		ON	ON	ON

DTC		563	601	604
<b>Name</b>		Battery Voltage	Internal Processor Diagnostics	Internal Processor Diagnostics
<b>DTC Name</b>		Battery Voltage (VBAT) High	Microprocessor Failure-FLASH	Microprocessor Failure-RAM
<b>J1939</b>	<b>SPN</b>	168	628	630
	<b>FMI</b>	15	13	12
<b>MIL</b>		ON	ON	ON
<b>Detected Item</b>		<ul style="list-style-type: none"> <li>System voltage abnormality (High side)</li> </ul>	<ul style="list-style-type: none"> <li>Faulty ECU</li> </ul>	<ul style="list-style-type: none"> <li>Faulty ECU</li> </ul>
<b>DTC Set Preconditions</b>		<ul style="list-style-type: none"> <li>Key-On, Engine Cranking, or Running</li> </ul>	<ul style="list-style-type: none"> <li>Key on</li> </ul>	<ul style="list-style-type: none"> <li>Key on</li> </ul>
<b>DTC Set Conditions</b>		<ul style="list-style-type: none"> <li>Voltage &gt; 16.00 V</li> </ul>	<ul style="list-style-type: none"> <li>Internal microprocessor error</li> </ul>	<ul style="list-style-type: none"> <li>Internal ECM microprocessor memory access failure</li> </ul>
<b>Period for Judgment or Number of Occurrence for Judgment</b>		<ul style="list-style-type: none"> <li>3 sec</li> </ul>	<ul style="list-style-type: none"> <li>N/A</li> </ul>	<ul style="list-style-type: none"> <li>N/A</li> </ul>
<b>System Action</b>		<ul style="list-style-type: none"> <li>AL Disable KC</li> <li>Low Rev Limit</li> </ul>	<ul style="list-style-type: none"> <li>Never Forget</li> <li>AL Disable KC</li> <li>Power derate 2</li> </ul>	<ul style="list-style-type: none"> <li>Never Forget</li> <li>AL Disable KC</li> <li>Power derate 2</li> </ul>
<b>Engine Warning Light</b>		ON	OFF	OFF

DTC		606	627	628	
<b>Name</b>		Internal Processor Diagnostics	Fuel Pump Relay Control/Coil	Fuel Pump Relay Control/Coil	Fuel Pump Motor Feedback
<b>DTC Name</b>		Microprocessor Failure-COP	Fuel Pump Relay Coil Open	Fuel Pump Relay Ground Short	
<b>J1939</b>	<b>SPN</b>	629	1348	1348	1347
	<b>FMI</b>	31	5	4	5
<b>MIL</b>		ON	ON	ON	ON
<b>Detected Item</b>		<ul style="list-style-type: none"> <li>Faulty ECU</li> </ul>	<ul style="list-style-type: none"> <li>Open coil in relay</li> <li>Open in relay driver circuit in engine harness</li> </ul>	<ul style="list-style-type: none"> <li>Relay pull in coil shorted internally</li> <li>relay driver circuit shorted to ground in wire harness</li> </ul>	
<b>DTC Set Preconditions</b>		<ul style="list-style-type: none"> <li>Key on</li> </ul>	<ul style="list-style-type: none"> <li>Key On, Engine Off</li> </ul>	<ul style="list-style-type: none"> <li>Engine Running</li> </ul>	
<b>DTC Set Conditions</b>		<ul style="list-style-type: none"> <li>Internal microprocessor error</li> </ul>	<ul style="list-style-type: none"> <li>Fuel Pump relay coil output open circuit</li> </ul>	<ul style="list-style-type: none"> <li>Fuel Pump relay coil output shorted to ground</li> </ul>	<ul style="list-style-type: none"> <li>Fuel pump motor high-side on-state &lt; 4.0 volts</li> <li>battery voltage &gt; 8.0 volts</li> </ul>
<b>Period for Judgment or Number of Occurrence for Judgment</b>		<ul style="list-style-type: none"> <li>N/A</li> </ul>	<ul style="list-style-type: none"> <li>10 samples</li> </ul>	<ul style="list-style-type: none"> <li>10 samples</li> </ul>	<ul style="list-style-type: none"> <li>2 sec</li> </ul>
<b>System Action</b>		<ul style="list-style-type: none"> <li>Never Forget</li> <li>AL Disable KC</li> <li>Power derate 2</li> </ul>	<ul style="list-style-type: none"> <li>None</li> </ul>	<ul style="list-style-type: none"> <li>None</li> </ul>	<ul style="list-style-type: none"> <li>None</li> </ul>
<b>Engine Warning Light</b>		OFF	ON	ON	ON

DTC		629		642	643
<b>Name</b>		Fuel Pump Relay Control/Coil	Fuel Pump Motor Feedback	5 V External	5 V External
<b>DTC Name</b>		Fuel Pump Relay Coil Short-To-Power		Sensor Supply Voltage 1 Low (5Vext1)	Sensor Supply Voltage 1 High (5Vext1)
J1939	<b>SPN</b>	1348	1347	1079	1079
	<b>FMI</b>	3	6	4	3
<b>MIL</b>		ON	ON	ON	ON
<b>Detected Item</b>		<ul style="list-style-type: none"> <li>Shorted relay pull in coil</li> <li>relay driver circuit shorted to voltage in wire harness</li> </ul>		<ul style="list-style-type: none"> <li>Wiring harness short to ground</li> <li>ECM malfunction</li> </ul>	<ul style="list-style-type: none"> <li>Wiring harness short to 12.0 V power</li> <li>ECM malfunction</li> </ul>
<b>DTC Set Preconditions</b>		<ul style="list-style-type: none"> <li>Engine Running</li> </ul>		<ul style="list-style-type: none"> <li>Key-On, Engine OFF, or Running</li> </ul>	<ul style="list-style-type: none"> <li>Key-On, Engine OFF, or Running</li> </ul>
<b>DTC Set Conditions</b>		<ul style="list-style-type: none"> <li>Fuel Pump relay coil output short to power/ voltage</li> </ul>	<ul style="list-style-type: none"> <li>Fuel pump motor high-side off-state &lt; 4.0 volts</li> <li>battery voltage &lt; 16.0 volts</li> </ul>	<ul style="list-style-type: none"> <li>5VE1 &lt; 4.60 V</li> </ul>	<ul style="list-style-type: none"> <li>5VE1 &gt; 5.40 V</li> </ul>
<b>Period for Judgment or Number of Occurrence for Judgment</b>		<ul style="list-style-type: none"> <li>10 samples</li> </ul>	<ul style="list-style-type: none"> <li>2 sec</li> </ul>	<ul style="list-style-type: none"> <li>1 sec</li> </ul>	<ul style="list-style-type: none"> <li>1 sec</li> </ul>
<b>System Action</b>		<ul style="list-style-type: none"> <li>None</li> </ul>	<ul style="list-style-type: none"> <li>None</li> </ul>	<ul style="list-style-type: none"> <li>AL Disable</li> <li>Power derate 1</li> </ul>	<ul style="list-style-type: none"> <li>AL Disable</li> <li>Power derate 1</li> </ul>
<b>Engine Warning Light</b>		ON	ON	ON	ON

DTC		652		653	686
<b>Name</b>		5 V External		5 V External	Power Relay Control/Coil
<b>DTC Name</b>		Sensor Supply Voltage 2 Low (5Vext2)		Sensor Supply Voltage 2 High (5Vext2)	Power Relay Ground Short
J1939	<b>SPN</b>	1080		1080	1485
	<b>FMI</b>	4		3	4
<b>MIL</b>		ON		ON	ON
<b>Detected Item</b>		<ul style="list-style-type: none"> <li>Wiring harness short to ground</li> <li>ECM malfunction</li> </ul>		<ul style="list-style-type: none"> <li>Wiring harness short to 12.0 V power</li> <li>ECM malfunction</li> </ul>	<ul style="list-style-type: none"> <li>Short to ground in relay pull in coil</li> <li>short to ground in relay driver circuit in wire harness</li> </ul>
<b>DTC Set Preconditions</b>		<ul style="list-style-type: none"> <li>Key-On, Engine OFF, or Running</li> </ul>		<ul style="list-style-type: none"> <li>Key-On, Engine OFF, or Running</li> </ul>	<ul style="list-style-type: none"> <li>Key On, Engine Off</li> </ul>
<b>DTC Set Conditions</b>		<ul style="list-style-type: none"> <li>5VE2 &lt; 4.60 V</li> </ul>		<ul style="list-style-type: none"> <li>5VE2 &gt; 5.40 V</li> </ul>	<ul style="list-style-type: none"> <li>Power relay coil output shorted to ground</li> </ul>
<b>Period for Judgment or Number of Occurrence for Judgment</b>		<ul style="list-style-type: none"> <li>1 sec</li> </ul>		<ul style="list-style-type: none"> <li>1 sec</li> </ul>	<ul style="list-style-type: none"> <li>10 samples</li> </ul>
<b>System Action</b>		<ul style="list-style-type: none"> <li>AL Disable</li> <li>Power derate 1</li> </ul>		<ul style="list-style-type: none"> <li>AL Disable</li> <li>Power derate 1</li> </ul>	<ul style="list-style-type: none"> <li>None</li> </ul>
<b>Engine Warning Light</b>		ON		ON	OFF

DTC		687	1111	1112
Name		Power Relay Control/Coil	Engine Speed	Engine Speed
DTC Name		Power Relay Coil Short-To-Power	RPM Above Fuel Rev Limit Level	RPM Above Spark Rev Limit Level
J1939	SPN	1485	515	515
	FMI	3	16	0
MIL		ON	ON	ON
Detected Item		<ul style="list-style-type: none"> <li>Shorted relay pull in coil</li> <li>relay driver circuit shorted to voltage in wire harness</li> </ul>	<ul style="list-style-type: none"> <li>Engine overspeed condition, faulty Crank sensor or input</li> </ul>	<ul style="list-style-type: none"> <li>Engine overspeed condition, faulty Crank sensor or input</li> </ul>
DTC Set Preconditions		<ul style="list-style-type: none"> <li>Key On, Engine Off</li> </ul>	<ul style="list-style-type: none"> <li>Engine Running</li> </ul>	<ul style="list-style-type: none"> <li>Engine Running</li> </ul>
DTC Set Conditions		<ul style="list-style-type: none"> <li>Power relay coil output short to power/voltage</li> </ul>	<ul style="list-style-type: none"> <li>RPM &gt; 4200 min<sup>-1</sup> (rpm)</li> </ul>	<ul style="list-style-type: none"> <li>RPM &gt; 4300 min<sup>-1</sup> (rpm)</li> </ul>
Period for Judgment or Number of Occurrence for Judgment		<ul style="list-style-type: none"> <li>10 samples</li> </ul>	<ul style="list-style-type: none"> <li>1 sec</li> </ul>	<ul style="list-style-type: none"> <li>1 sec</li> </ul>
System Action		<ul style="list-style-type: none"> <li>None</li> </ul>	<ul style="list-style-type: none"> <li>disable fuel injectors or gaseous fuel control actuator</li> </ul>	<ul style="list-style-type: none"> <li>disable ignition coils</li> </ul>
Engine Warning Light		OFF	ON	ON

DTC		1121	1151	1152
Name		FPP	Closed Loop	Closed Loop
DTC Name		FPP1/2 Simultaneous Voltages Out-of-Range	Closed Loop High (LPG)	Closed Loop Low (LPG)
J1939	SPN	91	4236	4236
	FMI	31	0	1
MIL		ON	ON	ON
Detected Item		<ul style="list-style-type: none"> <li>Wiring harness open/short/damage</li> <li>FPP malfunction</li> </ul>	<ul style="list-style-type: none"> <li>exhaust leaks upstream or near the HEGO sensor</li> <li>reduced fuel supply pressure to the gaseous fuel control system</li> <li>a fuel supply or manifold leak</li> <li>a non-responsive HEGO sensor</li> </ul>	<ul style="list-style-type: none"> <li>high fuel supply pressure to the gaseous fuel control or faulty pressure regulator</li> <li>a non-responsive HEGO sensor</li> </ul>
DTC Set Preconditions		<ul style="list-style-type: none"> <li>Key on, Engine Off</li> </ul>	<ul style="list-style-type: none"> <li>Engine Running, Closed Loop Mode</li> </ul>	<ul style="list-style-type: none"> <li>Engine Running, Closed Loop Mode</li> </ul>
DTC Set Conditions		<ul style="list-style-type: none"> <li>User same parameter as individual FPP 1/2 voltage fault detection above</li> </ul>	<ul style="list-style-type: none"> <li>CL_BM &gt; 35 %</li> <li>and RPM &gt;= 0 min<sup>-1</sup> (rpm)</li> <li>and RPM &lt;= 9999 min<sup>-1</sup> (rpm)</li> <li>and MAP &gt;= 0.0 kPa [abs] (0.0 kgf/cm<sup>2</sup>, 0.0 psia)</li> <li>and MAP &lt;= 682 kPa [abs] (6.96 kgf/cm<sup>2</sup>, 99.0 psia)</li> </ul>	<ul style="list-style-type: none"> <li>CL_BM &lt; -35 %</li> <li>and RPM &gt;= 0 min<sup>-1</sup> (rpm)</li> <li>and RPM &lt;= 9999 min<sup>-1</sup> (rpm)</li> <li>and MAP &gt;= 0.0 kPa [abs] (0.0 kgf/cm<sup>2</sup>, 0.0 psia)</li> <li>and MAP &lt;= 682 kPa [abs] (6.96 kgf/cm<sup>2</sup>, 99.0 psia)</li> </ul>
Period for Judgment or Number of Occurrence for Judgment		<ul style="list-style-type: none"> <li>0.5 sec</li> </ul>	<ul style="list-style-type: none"> <li>Power Derate2</li> <li>5 updates</li> </ul>	<ul style="list-style-type: none"> <li>5 updates</li> </ul>
System Action		<ul style="list-style-type: none"> <li>Power Derate 2</li> <li>Low Rev Limit</li> <li>Force Idle</li> </ul>	<ul style="list-style-type: none"> <li>CL Disable</li> <li>AL Disable KC</li> </ul>	<ul style="list-style-type: none"> <li>CL Disable</li> <li>AL Disable KC</li> </ul>
Engine Warning Light		OFF	ON	ON

DTC		1153	1154	1155
<b>Name</b>		Closed Loop	Closed Loop	Closed Loop
<b>DTC Name</b>		Closed Loop High (NG)	Closed Loop Low (NG)	Closed Loop Bank 1 High (Gasoline)
<b>J1939</b>	<b>SPN</b>	4236	4236	4236
	<b>FMI</b>	0	1	0
<b>MIL</b>		ON	ON	ON
<b>Detected Item</b>		<ul style="list-style-type: none"> <li>exhaust leaks upstream or near the HEGO sensor</li> <li>reduced fuel supply pressure to the gaseous fuel control system</li> <li>a fuel supply or manifold leak</li> <li>a non-responsive HEGO sensor</li> </ul>	<ul style="list-style-type: none"> <li>high fuel supply pressure to the gaseous fuel control or faulty pressure regulator</li> <li>a non-responsive HEGO sensor</li> </ul>	<ul style="list-style-type: none"> <li>exhaust leaks upstream or near the HEGO sensor</li> <li>reduced fuel supply pressure</li> <li>an injector that is stuck closed</li> </ul>
<b>DTC Set Preconditions</b>		<ul style="list-style-type: none"> <li>Engine Running, Closed Loop Mode</li> </ul>	<ul style="list-style-type: none"> <li>Engine Running, Closed Loop Mode</li> </ul>	<ul style="list-style-type: none"> <li>Engine Running, Closed Loop Mode</li> </ul>
<b>DTC Set Conditions</b>		<ul style="list-style-type: none"> <li>CL_BM &gt; 35 %</li> <li>and RPM ≤ 0 min<sup>-1</sup> (rpm)</li> <li>and RPM ≤ 9999 min<sup>-1</sup> (rpm)</li> <li>and MAP ≥ 0.0 kPa [abs] (0.0 kgf/cm<sup>2</sup>, 0.0 psia)</li> <li>and MAP ≤ 682 kPa [abs] (6.96 kgf/cm<sup>2</sup>, 99.0 psia)</li> </ul>	<ul style="list-style-type: none"> <li>CL_BM &lt; -35 %</li> <li>and RPM ≥ 0 min<sup>-1</sup> (rpm)</li> <li>and RPM ≤ 9999 min<sup>-1</sup> (rpm)</li> <li>and MAP ≥ 0.0 kPa [abs] (0.0 kgf/cm<sup>2</sup>, 0.0 psia)</li> <li>and MAP ≤ 682 kPa [abs] (6.96 kgf/cm<sup>2</sup>, 99.0 psia)</li> </ul>	<ul style="list-style-type: none"> <li>CL_BM &gt; 35 %</li> <li>and RPM ≥ 0 min<sup>-1</sup> (rpm)</li> <li>and RPM ≤ 9999 min<sup>-1</sup> (rpm)</li> <li>and MAP ≥ 0.0 kPa [abs] (0.0 kgf/cm<sup>2</sup>, 0.0 psia)</li> <li>and MAP ≤ 682 kPa [abs] (6.96 kgf/cm<sup>2</sup>, 99.0 psia)</li> </ul>
<b>Period for Judgment or Number of Occurrence for Judgment</b>		<ul style="list-style-type: none"> <li>5 updates</li> </ul>	<ul style="list-style-type: none"> <li>5 updates</li> </ul>	<ul style="list-style-type: none"> <li>5 updates</li> </ul>
<b>System Action</b>		<ul style="list-style-type: none"> <li>CL Disable</li> <li>AL Disable KC</li> </ul>	<ul style="list-style-type: none"> <li>CL Disable</li> <li>AL Disable KC</li> </ul>	<ul style="list-style-type: none"> <li>CL Disable</li> <li>AL Disable KC</li> </ul>
<b>Engine Warning Light</b>		ON	ON	ON



DTC		1156	1161	1162
<b>Name</b>		Closed Loop	Adaptive Learn	Adaptive Learn
<b>DTC Name</b>		Closed Loop Bank 1 Low (Gasoline)	Adaptive Learn High (LPG)	Adaptive Learn Low (LPG)
<b>J1939</b>	<b>SPN</b>	4236	4237	4237
	<b>FMI</b>	1	0	1
<b>MIL</b>		ON	ON	ON
<b>Detected Item</b>		<ul style="list-style-type: none"> <li>high fuel supply pressure to the fuel injection system</li> <li>a non-responsive HEGO sensor</li> <li>an injector that is stuck open</li> </ul>	<ul style="list-style-type: none"> <li>exhaust leaks upstream or near the HEGO sensor</li> <li>reduced fuel supply pressure to the gaseous fuel control system</li> <li>a fuel supply or manifold leak</li> <li>a non-responsive HEGO sensor</li> </ul>	<ul style="list-style-type: none"> <li>high fuel supply pressure to the gaseous fuel control or faulty pressure regulator</li> <li>a non-responsive HEGO sensor</li> </ul>
<b>DTC Set Preconditions</b>		<ul style="list-style-type: none"> <li>Engine Running, Closed Loop Mode</li> </ul>	<ul style="list-style-type: none"> <li>Engine Running, Adaptive Mode</li> </ul>	<ul style="list-style-type: none"> <li>Engine Running, Adaptive Mode</li> </ul>
<b>DTC Set Conditions</b>		<ul style="list-style-type: none"> <li>CL_BM &lt; -35 %</li> <li>and RPM &gt;= 0 min<sup>-1</sup> (rpm)</li> <li>and RPM &lt;= 9999 min<sup>-1</sup> (rpm)</li> <li>and MAP &gt;= 0.0 kPa [abs] (0.0 kgf/cm<sup>2</sup>, 0.0 psia)</li> <li>and MAP &lt;= 682 kPa [abs] (6.96 kgf/cm<sup>2</sup>, 99.0 psia)</li> </ul>	<ul style="list-style-type: none"> <li>AL_BM &gt; 30 %</li> <li>and RPM &gt;= 0 min<sup>-1</sup> (rpm)</li> <li>and RPM &lt;= 9999 min<sup>-1</sup> (rpm)</li> <li>and MAP &gt;= 0.0 kPa [abs] (0.0 kgf/cm<sup>2</sup>, 0.0 psia)</li> <li>and MAP &lt;= 682 kPa [abs] (6.96 kgf/cm<sup>2</sup>, 99.0 psia)</li> </ul>	<ul style="list-style-type: none"> <li>AL_BM &lt; -30 %</li> <li>and RPM &gt;= 0 min<sup>-1</sup> (rpm)</li> <li>and RPM &lt;= 9999 min<sup>-1</sup> (rpm)</li> <li>and MAP &gt;= 0.0 kPa [abs] (0.0 kgf/cm<sup>2</sup>, 0.0 psia)</li> <li>and MAP &lt;= 682 kPa [abs] (6.96 kgf/cm<sup>2</sup>, 99.0 psia)</li> </ul>
<b>Period for Judgment or Number of Occurrence for Judgment</b>		<ul style="list-style-type: none"> <li>5 updates</li> </ul>	<ul style="list-style-type: none"> <li>3 updates</li> </ul>	<ul style="list-style-type: none"> <li>3 updates</li> </ul>
<b>System Action</b>		<ul style="list-style-type: none"> <li>CL Disable</li> <li>AL Disable KC</li> </ul>	<ul style="list-style-type: none"> <li>CL Disable</li> <li>AL Disable KC</li> </ul>	<ul style="list-style-type: none"> <li>CL Disable</li> <li>AL Disable KC</li> </ul>
<b>Engine Warning Light</b>		ON	ON	ON

DTC		1163	1164	1165
<b>Name</b>		Adaptive Learn	Adaptive Learn	Catalyst
<b>DTC Name</b>		Adaptive Learn High (NG)	Adaptive Learn Low (NG)	Catalyst inactive on LPG
<b>J1939</b>	<b>SPN</b>	4237	4237	3050
	<b>FMI</b>	0	1	11
<b>MIL</b>		ON	ON	OFF
<b>Detected Item</b>		<ul style="list-style-type: none"> <li>exhaust leaks upstream or near the HEGO sensor</li> <li>reduced fuel supply pressure to the gaseous fuel control system</li> <li>a fuel supply or manifold leak</li> <li>a non-responsive HEGO sensor</li> </ul>	<ul style="list-style-type: none"> <li>high fuel supply pressure to the gaseous fuel control or faulty pressure regulator</li> <li>a non-responsive HEGO sensor</li> </ul>	
<b>DTC Set Preconditions</b>		<ul style="list-style-type: none"> <li>Engine Running, Adaptive Mode</li> </ul>	<ul style="list-style-type: none"> <li>Engine Running, Adaptive Mode</li> </ul>	<ul style="list-style-type: none"> <li>Engine Running</li> </ul>
<b>DTC Set Conditions</b>		<ul style="list-style-type: none"> <li>AL_BM &gt; 30 %</li> <li>and RPM &gt;= 0 min<sup>-1</sup> (rpm)</li> <li>and RPM &lt;= 9999 min<sup>-1</sup> (rpm)</li> <li>and MAP &gt;= 0.0 kPa [abs] (0.0 kgf/cm<sup>2</sup>, 0.0 psia)</li> <li>and MAP &lt;= 682 kPa [abs] (6.96 kgf/cm<sup>2</sup>, 99.0 psia)</li> </ul>	<ul style="list-style-type: none"> <li>AL_BM &lt; -30 %</li> <li>and RPM &gt;= 0 min<sup>-1</sup> (rpm)</li> <li>and RPM &lt;= 9999 min<sup>-1</sup> (rpm)</li> <li>and MAP &gt;= 0.0 kPa [abs] (0.0 kgf/cm<sup>2</sup>, 0.0 psia)</li> <li>and MAP &lt;= 682 kPa [abs] (6.96 kgf/cm<sup>2</sup>, 99.0 psia)</li> </ul>	<ul style="list-style-type: none"> <li>EGO3/4 RMS &gt; 0.008 phi</li> <li>and EGO3/4 RMS &gt; EGO1/2 RMS 50 %</li> <li>and EGO3/4 RMS &gt; CL waveform RMS 50 %</li> <li>and mass flow at ports &gt;= 10.0 g/sec and &lt;= CBT -CBT_ss +/- 50.0 degF</li> </ul>
<b>Period for Judgment or Number of Occurrence for Judgment</b>		<ul style="list-style-type: none"> <li>3 updates</li> </ul>	<ul style="list-style-type: none"> <li>3 updates</li> </ul>	<ul style="list-style-type: none"> <li>100 updates</li> </ul>
<b>System Action</b>		<ul style="list-style-type: none"> <li>CL Disable</li> <li>AL Disable KC</li> </ul>	<ul style="list-style-type: none"> <li>CL Disable</li> <li>AL Disable KC</li> </ul>	<ul style="list-style-type: none"> <li>Shutdown</li> <li>CL Disable</li> <li>AL Disable</li> <li>Hard Warning</li> </ul>
<b>Engine Warning Light</b>		ON	ON	ON

DTC		1166	1171	1172
<b>Name</b>		Catalyst	EPR Diagnostics	EPR Diagnostics
<b>DTC Name</b>		Catalyst inactive on NG	EPR/CFV Regulation Pressure Higher than Expected	EPR/CFV Regulation Pressure Lower than Expected
<b>J1939</b>	<b>SPN</b>	3050	520260	520260
	<b>FMI</b>	11	0	1
<b>MIL</b>		OFF	ON	ON
<b>Detected Item</b>			<ul style="list-style-type: none"> <li>Inlet pressure to DEPR is too high.</li> </ul>	<ul style="list-style-type: none"> <li>Inlet pressure to DEPR is too low.</li> <li>Malfunctioning lock off valve, plugged fuel filter, closed manual valve or fuel tank out of fuel</li> </ul>
<b>DTC Set Preconditions</b>		<ul style="list-style-type: none"> <li>Engine Running</li> </ul>	<ul style="list-style-type: none"> <li>Engine Running</li> </ul>	<ul style="list-style-type: none"> <li>Engine Running</li> </ul>
<b>DTC Set Conditions</b>		<ul style="list-style-type: none"> <li>EGO3/4 RMS &gt; 0.008 phi</li> <li>and EGO3/4 RMS &gt; EGO1/2 RMS 50 %</li> <li>and EGO3/4 RMS &gt; CL waveform RMS 50 %</li> <li>and mass flow at ports &gt;= 10.0 g/sec and &lt;= CBT -CBT_ss +/- 50.0 degF</li> </ul>	<ul style="list-style-type: none"> <li>EPR actual-commanded pressure &gt; 2.50 in H<sub>2</sub>O</li> </ul>	<ul style="list-style-type: none"> <li>EPR actual-commanded pressure &lt; -2.50 in H<sub>2</sub>O</li> </ul>
<b>Period for Judgment or Number of Occurrence for Judgment</b>		<ul style="list-style-type: none"> <li>100 updates</li> </ul>	<ul style="list-style-type: none"> <li>5 sec</li> </ul>	<ul style="list-style-type: none"> <li>5 sec</li> </ul>
<b>System Action</b>		<ul style="list-style-type: none"> <li>CL Disable</li> <li>AL Disable KC</li> </ul>	<ul style="list-style-type: none"> <li>AL Disable</li> </ul>	<ul style="list-style-type: none"> <li>AL Disable</li> </ul>
<b>Engine Warning Light</b>		ON	ON	ON

DTC		1173	1174	1175
<b>Name</b>		EPR Diagnostics	EPR Diagnostics	EPR Diagnostics
<b>DTC Name</b>		EPR/CFV comm lost	EPR/CFV Voltage Supply High	EPR/CFV Voltage Supply Low
<b>J1939</b>	<b>SPN</b>	520620	520260	520260
	<b>FMI</b>	31	3	4
<b>MIL</b>		OFF	ON	ON
<b>Detected Item</b>		<ul style="list-style-type: none"> <li>Faulty CAN connection</li> <li>CAN terminal incorrect</li> </ul>	<ul style="list-style-type: none"> <li>Supply voltage to the EPR/CFV is too high</li> </ul>	<ul style="list-style-type: none"> <li>Supply voltage to the EPR/CFV is too low</li> </ul>
<b>DTC Set Preconditions</b>		<ul style="list-style-type: none"> <li>Engine Running</li> </ul>	<ul style="list-style-type: none"> <li>Engine Running</li> </ul>	<ul style="list-style-type: none"> <li>Engine Running</li> </ul>
<b>DTC Set Conditions</b>		<ul style="list-style-type: none"> <li>No EPR packets received within 500 ms</li> </ul>	<ul style="list-style-type: none"> <li>Voltage supply to EPR/CFV is &gt; 33.0 VDC</li> </ul>	<ul style="list-style-type: none"> <li>Voltage supply to EPR/CFV is &lt; 18.0 VDC</li> </ul>
<b>Period for Judgment or Number of Occurrence for Judgment</b>		<ul style="list-style-type: none"> <li>0.5 sec</li> </ul>	<ul style="list-style-type: none"> <li>5 sec</li> </ul>	<ul style="list-style-type: none"> <li>5 sec</li> </ul>
<b>System Action</b>		<ul style="list-style-type: none"> <li>CL Disable</li> <li>AL Disable KC</li> </ul>	<ul style="list-style-type: none"> <li>AL Disable</li> <li>AL Disable KC</li> <li>Power Derate 2</li> <li>Low Rev Limit</li> </ul>	<ul style="list-style-type: none"> <li>AL Disable</li> <li>AL Disable KC</li> <li>Power Derate 2</li> <li>Low Rev Limit</li> </ul>
<b>Engine Warning Light</b>		ON	ON	ON

DTC		1176	1177	1611
<b>Name</b>		EPR Diagnostics	EPR Diagnostics	5V External
<b>DTC Name</b>		EPR/CFV Internal Actuator Fault Detection	EPR/CFV Internal Circuitry Fault Detection	Sensor Supply Voltage (5Vext 1/2) Simultaneous Out-of-Range
<b>J1939</b>	<b>SPN</b>	520260	520260	1079
	<b>FMI</b>	12	12	31
<b>MIL</b>		ON	ON	ON
<b>Detected Item</b>		<ul style="list-style-type: none"> <li>Short or open circuit in actuator coil</li> <li>Associated wiring</li> <li>Overheating of actuator drive electronics</li> </ul>	<ul style="list-style-type: none"> <li>DEPR internal microprocessor or memory failure, fuel temperature sensor failure.</li> </ul>	<ul style="list-style-type: none"> <li>Wiring harness short to 12V power or ground</li> <li>ECM malfunction</li> </ul>
<b>DTC Set Preconditions</b>		<ul style="list-style-type: none"> <li>Engine Running</li> </ul>	<ul style="list-style-type: none"> <li>Engine Running</li> </ul>	<ul style="list-style-type: none"> <li>Engine On</li> </ul>
<b>DTC Set Conditions</b>		<ul style="list-style-type: none"> <li>the DEPR electronics detect a fault condition associated with its internal actuator.</li> </ul>	<ul style="list-style-type: none"> <li>the DEPR electronics detect a fault condition associated with its internal circuitry.</li> </ul>	<ul style="list-style-type: none"> <li>5Vext1 &gt; 5.40 V or 5Vext1 &lt; 4.60 V, and 5Vext2 &gt; 5.40 V or 5Vext2 &lt; 4.60 V</li> </ul>
<b>Period for Judgment or Number of Occurrence for Judgment</b>		<ul style="list-style-type: none"> <li>0.25 sec</li> </ul>	<ul style="list-style-type: none"> <li>0.25 sec</li> </ul>	<ul style="list-style-type: none"> <li>1 sec</li> </ul>
<b>System Action</b>		<ul style="list-style-type: none"> <li>AL Disable</li> </ul>	<ul style="list-style-type: none"> <li>AL Disable</li> </ul>	<ul style="list-style-type: none"> <li>Power Derate 2</li> <li>Low Rev Limit</li> <li>Force Idle</li> </ul>
<b>Engine Warning Light</b>		ON	ON	ON

DTC		1612	1613	1614
<b>Name</b>		Internal Processor Diagnostics	Internal Processor Diagnostics	Internal Processor Diagnostics
<b>DTC Name</b>		Microprocessor Failure-RTI 1	Microprocessor Failure-RTI 2	Microprocessor Failure-RTI 3
<b>J1939</b>	<b>SPN</b>	629	629	629
	<b>FMI</b>	31	31	31
<b>MIL</b>		ON	ON	ON
<b>Detected Item</b>		• Faulty ECU	• Faulty ECU	• Faulty ECU
<b>DTC Set Preconditions</b>		• Key on	• Key on	• Key on
<b>DTC Set Conditions</b>		• Internal microprocessor error	• Internal microprocessor error	• Internal microprocessor error
<b>Period for Judgment or Number of Occurrence for Judgment</b>		• N/A	• N/A	• N/A
<b>System Action</b>		<ul style="list-style-type: none"> <li>• Shutdown</li> <li>• CL Disable</li> <li>• AL Disable</li> <li>• Hard Warning</li> </ul>	<ul style="list-style-type: none"> <li>• Never Forget</li> <li>• AL Disable KC</li> <li>• Power derate 2</li> </ul>	<ul style="list-style-type: none"> <li>• Never Forget</li> <li>• AL Disable KC</li> <li>• Power derate 2</li> </ul>
<b>Engine Warning Light</b>		ON	OFF	OFF

DTC		1615	1616	1673
<b>Name</b>		Internal Processor Diagnostics	Internal Processor Diagnostics	General System Diagnostics
<b>DTC Name</b>		Microprocessor Failure-A/D	Microprocessor Failure-Interrupt	Calibration Configuration Error
<b>J1939</b>	<b>SPN</b>	629	629	1634
	<b>FMI</b>	31	31	13
<b>MIL</b>		ON	ON	ON
<b>Detected Item</b>		• Faulty ECU	• Faulty ECU	• ECM malfunction
<b>DTC Set Preconditions</b>		• Key on	• Key on	• Key ON
<b>DTC Set Conditions</b>		• Internal microprocessor error	• Internal microprocessor error	• Specific calibration variable checks do not return expected results
<b>Period for Judgment or Number of Occurrence for Judgment</b>		• N/A	• N/A	• N/A
<b>System Action</b>		<ul style="list-style-type: none"> <li>• Never Forget</li> <li>• AL Disable KC</li> <li>• Power derate 2</li> </ul>	<ul style="list-style-type: none"> <li>• Never Forget</li> <li>• AL Disable KC</li> <li>• Power derate 2</li> </ul>	<ul style="list-style-type: none"> <li>• Never Forget</li> <li>• AL Disable KC</li> <li>• Power derate 2</li> </ul>
<b>Engine Warning Light</b>		OFF	OFF	OFF

DTC		2111	2112	2121
Name		TPS	TPS	FPP
DTC Name		Unable to Reach Lower TPS	Unable to Reach Higher TPS	FPP1 Lower Than FPP2
J1939	SPN	51	51	91
	FMI	7	7	18
MIL		ON	ON	ON
Detected Item		<ul style="list-style-type: none"> <li>TPS malfunction</li> </ul>	<ul style="list-style-type: none"> <li>TPS malfunction</li> </ul>	<ul style="list-style-type: none"> <li>Wiring harness open/short/damage</li> <li>FPP malfunction</li> </ul>
DTC Set Preconditions		<ul style="list-style-type: none"> <li>Cranking or Running</li> </ul>	<ul style="list-style-type: none"> <li>Cranking or Running</li> </ul>	<ul style="list-style-type: none"> <li>Key On, Engine Off</li> </ul>
DTC Set Conditions		<ul style="list-style-type: none"> <li>target TPS-actual TPS &lt; -20.0 %</li> <li>persistently longer than 200 ms while battery voltage &gt; 9.00 V and battery voltage &lt; 16.0 V</li> </ul>	<ul style="list-style-type: none"> <li>target TPS-actual TPS &gt; 20.0 %</li> <li>persistently longer than 200 ms while battery voltage &gt; 9.00 V and battery voltage &lt; 16.0 V</li> </ul>	<ul style="list-style-type: none"> <li>(FPP 1 % - FPP 2 %) &lt; 20.0 %</li> </ul>
Period for Judgment or Number of Occurrence for Judgment		<ul style="list-style-type: none"> <li>1 sec</li> </ul>	<ul style="list-style-type: none"> <li>1 sec</li> </ul>	<ul style="list-style-type: none"> <li>1.5 sec</li> </ul>
System Action		<ul style="list-style-type: none"> <li>Shutdown</li> </ul>	<ul style="list-style-type: none"> <li>Shutdown</li> </ul>	<ul style="list-style-type: none"> <li>Power derate 2</li> <li>Low Rev Limit</li> </ul>
Engine Warning Light		ON	ON	ON

DTC		2122	2123	2126
Name		FPP	FPP	FPP
DTC Name		FPP1 Voltage High	FPP1 Voltage Low	FPP1 Higher Than FPP2
J1939	SPN	91	91	91
	FMI	3	4	16
MIL		ON 2Hz	ON 2Hz	ON
Detected Item		<ul style="list-style-type: none"> <li>Wiring harness open/short/damage</li> <li>FPP malfunction</li> </ul>	<ul style="list-style-type: none"> <li>Wiring harness open/short/damage</li> <li>FPP malfunction</li> </ul>	<ul style="list-style-type: none"> <li>Wiring harness open/short/damage</li> <li>FPP malfunction</li> </ul>
DTC Set Preconditions		<ul style="list-style-type: none"> <li>Key On</li> </ul>	<ul style="list-style-type: none"> <li>Key On, Engine Off</li> </ul>	<ul style="list-style-type: none"> <li>Key On, Engine Off</li> </ul>
DTC Set Conditions		<ul style="list-style-type: none"> <li>FPP1 voltage &gt; 4.80 V</li> </ul>	<ul style="list-style-type: none"> <li>FPP1 voltage &lt; 0.200 V</li> </ul>	<ul style="list-style-type: none"> <li>(FPP 1 % - FPP 2 %) &gt; 20.0 %</li> </ul>
Period for Judgment or Number of Occurrence for Judgment		<ul style="list-style-type: none"> <li>0.5 sec</li> </ul>	<ul style="list-style-type: none"> <li>0.5 sec</li> </ul>	<ul style="list-style-type: none"> <li>1.5 sec</li> </ul>
System Action		<ul style="list-style-type: none"> <li>Power derate 1</li> <li>Low Rev Limit</li> </ul>	<ul style="list-style-type: none"> <li>Power derate 1</li> <li>Low Rev Limit</li> </ul>	<ul style="list-style-type: none"> <li>Power derate 2</li> <li>Low Rev Limit</li> </ul>
Engine Warning Light		ON	ON	ON

DTC		2127	2128	2135
Name		FPP	FPP	TPS
DTC Name		FPP2 voltage low	FPP2 voltage high	TPS1/2 Simultaneous Voltages out of range
J1939	SPN	29	29	51
	FMI	4	3	31
MIL		ON 2Hz	ON 2Hz	ON
Detected Item		<ul style="list-style-type: none"> <li>Wiring harness open/short/damage</li> <li>FPP malfunction</li> </ul>	<ul style="list-style-type: none"> <li>Wiring harness open/short/damage</li> <li>FPP malfunction</li> </ul>	<ul style="list-style-type: none"> <li>TPS malfunction</li> </ul>
DTC Set Preconditions		<ul style="list-style-type: none"> <li>Key On</li> </ul>	<ul style="list-style-type: none"> <li>Key On</li> </ul>	<ul style="list-style-type: none"> <li>Key On, Engine On</li> </ul>
DTC Set Conditions		<ul style="list-style-type: none"> <li>FPP1 voltage &lt; 0.200 V</li> </ul>	<ul style="list-style-type: none"> <li>FPP1 voltage &gt; 4.80 V</li> </ul>	<ul style="list-style-type: none"> <li>User same parameter as individual TPS1/2 voltage fault detection above</li> </ul>
Period for Judgment or Number of Occurrence for Judgment		<ul style="list-style-type: none"> <li>0.5 sec</li> </ul>	<ul style="list-style-type: none"> <li>0.5 sec</li> </ul>	<ul style="list-style-type: none"> <li>0.5 sec</li> </ul>
System Action		<ul style="list-style-type: none"> <li>Power derate 1</li> <li>Low Rev Limit</li> </ul>	<ul style="list-style-type: none"> <li>Power derate 1</li> <li>Low Rev Limit</li> </ul>	<ul style="list-style-type: none"> <li>Shutdown</li> </ul>
Engine Warning Light		ON	ON	ON

DTC		2300	2301	2303
Name		Spark Coil Primary	Spark Coil Primary	Spark Coil Primary
DTC Name		Spark Coil #1 Primary Open/Short-to-Ground	Spark Coil #1 Primary Short-to-Power	Spark Coil #2 Primary Open/Short-to-Ground
J1939	SPN	1268	1268	1269
	FMI	5	6	5
MIL		ON	ON	ON
Detected Item		<ul style="list-style-type: none"> <li>a short to ground or open circuit in the harness</li> <li>an open internal to the primary coil</li> </ul>	<ul style="list-style-type: none"> <li>a short to power in the harness</li> <li>a short internal to the primary coil</li> </ul>	<ul style="list-style-type: none"> <li>a short to ground or open circuit in the harness</li> <li>an open internal to the primary coil</li> </ul>
DTC Set Preconditions		<ul style="list-style-type: none"> <li>Key On, Engine On</li> </ul>	<ul style="list-style-type: none"> <li>Key On, Engine On</li> </ul>	<ul style="list-style-type: none"> <li>Key On, Engine On</li> </ul>
DTC Set Conditions		<ul style="list-style-type: none"> <li>Adaptive dwell adjustment &gt;= 2.0 ms</li> <li>or total dwell &gt;= 14.0 ms</li> <li>and battery voltage &gt; 11.0 V</li> </ul>	<ul style="list-style-type: none"> <li>Adaptive dwell adjustment &lt;= -2.0 ms</li> <li>or total dwell &lt;= 4.0 ms</li> <li>and battery voltage &lt; 16.0 V</li> </ul>	<ul style="list-style-type: none"> <li>Adaptive dwell adjustment &gt;= 2.0 ms</li> <li>or total dwell &gt;= 14.0 ms</li> <li>and battery voltage &gt; 11.0 V</li> </ul>
Period for Judgment or Number of Occurrence for Judgment		<ul style="list-style-type: none"> <li>10 sparks</li> </ul>	<ul style="list-style-type: none"> <li>10 sparks</li> </ul>	<ul style="list-style-type: none"> <li>10 sparks</li> </ul>
System Action		<ul style="list-style-type: none"> <li>CL Disable</li> <li>AL Disable</li> <li>Low Rev Limit</li> </ul>	<ul style="list-style-type: none"> <li>CL Disable</li> <li>AL Disable</li> <li>Low Rev Limit</li> </ul>	<ul style="list-style-type: none"> <li>CL Disable</li> <li>AL Disable</li> <li>Low Rev Limit</li> </ul>
Engine Warning Light		ON	ON	ON

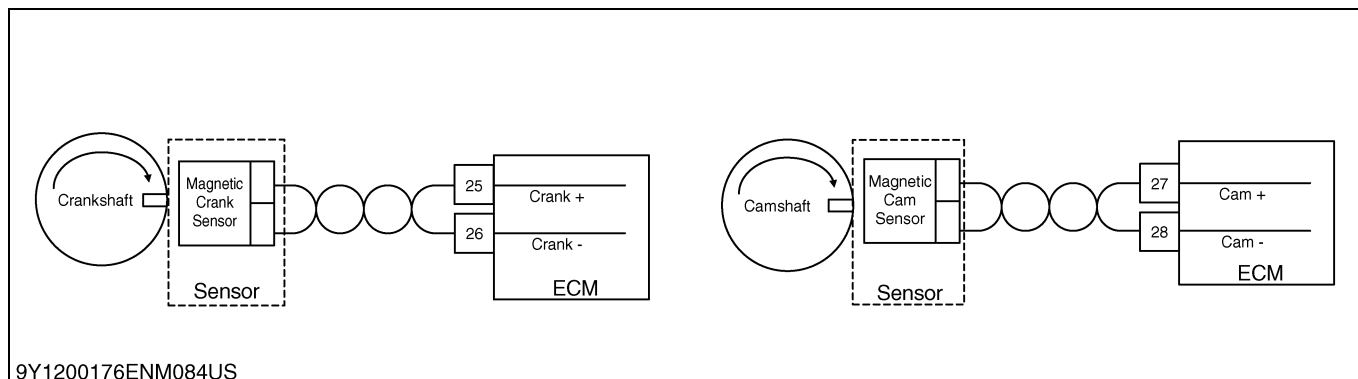
DTC		2304	2306	2307
<b>Name</b>		Spark Coil Primary	Spark Coil Primary	Spark Coil Primary
<b>DTC Name</b>		Spark Coil #2Primary Short-to-Power	Spark Coil #3 Primary Open/Short-to-Ground	Spark Coil #3 Primary Short-to-Power
J1939	<b>SPN</b>	1269	1270	1270
	<b>FMI</b>	6	5	6
<b>MIL</b>		ON	ON	ON
<b>Detected Item</b>		<ul style="list-style-type: none"> <li>• a short to power in the harness</li> <li>• a short internal to the primary coil</li> </ul>	<ul style="list-style-type: none"> <li>• a short to ground or open circuit in the harness</li> <li>• an open internal to the primary coil</li> </ul>	<ul style="list-style-type: none"> <li>• a short to power in the harness</li> <li>• a short internal to the primary coil</li> </ul>
<b>DTC Set Preconditions</b>		<ul style="list-style-type: none"> <li>• Key On, Engine On</li> </ul>	<ul style="list-style-type: none"> <li>• Key On, Engine On</li> </ul>	<ul style="list-style-type: none"> <li>• Key On, Engine On</li> </ul>
<b>DTC Set Conditions</b>		<ul style="list-style-type: none"> <li>• Adaptive dwell adjustment &lt;= -2.0 ms</li> <li>• or total dwell &lt;= 4.0 ms</li> <li>• and battery voltage &lt; 16.0 V</li> </ul>	<ul style="list-style-type: none"> <li>• Adaptive dwell adjustment &gt;= 2.0 ms</li> <li>• or total dwell &gt;= 14.0 ms</li> <li>• and battery voltage &gt; 11.0 V</li> </ul>	<ul style="list-style-type: none"> <li>• Adaptive dwell adjustment &lt;= -2.0 ms</li> <li>• or total dwell &lt;= 4.0 ms</li> <li>• and battery voltage &lt; 16.0 V</li> </ul>
<b>Period for Judgment or Number of Occurrence for Judgment</b>		<ul style="list-style-type: none"> <li>• 10 sparks</li> </ul>	<ul style="list-style-type: none"> <li>• 10 sparks</li> </ul>	<ul style="list-style-type: none"> <li>• 10 sparks</li> </ul>
<b>System Action</b>		<ul style="list-style-type: none"> <li>• CL Disable</li> <li>• AL Disable</li> <li>• Low Rev Limit</li> </ul>	<ul style="list-style-type: none"> <li>• CL Disable</li> <li>• AL Disable</li> <li>• Low Rev Limit</li> </ul>	<ul style="list-style-type: none"> <li>• CL Disable</li> <li>• AL Disable</li> <li>• Low Rev Limit</li> </ul>
<b>Engine Warning Light</b>		ON	ON	ON

DTC		2309	2310
<b>Name</b>		Spark Coil Primary	Spark Coil Primary
<b>DTC Name</b>		Spark Coil #4 Primary Open/Short-to-Ground	Spark Coil #4 Primary Short-to-Power
J1939	<b>SPN</b>	1271	1271
	<b>FMI</b>	5	6
<b>MIL</b>		ON	ON
<b>Detected Item</b>		<ul style="list-style-type: none"> <li>• a short to ground or open circuit in the harness</li> <li>• an open internal to the primary coil</li> </ul>	<ul style="list-style-type: none"> <li>• a short to power in the harness</li> <li>• a short internal to the primary coil</li> </ul>
<b>DTC Set Preconditions</b>		<ul style="list-style-type: none"> <li>• Key On, Engine On</li> </ul>	<ul style="list-style-type: none"> <li>• Key On, Engine On</li> </ul>
<b>DTC Set Conditions</b>		<ul style="list-style-type: none"> <li>• Adaptive dwell adjustment &gt;= 2.0 ms</li> <li>• or total dwell &gt;= 14.0 ms</li> <li>• and battery voltage &gt; 11.0 V</li> </ul>	<ul style="list-style-type: none"> <li>• Adaptive dwell adjustment &lt;= -2.0 ms</li> <li>• or total dwell &lt;= 4.0 ms</li> <li>• and battery voltage &lt; 16.0 V</li> </ul>
<b>Period for Judgment or Number of Occurrence for Judgment</b>		<ul style="list-style-type: none"> <li>• 10 sparks</li> </ul>	<ul style="list-style-type: none"> <li>• 10 sparks</li> </ul>
<b>System Action</b>		<ul style="list-style-type: none"> <li>• CL Disable</li> <li>• AL Disable</li> <li>• Low Rev Limit</li> </ul>	<ul style="list-style-type: none"> <li>• CL Disable</li> <li>• AL Disable</li> <li>• Low Rev Limit</li> </ul>
<b>Engine Warning Light</b>		ON	ON



## [4] Diagnosis Procedure by DTC

### (1) Crank/Cam Sensors (DTC 16, 336, 337, 341, 342)



#### **DTC 16-Crank and/or Cam Could Not Synchronize During Start**

- Hardware: Crankshaft Position Sensor/Camshaft Position Sensor Input Circuits
- Enabling Conditions: Engine Cranking or Running
- Set Conditions: Engine cranking longer than 4 revolutions above 90 min<sup>-1</sup> (rpm) without crank and/or cam synchronization
- Corrective Action(s): Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp
- Emissions related fault
- Possible causes: Mechanical misalignment between cam and crank, CMP or CKP signal (+)/ground (-) wires misplaced in connectors, bad ECM

The crankshaft position sensor is a magnetic pick-up sensor installed in the engine block adjacent to a "coded" trigger wheel located on the flywheel. The sensor-trigger wheel combination is used to determine crankshaft position (with respect to TDC cylinder #1 compression) and the rotational engine speed. Determination of the crankshaft position and speed is necessary to properly activate the ignition, fuel injection, and throttle governing systems for precise engine control.

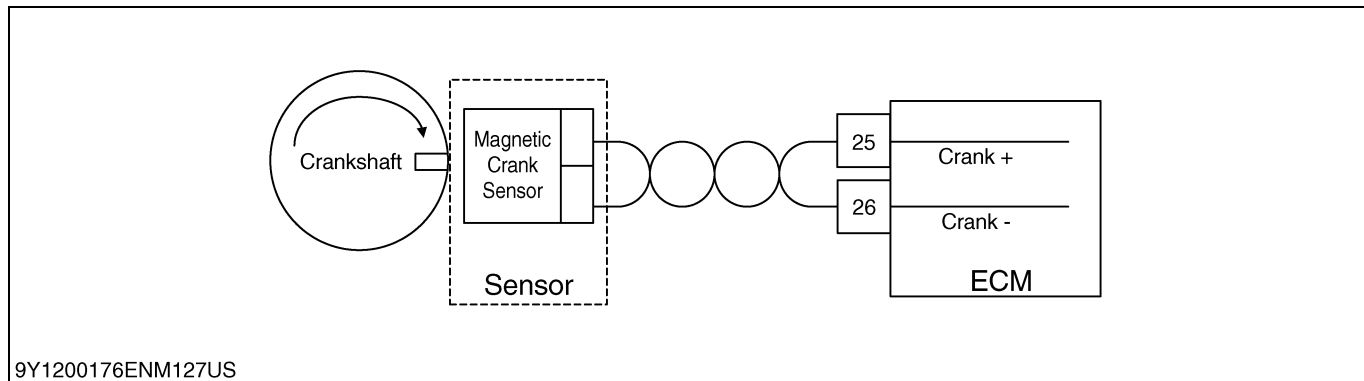
The camshaft position sensor is a magnetic pick-up sensor installed in the engine block or valve train adjacent to a "coded" trigger wheel located on or off of the camshaft. The sensor-trigger wheel combination is used to determine cam position (with respect to TDC cylinder #1 compression). Determination of the camshaft position is necessary to identify the stroke (or cycle) of the engine to properly activate the fuel injection system and ignition (for coil-on-plug engines) for precise engine control.

**Typically, this fault will result in an engine that will not start or run.**

#### **DTC 16-Crank and/or Cam Could Not Synchronize During Start**

##### **Diagnostic Aids**

- If there are any other CMP or CKP DTC's, diagnose them first
- Ensure that all 3 terminals are in the correct slot in the connector for both the CMP and the CKP sensors
- Ensure that the cam and crank are properly installed and timed
- Check that crankshaft and/or camshaft position sensor(s) is/are securely connected to harness
- Check that crankshaft and/or camshaft position sensor(s) is/are securely installed into engine block
- Check crankshaft and/or camshaft position sensor(s) circuit(s) wiring for open circuit
- Connect a 2 channel oscilloscope, scope CMP and CKP inputs and compare to known good waveforms



### **DTC 336-Crank Input Signal Noise**

- Hardware: Crankshaft Position sensor
- Enabling Conditions: Key On, Engine On
- Set Conditions: Electrical noise or irregular crank pattern detected causing more than 1 crank re-synchronization events in less than 800 ms
- Corrective Action(s): Illuminate MIL and disable fuel adaptive learn function for the rest of the key cycle.
- Emissions related fault
- Possible Causes: CKP+ or CKP- circuits in wrong connector terminal slot, improper CKP signal due to sensor air gap too large, excessive metal on sensor tip, improper wiring, intermittent connection in sensor circuitry, intermittent sensor internal problem

The crankshaft position sensor is a magnetic pick-up sensor installed in the engine block adjacent to a "coded" trigger wheel located on the flywheel. The sensor-trigger wheel combination is used to determine crankshaft position (with respect to TDC cylinder #1 compression) and the rotational engine speed. Determination of the crankshaft position and speed is necessary to properly activate the ignition, fuel injection, and throttle governing systems for precise engine control.

The ECM must see a valid crankshaft position signal while running. If no signal is present, the signal amplitude is too high (due to improper air gap with respect to trigger wheel), or an irregular crank pattern is detected causing the ECM to resynchronize  $\times$  times for  $y$  ms or longer as defined in the diagnostic calibration (see set conditions above), this fault will set. Irregular crank patterns can be detected by the ECM due to electrical noise, poor machining of trigger wheel, or trigger wheel run out and/or gear lash.

Ensure crank circuit used with VR/magnetic pick-up sensors are properly twisted.

### **DTC 337-Loss of Crankshaft Input Signal**

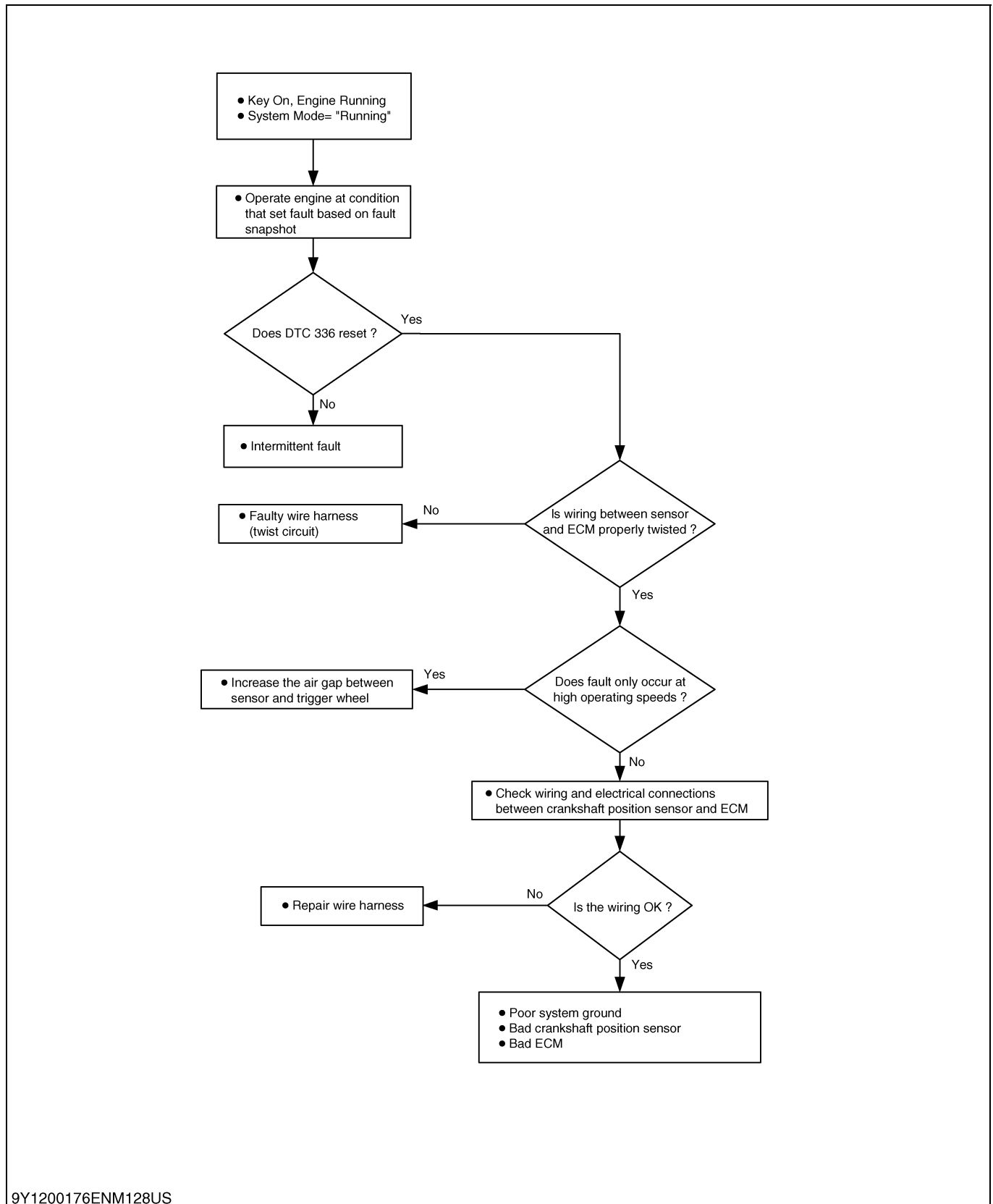
- Hardware: Crankshaft Position sensor
- Enabling Conditions: Key On, Engine On
- Set Conditions: Loss of crankshaft position signal (CKP) with more than 6 cam pulses from the camshaft position sensor (CMP).
- Corrective Action(s): Illuminate MIL
- Emissions related fault
- Possible Causes: Loss of sensor feed, open sensor ground (5 Vrtn1 and CKP-), open or shorted to ground signal wire

The crankshaft position sensor is a magnetic pick-up sensor installed in the engine block adjacent to a "coded" trigger wheel located on the flywheel. The sensor-trigger wheel combination is used to determine crankshaft position (with respect to TDC cylinder #1 compression) and the rotational engine speed. Determination of the crankshaft position and speed is necessary to properly activate the ignition, fuel injection, and throttle governing systems for precise engine control.

The ECM must see a valid crankshaft position signal while running. The engine typically stalls or dies as a result of this fault condition due to the lack of crankshaft speed input resulting in the inability to control ignition timing.

**DTC 336-Crank Input Signal Noise**

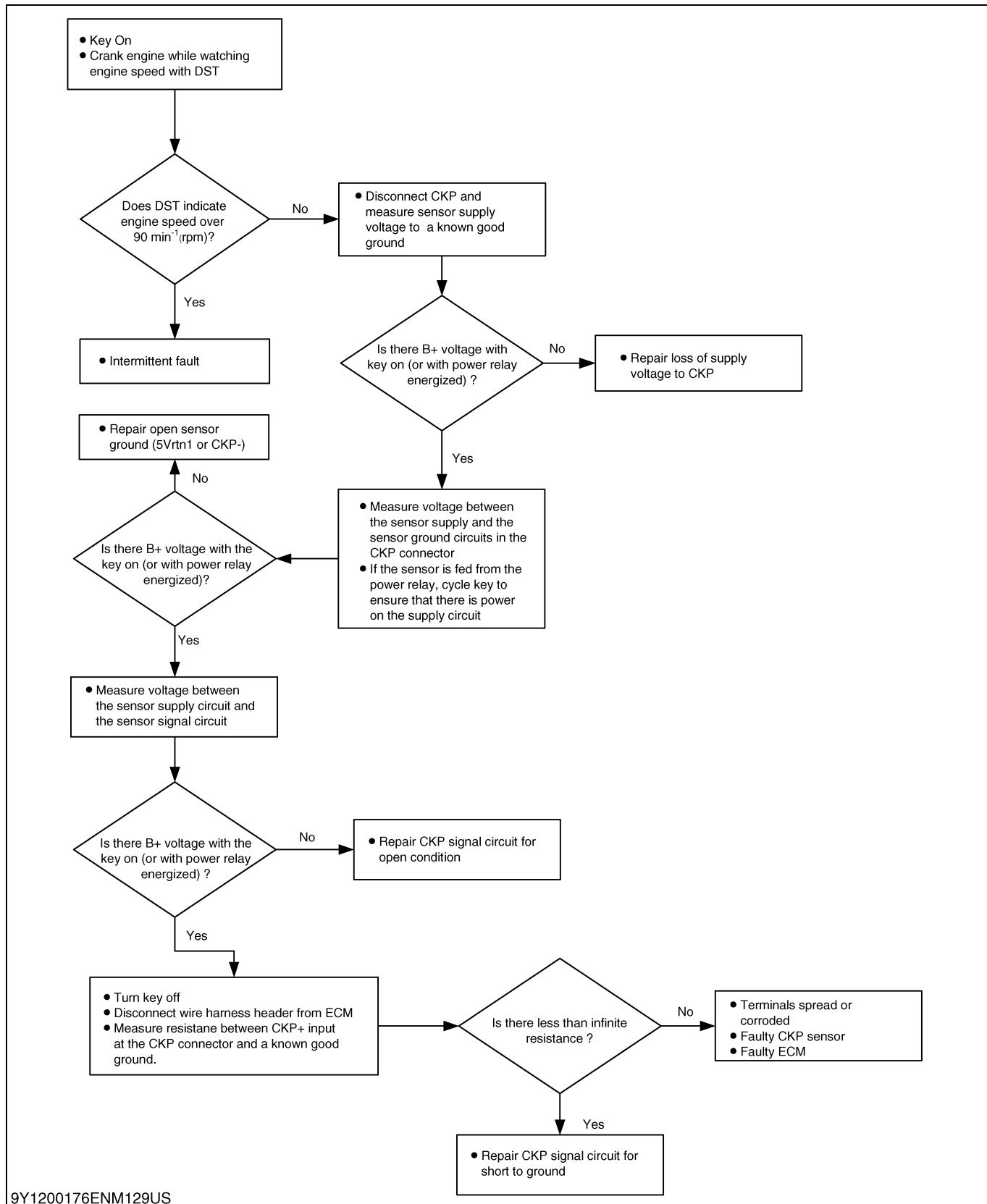
**Diagnostic Aids Chart**



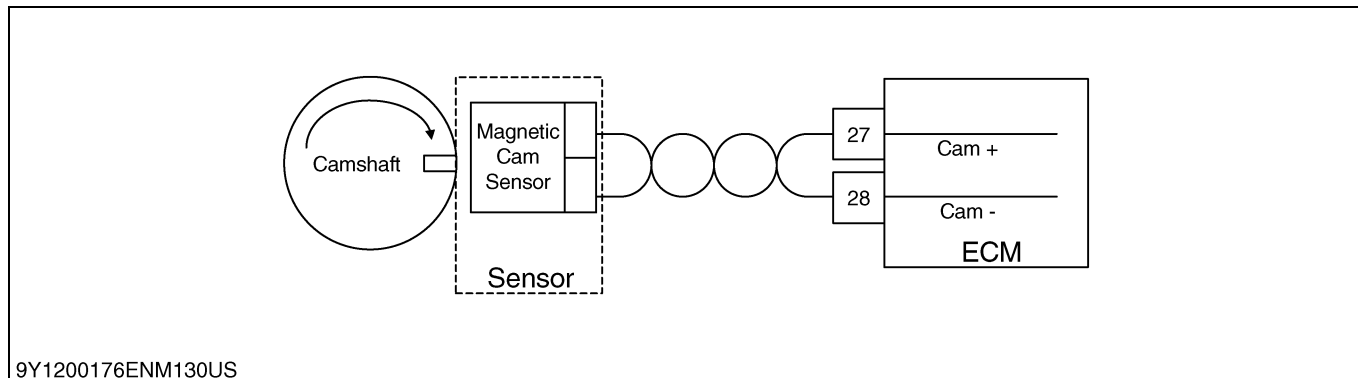
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**DTC 337-Loss of Crankshaft Input Signal**

**Diagnostic Aids Chart**



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### **DTC 341-Camshaft Input Signal Noise**

- Hardware: Camshaft Position sensor
- Enabling Conditions: Key On, Engine Running
- Set Conditions: Electrical noise or irregular cam pattern detected causing more than 1 cam re-synchronization events in less than 700 ms.
- Corrective Action(s): Illuminate MIL and disable fuel adaptive learn for remainder of key-cycle.
- Emissions related fault
- Possible Causes: CMP+ or CMP- circuits in wrong connector terminal slot, improper CMP signal due to sensor air gap too large, excessive metal on sensor tip, improper wiring, intermittent connection in sensor circuitry, intermittent sensor internal problem

The camshaft position sensor is a magnetic pick-up sensor installed in the engine block or valve train adjacent to a "coded" trigger wheel located on or off of the camshaft. The sensor-trigger wheel combination is used to determine cam position so the ECM can determine which piston is coming up on TDC. Determination of the camshaft position is necessary to identify the stroke (or cycle) of the engine to properly activate the fuel injection system and ignition (for coil-on-plug engines) for precise engine control.

For a cam synchronized engine, the ECM must see a valid camshaft position signal while running. If no signal is present, the signal amplitude is too high (due to improper air gap with respect to trigger wheel), or an irregular cam pattern is detected causing the ECM to resynchronize this fault will set. Irregular cam patterns can be detected by the ECM and can be caused by: electrical noise, poor machining of trigger wheel, or trigger wheel run out and/or gear lash. In some instances this fault can cause rough engine operation and can cause the engine to stall or die if attached with coil-on-plug ignition engines.

Ensure cam circuit used with VR/magnetic pick-up sensors are properly twisted.

### **DTC 342-Loss of Camshaft Input Signal**

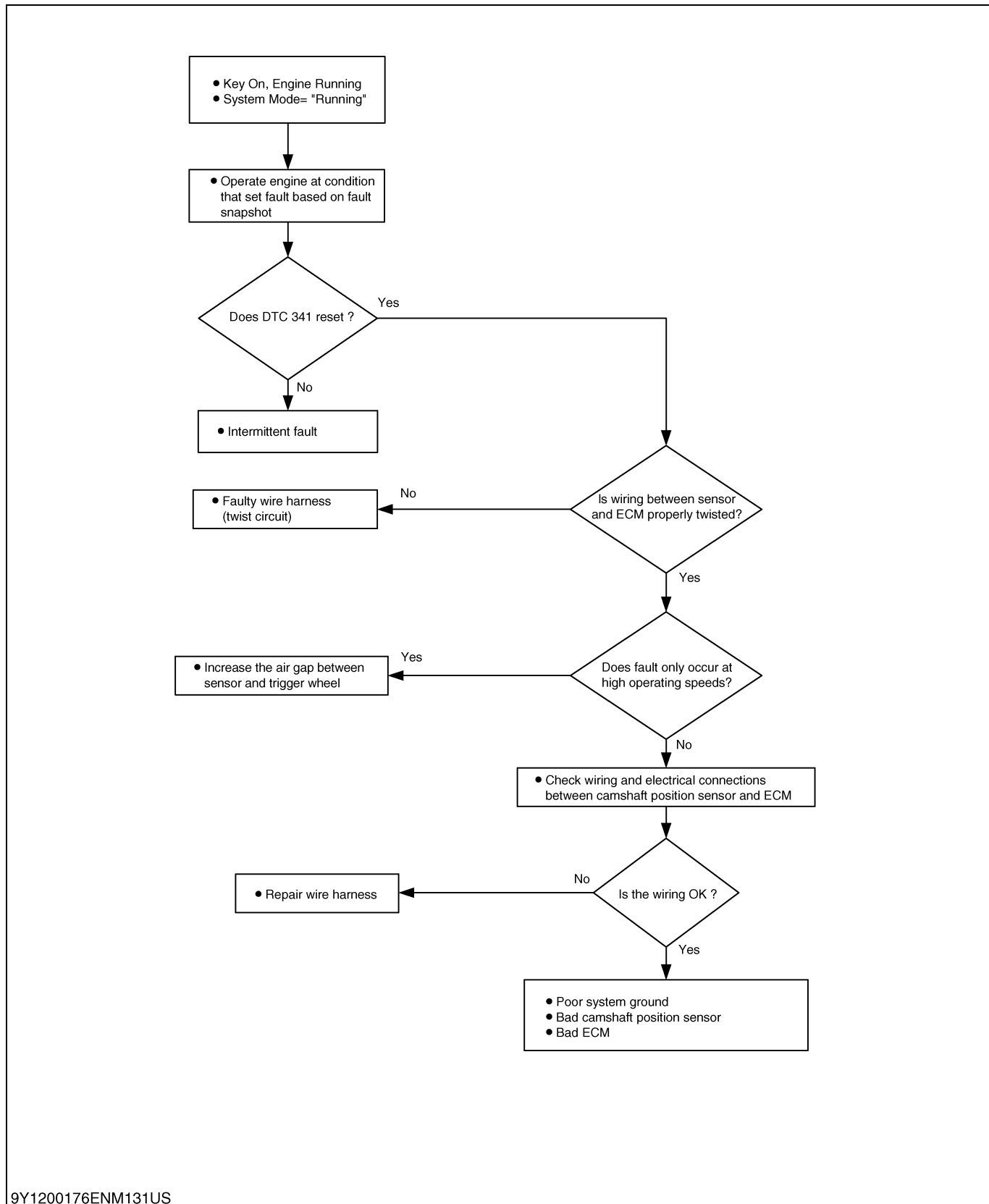
- Hardware: Camshaft Position sensor
- Enabling Conditions: Key On, Engine Running above 1000 min<sup>-1</sup> (rpm)
- Set Conditions: Loss of camshaft position signal while valid crankshaft position signals continue for 2.5 engine cycles for longer than 1 second
- Corrective Action(s): Illuminate MIL
- Emissions related fault
- Possible Causes: Loss of feed voltage to CMP sensor, loss of signal or ground circuits, faulty sensor, faulty ECM or damaged engine components

The camshaft position sensor is a magnetic sensor (hall-effect) installed in the engine block or valve train adjacent to a "coded" trigger wheel located on or off of the camshaft. The sensor-trigger wheel combination is used to determine cam position (with respect to TDC cylinder #1 compression). Determination of the camshaft position is necessary to identify the stroke (or cycle) of the engine to properly activate the fuel injection system and ignition (for coil-on-plug engines) for precise engine control.

For a cam synchronized engine, the ECM must see a valid camshaft position signal while running. In some instances this fault can cause rough engine operation and can cause the engine to stall or die if attached with coil-on-plug ignition engines.

**DTC 341-Camshaft Input Signal Noise**

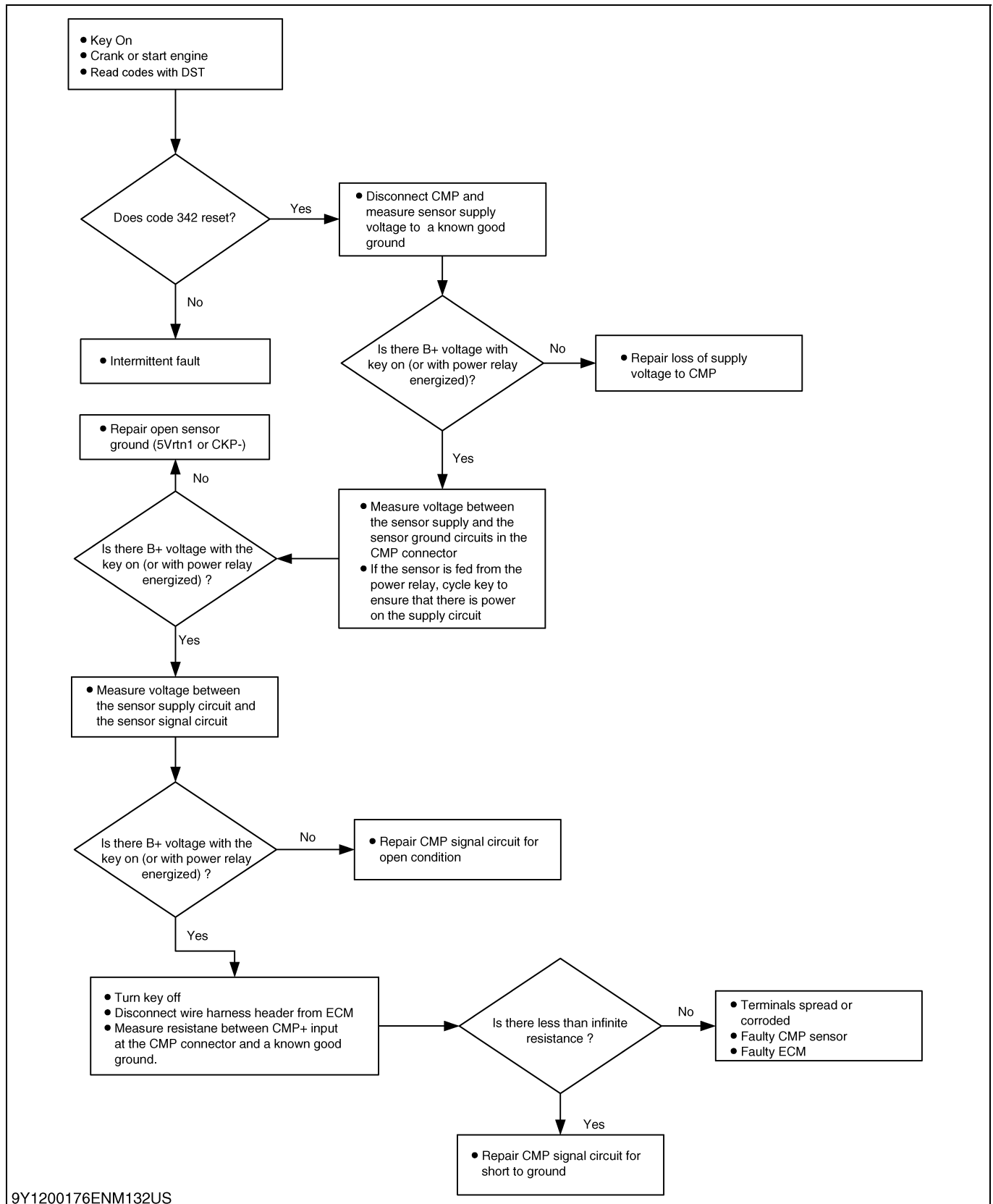
**Diagnostic Aids Chart**



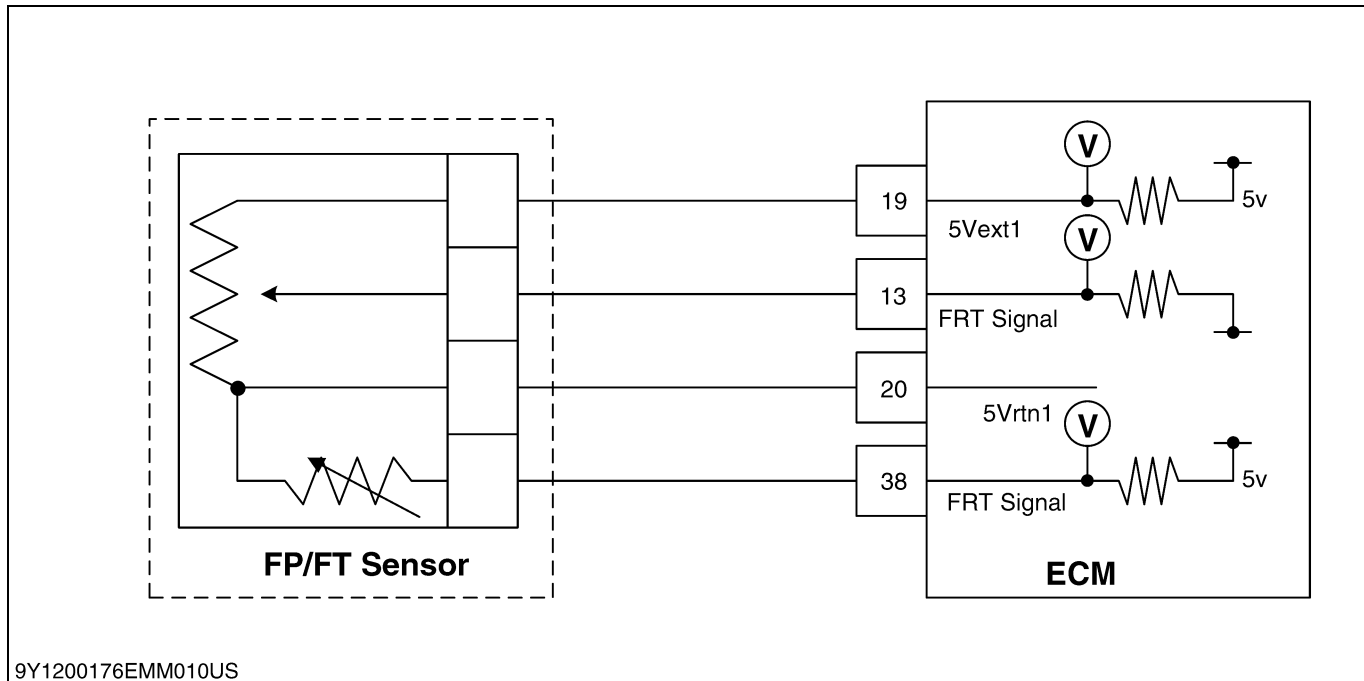
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**DTC 342-Loss of Camshaft Input Signal**

**Diagnostic Aids Chart**



9Y1200176ENM132US

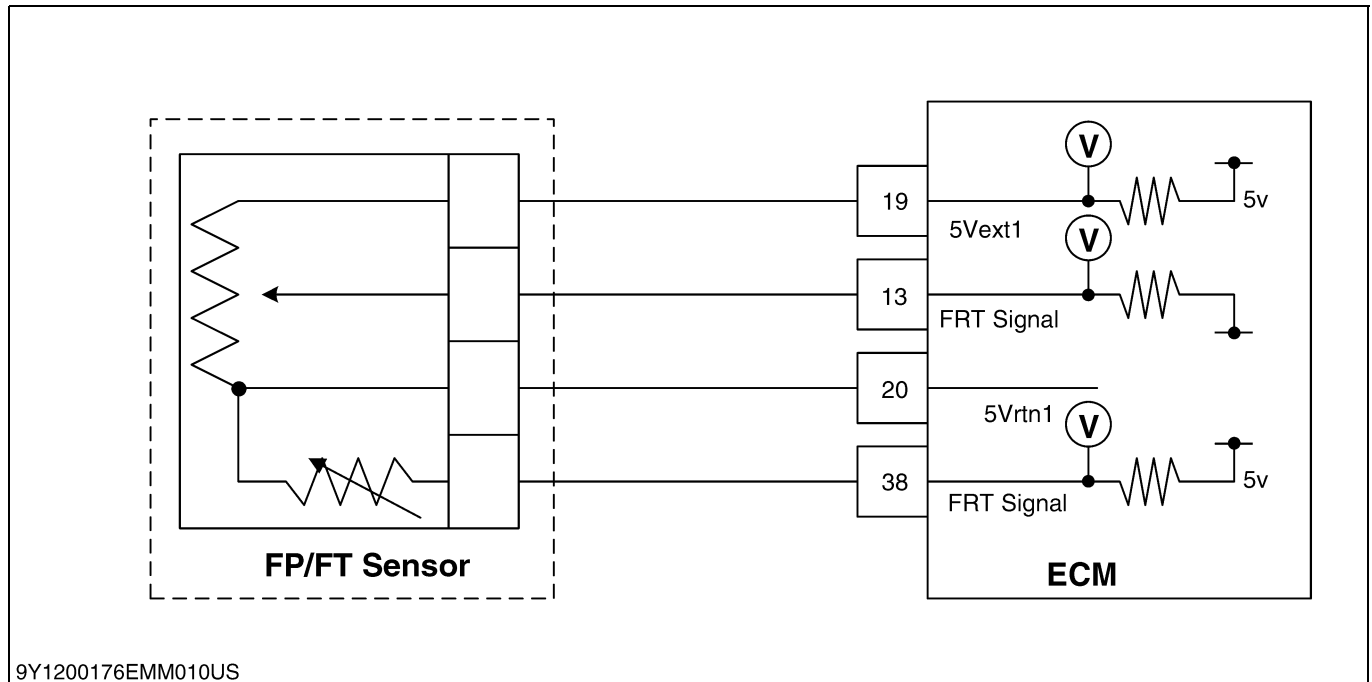
**(2) FP (Fuel Pressure Sensor) (DTC 87, 88, 91, 92)****DTC 87-Fuel Pressure Low**

- Hardware: Liquid Fuel Pressure and Temperature Sensor
- Enabling Conditions: Engine Running
- Set Conditions: FP fault mode Gasoline only, run time wait for fuel pressure low faults 5.0 sec, FP pressure < 345 kPa [abs] (3.52 kgf/cm<sup>2</sup>, 50.0 psia)
- Corrective Action(s): Illuminate the MIL and low rev limit, AL disable KC
- Emissions related fault
- Possible Causes: Fuel pressure problem with engine, Fuel pressure sensor failure, Fuel pressure sensor circuit shorted to ground, Faulty ECM

**DTC 88-Fuel Pressure High**

- Hardware: Liquid Fuel Pressure and Temperature Sensor
- Enabling Conditions: Engine Running
- Set Conditions: FP fault mode Gasoline only, run time wait for fuel pressure low faults 5.0 sec, FP pressure > 448 kPa [abs] (4.57 kgf/cm<sup>2</sup>, 65.0 psia)
- Corrective Action(s): Illuminate the MIL and low rev limit, AL disable KC
- Emissions related fault
- Possible Causes: Fuel pressure problem with engine, Fuel pressure sensor failure, Fuel pressure sensor circuit shorted to power, Faulty ECM





### **DTC 91-FP (Fuel Pressure Sensor) Low Voltage**

- Hardware: Liquid Fuel Pressure and Temperature Sensor
- Enabling Conditions: Key ON
- Set Conditions: Fuel pressure feedback voltage lower than 0.100 V for longer than 5 seconds
- Corrective Action(s): Illuminate the MIL and disable adaptive learn fueling correction for the rest of the key-cycle.
- Emissions related fault
- Possible Causes: FP sensor connector disconnected, an open-circuit or short-to-ground of the FP signal circuit in the wiring harness, a loss of sensor reference voltage, or a failure of the sensor.

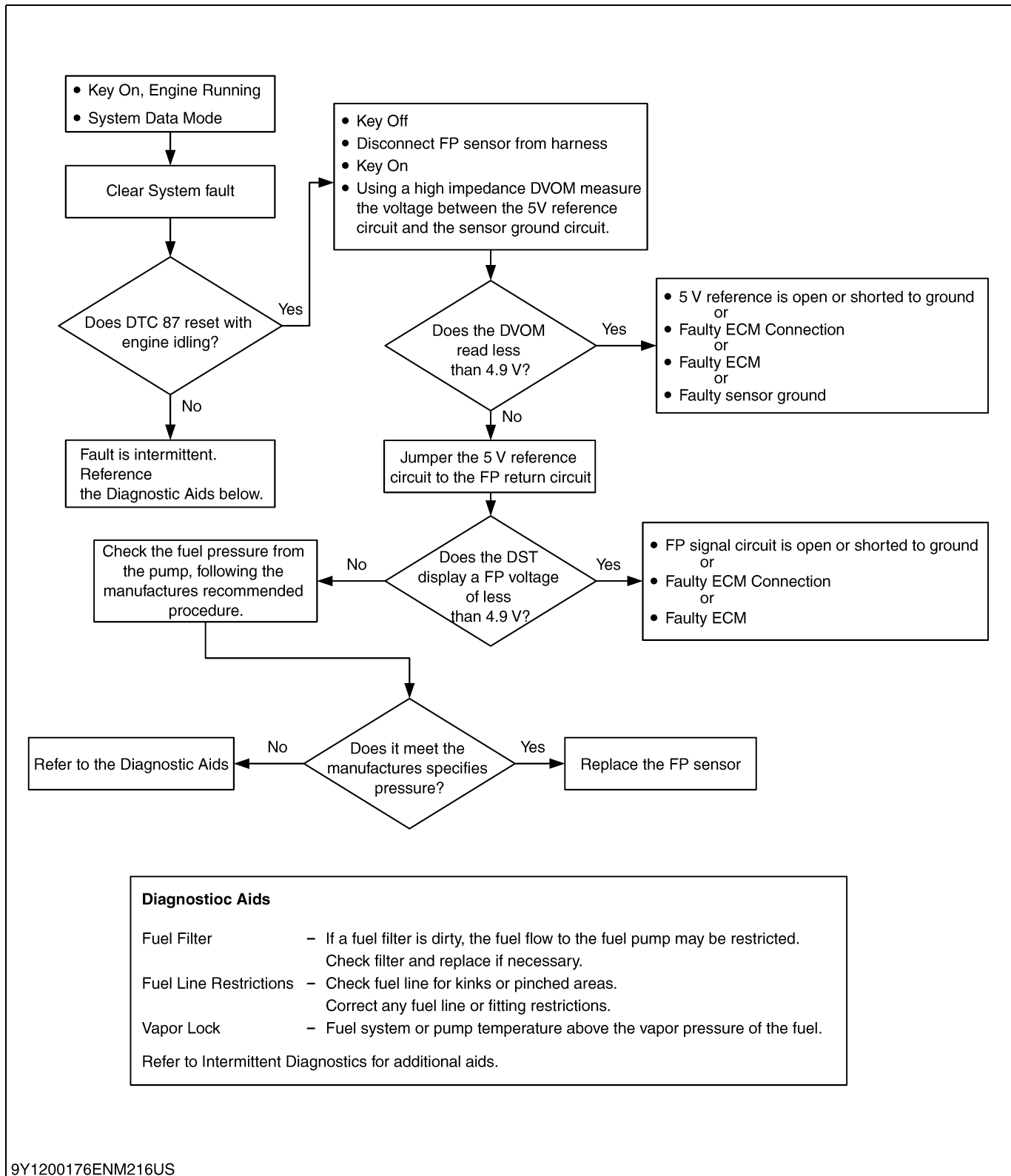
### **DTC 92-FP (Fuel Pressure Sensor) High Voltage**

- Hardware: Liquid Fuel Pressure and Temperature Sensor
- Enabling Conditions: Key ON
- Set Conditions: Fuel pressure feedback voltage higher than 4.90 V for longer than 1 second.
- Corrective Action(s): Illuminate MIL and disable adaptive learn fueling correction for the rest of the key-cycle.
- Emissions related fault
- Possible Causes: FP signal circuit or 5 V rtn1 open, open sensor or sensor signal shorted to voltage

The fuel pressure sensor is installed inline in the gasoline fuel supply line and is used to provide fuel pressure feedback to the ECM. The ECM sets a target rail pressure based on running conditions and then the fuel pump is PWM controlled through a low side driver in the ECM. The fuel pressure sensor feedback is used to determine when the actual rail pressure has reached the target rail pressure.

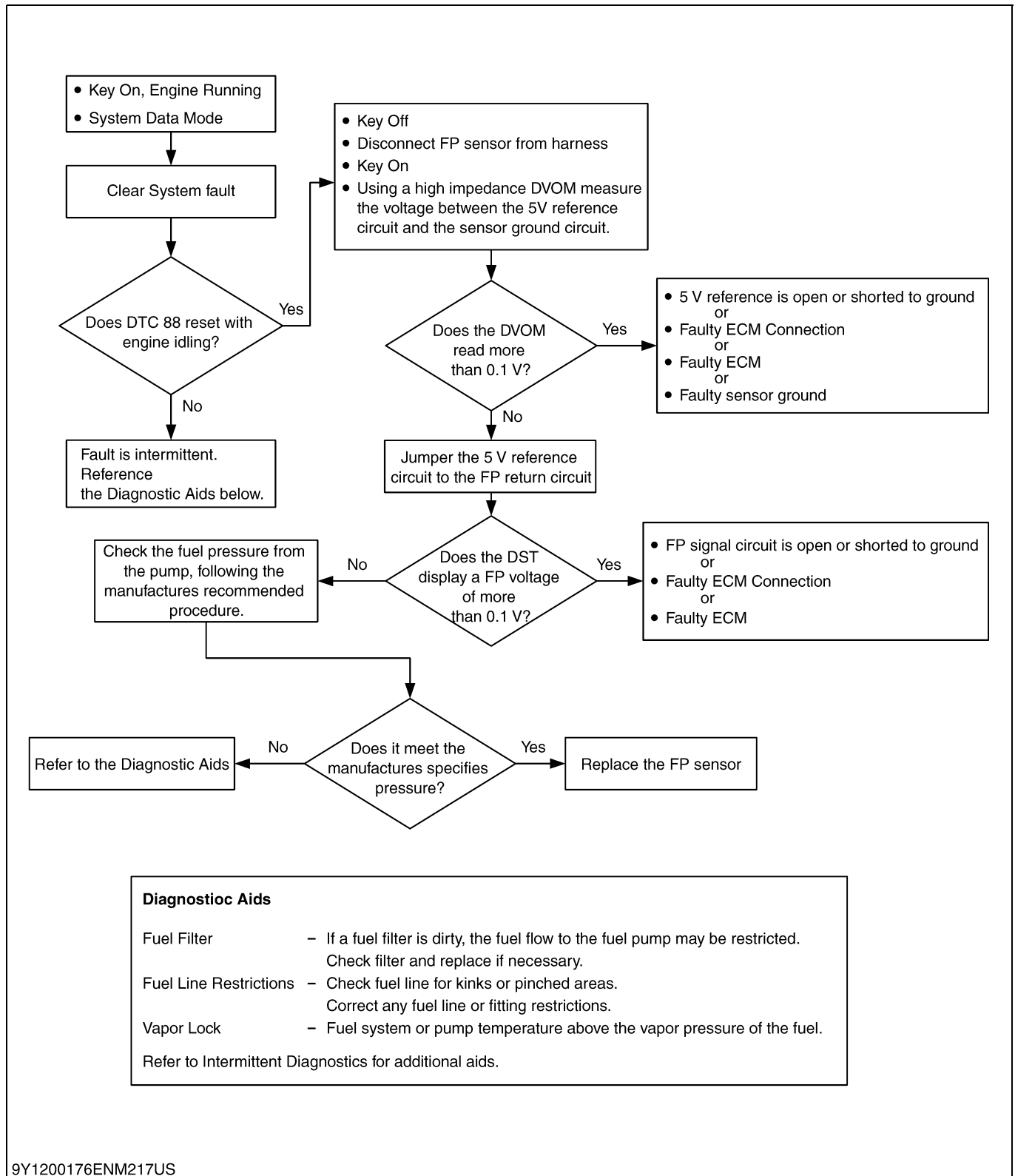
**DTC 87-Fuel Pressure Low**

**Diagnostic Aids Chart**



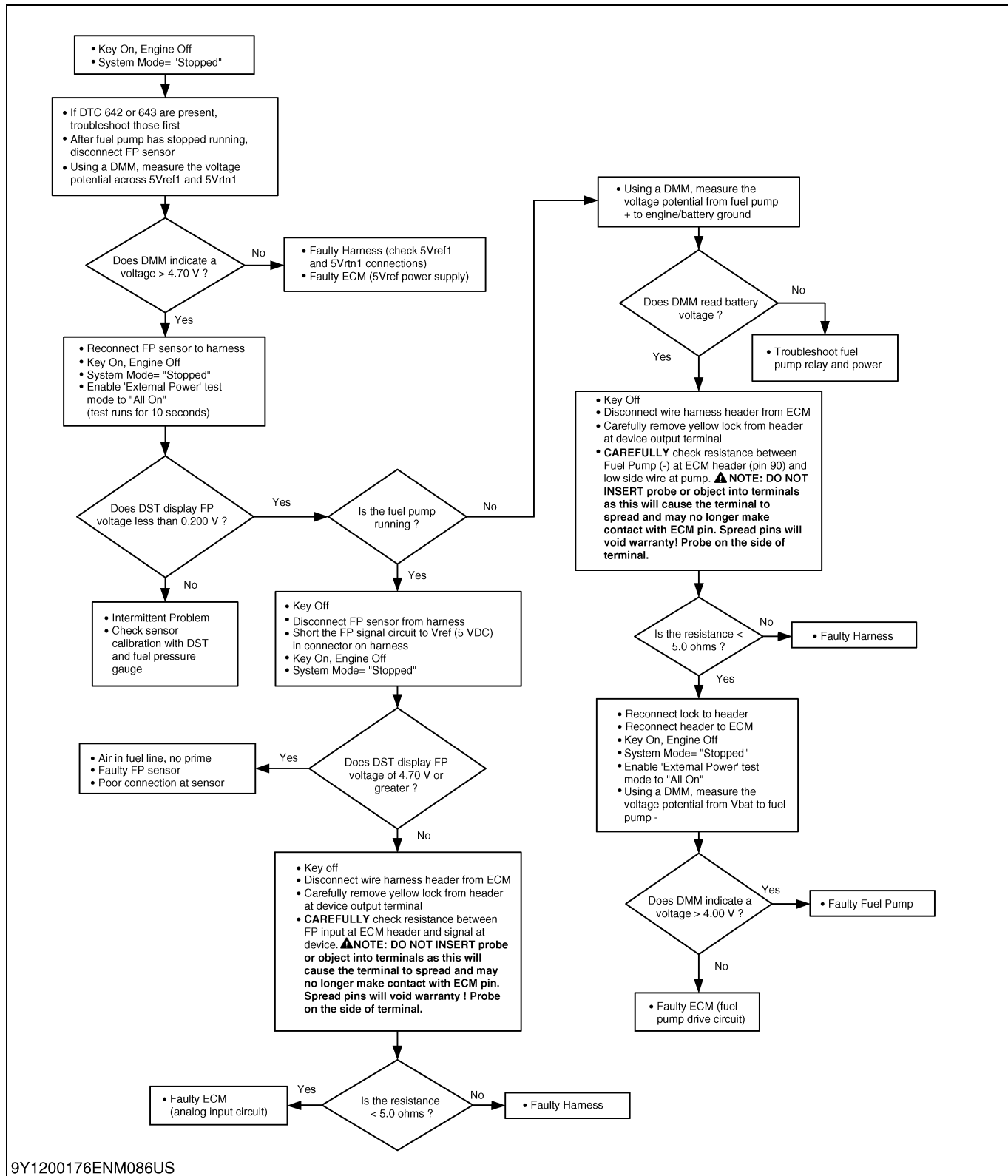
**DTC 88-Fuel Pressure High**

**Diagnostic Aids Chart**



**DTC 91-FP (Fuel Pressure) Low Voltage**

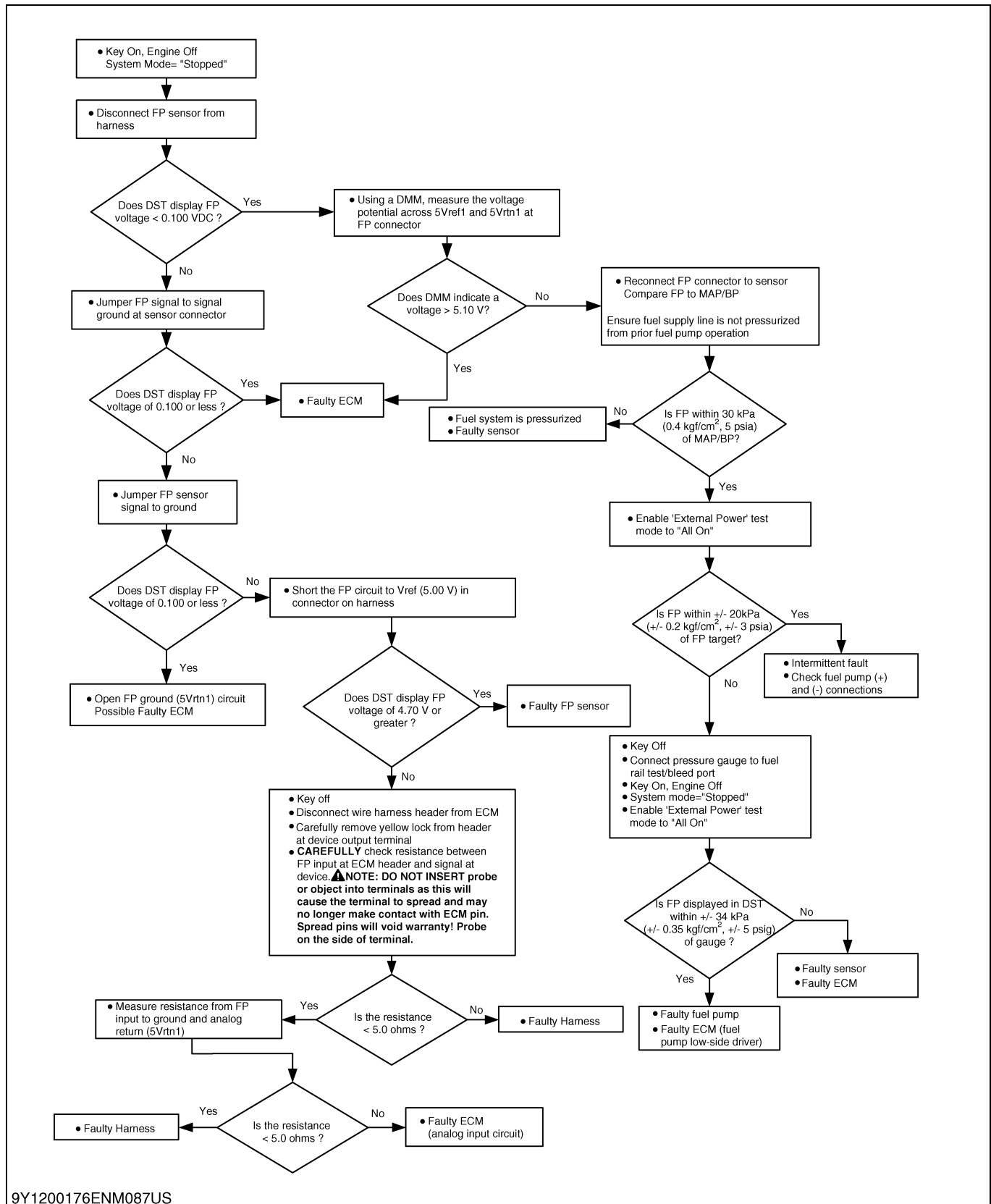
**Diagnostic Aids Chart**



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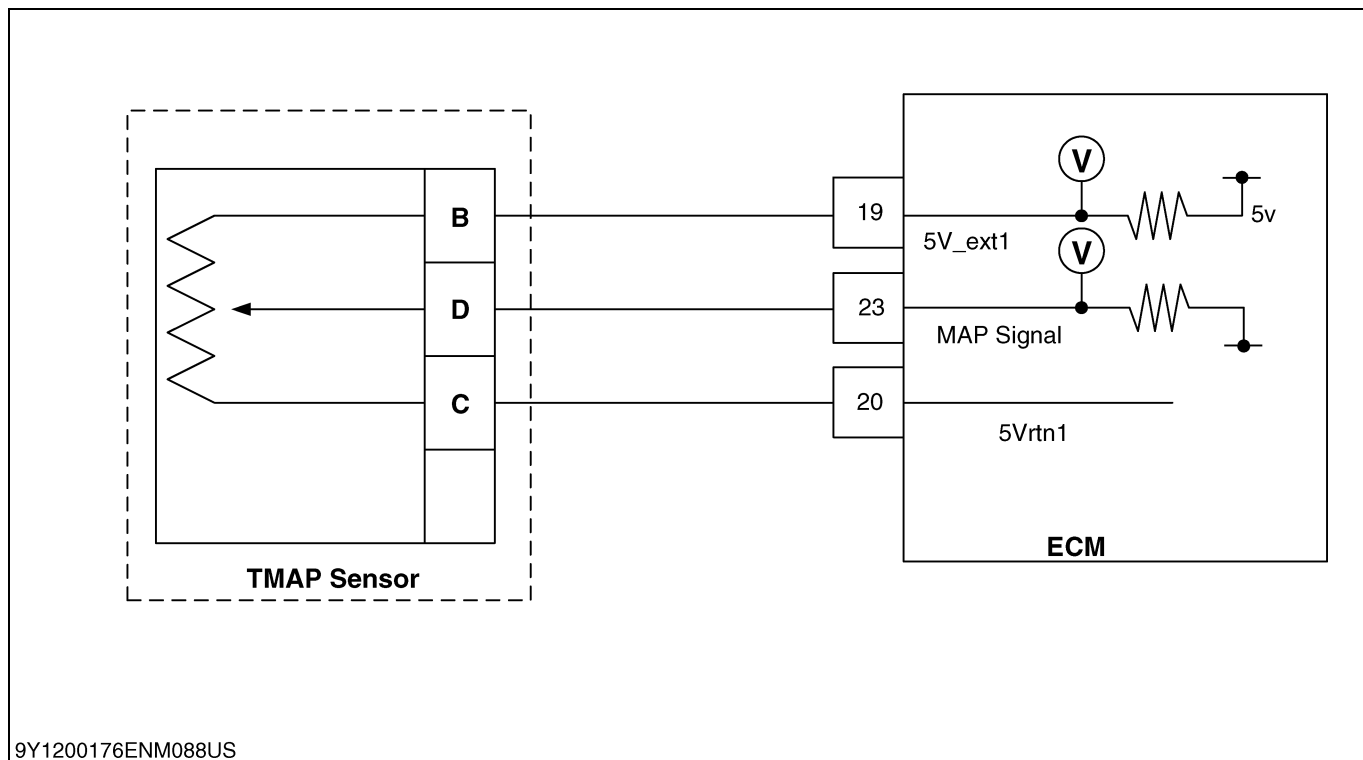
### DTC 92-FP (Fuel Pressure Sensor) High Voltage

#### Diagnostic Aids Chart



9Y1200176ENM087US

### (3) MAP (Manifold Absolute Pressure Sensor) (DTC 107, 108)



#### DTC 107-MAP Low Voltage

- Hardware: Manifold Absolute Pressure Sensor
- Enabling Conditions: Engine Cranking or Running
- Set Conditions: MAP sensor voltage feedback less than 0.050 V when throttle position is greater than 5 % and engine speed is less than 4000 min<sup>-1</sup> (rpm).
- Corrective Action(s): Illuminate MIL and disable adaptive learn fueling correction for the rest of the key-cycle.
- Emissions related fault
- Possible Causes: Loss of 5.00 V reference feed to sensor, open or shorted to ground sensor signal wire, faulty sensor or faulty ECM.

#### DTC 108-MAP High Pressure

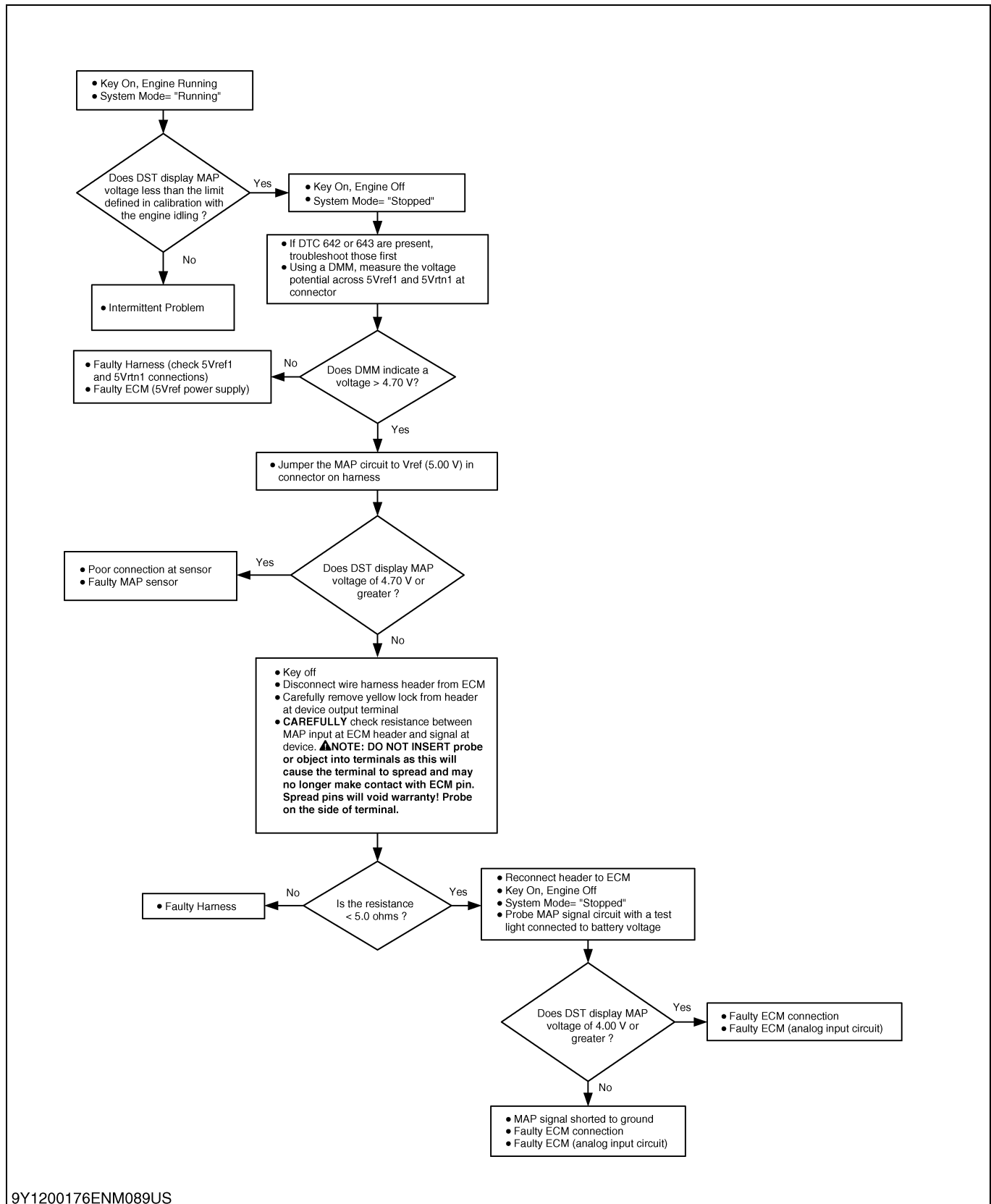
- Hardware: Manifold Absolute Pressure Sensor
- Enabling Conditions: Engine Cranking or Running
- Set Conditions: MAP is higher than 110 kPa [abs] (1.1 kgf/cm<sup>2</sup>, 16 psia) when throttle position is less than 3 % and engine speed is greater than 1000 min<sup>-1</sup> (rpm).
- Corrective Action(s): Illuminate MIL and disable adaptive learn fueling correction for the rest of the key-cycle.
- Emissions related fault
- Possible Causes: 5.00 V reference feed shorted to voltage, signal circuit shorted to voltage, open 5 Vrtn1 (sensor ground), faulty sensor or faulty ECM.

The Manifold Absolute Pressure sensor is a pressure transducer connected to the intake manifold. It is used to measure the pressure of air in the manifold prior to induction into the engine. The pressure reading is used in conjunction with other inputs to determine the rate of airflow to the engine. The rate of airflow into the engine is used to determine the required fuel flow rate.

When these fault are active, the ECM operates in a limp home mode in which an estimated MAP based on TPS feedback is used to fuel the engine.

**DTC 107-MAP Low Voltage**

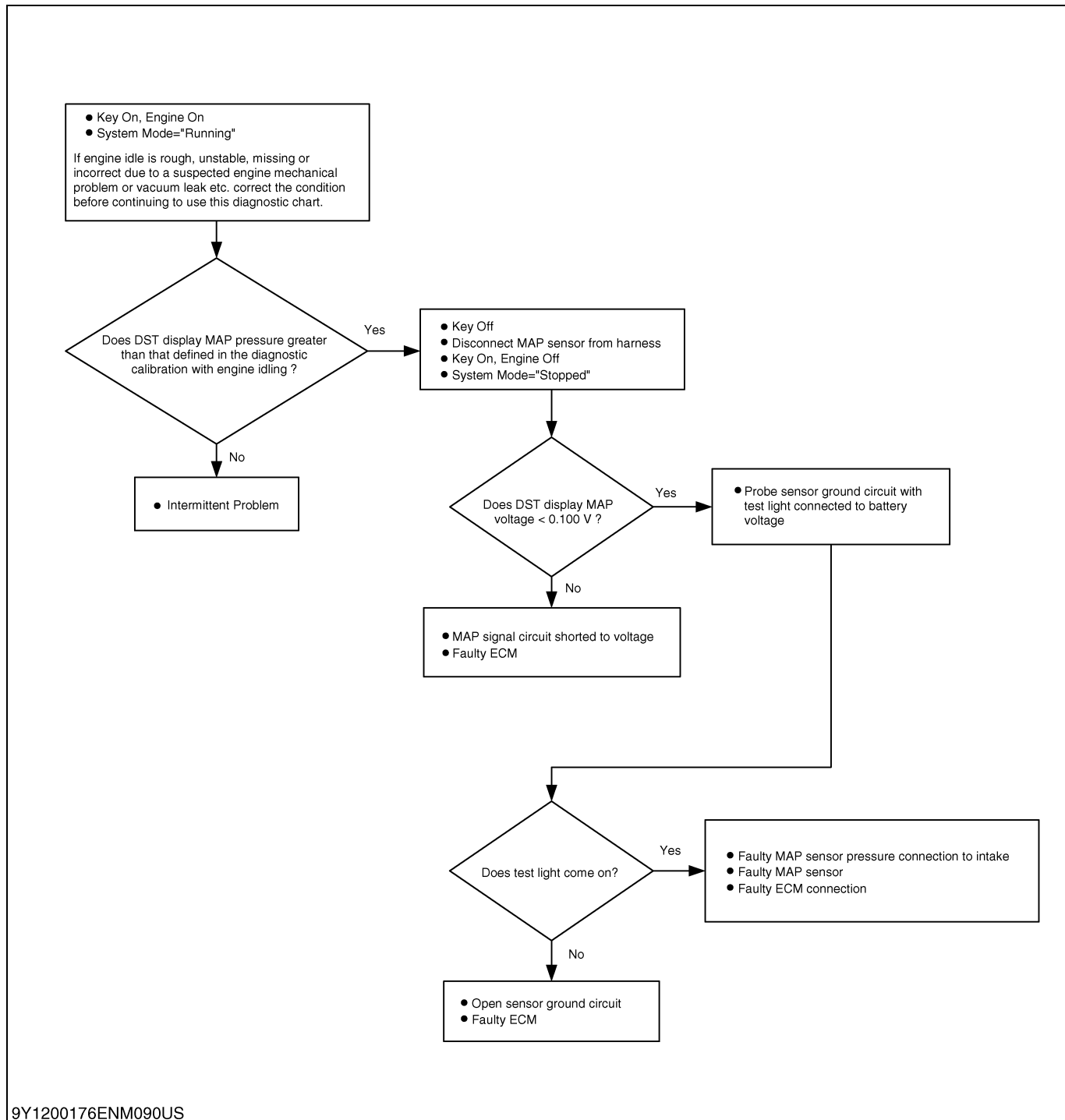
**Diagnostic Aids Chart**



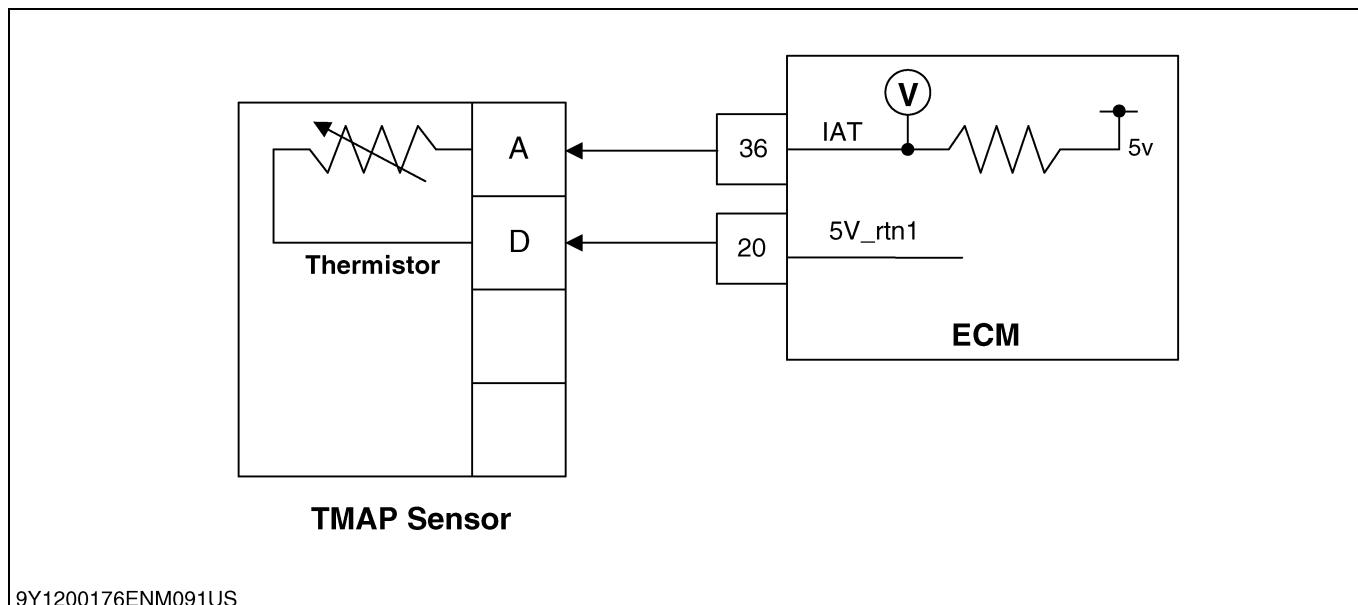
9Y1200176ENM089US

**DTC 108-MAP High Pressure**

**Diagnostic Aids Chart**





**(4) IAT (Intake Air Temperature Sensor) (DTC 111, 112, 113, 127, 129)****DTC 111-IAT Higher Than Expected Stage 1**

- Hardware: Intake Air Temperature Sensor
- Enabling Conditions: Engine Running higher than 1000 min<sup>-1</sup> (rpm)
- Set Conditions: Intake Air Temperature greater than stage 1 limit (71 °C (160 °F)) for longer than 60 seconds when rpm is above 1000 min<sup>-1</sup> (rpm).
- Corrective Action(s): Activate power derate 1 (max 50 % throttle angle)
- Non-emissions related fault
- Possible Causes: Damaged inlet air system allowing hotter than normal air into engine intake system

**DTC 112-IAT Low Voltage**

- Hardware: Intake Air Temperature Sensor
- Enabling Conditions: Engine Running
- Set Conditions: IAT sensor voltage less than 0.050 V for longer than 1 second
- Corrective Action(s): Illuminate MIL, disable fuel adaptive learning while the code is active.
- Emissions related fault
- Possible Causes: Faulty ECM (no voltage on signal wire), signal wire shorted to ground or sensor internally shorted

**DTC 113-IAT High Voltage**

- Hardware: Intake Air Temperature Sensor
- Enabling Conditions: Engine Running
- Set Conditions: IAT sensor voltage greater than 4.95 V for longer than 1 second
- Corrective Action(s)-Disable fuel adaptive learn while code is active
- Emissions related fault
- Possible Causes: Signal wire shorted to 12.0 V, signal wire open, sensor open internally or open 5 Vrtn1 (sensor ground)

**DTC 127-IAT Higher Than Expected Stage 2**

- Hardware: Intake Air Temperature
- Enabling Conditions: Engine Running higher than 1000 min<sup>-1</sup> (rpm)
- Set Conditions: Intake Air Temperature greater than stage 2 limit (93 °C (200 °F)) for longer than 2 minutes
- Corrective Action(s)-Illuminate MIL, disable fuel adaptive learning while code is active
- Emissions related fault
- Possible Causes: Damaged inlet air system allowing hotter than normal air into engine intake system

The Intake Air Temperature sensor is a thermistor (temperature sensitive resistor) located in the intake manifold of the engine. It is used to monitor incoming air and the output, in conjunction with other sensors, is used to determine the airflow to the engine. The ECM provides a voltage divider circuit so that when the air is cool, the signal reads higher voltage, and lower when warm.

The Manifold Air Temperature is a calculated value based mainly on the IAT sensor at high airflow and influenced more by the ECT/CHT at low airflow. It is used to monitor incoming air and the output, in conjunction with other sensors, is used to determine the airflow to the engine, and ignition timing.

### **DTC 129-BP Low Pressure**

- Hardware: Barometric Temperature/Manifold Absolute Pressure Sensor
- Enabling Conditions: Engine Running
- Set Conditions: BP pressure is less than 57.2 kPa [abs] (0.584 kgf/cm<sup>2</sup>, 8.30 psia) for longer than 1 sec.
- Corrective Action(s): Illuminate MIL, disable fuel adaptive learning while the code is active.
- Emissions related fault
- Possible Causes: Faulty ECM (no voltage on signal wire), signal wire shorted to ground or sensor internally shorted

This fault sets if the barometric pressure is lower than the minimum set pressure (psia) as defined in the diagnostic calibration. In the event of an active fault, the MIL is illuminated for the remainder of the key on cycle, an audible warning and/or a secondary warning lamp is activated, and the Adaptive Learn function is disabled to prevent improper learning and population of the table.

Barometric Pressure is estimated from the MAP sensor at key-on and in some calibrations during low speed/high load operation as defined in the engine's calibration. The barometric pressure value is used for fuel and airflow calculations and equivalence ratio targets based on altitude.

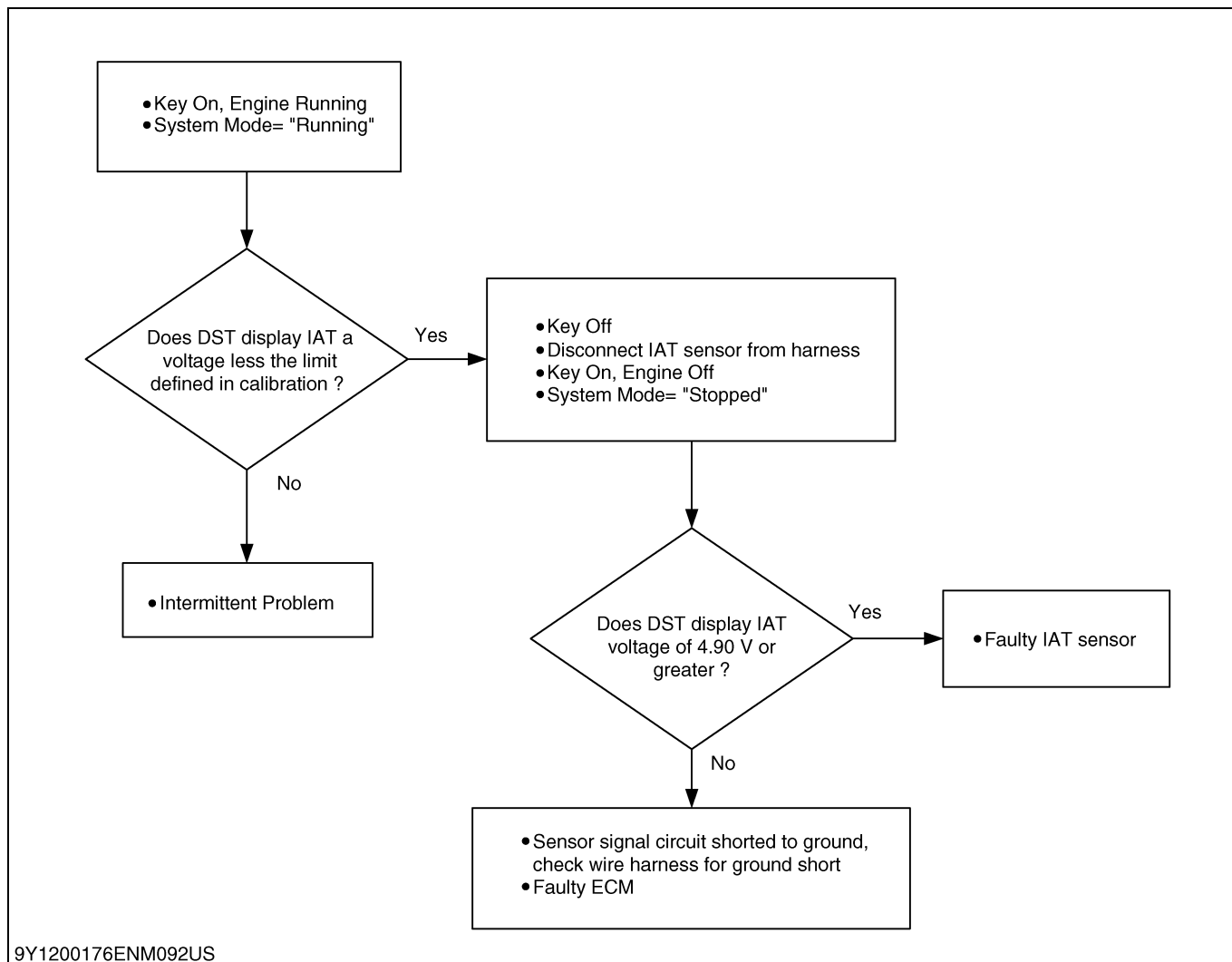
### **DTC 111-IAT Higher Than Expected Stage 1**

#### **Diagnostic Aids**

- This fault will set when inlet air is hotter than normal. The most common cause of high inlet air temperature is a result of a problem with routing of the inlet air. Ensure inlet plumbing sources are external, is cool, and is not too close to the exhaust at any point.
- Inspect the inlet air system for cracks or breaks that may allow unwanted underhood air to enter the engine.
- If no problem is found, replace the IAT sensor with a known good part and retest.

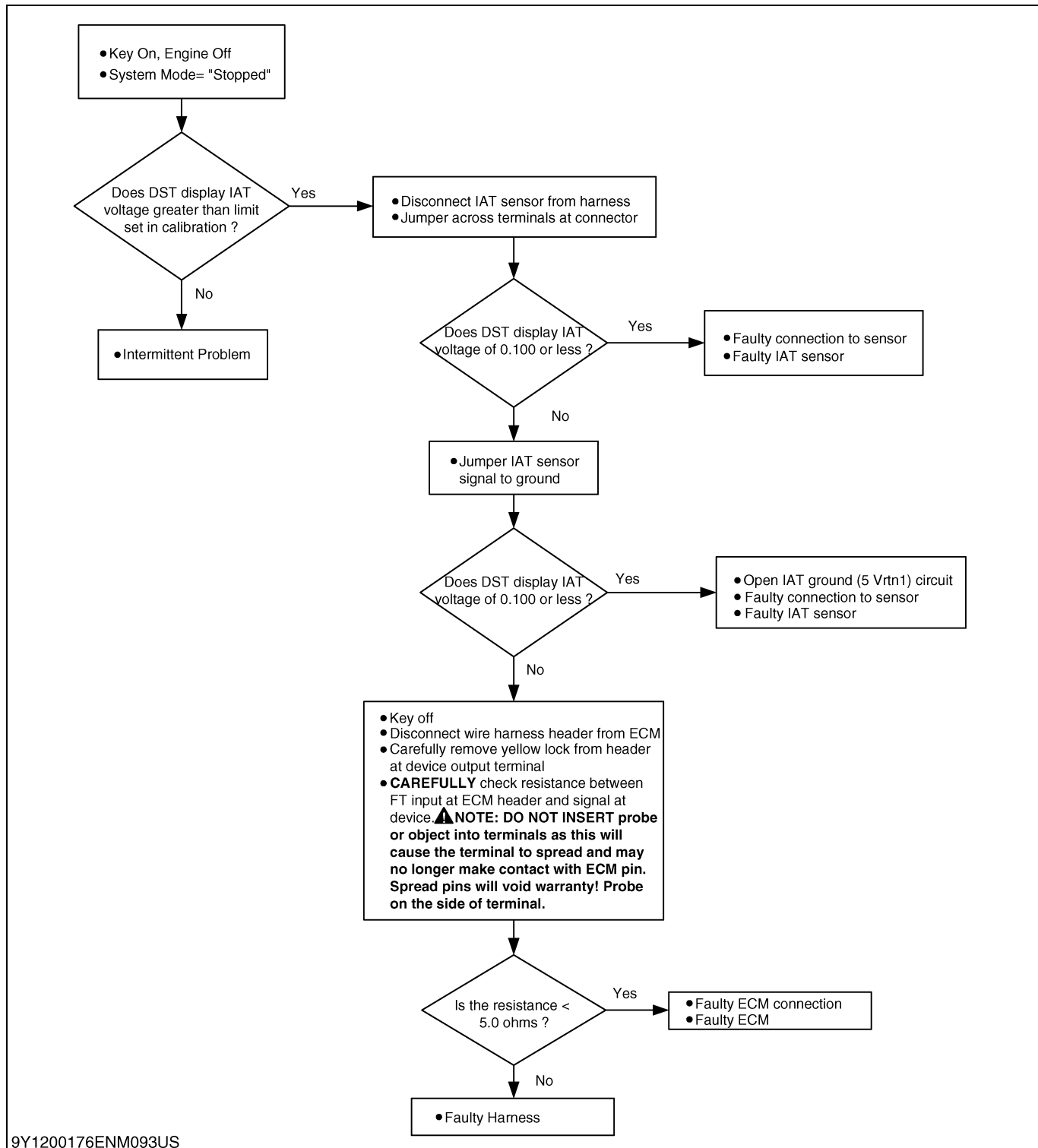
**DTC 112-IAT Low Voltage**

**Diagnostic Aids Chart**



**DTC 113-IAT High Voltage**

**Diagnostic Aids Chart**



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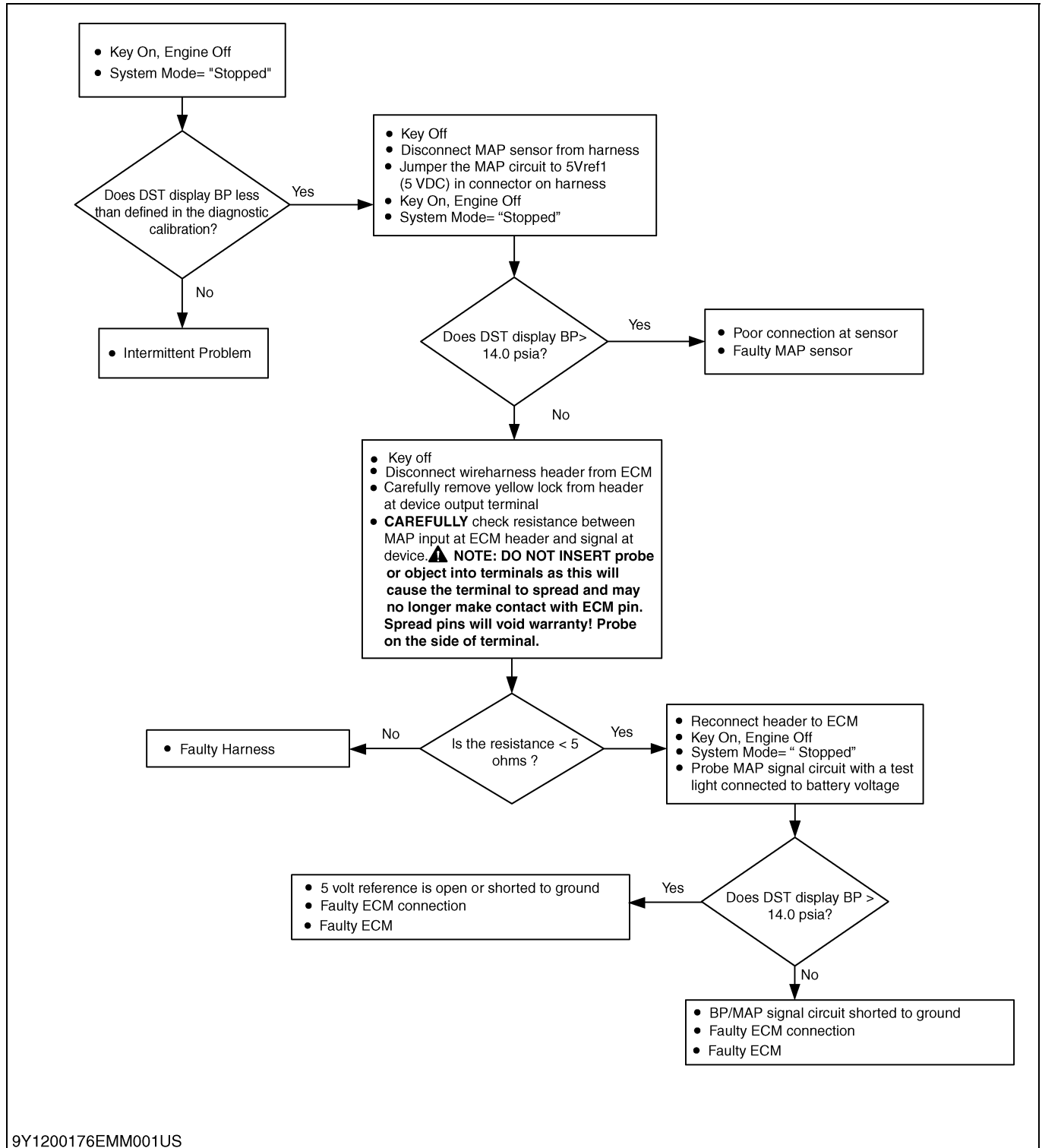
**DTC 127-IAT Higher Than Expected Stage 2**

**Diagnostic Aids**

- This fault will set when inlet air is hotter than normal. The most common cause of high inlet air temperature is a result of a problem with routing of the inlet air. Ensure inlet plumbing sources are external, is cool, and is not too close to the exhaust at any point.
- Inspect the inlet air system for cracks or breaks that may allow unwanted underhood air to enter the engine.
- If no problem is found, replace the IAT sensor with a known good part and retest.

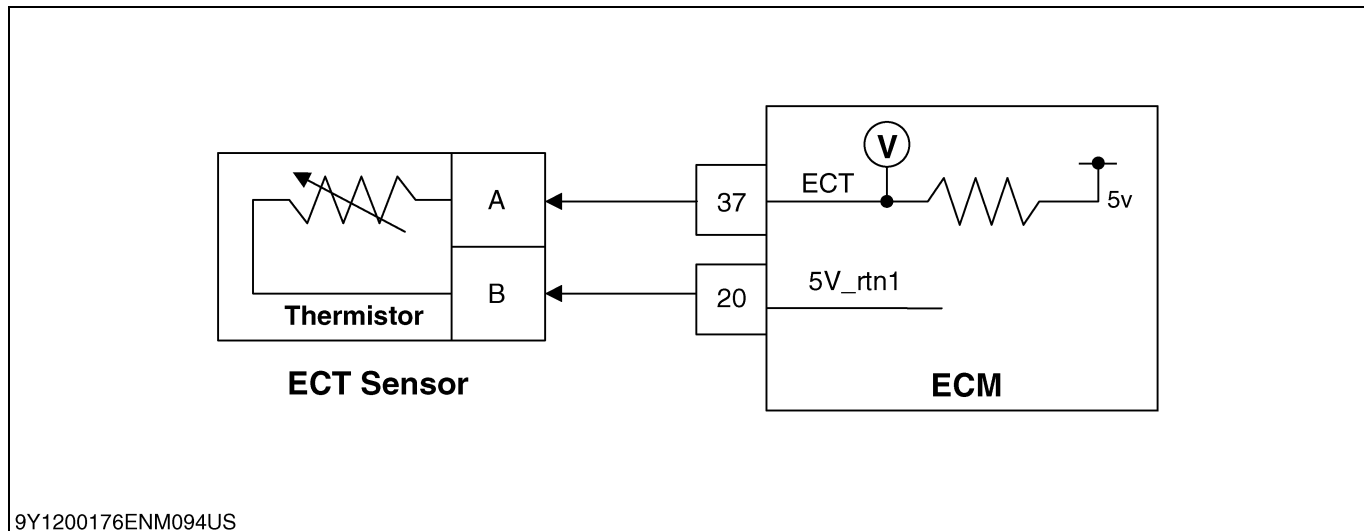
**DTC 129-BP Low Pressure**

**Daiganostic Aids Chart**



9Y1200176EMM001US

## (5) ECT (Engine Coolant Temperature) (DTC 116, 117, 118, 217)



### DTC 116-ECT Higher Than Expected Stage 1

- Hardware: Engine Coolant Temperature Sensor
- Enabling Conditions: Engine Running above 500 min<sup>-1</sup> (rpm)
- Set Conditions: Engine Coolant Temperature reading or estimate greater than the stage 1 limit (110 °C (230 °F)) for longer than 30 seconds
- Corrective Action(s): Illuminate MIL, active power derate 1
- Non-emissions related fault
- Possible Causes: Overheating engine, sensor out of calibration, signal wire partially shorted to ground or faulty ECM

### DTC 117-ECT Low Voltage

- Hardware: Engine Coolant Temperature Sensor
- Enabling Conditions: Engine Running
- Set Conditions: ECT sensor voltage less than 0.100 V for longer than 1 second
- Corrective Action(s): Illuminate MIL, disable fuel adaptive learn while code is active
- Emissions related fault
- Possible Causes: Faulty ECM (no voltage on signal wire), signal wire shorted to ground or sensor internally shorted

### DTC 118-ECT High Voltage

- Hardware: Engine Coolant Temperature Sensor
- Enabling Conditions: Engine Running
- Set Condition: ECT sensor voltage greater than 4.90 V for longer than 1 second
- Corrective Action(s): Turn on MIL, disable fuel adaptive learn while code is active.
- Emissions related fault
- Possible Causes: Signal wire shorted to 12.0 V, signal wire open, sensor open internally or open 5 Vrtn1 (sensor ground)

### DTC 217-ECT Higher Than Expected Stage 2

- Hardware: Engine Coolant Temperature Sensor
- Enabling Conditions: Engine Running above 500 min<sup>-1</sup> (rpm)
- Set Conditions: Engine Coolant Temperature reading or estimate greater than the stage 1 limit (120 °C (248 °F)) for longer than 10 seconds
- Corrective Action(s): Illuminate MIL, active power derate 2
- Emissions related fault
- Possible Causes: Overheating engine, sensor out of calibration, signal wire partially shorted to ground or faulty ECM

The Engine Coolant Temperature sensor is a thermistor (temperature sensitive resistor) located in the engine coolant. The ECT is used for engine fuel calculation (cold engine), ignition timing control, to enable certain features, and for engine protection (overheats). The ECM provides a voltage divider circuit so when the sensor reading is cool the sensor reads higher voltage, and lower when warm.

The fault of DTC 116 and DTC 217 will help protect the engine in the event of over temperature.

The ECM will use a default value for the ECT sensor in the event of the faults of DTC 117 or DTC 118.

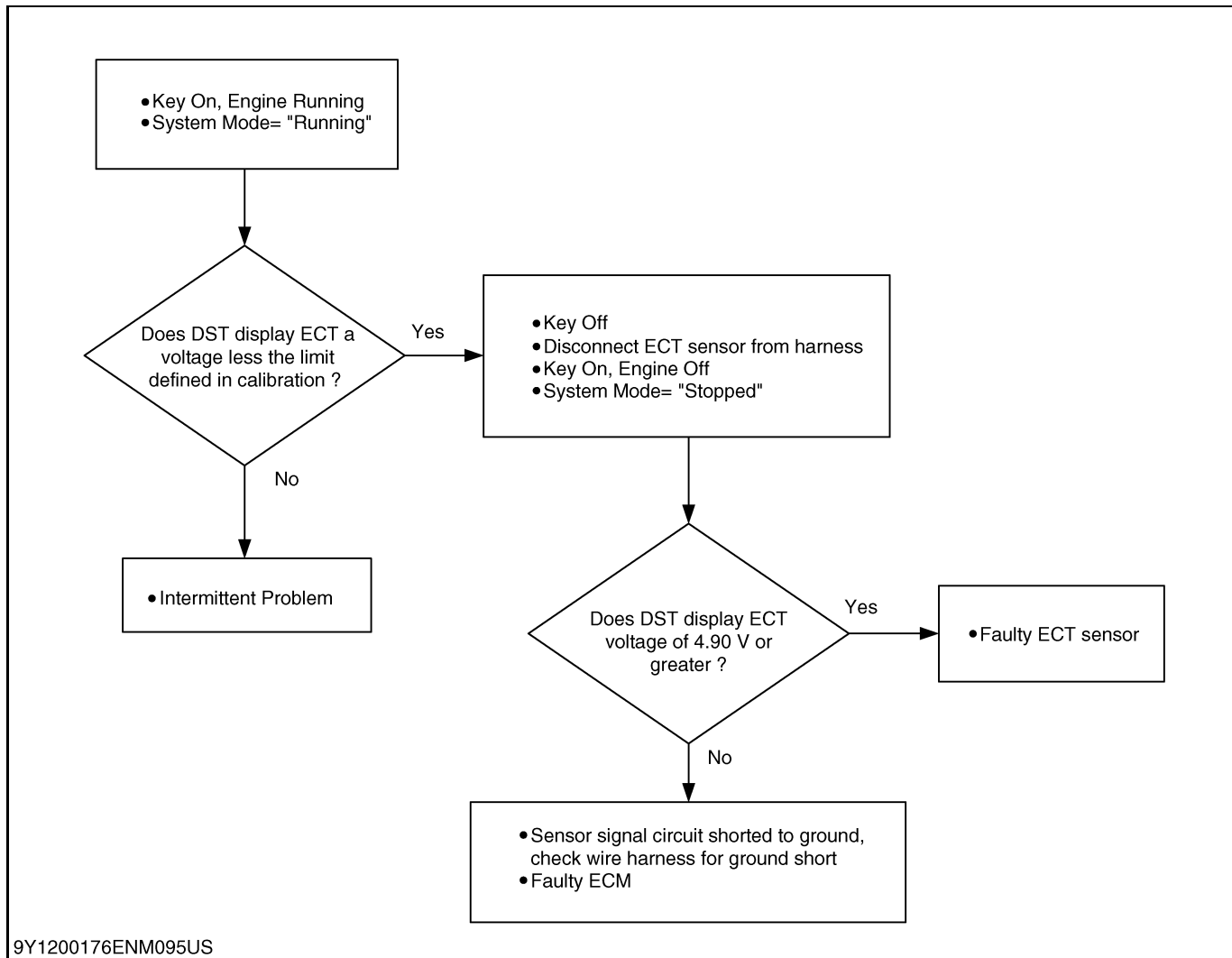
### **DTC 116-ECT Higher Than Expected Stage 1**

#### **Diagnostic Aids**

- If the "ECT High Voltage" fault is also present, follow the troubleshooting procedures for that fault as it may have caused "ECT Higher Than Expected 1".
- If the cooling system utilizes an air-to-water heat exchanger (radiator) and fan:
  - Check that the radiator has a proper amount of ethylene glycol/water and that the radiator is not leaking
  - Ensure that there is no trapped air in the cooling path
  - Inspect the cooling system (radiator and hoses) for cracks and ensure connections are leak free
  - Check that the fan is operating properly
  - Check that the thermostat is not stuck closed
- If the cooling system utilizes a water-to-water heat exchanger:
  - Check that the heat exchanger has a proper amount of ethylene glycol/water and that the heat exchanger is not leaking
  - Ensure that there is no trapped air in the cooling path
  - Inspect the cooling system (radiator and hoses) for cracks and ensure connections are leak free
  - Check that the raw water pickup is not blocked/restricted by debris and that the hose is tightly connected
  - Check that the thermostat is not stuck closed
  - Check that the raw water pump/impeller is tact and that it is not restricted

**DTC 117-ECT Low Voltage**

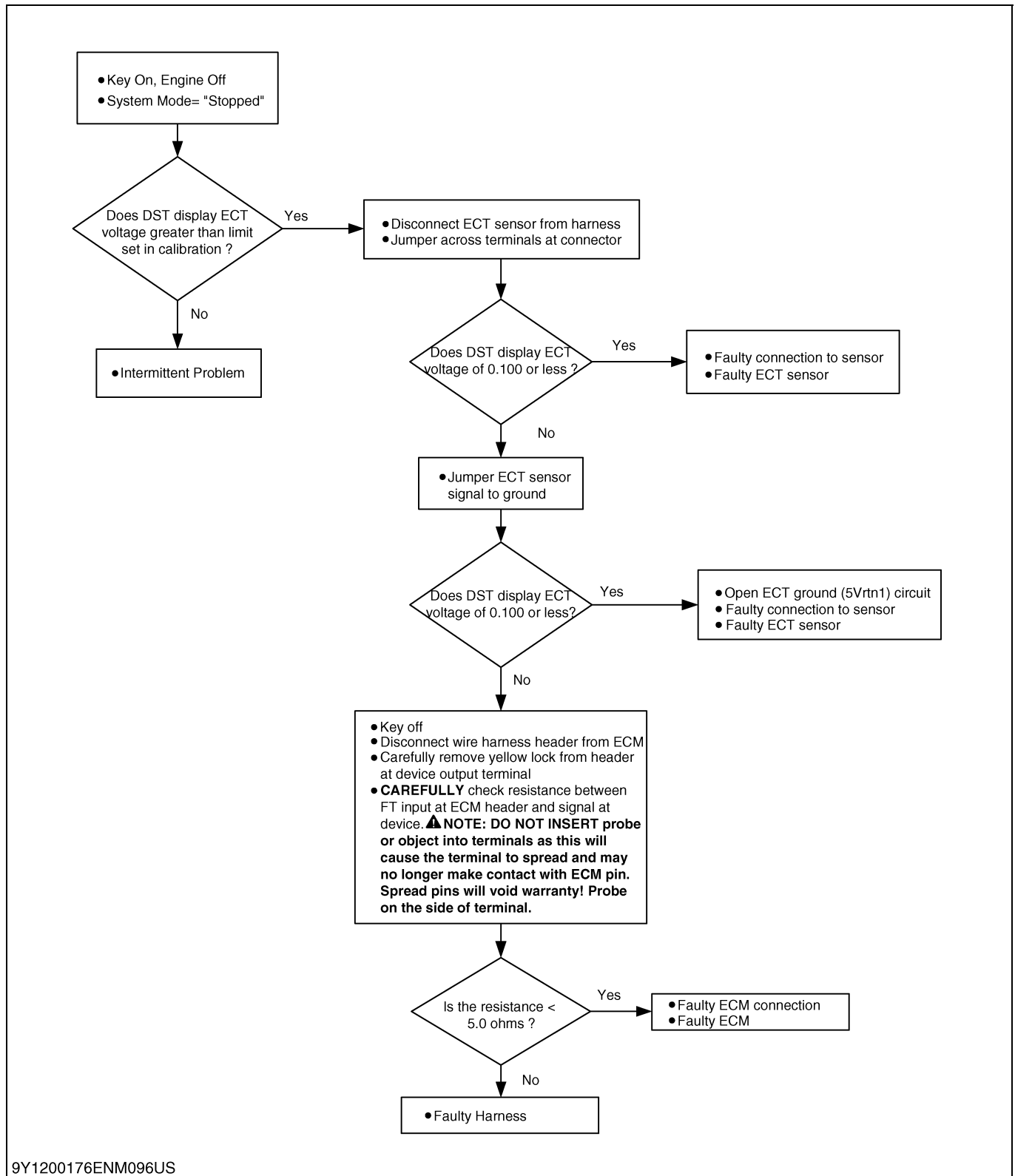
**Diagnostic Aids Chart**





**DTC 118-ECT High Voltage**

**Diagnostic Aids Chart**

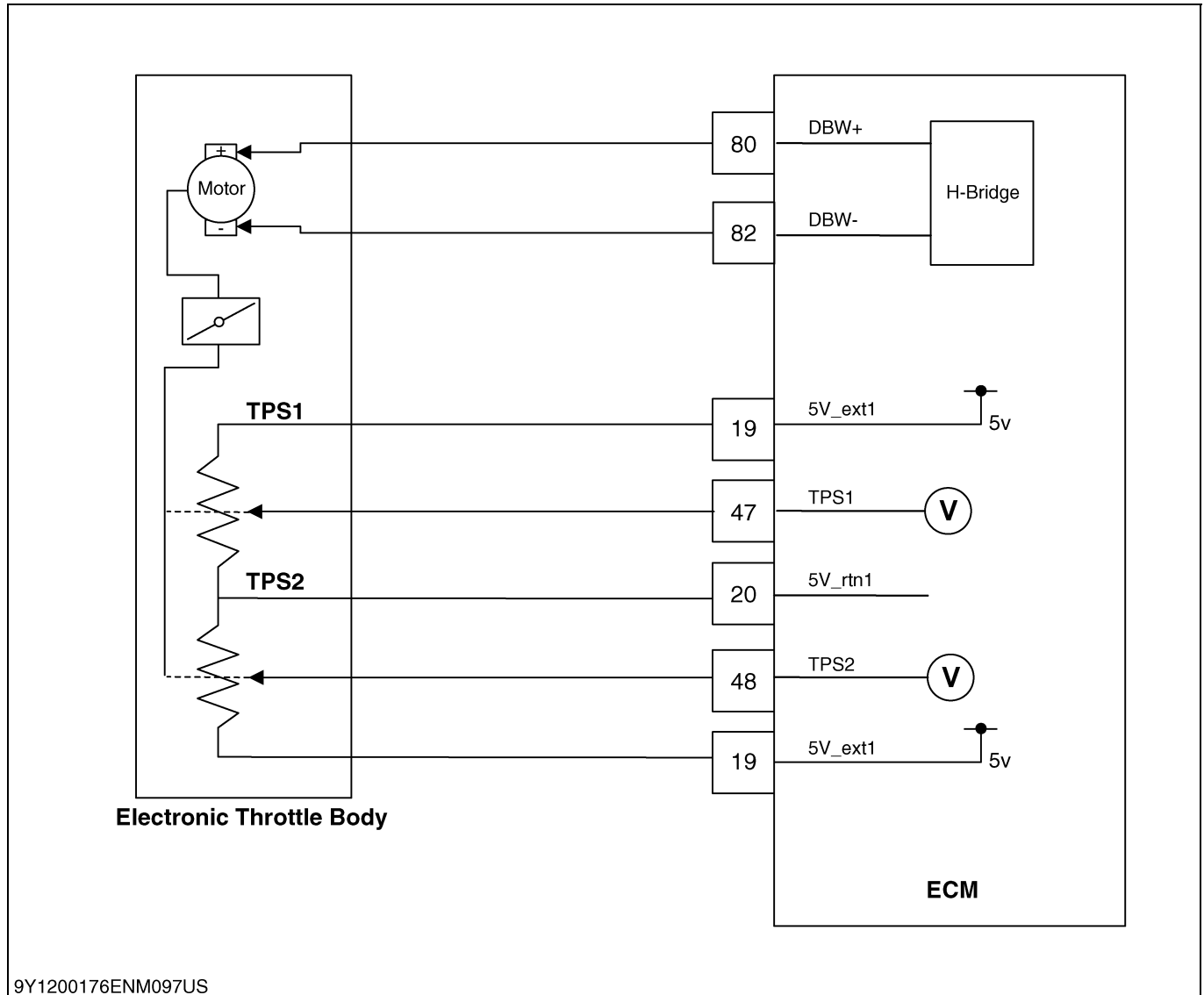


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**DTC 217-ECT Higher Than Expected Stage 2****Diagnostic Aids**

- If the "ECT High Voltage" fault is also present, follow the troubleshooting procedures for that fault as it may have caused "ECT Higher Than Expected 2".
- If the cooling system utilizes an air-to-water heat exchanger (radiator) and fan:
  - Check that the radiator has a proper amount of ethylene glycol/water and that the radiator is not leaking
  - Ensure that there is no trapped air in the cooling path
  - Inspect the cooling system (radiator and hoses) for cracks and ensure connections are leak free
  - Check that the fan is operating properly
  - Check that the thermostat is not stuck closed
- If the cooling system utilizes a water-to-water heat exchanger:
  - Check that the heat exchanger has a proper amount of ethylene glycol/water and that the heat exchanger is not leaking
  - Ensure that there is no trapped air in the cooling path
  - Inspect the cooling system (radiator and hoses) for cracks and ensure connections are leak free
  - Check that the raw water pickup is not blocked/restricted by debris and that the hose is tightly connected
  - Check that the thermostat is not stuck closed
  - Check that the raw water pump/impeller is tact and that it is not

## (6) TPS (Throttle Position Sensor) (DTC 121 to 123, 221 to 223, 2111, 2112, 2135)



### **DTC 121-TPS1 % Lower Than TPS2 %**

- Hardware: Throttle Body-Throttle Position Sensors 1 & 2 relationship
- Enabling Conditions: Key-On, Engine Cranking, or Running
- Set Conditions-TPS1 % lower than TPS2 % by more than 20 % for longer than 1 second
- Corrective Action(s): Turn on MIL, **activate engine shutdown mode**
- Emissions related fault
- Possible Causes: TPS1 or TPS2 out of calibration in throttle body, unwanted resistance in either TPS1 or TPS2 signal circuits, unwanted resistance in either the shared reference feed (5 V\_ext1) or shared sensor ground (5 Vrtn1), bad ECM

### **DTC 122-TPS1 Signal Voltage Low**

- Hardware: Throttle Body-Throttle Position Sensor 1
- Enabling Conditions: Engine running
- Set Conditions: TPS1 sensor voltage lower than 0.200 V for longer than 0.5 seconds
- Corrective Action(s): Illuminate MIL, shutdown engine
- Emissions related fault
- Possible Causes: Loss of 5.00 V reference feed, open or shorted to ground signal circuit, open or shorted to ground TPS in throttle body, bad ECM

**DTC 123-TPS1 Signal Voltage High**

- Hardware: Throttle Body-Throttle Position Sensor 1
- Enabling Conditions: Engine running
- Set Conditions: TPS1 sensor voltage higher than 4.80 V for longer than 0.5 seconds
- Corrective Action(s): Illuminate MIL, shutdown engine
- Emissions related fault
- Possible Causes: 5.00 V reference feed (5 V\_ext1) shorted to voltage, Open sensor ground (5 Vrtn1) circuit, signal wire shorted to voltage or bad TPS in throttle body

**DTC 221-TPS1 % Higher Than TPS2 %**

- Hardware: Throttle Body-Throttle Position Sensor 1 & 2 relationship
- Enabling Conditions: Key-On, Engine Cranking, or Running
- Set Conditions: TPS1 % higher than TPS2 % by more than 20 % for longer than 1 second
- Corrective Action(s): Illuminate MIL, **activate engine shutdown**
- Non-emissions related fault
- Possible Causes: TPS1 or TPS2 out of calibration in throttle body, unwanted resistance in either TPS1 or TPS2 signal circuits, unwanted resistance in either the shared reference feed (5 V\_ext1) or shared sensor ground (5 vrtn1), bad ECM

**DTC 222-TPS2 Signal Voltage Low**

- Hardware: Throttle Body-Throttle Position Sensor 2 (electronic throttle body only)
- Enabling Condition: Key-On, Engine Off
- Set Condition: TPS2 sensor voltage lower 0.200 V for longer than 0.5 seconds
- Corrective Action(s): Illuminate MIL, **activate engine shutdown**
- Emissions related fault
- Possible Causes: Loss of 5.00 V reference feed, open or shorted to ground signal circuit, open or shorted to ground TPS in throttle body, bad ECM

**DTC 223-TPS2 Signal Voltage High**

- Hardware: Throttle Body-Throttle Position Sensor 2 (electronic throttle body only)
- Enabling Conditions: Engine running
- Set Conditions: TPS2 sensor voltage higher than 4.80 V for longer than 0.5 seconds
- Corrective Action(s): Illuminate MIL, **activate engine shutdown**
- Emissions related fault
- Possible Causes: 5.00 V reference feed (5 V\_ext1) shorted to voltage, Open sensor ground (5 Vrtn1) circuit, signal wire shorted to voltage or bad TPS in throttle body

The throttle controls the airflow through the engine, directly affecting the power output of the engine. When the throttle is electronically controlled in an Electronic Throttle Body it can be used to control the idle stability and limit engine speed based on operating conditions.

Each Throttle Position Sensor uses a variable resistor and voltage divider circuit to determine throttle plate position, and is located within the throttle body. The output of the TPS is linear with angular position. The TPS input(s) provide angular position feedback of the throttle plate. In an Electronic Throttle Body multiple position feedback sensors (usually two counteracting potentiometers) are used to perform speed governing with improved safety and redundancy.

**DTC 2111: Unable to Reach Lower TPS**

- Hardware: Throttle Position Sensor
- Enabling Conditions: Cranking or Running
- Set Conditions: Throttle command is 20 % less than throttle position for 0.2 seconds or longer
- Corrective Action(s): Turn on MIL, activate engine shut down
- Emissions related fault
- Possible Causes: Follow at DTC 2112

**DTC 2112: Unable to Reach Higher TPS**

- Hardware: Throttle Position Sensor
- Enabling Conditions: Cranking or Running
- Set Conditions: Throttle command is 20 % more than actual throttle position
- Corrective Action(s): MIL-On during active fault, Adaptive-Enabled, Closed Loop-Enabled, Engine Shut Down
- Emissions related fault
- Possible Causes:

There are 2 Throttle Position Sensors located within the throttle which use variable resistors to determine signal voltage based on throttle plate position. TPS1 will read low voltage when closed and TPS2 will read high voltage when closed. The TPS1 and TPS2 % ages are calculated from these voltages. Although the voltages are different, the calculated values for the throttle position % ages should be very close to the same. The TPS values are used by the ECM to determine if the throttle is opening as commanded.

The DBW motor is a 2 wire DC motor that is PWM controlled by the ECM. Neither of these wires is watched by the ECM for electrical problems. DTCs 2111 and 2112 usually indicate that the ECM has lost control of the motor due to an electrical problem with the motor or a mechanical problem with the motor.

This fault of DTC 2111 will set if the throttle command is 20 % lower or more than the actual throttle position. During this active fault the MIL light will be on and the engine will shut down.

This fault of DTC 2112 will set if the throttle command is 20 % lower or more than the actual throttle position. During this active fault the MIL light will be on and the engine will shut down.

**DTC 2135-TPS1/2 Simultaneous Voltages Out-of-Range**

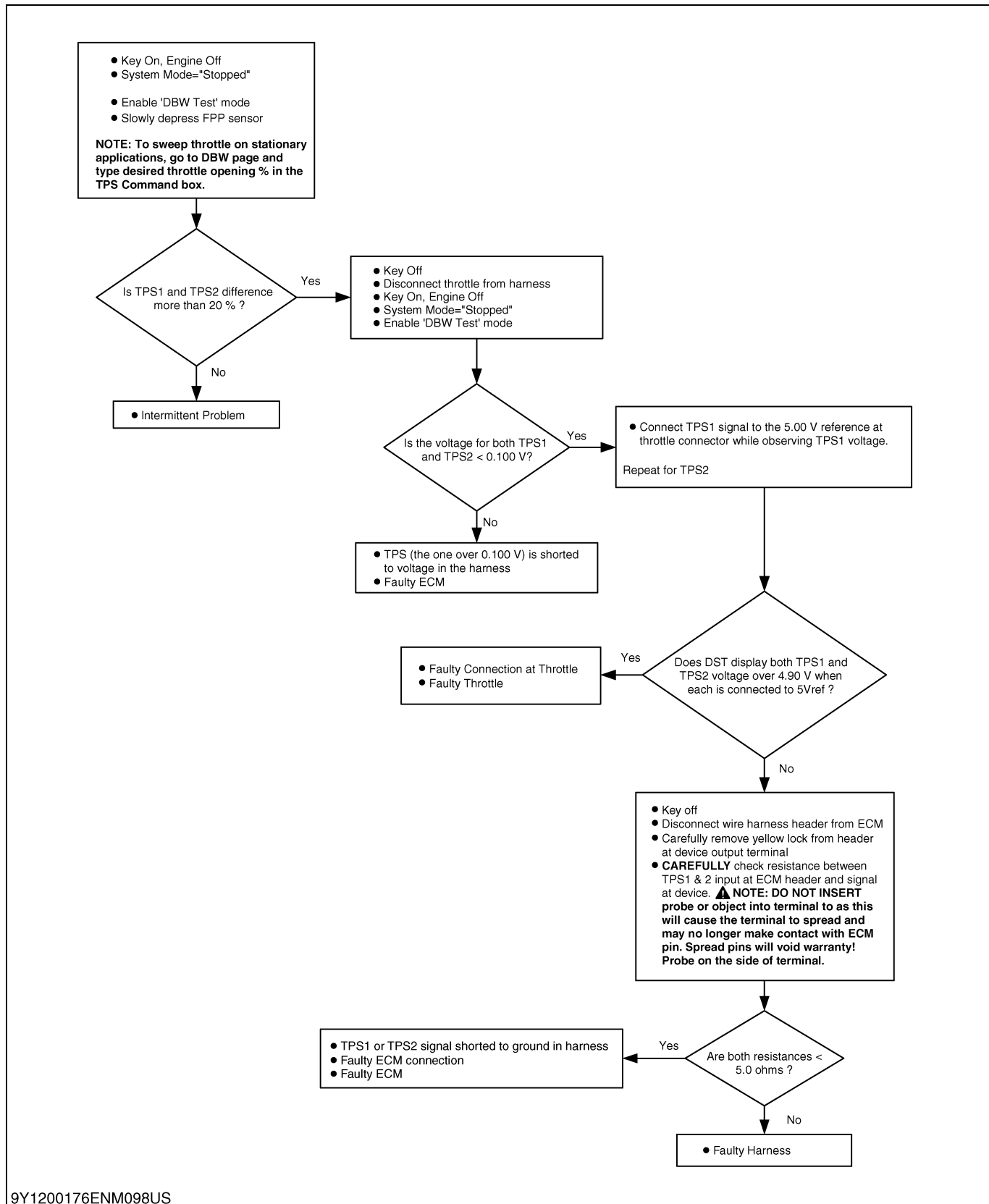
- Hardware: Electronic throttle body
- Enabling Conditions: Key On, Engine Cranking or Running
- Set Condition: TPS1 and TPS2 voltages are both simultaneously out-of-range for longer than 0.5 seconds
- Corrective Action(s): Illuminate MIL and shutdown engine
- Non-emissions related fault
- Possible Causes: Loss of 5.00 V feed to both sensors, loss of ground (5 V\_rtn1) to both sensors, problem with both TPSs at the same time

The throttle is an air valve used to control the amount of air available to the engine for combustion and thereby the engine's power output. An electronic throttle simply means that a motor is controlled electronically through an electronic control system to actuate the throttle valve. Electronic throttle control is advantageous because it tends to offer improved starting, improved idle governing, improved maximum speed governing, excellent load acceptance and steady-state speed governing, permits engine synchronization, and offers flexibility to protect the engine during certain fault conditions.

This fault is generated when both feedback sensors in the ETB (TPS1 and TPS2) simultaneously produce out-of-range faults. This fault indicates that there is no feedback of the throttle valve and as a result throttle control cannot take place.

**DTC 121-TPS1 % Lower Than TPS2 %**

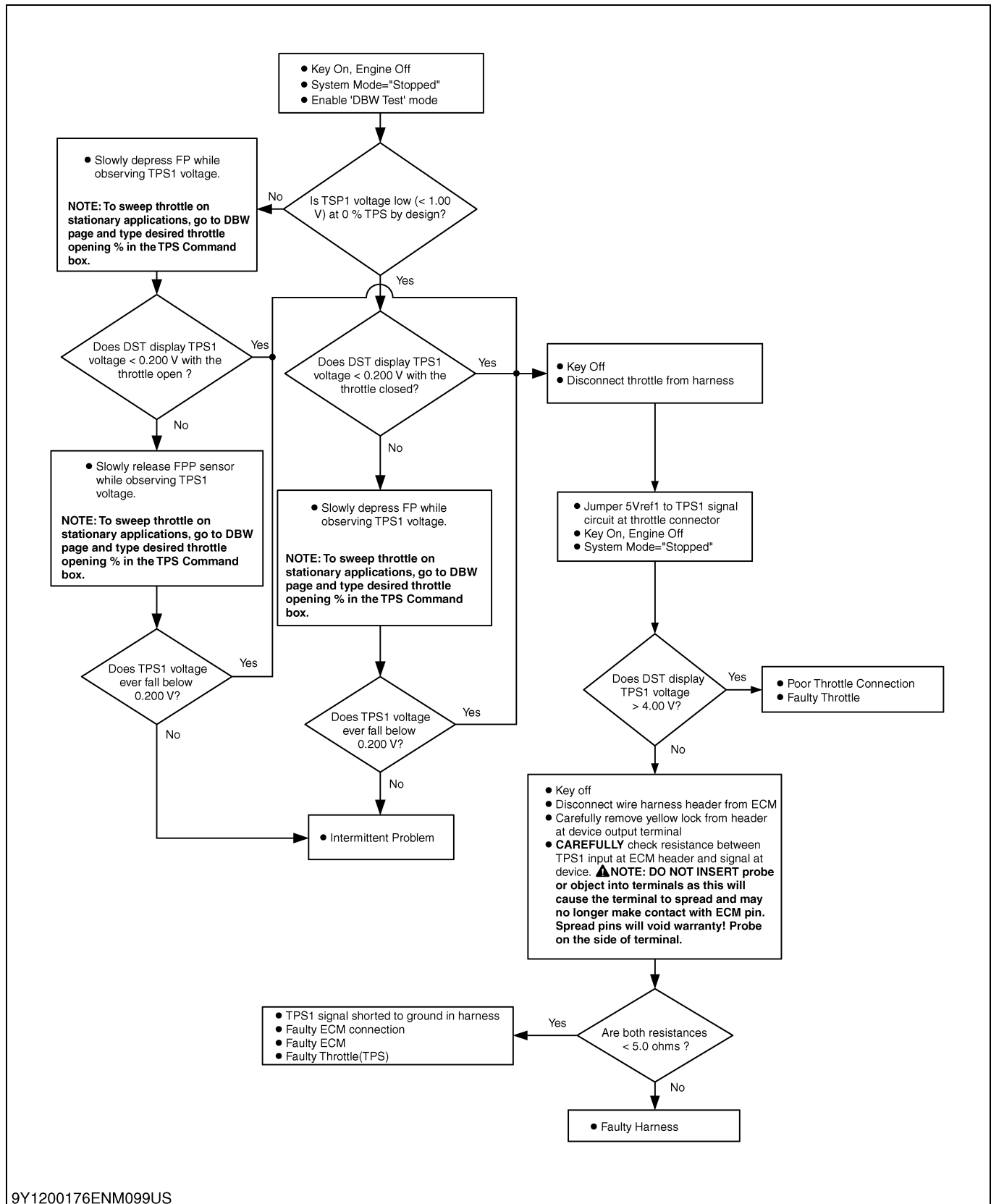
**Diagnostic Aids Chart**



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**DTC 122-TPS1 Signal Voltage Low**

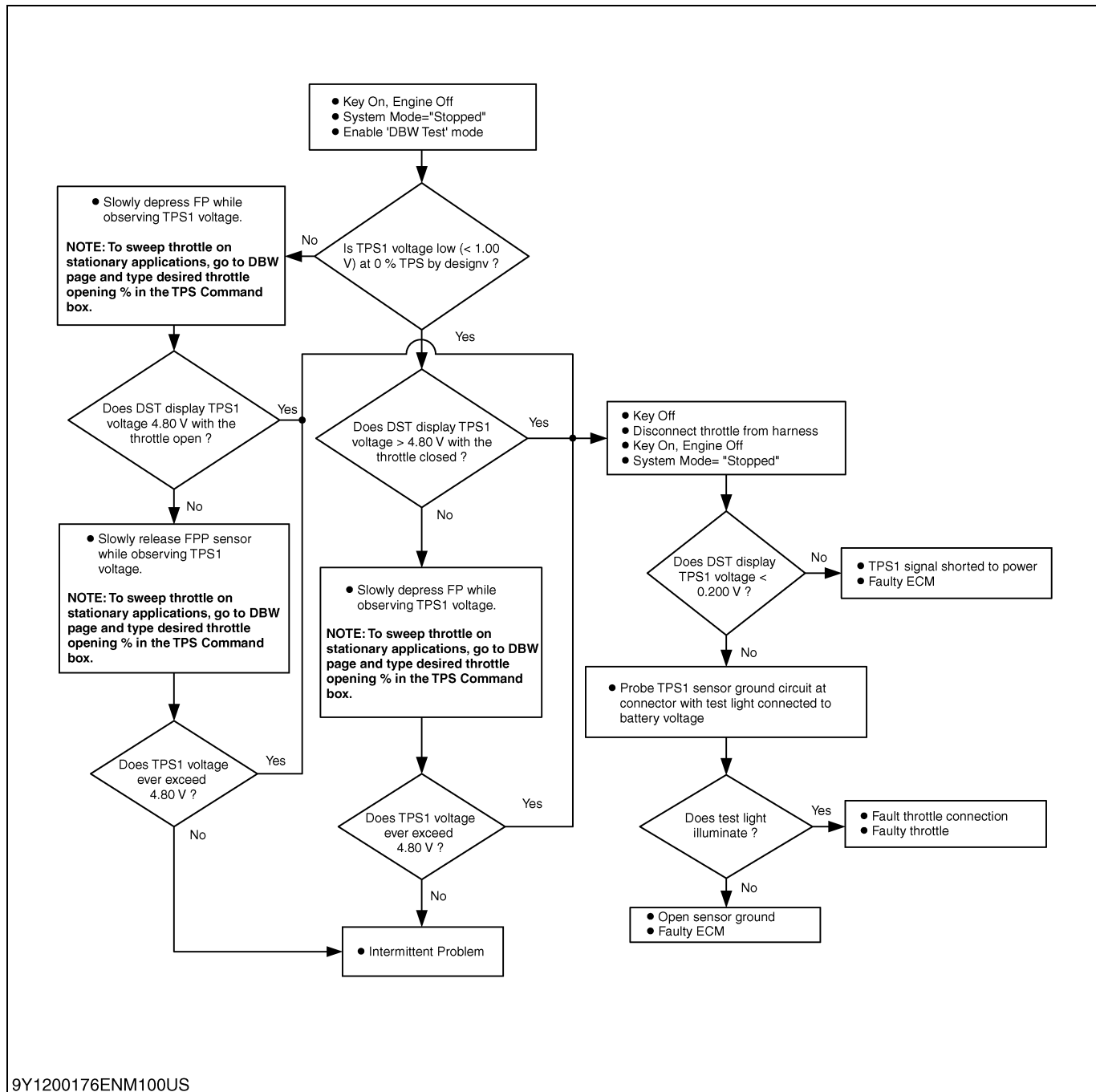
**Diagnostic Aids Chart**



9Y1200176ENM099US

**DTC 123-TPS1 Signal Voltage High**

**Diagnostic Aids Chart**

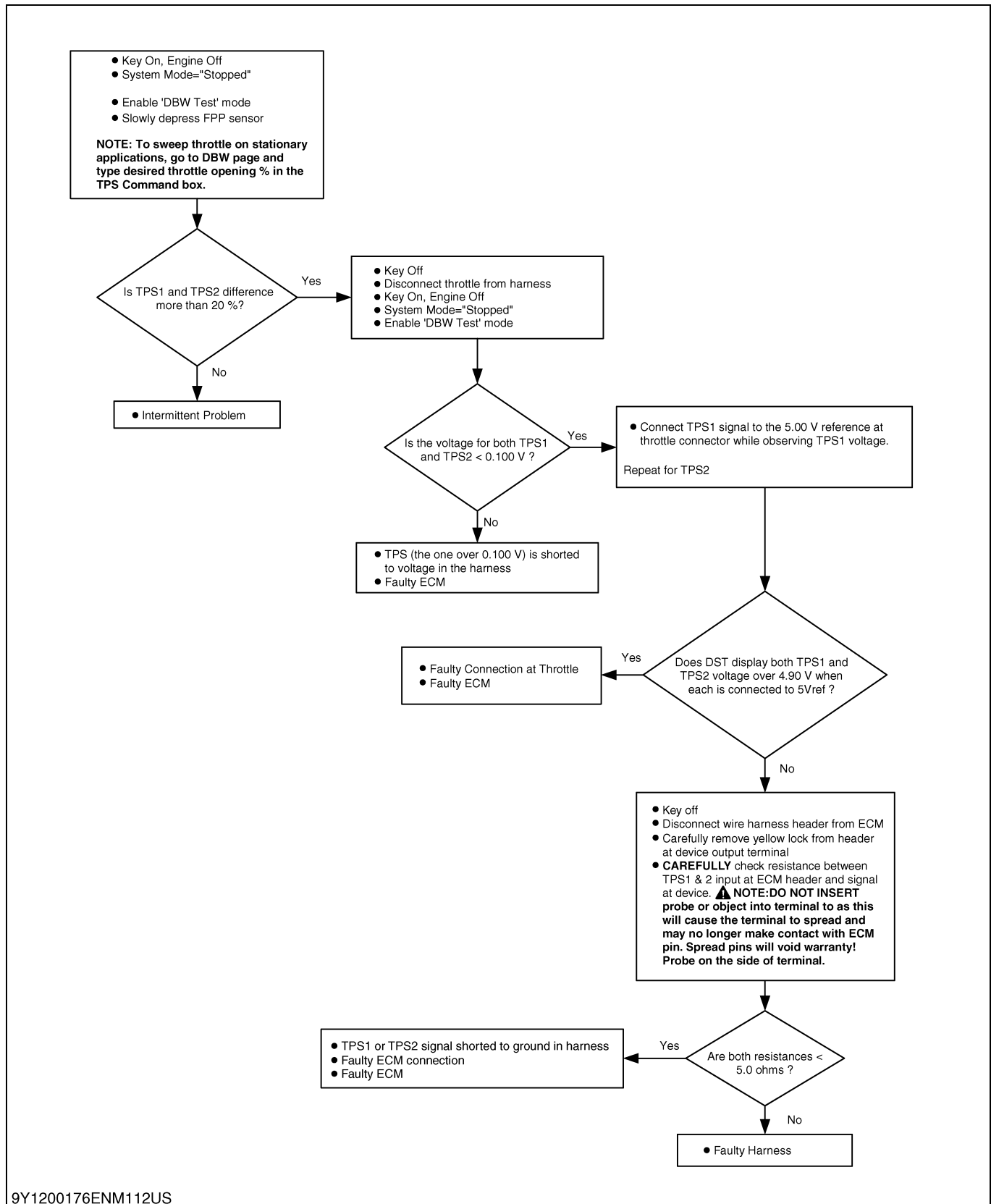


9Y1200176ENM100US



**DTC 221-TPS1 % Higher Than TPS2 %**

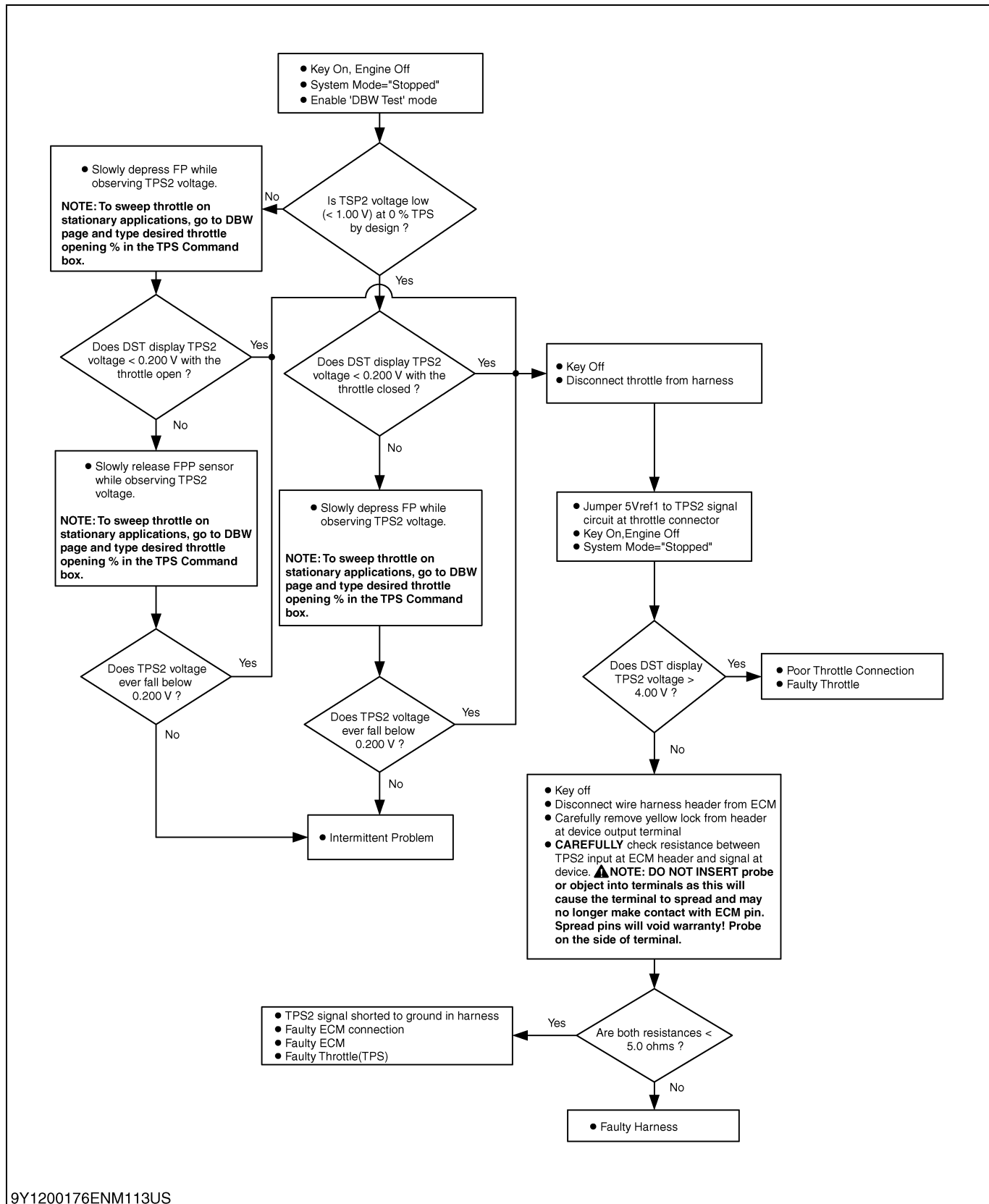
**Diagnostic Aids Chart**



9Y1200176ENM112US

**DTC 222-TPS2 Signal Voltage Low**

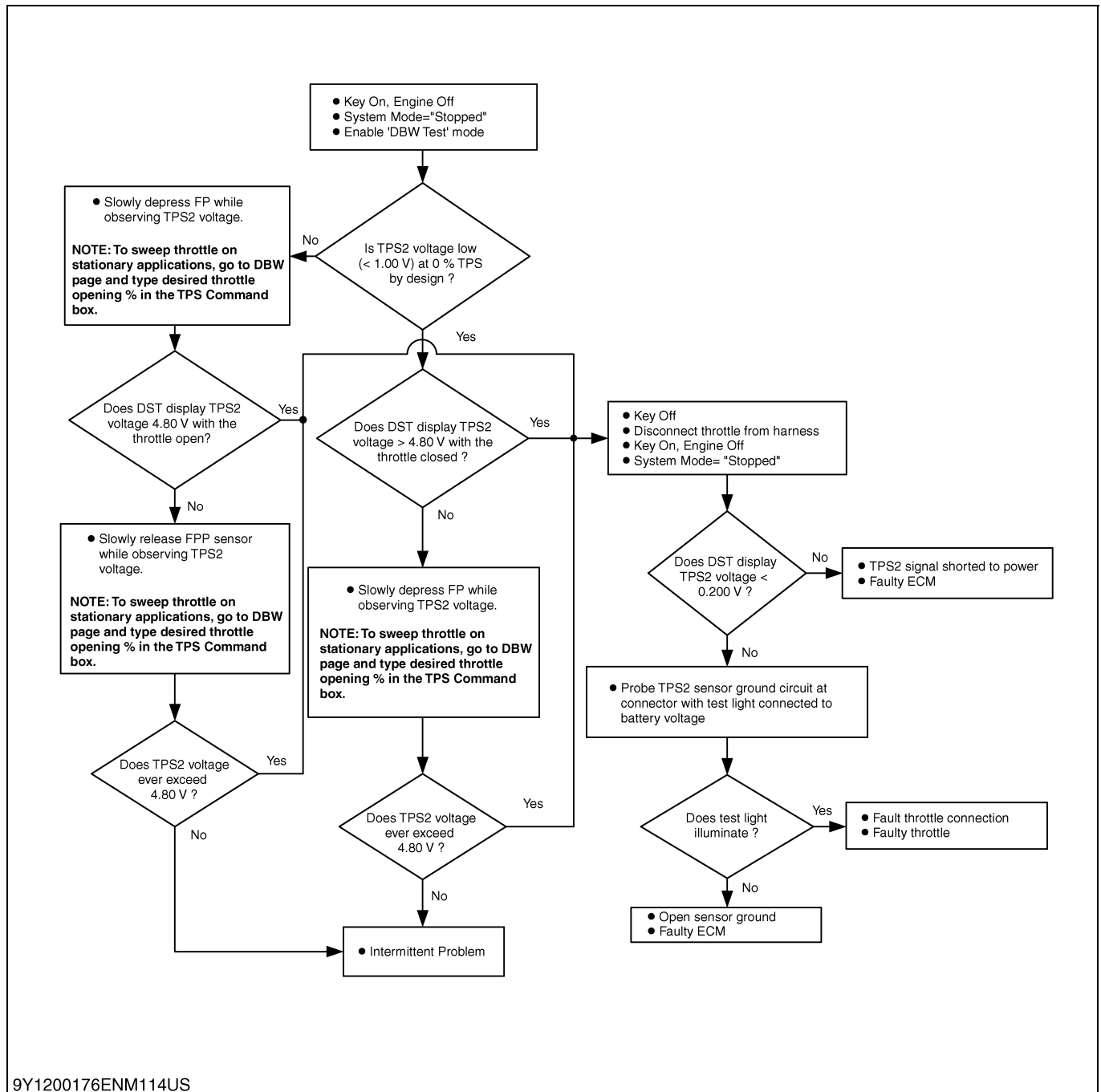
**Diagnostic Aids Chart**



9Y1200176ENM113US

**DTC 223-TPS2 Signal Voltage High**

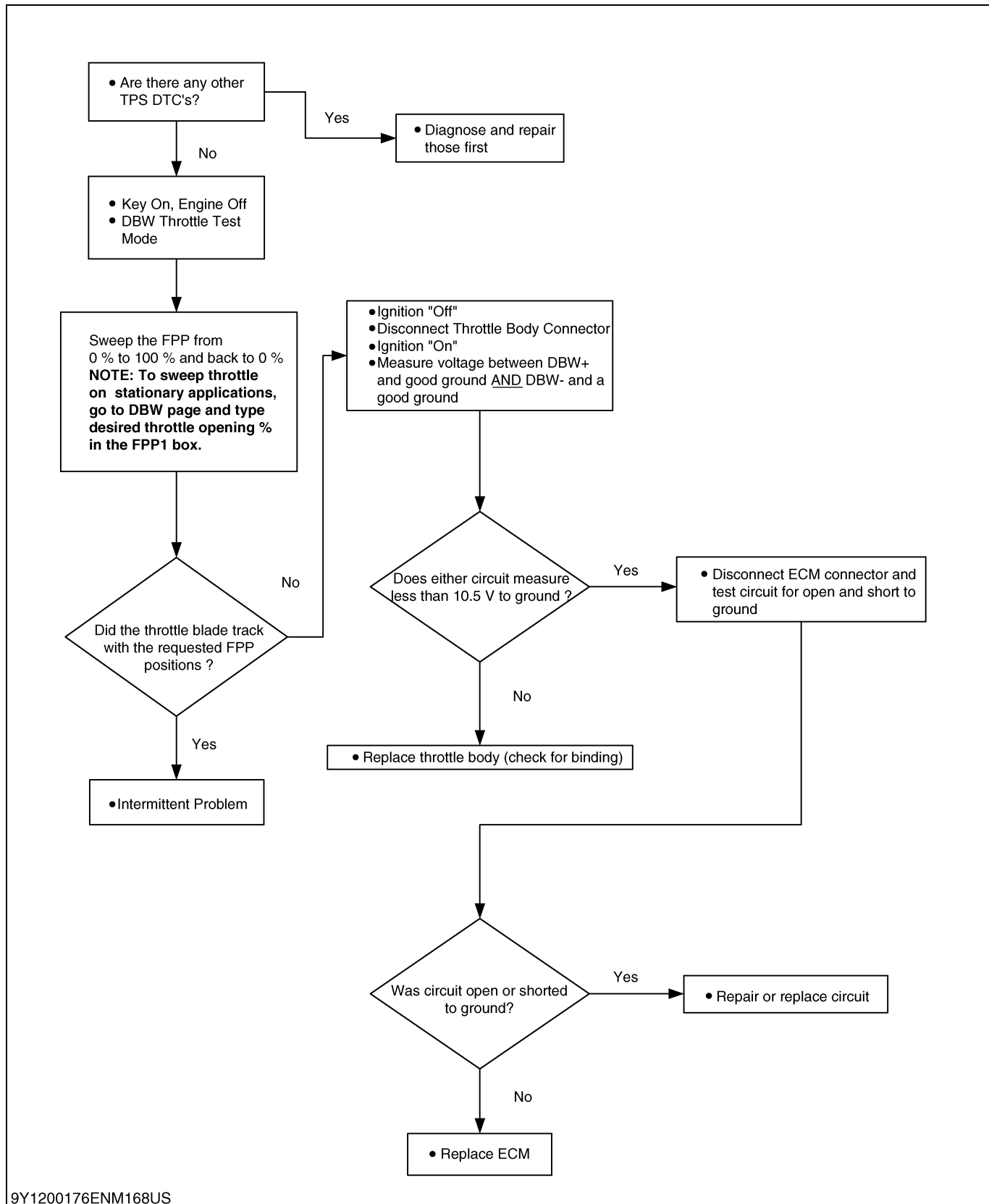
**Diagnostic Aids Chart**



9Y1200176ENM114US

**DTC 2111: Unable to Reach Lower TPS**

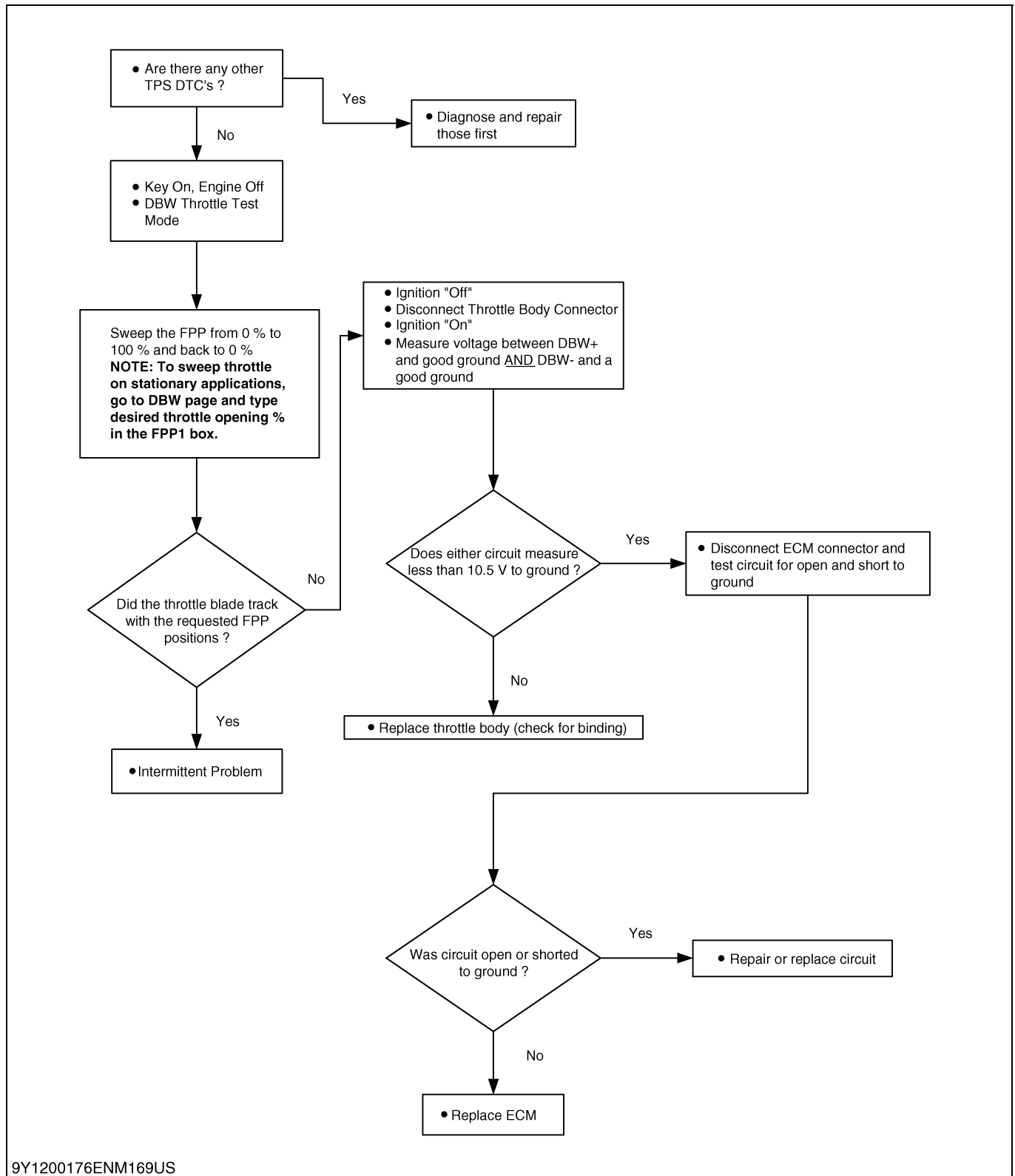
**Diagnostic Aids Chart**



9Y1200176ENM168US

**DTC 2112: Unable to Reach Higher TPS**

**Diagnostic Aids Chart**

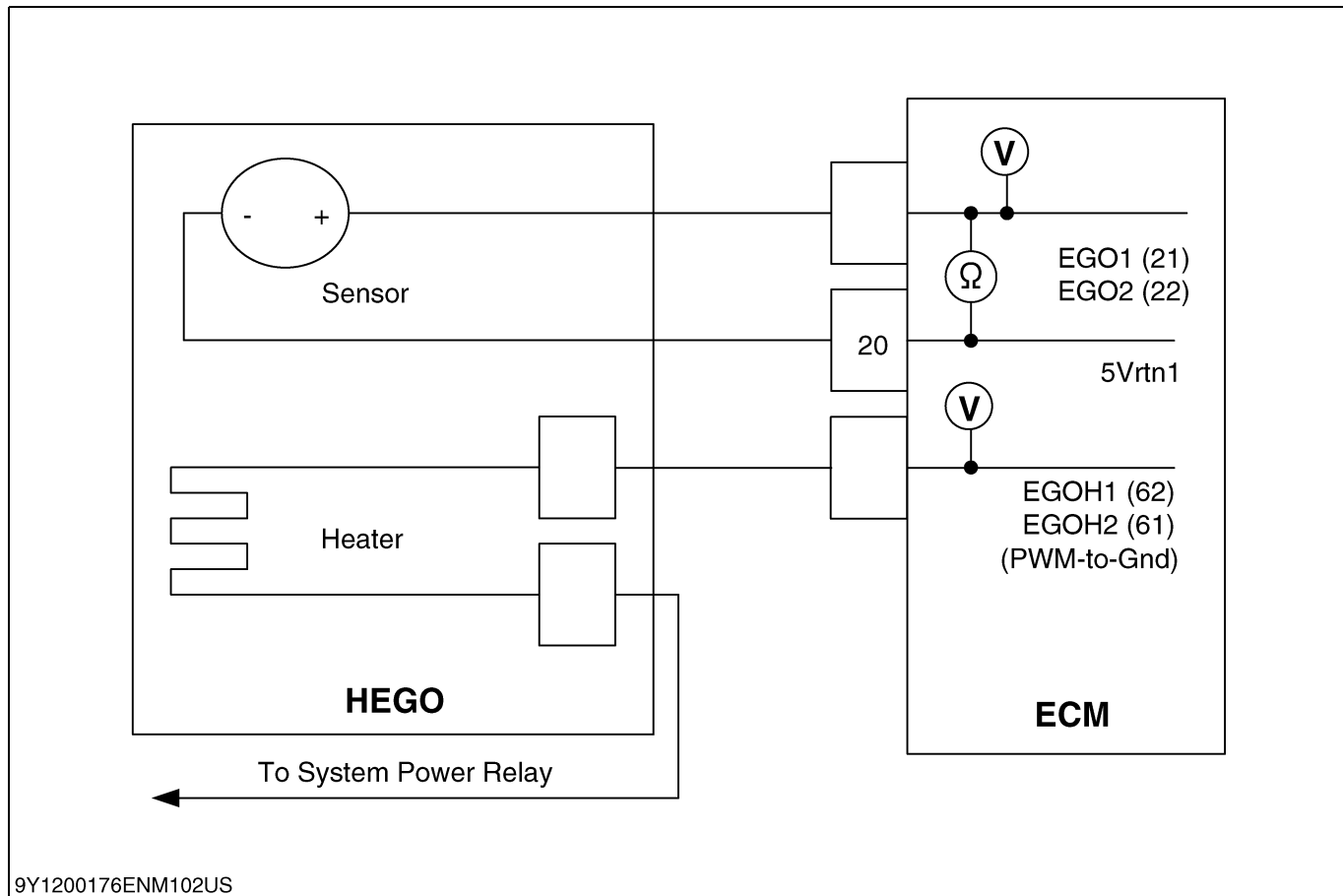


9Y1200176ENM169US

**DTC 2135-TPS1/2 Simultaneous Voltages Out-of-Range**

**Diagnostic Aids**

Troubleshoot according to TPS1 voltage out-of-range following DTC 122 and 123 procedures.  
 Troubleshoot according to TPS2 voltage out-of-range following DTC 222 and 223 procedures.

**(7) EGO Sensors ((Exhaust Gas Oxygen) Sensors) (DTC 134, 154)****DTC 134-EGO1 Open/Lazy (HO<sub>2</sub>S1)**

- Hardware: Heated Exhaust Gas Oxygen Sensor (Pre-Catalyst)
- Enabling Conditions: Engine Running
- Set Conditions: HEGO/HO<sub>2</sub>S cold or non-responsive for longer than 120 seconds
- Corrective Action(s): Illuminate MIL, disable closed loop operation and fuel adaptive learn correction (both) while the code is active.
- Emissions related fault
- Possible Causes: Open feed circuit to O<sub>2</sub> heater, Open heater ground circuit, Open or shorted to ground O<sub>2</sub> signal wire, open sensor ground (5 Vrtn1), inoperative sensor

The HEGO/HO<sub>2</sub>S sensor is a switching-type sensor about stoichiometry that measures the oxygen content present in the exhaust to determine if the fuel flow to the engine is correct. If there is a deviation between the expected reading and the actual reading, fuel flow is precisely adjusted using the Closed Loop multiplier and then "learned" with the Adaptive multiplier. The multipliers only update when the system is in either "CL Active" or "CL + Adapt" control modes.

Cold or non-responsive is defined as the actual impedance of the sensor heater not reaching the target impedance.

**DTC 154-EGO2 Open/Lazy (HO<sub>2</sub>S2)**

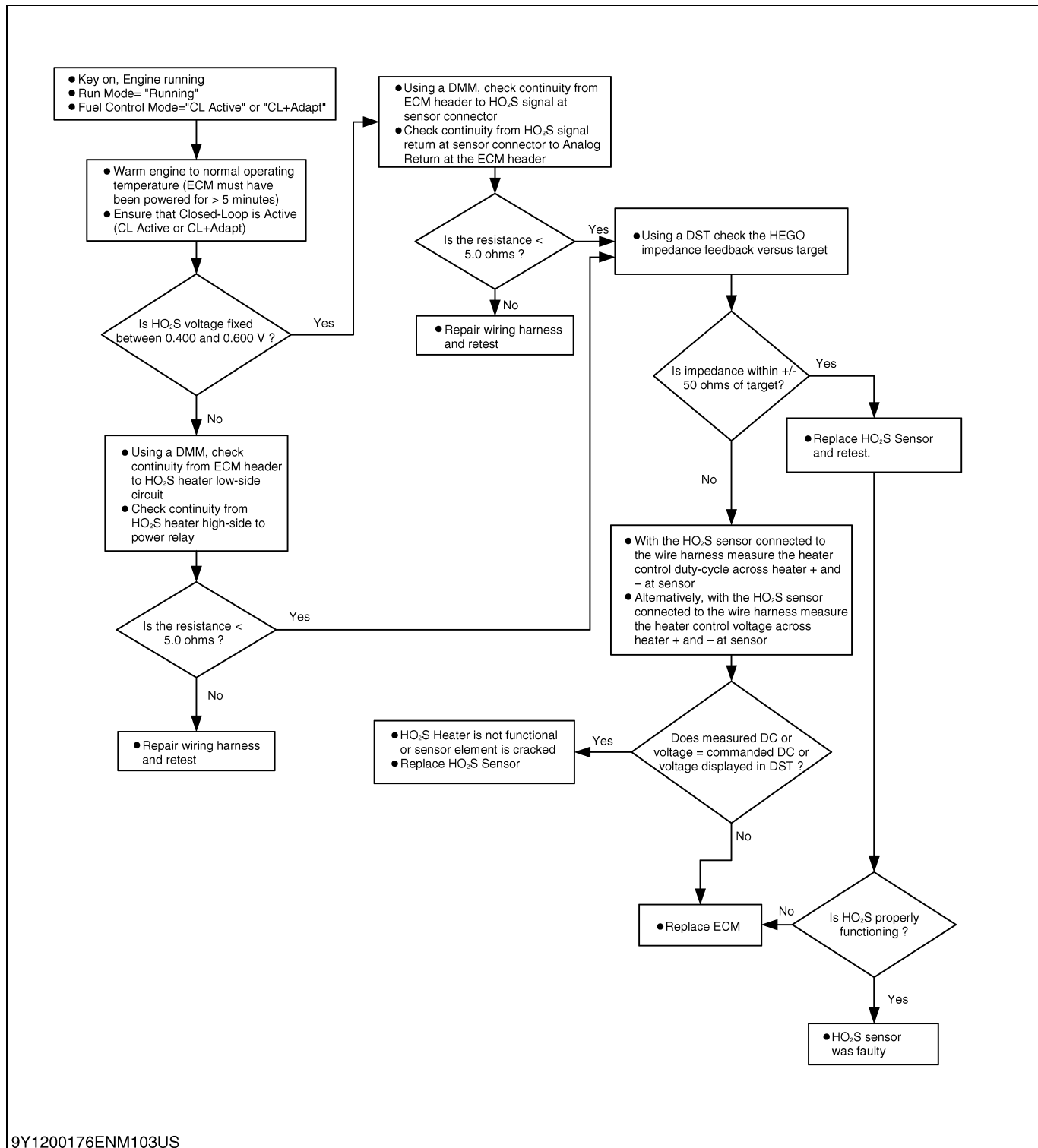
- Hardware: Heated Exhaust Gas Oxygen Sensor (Post-Catalyst)
- Enabling Conditions: Engine Running
- Set Conditions: HEGO/HO<sub>2</sub>S cold or non-responsive longer than 120 seconds
- Corrective Action(s): Illuminate MIL.
- Emissions related fault
- Possible Causes: Open feed circuit to O<sub>2</sub> heater, Open heater ground circuit, Open or shorted to ground O<sub>2</sub> signal wire, open sensor ground (5 Vrtn1), inoperative sensor

In a post-catalyst configuration the HEGO/HO<sub>2</sub>S sensor is a switching-type sensor around stoichiometry that measures the oxygen content downstream of the catalyst for two main functions: 1) to compare it to the oxygen content upstream of the catalyst to determine how efficiently the catalyst is using oxygen to determine its effectiveness and 2) trim the commanded equivalence ratio target to maximize the catalyst conversion efficiency. The post-catalyst strategy and diagnostic is only active when the system is in either "CL Active" or "CL + Adapt" control modes.

Cold or non-responsive is defined as the actual impedance of the sensor heater not reaching the target impedance.

**DTC 134-EGO1 Open/Lazy (HO<sub>2</sub>S1)**

**Diagnostic Aids Chart**

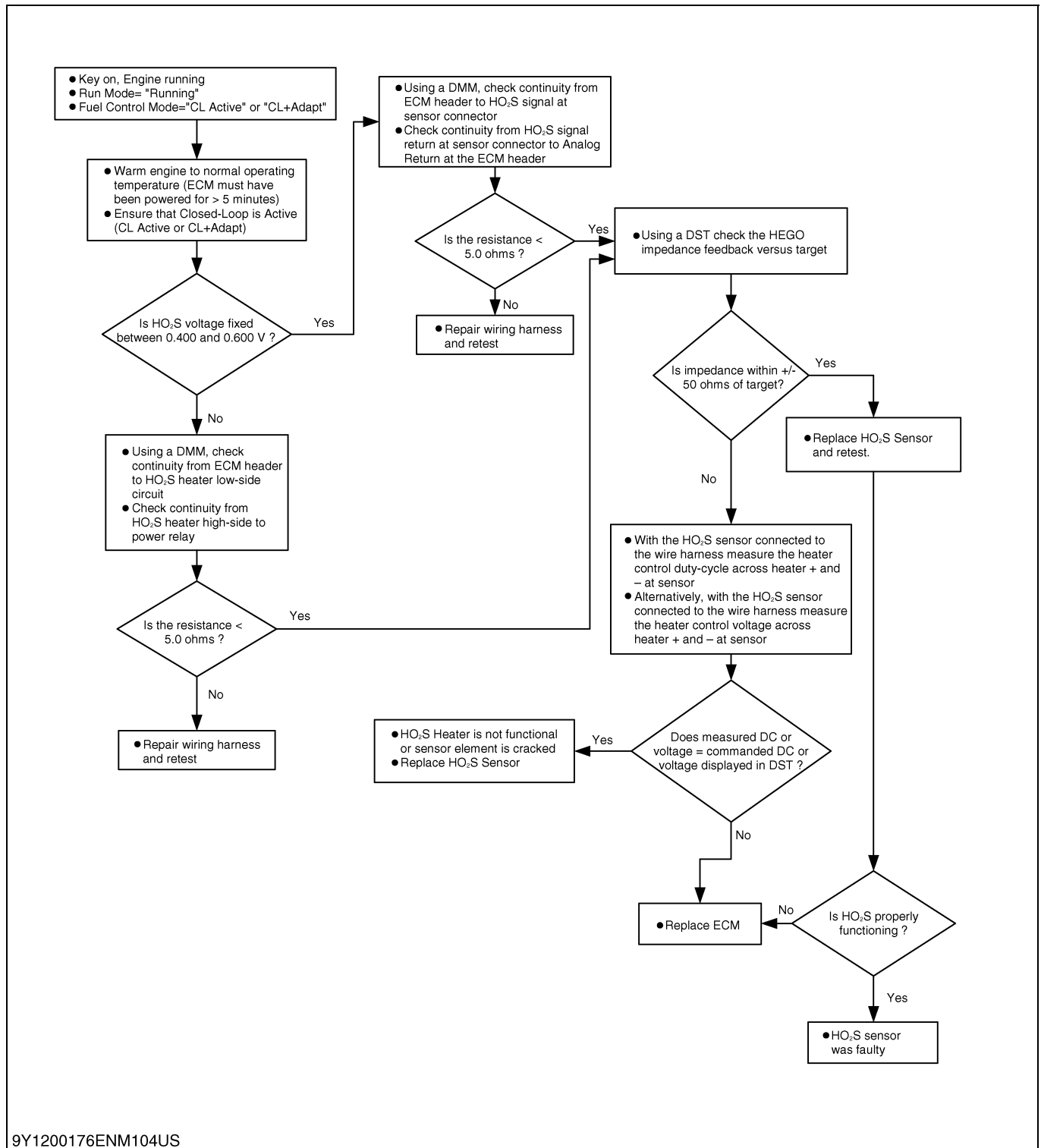


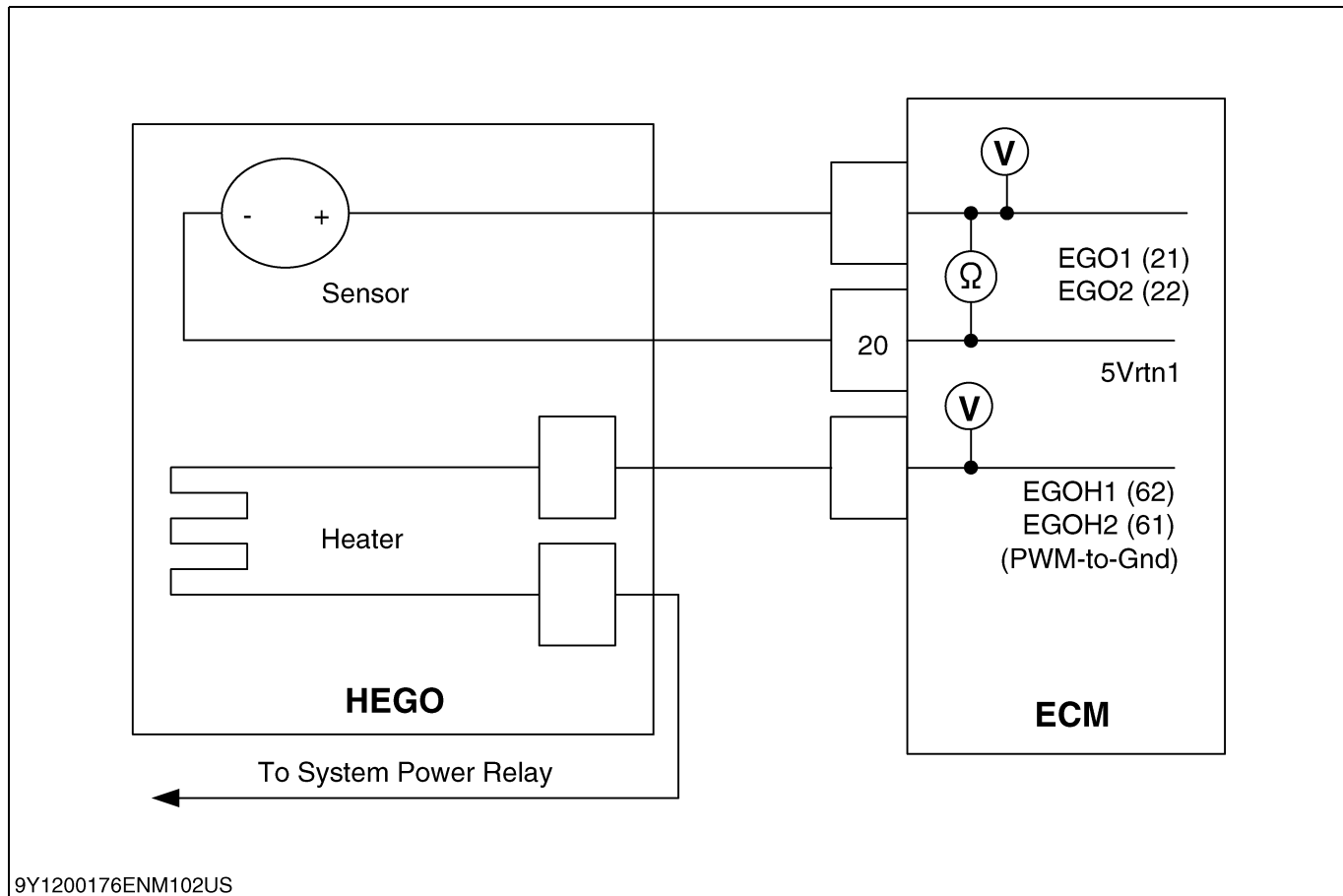
9Y1200176ENM103US



**DTC 154-EGO2 Open/Lazy (HO<sub>2</sub>S2)**

**Diagnostic Aids Chart**



**(8) Adaptive Learn (DTC 171, 172, 1161 to 1164)****DTC 171-Adaptive Learn Bank 1 High (Gasoline)**

- Hardware: HEGO Sensor (Pre-Catalyst) rich-lean switch rate
- Enabling Conditions: Engine Running in closed loop active mode updating adaptive learn multiplier (CL+Adap mode)
- Set Conditions: Bank 1 adaptive learn multiplier  $\geq +30\%$  for longer than 3 updates (see below)
- Corrective Action(s): Illuminate MIL
- Emissions related fault
- Possible Causes: See Diagnostic aids below and on next page

**DTC 172-Adaptive Learn Bank1 Low (Gasoline)**

- Hardware: HEGO Sensor (Pre-Catalyst) rich-lean switch rate
- Enabling Conditions: Engine Running in closed loop active mode updating adaptive learn multiplier (CL+Adap mode)
- Set Condition: Bank 1 adaptive learn multiplier  $\leq 30\%$  for longer than 3 updates (see below)
- Corrective Action(s): Illuminate MIL
- Emissions related fault
- Possible Causes: See Diagnostic aids below and on next page

The purpose of the Adaptive Learn Multiplier is to adjust fuel flow due to variations in fuel composition, engine wear, engine-to-engine build variances, and component degradation. The Adaptive Learn multiplier values are held in a table and are remembered between key cycles. Adaptive memory tables are erased at battery disconnects and with the DST.

An "update" (from Set Conditions above) can be thought of as a "variable timer", one that takes longer to set a fault at low engine speeds than at higher speeds.

This fault of DTC 171 sets if the Adaptive multiplier exceeds the high limit of normal operation indicating that the engine is operating lean (excess oxygen) and requires more fuel than allowed by corrections. Often high positive fueling corrections are a function of one or more of the following conditions: 1) exhaust leaks upstream or near the HEGO sensor, 2) reduced fuel supply pressure to the fuel injection system, 3) an inoperative sensor, 3) an injector that is stuck closed or dirty, 4) weak spark or lack of spark to a cylinder and/or 5) a MAP sensor that indicates pressure that is lower than true pressure.

This fault of DTC 172 sets if the Adaptive multiplier exceeds the low limit of normal operation indicating that the engine is operating rich (low oxygen content) and requires less fuel than allowed by corrections. Often high negative fueling corrections are a function of one or more of the following conditions: 1) an inoperative O<sub>2</sub> sensor, 2) high fuel supply pressure or temperature, 3) internal mechanical engine damage, 3) an injector that is stuck open or leaking, and/or 4) improper airflow through the engine due to things such as valve timing problems, collapsed lifters/followers, worn cam lobes or bent pushrods.

To test the O<sub>2</sub> sensor run the CL test. This test tests both pre-cat and post-cat O<sub>2</sub> sensor functionality.

### **DTC 171-Adaptive Learn Bank 1 High (Gasoline)**

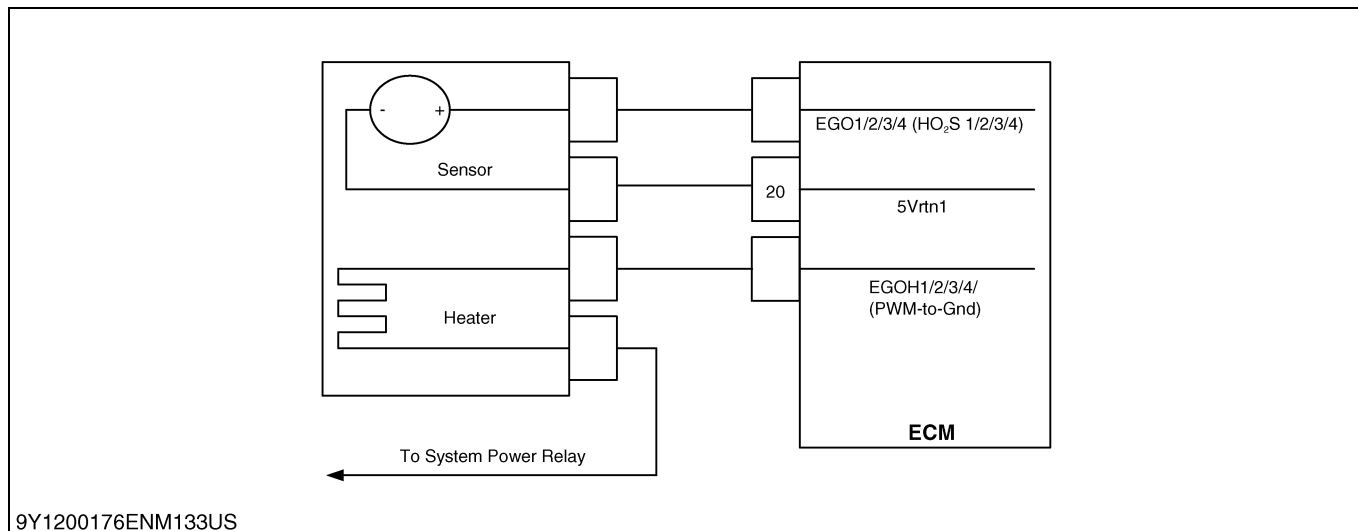
#### **Diagnostic Aids**

#### **■ NOTE**

- **If any other DTCs are present, diagnose those first.**
- Oxygen Sensor Wire-Sensor may be mispositioned contacting the exhaust. Check for short to ground between harness and sensor and on sensor harness
- Inoperative Oxygen Sensor-sensor may be damaged internally and unable to switch resulting in a system that over fuels or under fuels the engine.
- Weak Spark or Lack of Spark to a Cylinder-improper burning of the fuel/air mixture in a cylinder results in excess unburned oxygen exiting the cylinder causing the pre-cat O<sub>2</sub> sensor to see a lean condition
- Vacuum Leaks-Large vacuum leaks and crankcase leaks can cause a lean exhaust condition at light load.
- Injectors-System will be lean if an injector driver or driver circuit fails. The system will also be lean if an injector fails in a closed manner or is dirty.
- Fuel Pressure-System will be lean if fuel pressure is too low. Check fuel pressure in the fuel rail during key-on, engine off and during normal operating conditions.
- Air in Fuel - If the fuel return hose/line is too close to the fuel supply pickup in the fuel tank, air may become entrapped in the pump or supply line causing a lean condition and driveability problems.
- Exhaust Leaks - If there is an exhaust leak, outside air can be pulled into the exhaust and past the O<sub>2</sub> sensor causing a false lean condition.
- Fuel Quality - A drastic variation in fuel quality may cause the system to be lean including oxygenated fuels.
- System Grounding - ECM and engine must be grounded to the battery with very little resistance allowing for proper current flow. Faulty grounds can cause current supply issues resulting in many undesired problems.
- If all tests are OK, replace the HO<sub>2</sub>S sensor with a known good part and retest.

**DTC 172-Adaptive Learn Bank1 Low (Gasoline)****Diagnostic Aids****■ NOTE**

- **If any other DTCs are present, diagnose those first.**
- Oxygen Sensor Wire - Sensor may be mispositioned contacting the exhaust. Check for short to ground between harness and sensor and on sensor harness
- Injectors - System will be rich if an injector driver or driver circuit fails shorted-to-ground. The system will also be rich if an injector fails in an open position or leaks.
- Fuel Pressure - System will be rich if fuel pressure is too high. Check fuel pressure in the fuel rail during key-on, engine off and during normal operating conditions.
- System Electrical Grounding - ECM and engine must be grounded to the battery with very little resistance allowing for proper current flow. Faulty grounds can cause current supply issues resulting in many undesired problems (causing sensors to provide bad information to the ECM).
- Internal mechanical engine damage causing lower than normal intake manifold vacuum
- MAP sensor that indicates pressure higher than true pressure
- Coolant Temperature Sensor - A sensor that indicates the engine is colder than actual engine temperature
- If all tests are OK, replace the HO<sub>2</sub>S sensor with a known good part and retest.

**DTC 1161-Adaptive Learn High (LPG)****DTC 1163-Adaptive Learn High (NG)**

- Hardware: Heated or Universal Exhaust Gas Oxygen Sensor (Bank 1-Sensor 1/Bank 1-Before Catalyst)
- Enabling Conditions: Engine Running in closed loop and with fuel adaptive learn active
- Set Conditions: Adaptive fuel multiplier higher than 30 % for longer than 3 updates
- Corrective Action(s): Illuminate MIL
- Emissions related fault
- Possible Causes:

The HEGO/HO<sub>2</sub>S sensor is a switching-type sensor around stoichiometry that measures the oxygen content present in the exhaust to determine if the fuel flow to the engine is correct. A UEGO sensor measures the exhaust content across a wide-range of air-fuel ratios with a linear output proportional to lambda/equivalence ratio/air-fuel ratio. In either case, if there is a deviation between the expected reading and the actual reading, fuel flow is precisely adjusted for each bank using the Closed Loop multiplier and then "learned" with the Adaptive multiplier. The multipliers only update when the system is in either "CL Active" or "CL + Adapt" control modes. The purpose of the Adaptive Learn fuel multiplier is to adjust fuel flow due to variations in fuel composition, engine wear, engine-to-engine build variances, and component degradation.

This fault sets if the Adaptive multiplier exceeds the high limit of normal operation indicating that the engine is operating lean (excess oxygen) and requires more fuel than allowed by corrections. Often high positive fueling corrections are a function of one or more of the following conditions: 1) exhaust leaks upstream or near the HEGO sensor, 2) reduced fuel supply pressure to the gaseous fuel control system, 3) a fuel supply or manifold leak, 4) a non-responsive HEGO/UEGO sensor, and/or 5) a defective gaseous fuel control component (actuator/valve and/or mixer). This fault should be configured to disable adaptive learn for the remainder of the key-cycle to avoid improperly learning the adaptive learn table and may be configured to disable closed loop.

**DTC 1162-Adaptive Learn Low (LPG)****DTC 1164-Adaptive Learn Low (NG)**

- Hardware: Heated or Universal Exhaust Gas Oxygen Sensor (Bank 1-Sensor 1/Bank 1-Before Catalyst)
- Enabling Conditions: Engine Running in closed loop and with fuel adaptive learn active
- Set Conditions: Adaptive fuel multiplier lower than -30 % for longer than 3 updates
- Corrective Action(s): Illuminate MIL
- Emissions related fault
- Possible Causes:

The HEGO/HO<sub>2</sub>S sensor is a switching-type sensor around stoichiometry that measures the oxygen content present in the exhaust to determine if the fuel flow to the engine is correct. A UEGO sensor measures the exhaust content across a wide-range of air-fuel ratios with a linear output proportional to lambda/equivalence ratio/air-fuel ratio. In either case, if there is a deviation between the expected reading and the actual reading, fuel flow is precisely adjusted for each bank using the Closed Loop multiplier and then "learned" with the Adaptive multiplier. The multipliers only update when the system is in either "CL Active" or "CL + Adapt" control modes. The purpose of the Adaptive Learn fuel multiplier is to adjust fuel flow due to variations in fuel composition, engine wear, engine-to-engine build variances, and component degradation.

This fault sets if the Adaptive multiplier exceeds the low limit of normal operation indicating that the engine is operating rich (excess fuel) and requires less fuel than allowed by corrections. Often high negative fueling corrections are a function of one or more of the following conditions: 1) high fuel supply pressure to the gaseous fuel control or faulty pressure regulator and/or 2) a non-responsive HEGO/UEGO sensor. This fault should be configured to disable adaptive learn for the remainder of the key-cycle to avoid improperly learning the adaptive learn table and may be configured to disable closed loop.

#### **DTC 1161-Adaptive Learn High (LPG)**

#### **DTC 1163-Adaptive Learn High (NG)**

##### **Diagnostic Aids**

###### **■ NOTE**

- **If any other DTCs are present, diagnose those first.**
- Oxygen Sensor Wire - Sensor may be mispositioned contacting the exhaust. Check for short to ground between harness and sensor sense signal.
- Vacuum Leaks - Large vacuum leaks and crankcase leaks can cause a lean exhaust condition at light load.
- Fuel Pressure - System will be lean if fuel pressure is too low. Ensure fuel tank pressure is not too low and that gaseous fuel control actuator/regulator has proper fuel pressure under all operating conditions.
- Exhaust Leaks - If there is an exhaust leak, outside air can be pulled into the exhaust and past the O<sub>2</sub> sensor causing a false lean condition.
- Fuel Quality - A drastic variation in fuel quality may cause the system to be lean including fuels with high inert gas content.
- System Grounding - ECM and engine must be grounded to the battery with very little resistance allowing for proper current flow. Faulty grounds can cause current supply issues resulting in many undesired problems.
- If all tests are OK, replace the HO<sub>2</sub>S or UEGO sensor with a known good part and retest.

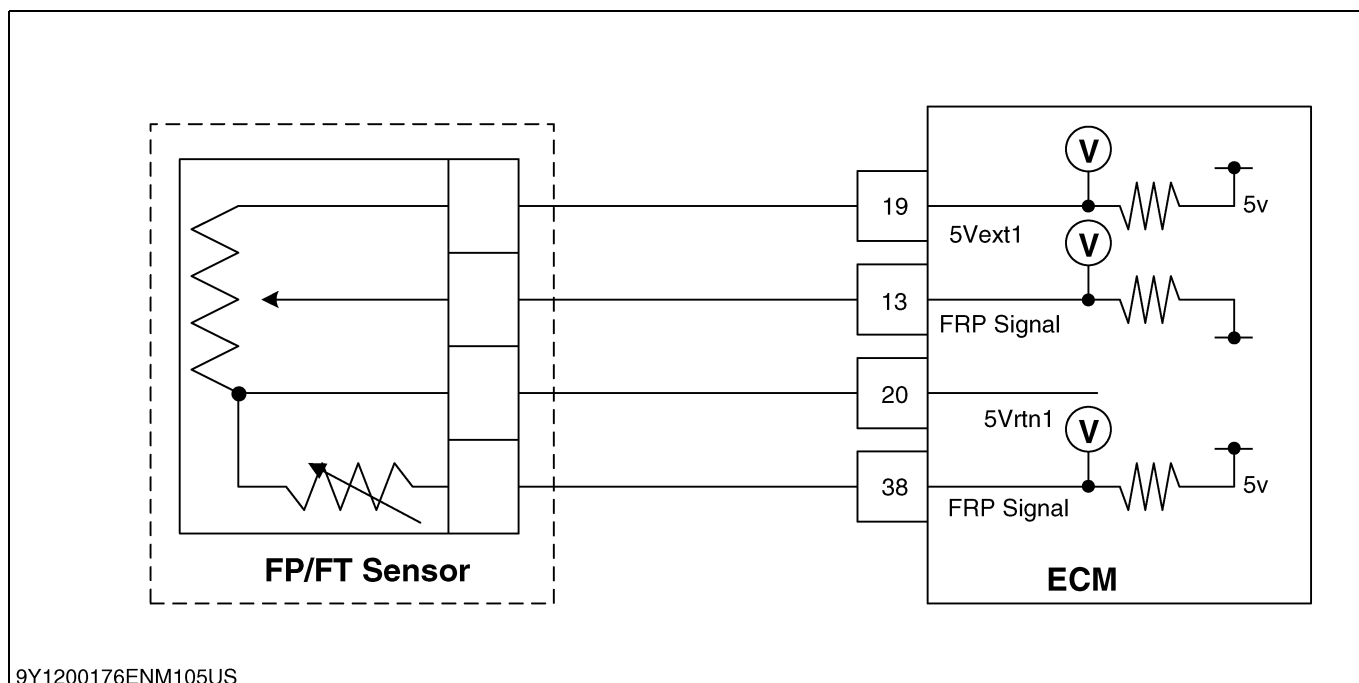
#### **DTC 1162-Adaptive Learn Low (LPG)**

#### **DTC 1164-Adaptive Learn Low (NG)**

##### **Diagnostic Aids**

###### **■ NOTE**

- **If any other DTCs are present, diagnose those first.**
- Oxygen Sensor Wire - Sensor may be mispositioned contacting the exhaust. Check for short to ground between harness and sensor and on sensor harness
- Fuel Pressure - System will be rich if fuel delivery pressure is too high to gaseous control system. Check fuel pressure at the control actuator/valve under all operating conditions.
- System Grounding - ECM and engine must be grounded to the battery with very little resistance allowing for proper current flow. Faulty grounds can cause current supply issues resulting in many undesired problems.
- If all tests are OK, replace the HO<sub>2</sub>S or UEGO sensor with a known good part and retest.

**(9) Fuel Temp (Fuel Temperature Sensor) (DTC 182, 183, 187)****DTC 182-Fuel Temp (Gasoline) Low Voltage/Low Temp**

- Hardware: Liquid Fuel Temperature Sensor
- Enabling Conditions: Engine Running
- Set Conditions: FT sensor voltage less than 0.050 V **OR** indicated temperature below  $-37^{\circ}\text{C}$  ( $-35^{\circ}\text{F}$ ) for longer than 1 second
- Corrective Action(s): Illuminate MIL and disable fuel adaptive learn for the rest of the key cycle
- Emissions related fault (evaporative emissions)
- Possible causes:
  - Voltage Low: Sensor signal wire shorted to ground, sensor shorted internally, faulty ECM
  - Temperature Low: Operating in a frigid atmosphere, Sensor out of calibration, partial short to ground in signal circuit causing circuit to indicate a very cold temp (below  $-37^{\circ}\text{C}$  ( $-35^{\circ}\text{F}$ )) but not high enough to set a high voltage fault

The Fuel Temperature sensor is a thermistor (temperature sensitive resistor) integrated into the fuel pressure located in the fuel supply line between the fuel pump and the fuel rail. It is used to monitor the fuel temperature exiting the fuel pump to set a fault if the fuel temperature is too high resulting in increased fuel vapor from the fuel tank causing excessive evaporative emissions (for emissions regulations compliance). The ECM provides a voltage divider circuit so that when the fuel is cool, the signal reads higher voltage, and lower when warm.

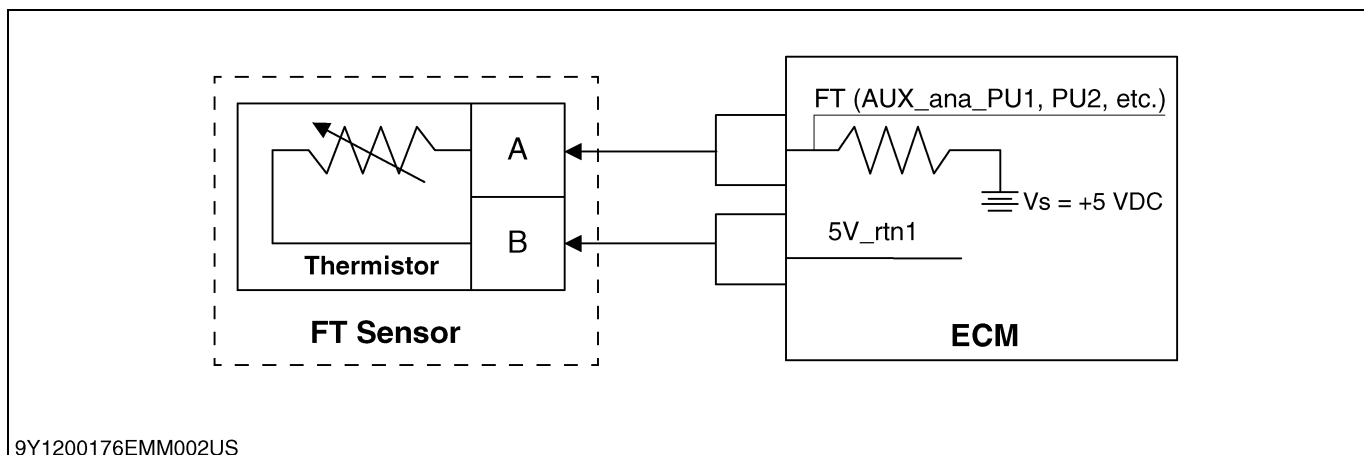
This fault will set if the signal voltage is less than 0.050 V anytime that the engine is running **OR** the indicated temperature from the sensor is below  $-37^{\circ}\text{C}$  ( $-35^{\circ}\text{F}$ ) for longer than 1 second.

**DTC 183-Fuel Temp (Gasoline) High Voltage/High Temp**

- Hardware: Liquid Fuel Temperature Sensor
- Enabling Conditions: Engine Running
- Set Conditions: FT sensor voltage higher than 4.90 V **OR** indicated temperature above 59 °C (138 °F) for longer than 2 minutes
- Corrective Action(s): Illuminate MIL and disable fuel adaptive learn for the rest of the key cycle
- Emissions related fault
- Possible Causes:
  - Voltage High: Sensor signal wire shorted to voltage, sensor open, signal circuit open or faulty ECM
  - Temperature High: Operating in a hot environment, Sensor out of calibration, unwanted resistance in signal circuit causing circuit to indicate a very hot temp (above 59 °C (138 °F)) but voltage not low enough to set a low voltage fault

The Fuel Temperature sensor is a thermistor (temperature sensitive resistor) integrated into the fuel pressure located in the fuel supply line between the fuel pump and the fuel rail. It is used to monitor the fuel temperature exiting the fuel pump to set a fault if the fuel temperature is too high resulting in increased fuel vapor from the fuel tank causing excessive evaporative emissions. The ECM provides a voltage divider circuit so that when the fuel is cool, the signal reads higher voltage, and lower when warm.

This fault will set if the signal voltage is higher than 4.90 V anytime that the engine is running **OR** the indicated temperature from the sensor is above 59 °C (138 °F) for longer than 1 second.

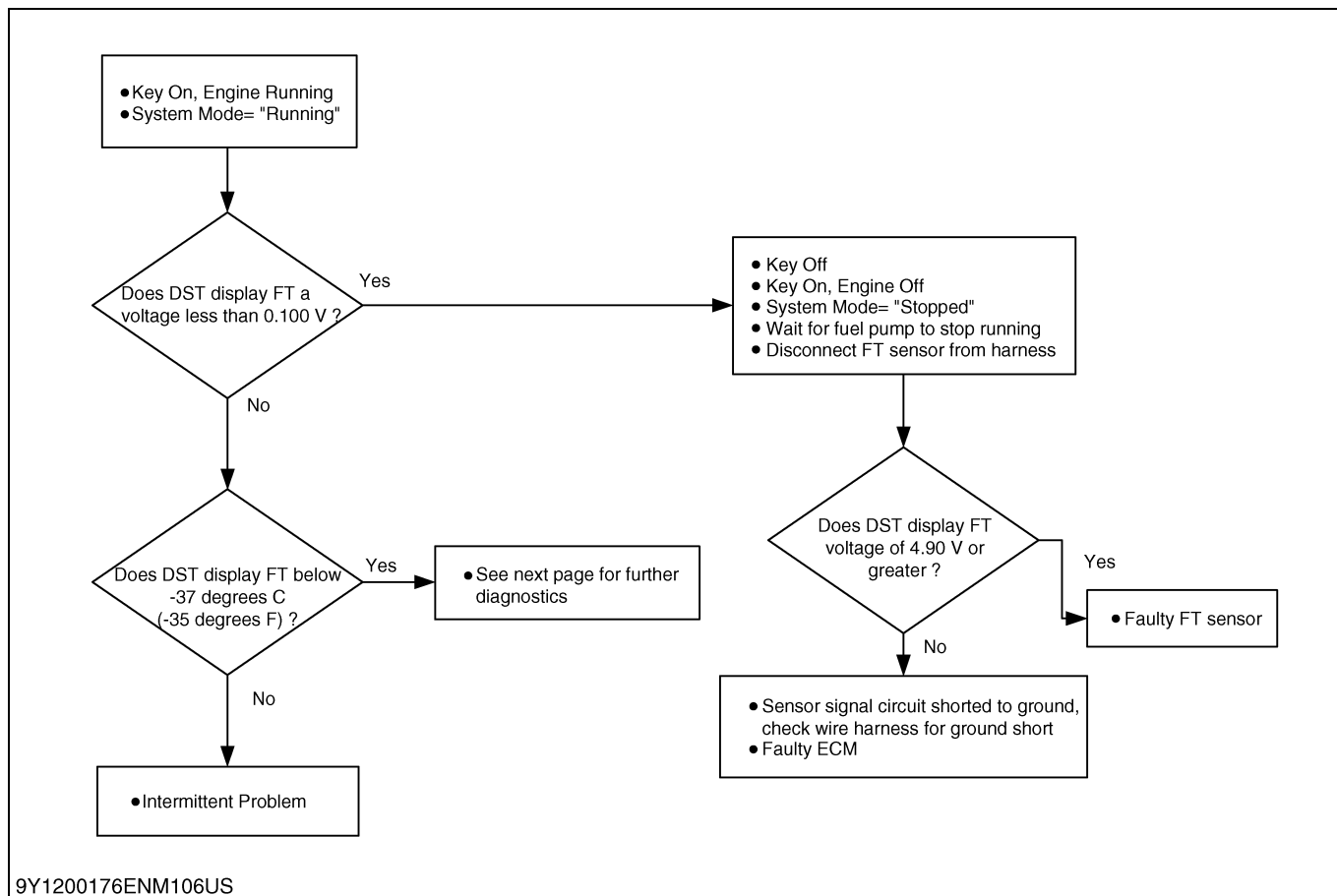
**DTC 187-BP FT Gaseous Fuel Extremely Low**

- Hardware: Gaseous Fuel Temperature Sensor (built-in DEPR)
- Enabling Conditions: Engine Running
- Set Conditions: Fuel temperature is lower than (-40 °F) for longer than 1 sec.
- Corrective Action(s): Illuminate MIL
- NO emissions related fault
- Possible Causes: Not vaporized completely



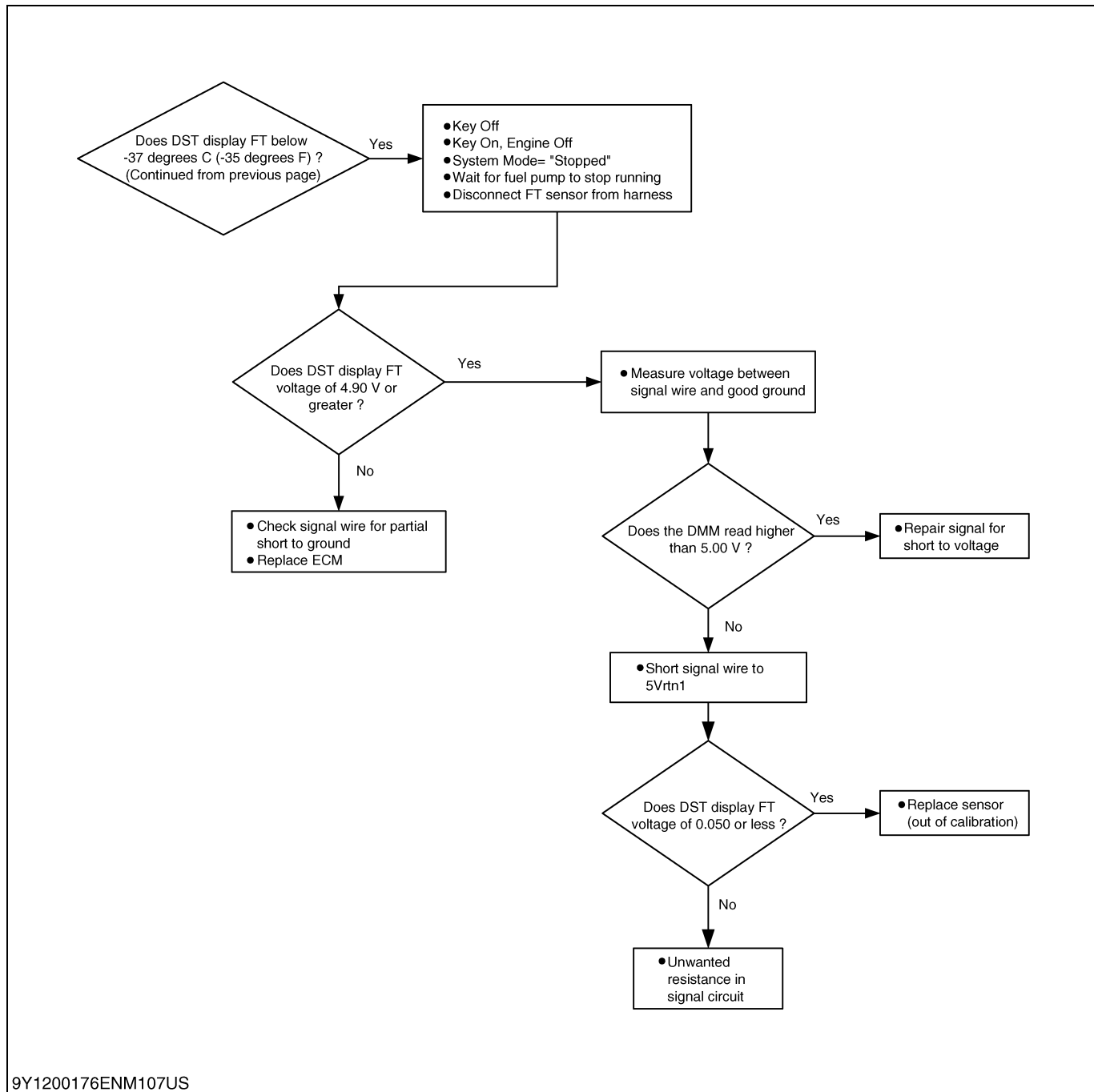
### DTC 182-Fuel Temp (Gasoline) Low Voltage/Low Temp

#### Diagnostic Aids Chart (Low Voltage/Low Temp)



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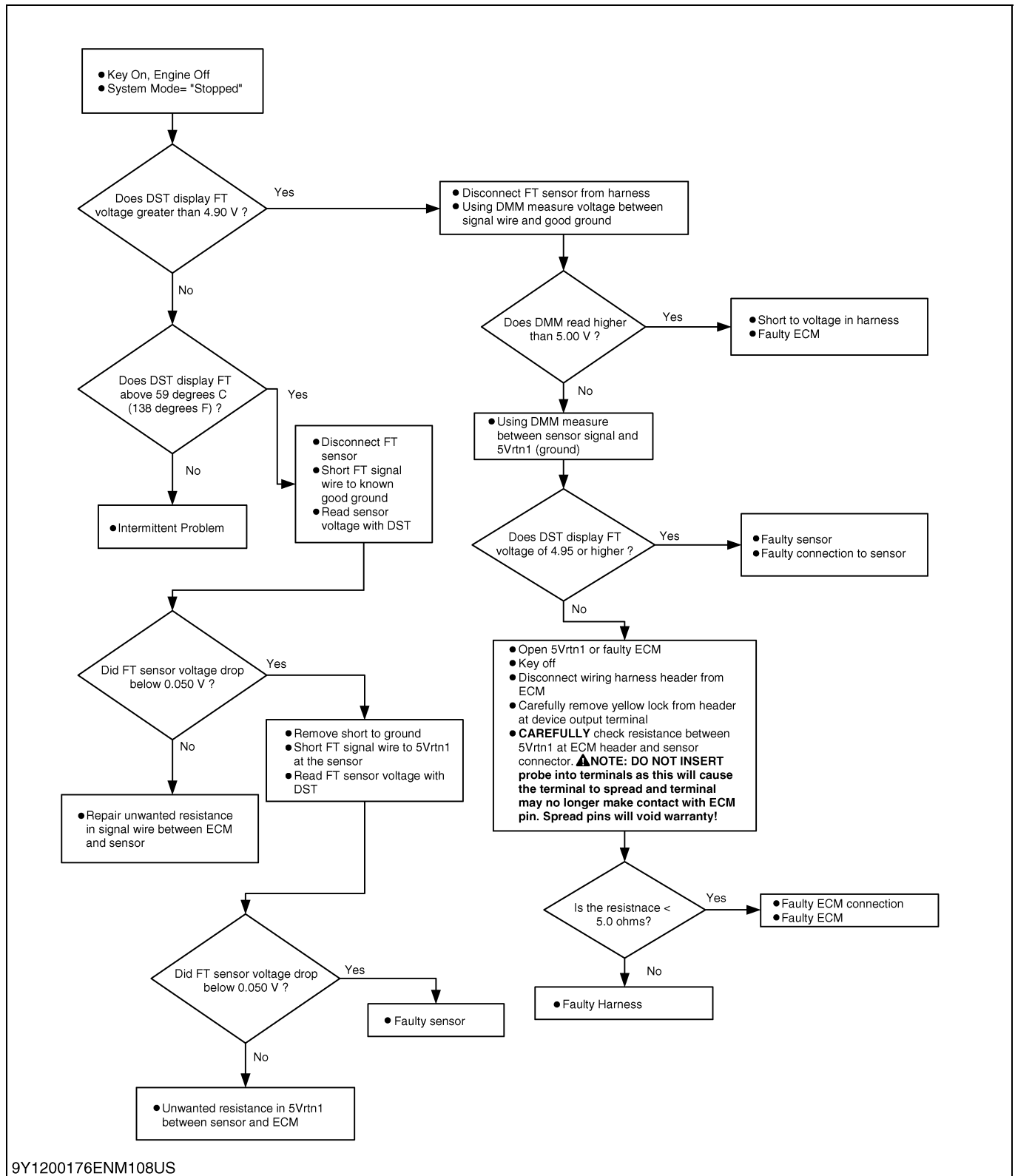
### Diagnostic Aids Chart (Low Voltage/Low Temp)

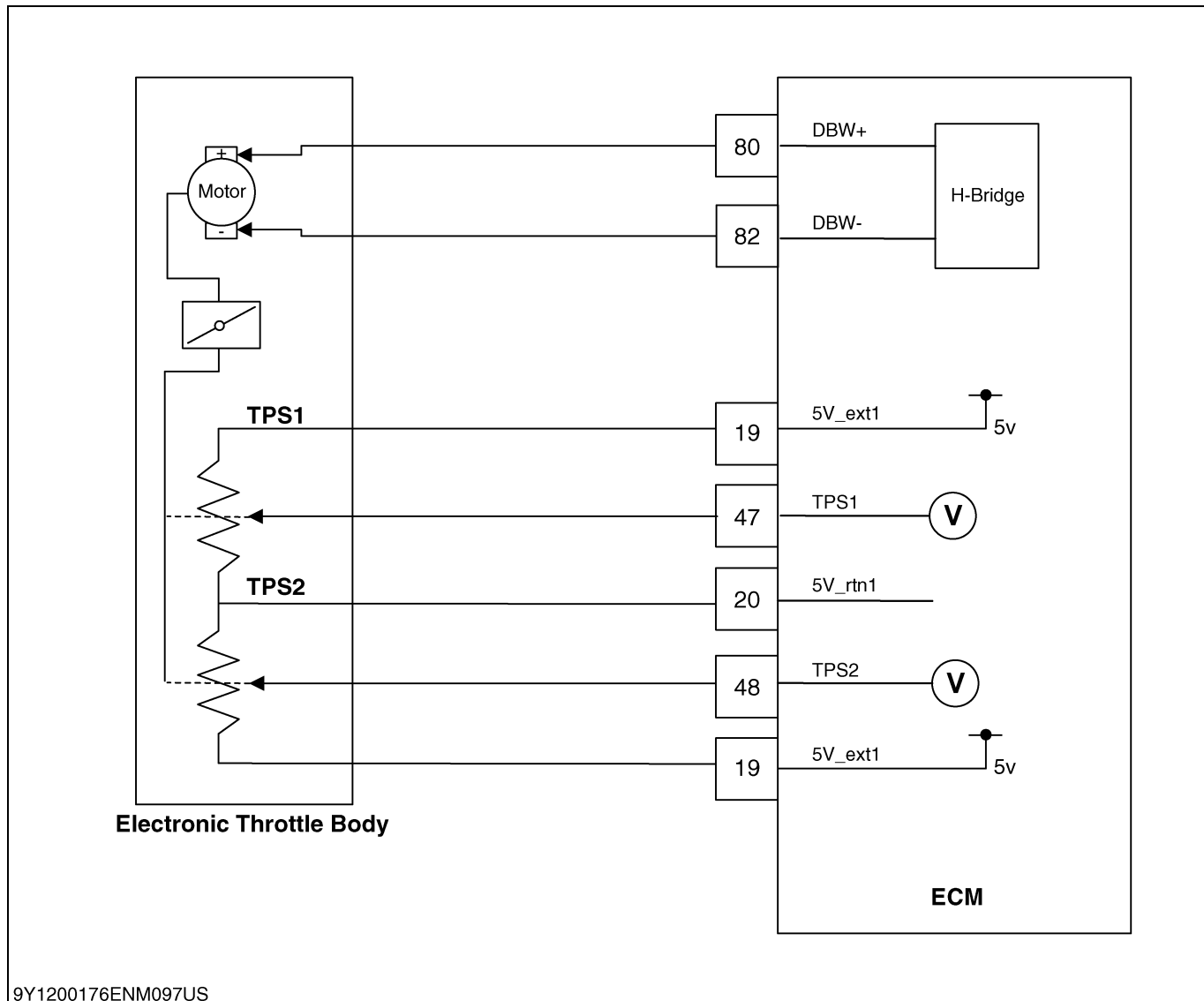


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**DTC 183-Fuel Temp (Gasoline) High Voltage/High Temp**

**Diagnostic Aids Chart**



**(10) Engine Speed (DTC 219, 1111, 1112)****DTC 219-RPM Higher Than Max Allowed Governed Speed**

- Hardware: Max Govern Speed Override- Crankshaft Position Sensor
- Enabling Conditions: Engine Running
- Fault Condition-Engine speed greater  $3900 \text{ min}^{-1}$  (rpm) for longer than 1 second
- Corrective Action(s): Illuminate MIL
- Non-emissions related fault
- Possible Causes: Engine over speed condition, stuck throttle, large vacuum leak into intake manifold after throttle blade

**DTC 1111-RPM Above Fuel Rev Limit Level**

- Hardware: Fuel Rev Limit- Crankshaft Position Sensor
- Enabling Conditions: Engine Running
- Set Conditions: Engine speed greater than the Fuel Rev Limit speed ( $4000 \text{ min}^{-1}$  (rpm)) for longer than 0.5 seconds
- Corrective Action(s): Illuminate MIL
- Non-emissions related fault
- Possible Causes: Engine over speed condition, faulty CKP sensor or input

**DTC 1112-RPM Above Spark Rev Limit Level**

- Hardware: Spark Rev Limit- Crankshaft Position Sensor
- Enabling Conditions: Engine Running
- Set Conditions: Engine speed greater than the Spark Rev Limit speed ( $4200 \text{ min}^{-1}$  (rpm)) for longer than 0.5 seconds
- Corrective Action(s): Illuminate MIL
- Non-emissions related fault
- Possible Causes: Engine over speed condition, faulty CKP sensor or input

The fault of DTC 219 will set anytime the engine RPM exceeds  $3900 \text{ min}^{-1}$  (rpm) for longer than 1 second. This fault is designed to help prevent engine or equipment damage. The throttle will be lowered in order to govern the engine to the speed set in the diagnostic calibration.

The fault of DTC 1111 will set anytime the engine RPM exceeds the limit set in the diagnostic calibration for the latch time or more. This speed overrides any higher max governor speeds programmed by the user. This fault is designed to help prevent engine or equipment damage and will disable fuel injectors or gaseous fuel actuator to reduce engine speed. The throttle will also be lowered in order to govern the engine to the speed set in the diagnostic calibration for Max Gov Override.

The fault of DTC 1112 will set anytime the engine RPM exceeds the limit set in the diagnostic calibration for the latch time or more. This speed overrides any higher max governor speeds programmed by the user. This fault is designed to help prevent engine or equipment damage and will disable the ignition coils to reduce engine speed. In addition, the throttle will be lowered in order to govern the engine to the speed set in the diagnostic calibration for Max Gov Override and the fuel injectors or gaseous fuel control actuator will be disabled to reduce the engine speed below the speed set in the diagnostic calibration for Fuel Rev Limit.

**DTC 219-RPM Higher Than Max Allowed Governed Speed****Diagnostic Aids****■ NOTE**

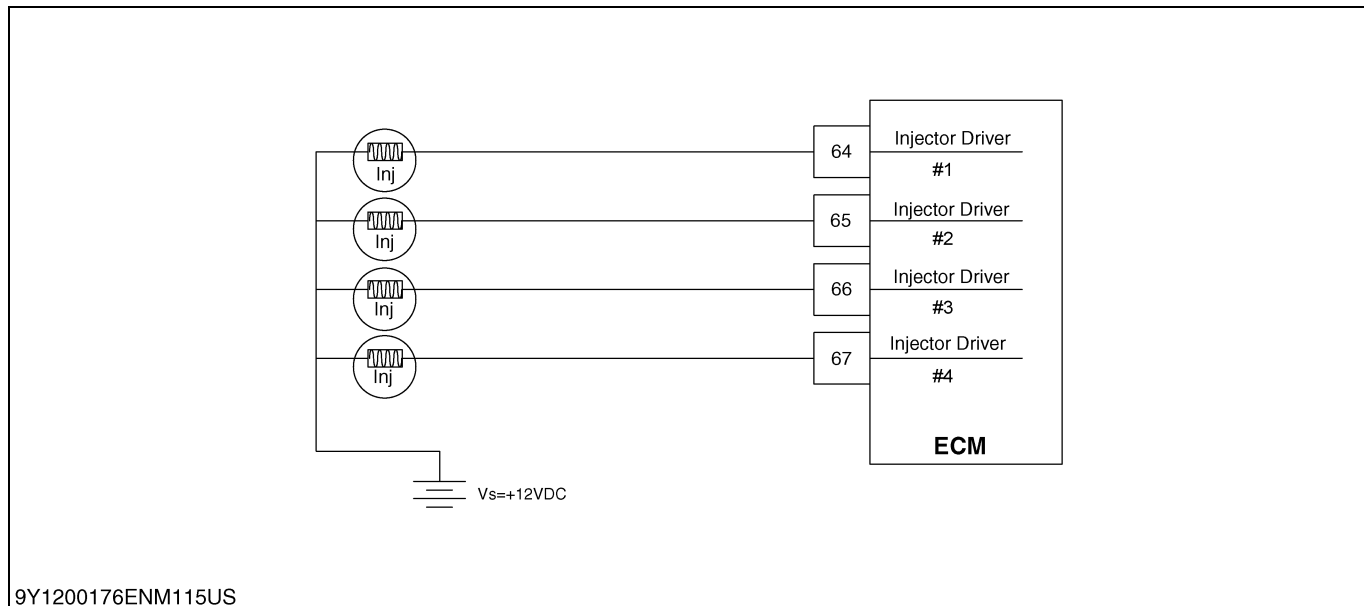
- **If any other DTCs are present, diagnose those first.**
- Ensure that no programmed governor speeds exceed the limit set in the diagnostic calibration for Max Gov Override Speed
- Check mechanical operation of the throttle
- Check the engine intake for large air leaks downstream of the throttle body

**DTC 1111-RPM Above Fuel Rev Limit Level****Diagnostic Aids****■ NOTE**

- **If any other DTCs are present, diagnose those first.**
- Ensure that no programmed governor speeds exceed the limit set in the diagnostic calibration for Max Gov Override Speed
- Check mechanical operation of the throttle
- Check the engine intake for large air leaks downstream of the throttle body

**DTC 1112-RPM Above Spark Rev Limit Level****Diagnostic Aids****■ NOTE**

- **If any other DTCs are present, diagnose those first.**
- Ensure that no programmed governor speeds exceed the limit set in the diagnostic calibration for Max Gov Override Speed
- Check mechanical operation of the throttle
- Check the engine intake for large air leaks downstream of the throttle body

**(11) Injectors (DTC 261, 262, 264, 265, 267, 268, 270, 271)****DTC 261-Injector Driver #1 Open/Short-To-Ground****DTC 264-Injector Driver #2 Open/Short-To-Ground****DTC 267-Injector Driver #3 Open/Short-To-Ground****DTC 270-Injector Driver #4 Open/Short-To-Ground**

- Hardware: Each Injector Driver (**each cylinder in the block order**)
- Enabling Conditions: Key-On, Engine Running
- Set Conditions: Battery voltage at ECM greater than 9.00 V and each injector driver off voltage less than 4.00 V for 10 samples
- Corrective Action(s): Illuminate MIL, Disable Closed Loop operation while fault is active, disable fuel adaptive learn for the rest of the key cycle.
- Emissions-related fault
- Possible Causes: Loss of 12.0 V feed to injector, open injector coil, open or shorted to ground injector driver circuit in engine harness, bad ECM

**DTC 262-Injector Driver #1 Short-To-Power****DTC 265-Injector Driver #2 Short-To-Power****DTC 268-Injector Driver #3 Short-To-Power****DTC 271-Injector Driver #4 Short-To-Power**

- Hardware: Each Injector Driver (**each cylinder in the block order**)
- Enabling Conditions: Key-On, Engine Running
- Set Conditions: Battery voltage at ECM less than 16.0 V and each injector driver on voltage greater than 4.00 V for 10 samples
- Corrective Action(s): Illuminate MIL, Disable Closed Loop operation while fault is active, disable fuel adaptive learn for the rest of the key cycle.
- Emissions-related fault
- Possible Causes: Injector coil shorted internally, injector driver circuit shorted to voltage between injector and ECM, bad ECM

The fuel injector is an electronically controlled valve and nozzle that is controlled to deliver a precise quantity of fuel to a cylinder. Each fuel injector is supplied 12.0 V from the power relay and is operated by the ECM through a low side driver (LSD) circuit that is monitored for the correct voltage for the current state of the injector (on or off).

**DTC 261-Injector Driver #1 Open/Short-To-Ground**

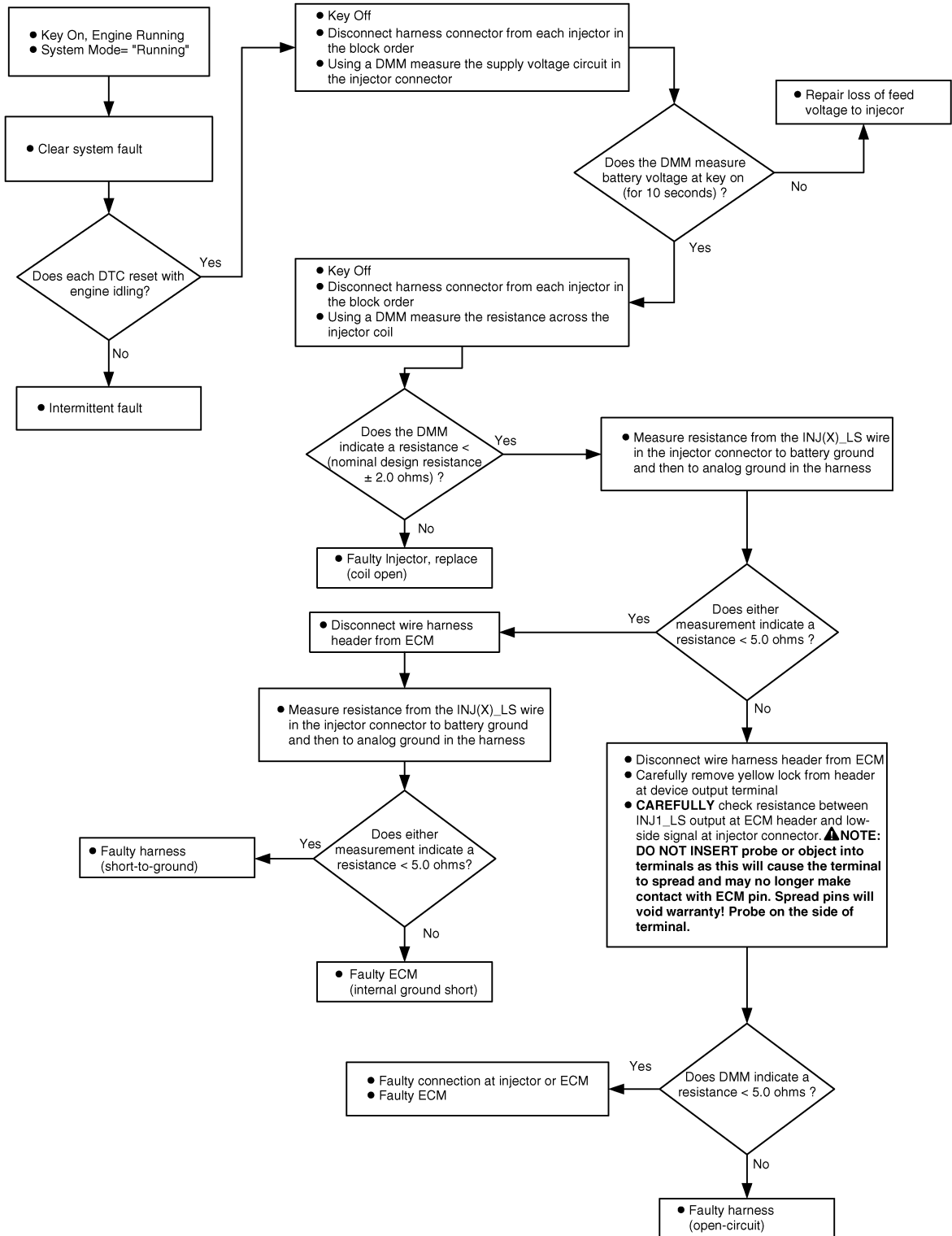
**DTC 264-Injector Driver #2 Open/Short-To-Ground**

**DTC 267-Injector Driver #3 Open/Short-To-Ground**

**DTC 270-Injector Driver #4 Open/Short-To-Ground**

**Diagnostic Aids Chart**

**Firing Order Example**



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**DTC 262-Injector Driver #1 Short-To-Power**

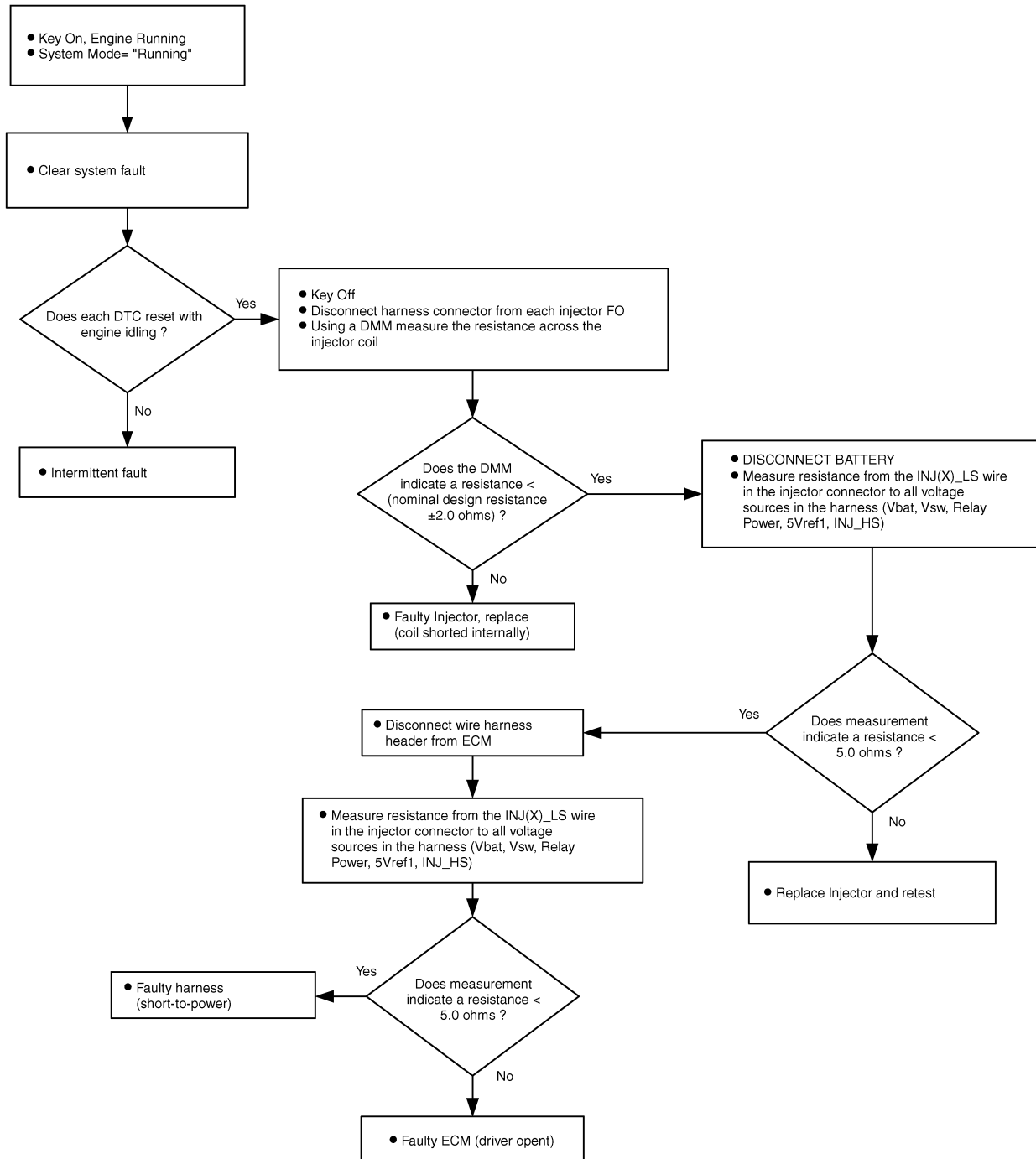
**DTC 265-Injector Driver #2 Short-To-Power**

**DTC 268-Injector Driver #3 Short-To-Power**

**DTC 271-Injector Driver #4 Short-To-Power**

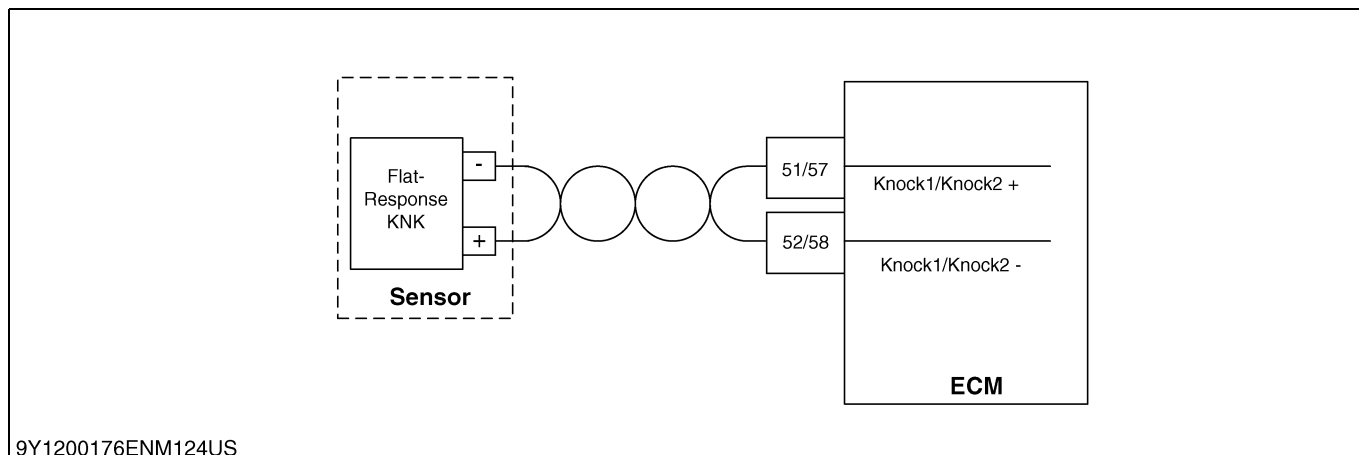
**Diagnostic Aids Chart**

**Firing Order Example**





## (12) Knock Sensor (DTC 326, 327)



### DTC 326-Knock 1 Excessive or Erratic Signal

- Hardware: Knock sensor #1
- Enabling Conditions: Key On, Engine On
- Set Conditions: Knock sensor 1 voltage above 2.00 V with MAP less than 62 kPa [abs] (0.63 kgf/cm<sup>2</sup>, 9 psia) and knock retard is a maximum retard value for longer than 3 seconds.
- Corrective Action(s): Illuminate MIL
- Emissions related fault
- Possible Causes: Internal engine damage causing audible noise, knock sensor signal wire routed too close to spark plug wire, bad sensor, bad ECM

The knock sensor is used to detect detonation through mechanical vibration in the engine block and/or cylinder heads and provide feedback for the ignition system to retard spark to reduce knock intensity. The knock sensor is used to protect the engine from damage that can be caused from detonation or knock based on fixed spark advance.

This fault sets if the signal from knock sensor 1 is higher than expected for low load operation as defined in calibration. If this fault sets, spark is lowered by the amount defined in calibration for Faulted KNK Retard.

### DTC 327-Knock 1 Sensor Open or Not Present

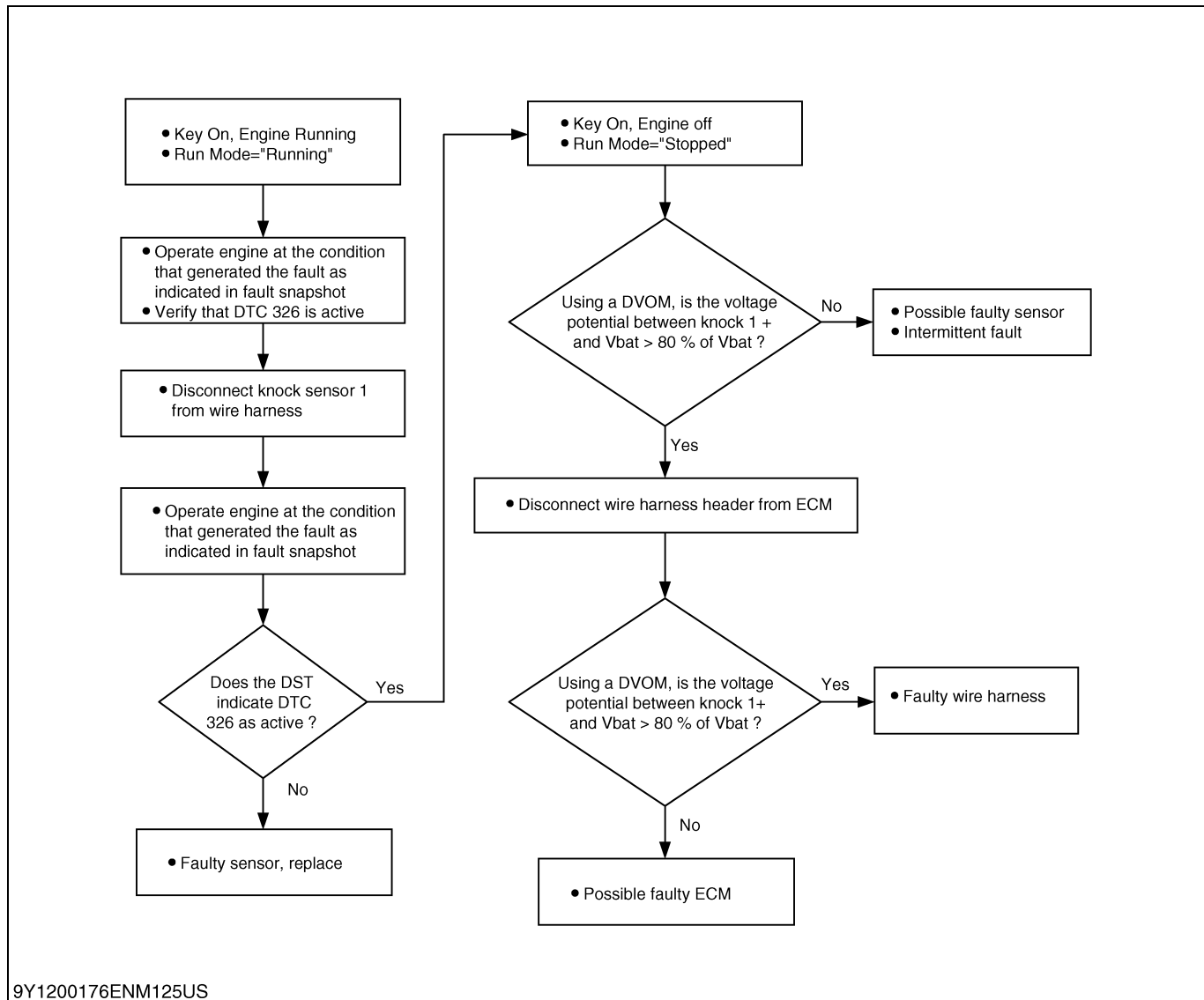
- Hardware: Knock sensor #1
- Enabling Conditions: Key On, Engine On
- Set Conditions: Knock sensor 1 signal below 0.005 V, rpm above 2000 min<sup>-1</sup> (rpm) and MAP above 83 kPa [abs] (0.84 kgf/cm<sup>2</sup>, 12 psia) for longer than 3 seconds.
- Corrective Action(s): Illuminate MIL
- Emissions related fault
- Possible Causes: Knock sensor open internally, signal circuit open or shorted to ground or bad ECM

The knock sensor is used to detect detonation through mechanical vibration in the engine block and/or cylinder heads and provide feedback for the ignition system to retard spark to reduce knock intensity. In most applications the knock sensor is used to protect the engine from damage that can be caused from detonation or knock based on fixed spark advance. In other applications, the knock sensor is used to optimize spark advance and "learn" between spark tables based on fuel quality.

This fault sets if the signal from knock sensor 1 is lower than expected for higher speed and load operation as defined in calibration. If this fault sets, spark is lowered by the amount defined in calibration for Faulted KNK Retard.

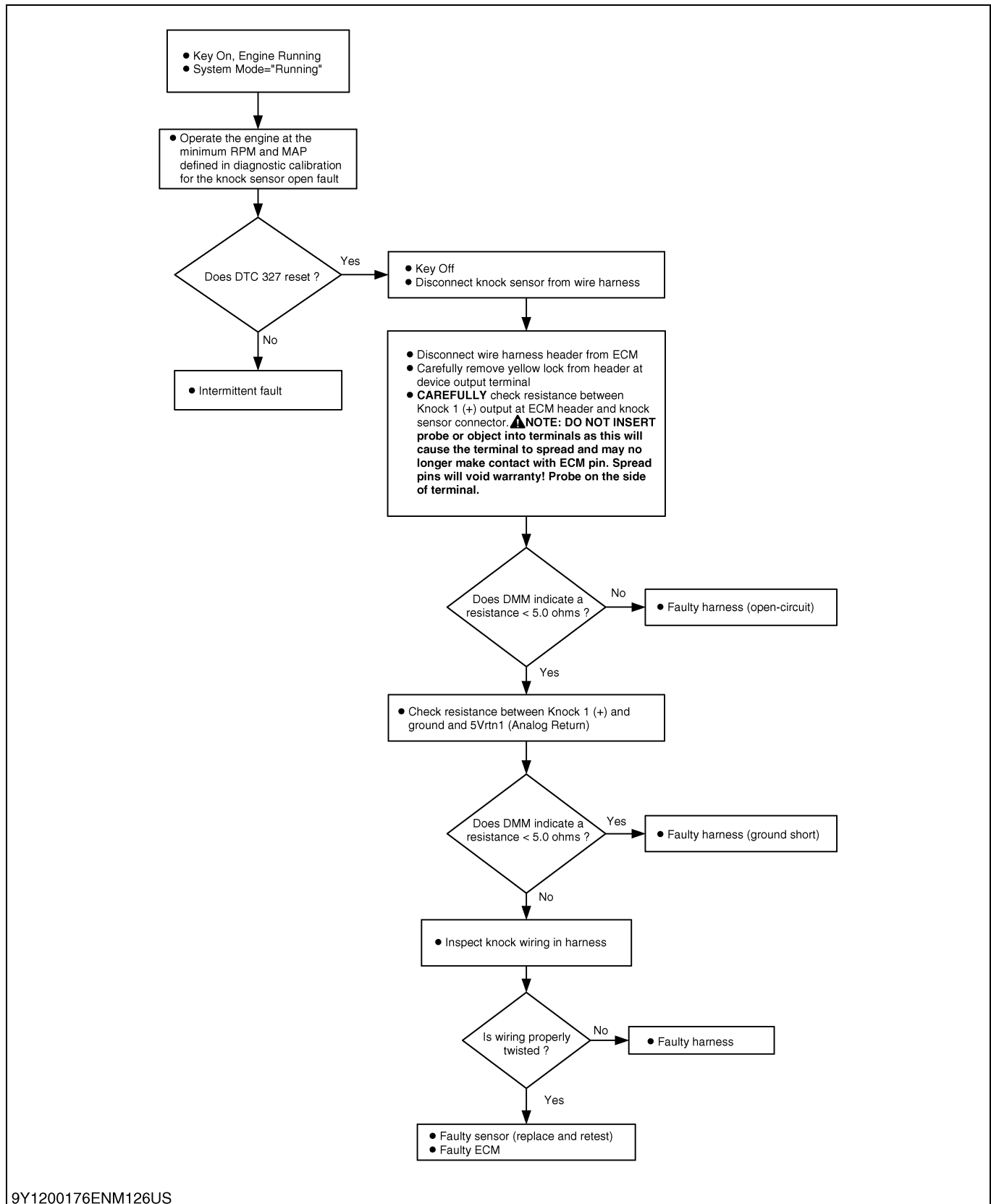
### DTC 326-Knock 1 Excessive or Erratic Signal

#### Diagnostic Aids Chart

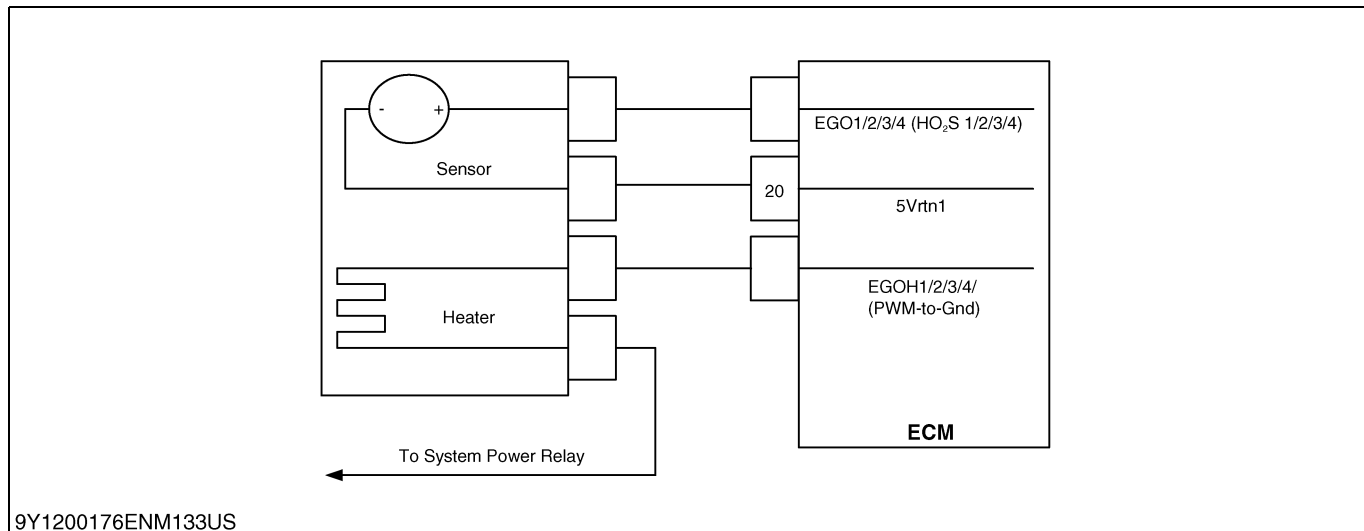


**DTC 327-Knock 1 Sensor Open or Not Present**

**Diagnostic Aids Chart**



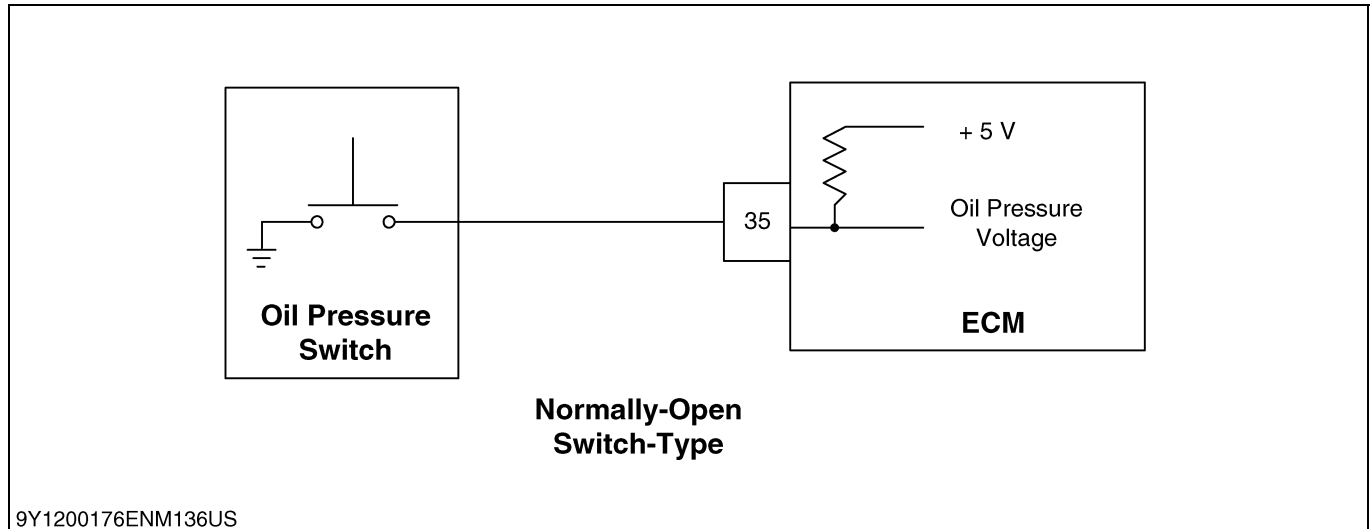
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**(13) Catalyst Monitor (DTC 420, 1165, 1166)****DTC 420-Catalyst Inactive on Gasoline (Bank1)**

- Hardware: Bank 1 Pre-Catalyst Exhaust Gas Oxygen Sensor and Bank 1 Post-Catalyst Exhaust Gas Oxygen Sensor
- Enabling Conditions: Engine Running
- Set Conditions: Bank 1 catalyst inactive on gasoline or LPG / natural gas engine
- Corrective Action(s): Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp.
- Emissions related fault
- Possible Causes: Physically damaged catalyst element, contaminated catalyst element or post catalyst oxygen sensor signal circuit shorted to pre-catalyst oxygen sensor signal circuit

**DTC 1165-Catalyst Inactive on LPG****DTC 1165-Catalyst Inactive on NG**

- Hardware: Bank 1 Catalyst, Heated or Universal Exhaust Gas Oxygen Sensor (Bank 1-Sensor 2-After Catalyst)
- Enabling Conditions: Engine Running
- Set Conditions: Catalyst inactive on LPG (NG)
- Corrective Action(s): Illuminate MIL, disable fuel adaptive learn and closed loop while fault is active
- Emissions related fault
- Possible Causes: Physically damaged catalyst element, contaminated catalyst element

**(14) Oil Pressure Sensor (DTC 524)****DTC 524-Oil Pressure Low**

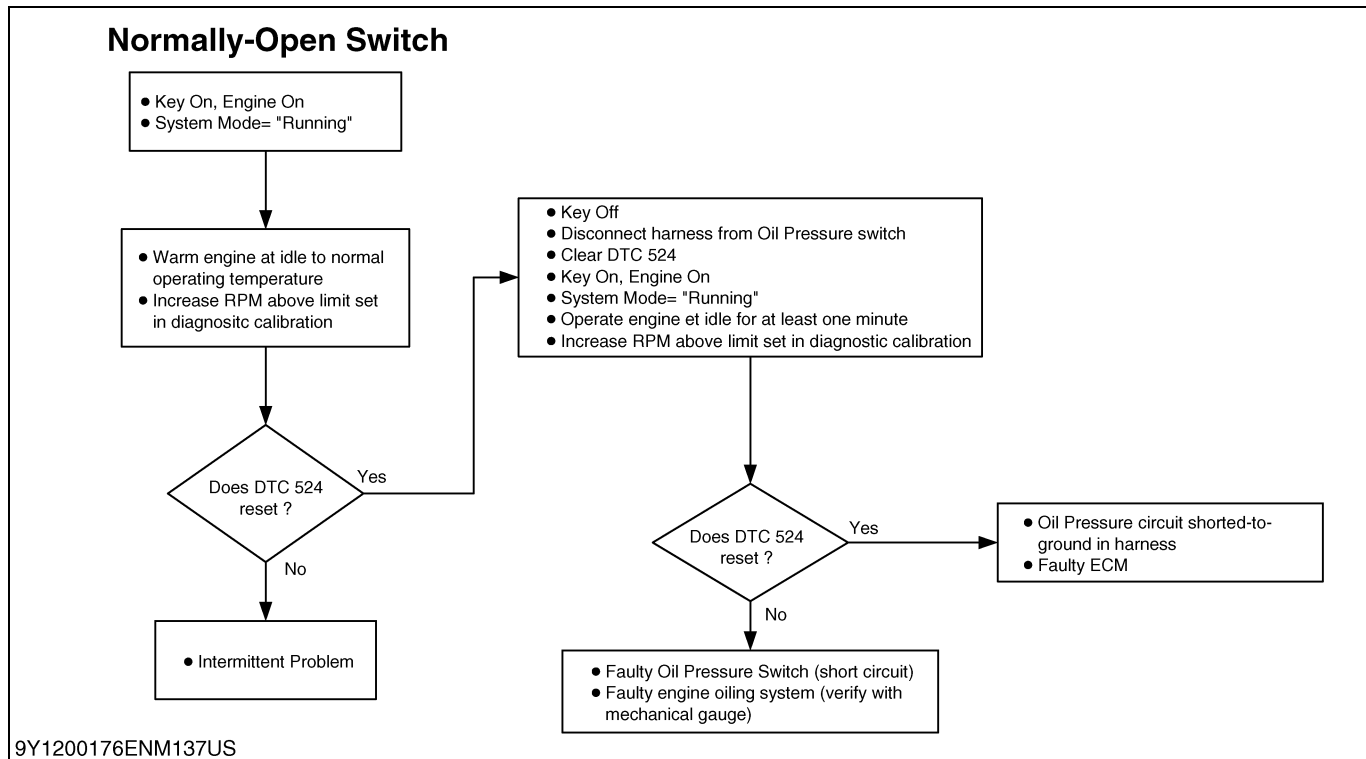
- Hardware: Engine Oil Pressure Sensor or Switch
- Enabling Conditions: Key on, Engine Running longer than 15 seconds and running higher than 1300 min<sup>-1</sup> (rpm)
- Set Conditions: Engine oil pressure switch circuit < 2.50 V for longer than 3 seconds
- Corrective Action(s): Illuminate MIL and initiate an engine shutdown
- Non-emissions related fault
- Possible Causes: Oil pressure problem with engine, oil pressure switch failure, oil pressure switch circuit shorted to ground, faulty ECM

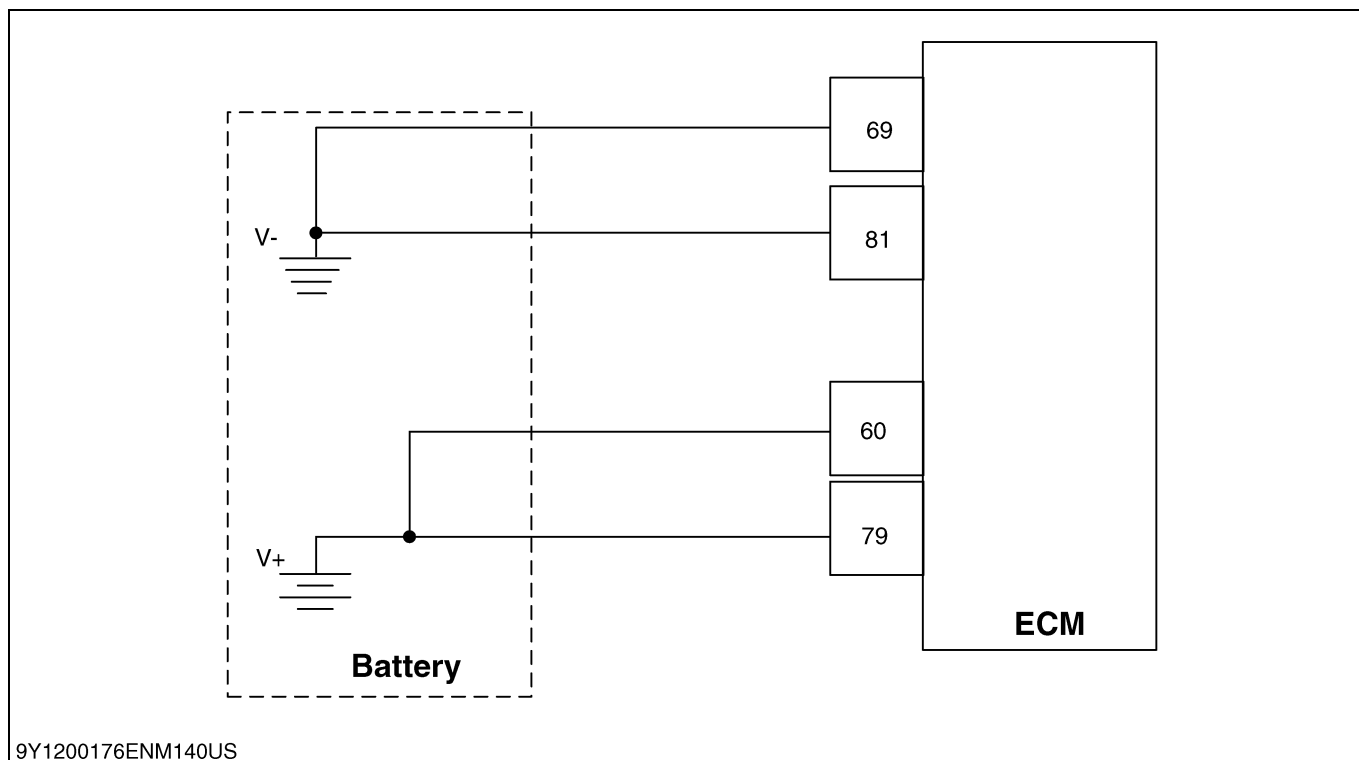
The ECM can be configured to monitor oil pressure through a switch. Oil pressure monitoring is important to prevent engine damage due to low oil pressure resulting in higher friction and lack of lubrication. In addition, high oil pressure can be undesirable because it can cause oil to leak past seals and rings, can be a result of a restriction in the oil flow path, or can be a sign of a malfunctioning oiling system.

If the switch is normally open, the fault will set if the circuit becomes grounded. Go to the Faults page in EDIS to determine how the input is configured. ("Open=OK" is normally open). The engine will should be configured to derate or force idle and/or shut down in the event of this fault to help prevent possible damage.

### DTC 524-Oil Pressure Low

#### Diagnostic Aids Chart



**(15) Battery Voltage (DTC 562, 563)****DTC 562-Battery Voltage (VBat) Low**

- Hardware: System voltage to ECM
- Enabling Conditions: Key on, Engine running above 1000 min<sup>-1</sup> (rpm)
- Set Conditions: Battery voltage to ECM less than 9.00 V for longer than 5 seconds
- Corrective Action(s): Illuminate MIL and disable fuel adaptive learn for the remainder of key cycle
- Non-emissions related fault
- Possible Causes: Low charging system output, low voltage input into ECM, faulty battery

**DTC 563-Battery Voltage (VBat) High**

- Hardware: System voltage to ECM
- Enabling Conditions: Key on, Engine running
- Set Conditions: Battery voltage to ECM greater than 16.0 V for longer than 3 seconds while the engine is running
- Corrective Action(s): Illuminate MIL and disable fuel adaptive learn for remainder of key cycle
- Non-emissions related fault
- Possible Causes: Charging system overcharging

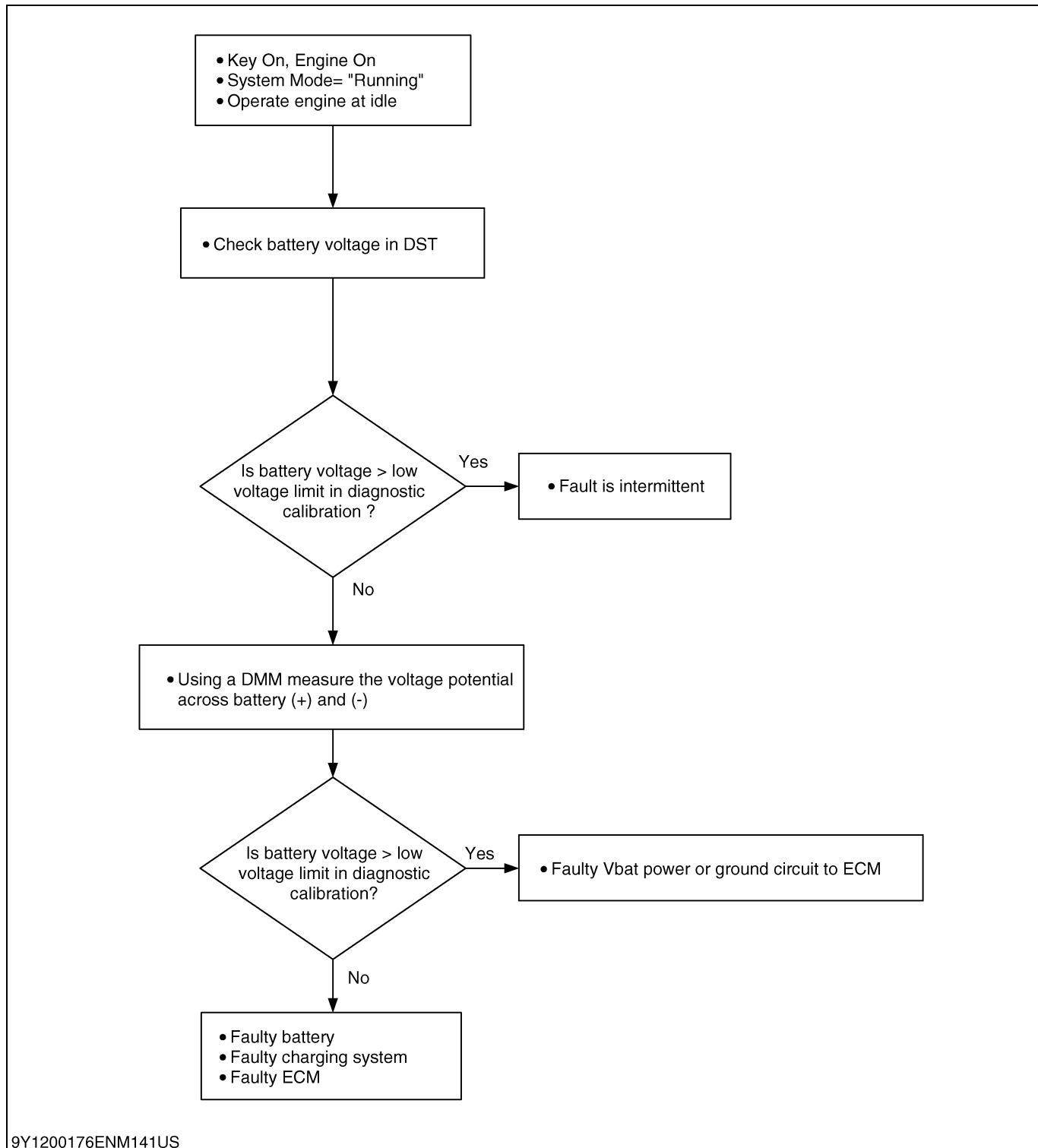
The battery voltage powers the ECM and must be within limits to correctly operate injector drivers, ignition coils, throttle, power supplies, and other powered devices that the ECM controls.

The fault of DTC 562 will set if the ECM detects system voltage less than 9.00 V while the engine is operating at above 1000 min<sup>-1</sup> (rpm) as defined in the diagnostic calibration as the alternator should be charging the system. The adaptive learn is disabled to avoid improper adaptive learning due to the inability to correctly time injector firings.

The fault of DTC 563 will set if the ECM detects system voltage greater than 16.0 V for longer than 3 seconds while the engine is running. The adaptive learn is disabled to avoid improper adaptive learning.

**DTC 562-Battery Voltage (VBat) Low**

**Diagnostic Aids Chart**

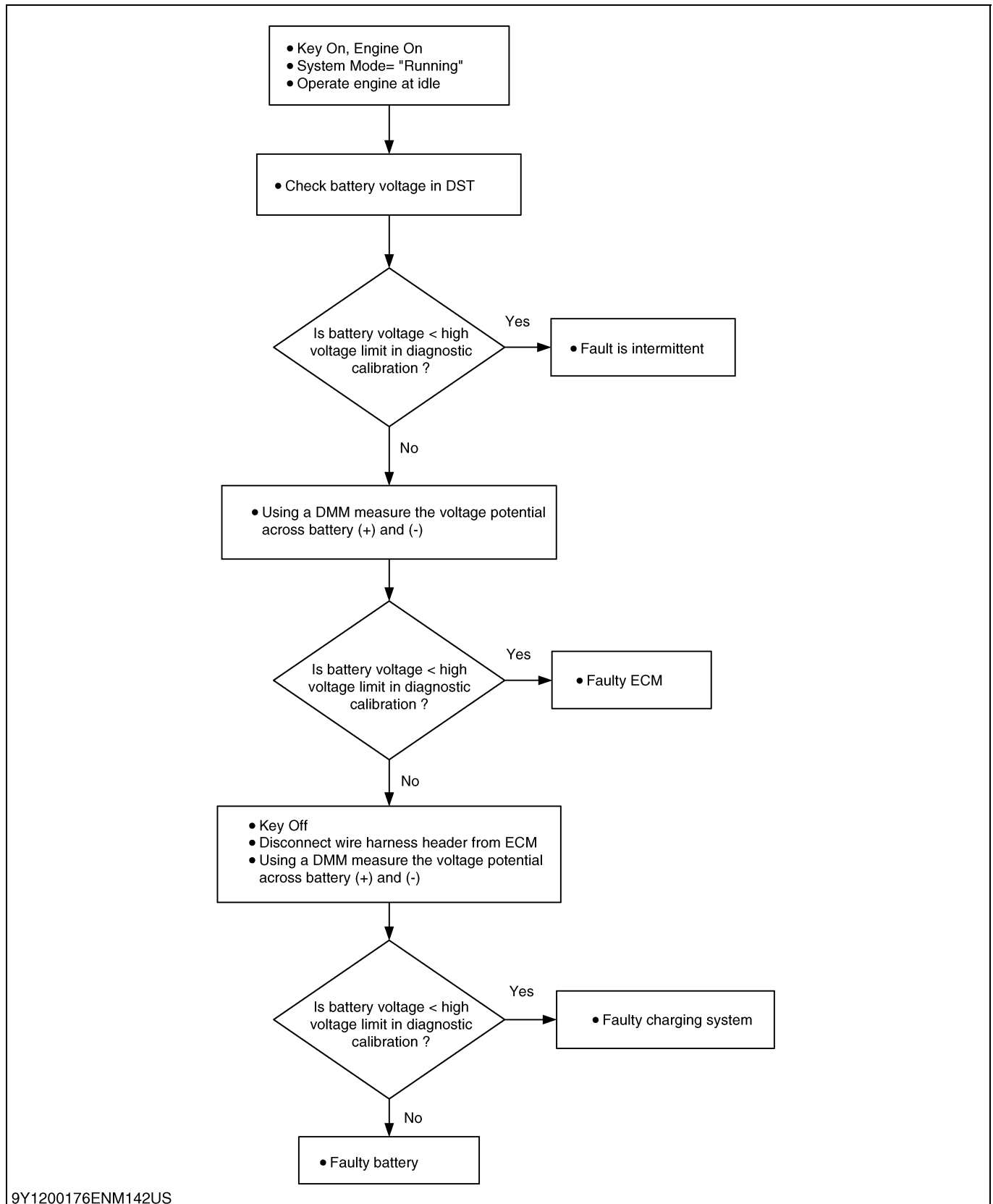


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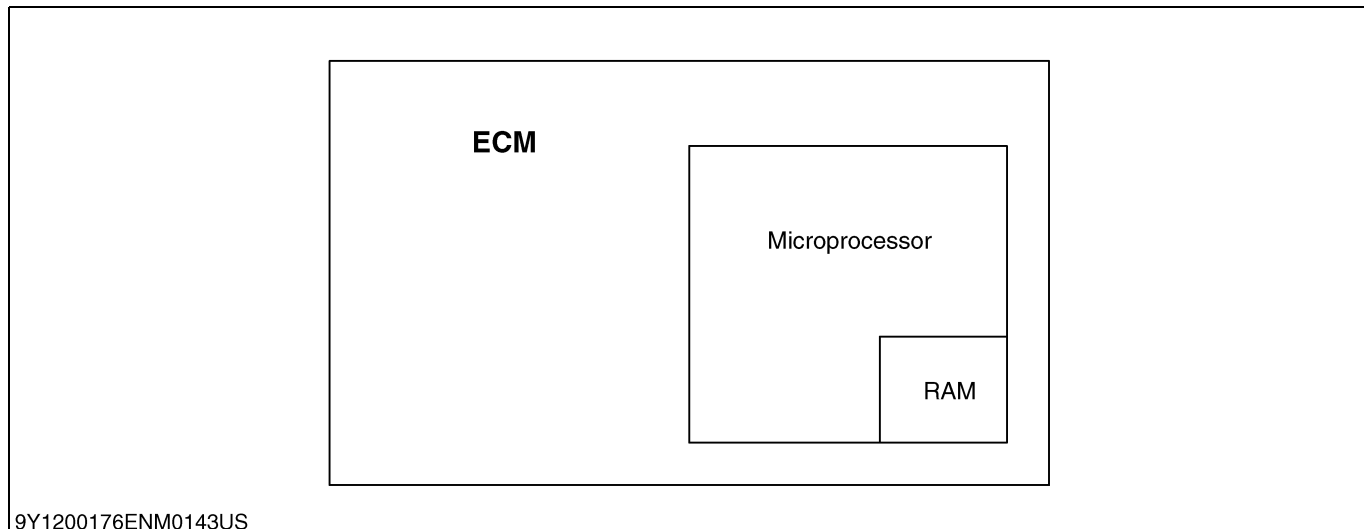
**DTC 563-Battery Voltage (VBat) High**

**Diagnostic Aids Chart**



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## (16) Internal Processor Diagnostics (DTC 601, 604, 606, 1612 to 1616, 1673)



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### **DTC 601-Microprocessor Failure-FLASH**

- Hardware: Engine Control Module-Flash Memory
- Enabling Conditions: Key on
- Set Conditions: Internal microprocessor error
- Corrective Action(s): Illuminate MIL, disable fuel adaptive learn for remainder of key cycle, activate power derate 2 and never forget code (code must be manually erased by technician with DST)
- Non-emissions related fault
- Possible Causes: Faulty ECM

The ECM has checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault.

If this fault sets, the ECM will reset itself and log the code. A fault of flash memory can occur for any calibration variable set and thus could cause undesirable operation.

### **DTC 604-Microprocessor Failure-RAM**

- Hardware: Engine Control Module-Random Access Memory
- Enabling Conditions: Key on
- Set Conditions: Internal ECM microprocessor memory access failure
- Corrective Action(s): Illuminate MIL, disable fuel adaptive learn for remainder of key cycle, activate power derate 2 and never forget code (code must be manually erased by technician with a DST)
- Non-emissions related fault
- Possible Causes: Faulty ECM

Random Access Memory is located within the microprocessor and can be read from or written to at any time. Data stored in RAM include DTCs (when fault configuration is set to "Battery Power Retained"), adaptive fuel learn tables, octane adaptation table, misfire adaptation tables, and closed loop fuel multipliers. The ECM has checks that must be satisfied each time an instruction is executed.

This fault will set if the ECM detects a problem accessing or writing information to RAM. If this fault sets, the ECM will reset itself and log the code. This fault should be erased by a technician after diagnostics are performed.

### **DTC 606-Microprocessor Failure-COP**

- Hardware: Engine Control Module
- Enabling Conditions: Key on
- Set Conditions: Internal microprocessor error
- Corrective Action(s): Illuminate MIL, disable fuel adaptive learn for remainder of key cycle, activate power derate 2 and never forget code (code must be manually erased by technician with a DST)
- Non-emissions related fault
- Possible Causes: Faulty ECM

The ECM has checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault.

If this fault sets, the ECM will reset itself and log the code.

### **DTC 1612-Microprocessor Failure-RTI 1**

- Hardware: Engine Control Module
- Enabling Conditions: Key on
- Set Conditions: Internal microprocessor error
- Corrective Action(s): MIL- On, fuel adaptive learn disabled and power derate 2 while code is active fault remembered until fault is cleared manually with a scan tool
- Non-emissions related fault
- Possible Causes: Faulty ECM

The ECM has checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased after diagnosis using a scan tool. It will not self-erase.

During this active fault, Power Derate 2 will be enforced. When this is enforced, maximum throttle position will be 15 %.

### **DTC 1613-Microprocessor Failure-RTI 2**

- Hardware: Engine Control Module
- Enabling Conditions: Key on
- Set Conditions: Internal microprocessor error
- Corrective Action(s): MIL- On, fuel adaptive learn disabled and power derate 2 while code is active fault remembered until fault is cleared manually with a scan tool
- Non-emissions related fault
- Possible Causes: Faulty ECM

The ECM has checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased after diagnosis using a scan tool. It will not self-erase.

During this active fault, Power Derate 2 will be enforced. When this is enforced, maximum throttle position will be 15 %.

### **DTC 1614-Microprocessor Failure-RTI 3**

- Hardware: Engine Control Module
- Enabling Conditions: Key on
- Set Conditions: Internal microprocessor error
- Corrective Action(s): MIL- On, fuel adaptive learn disabled and power derate 2 while code is active fault remembered until fault is cleared manually with a scan tool
- Non-emissions related fault
- Possible Causes: Faulty ECM

The ECM has checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased after diagnosis using a scan tool. It will not self-erase.

During this active fault, Power Derate 2 will be enforced. When this is enforced, maximum throttle position will be 15 %.

**DTC 1615-Microprocessor Failure-A/D**

- Hardware: Engine Control Module
- Enabling Conditions: Key on
- Set Conditions: Internal microprocessor error
- Corrective Action(s): MIL- On, fuel adaptive learn disabled and power derate 2 while code is active fault remembered until fault is cleared manually with a scan tool
- Non-emissions related fault
- Possible Causes: Faulty ECM

The ECM has checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased after diagnosis using a scan tool. It will not self-erase.

During this active fault, Power Derate 2 will be enforced. When this is enforced, maximum throttle position will be 15 %.

**DTC 1616-Microprocessor Failure-Interrupt**

- Hardware: Engine Control Module
- Enabling Conditions: Key on
- Set Conditions: Internal microprocessor error
- Corrective Action(s): MIL- On, fuel adaptive learn disabled and power derate 2 while code is active fault remembered until fault is cleared manually with a scan tool
- Non-emissions related fault
- Possible Causes: Faulty ECM

**DTC 1673-Calibration Configuration Error**

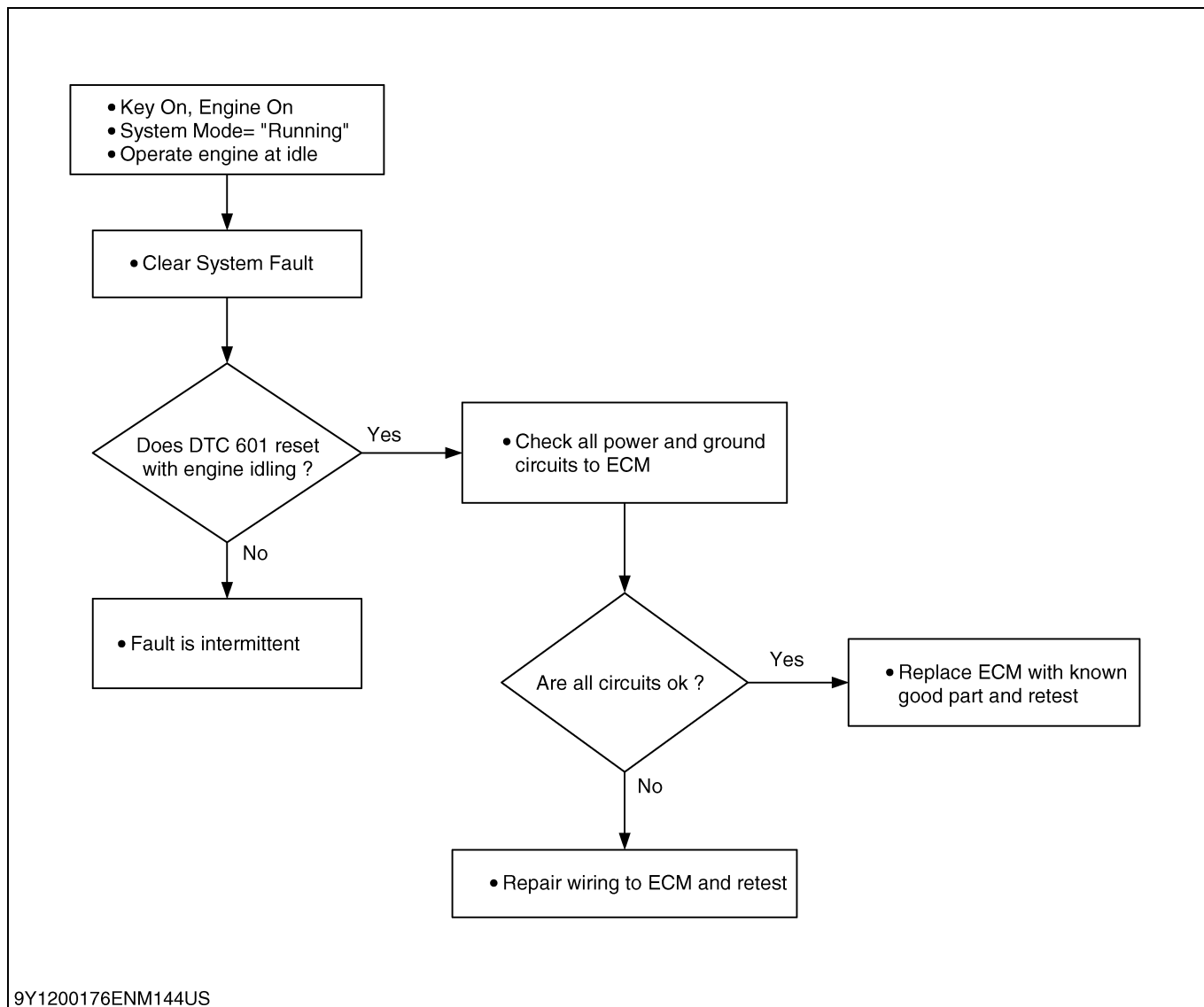
- Hardware: Engine Control Module
- Enabling Conditions: Key on
- Set Conditions: Specific calibration variable checks do not return expected results
- Corrective Action(s): Illuminate MIL, Never forget, AL disable in key cycle, Power derate 2
- Emissions related fault
- Possible Causes: Faulty ECM

The ECM has checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased after diagnosis using a scan tool. It will not self-erase.

During this active fault, Power Derate 2 will be enforced. When this is enforced, maximum throttle position will be 15 %.

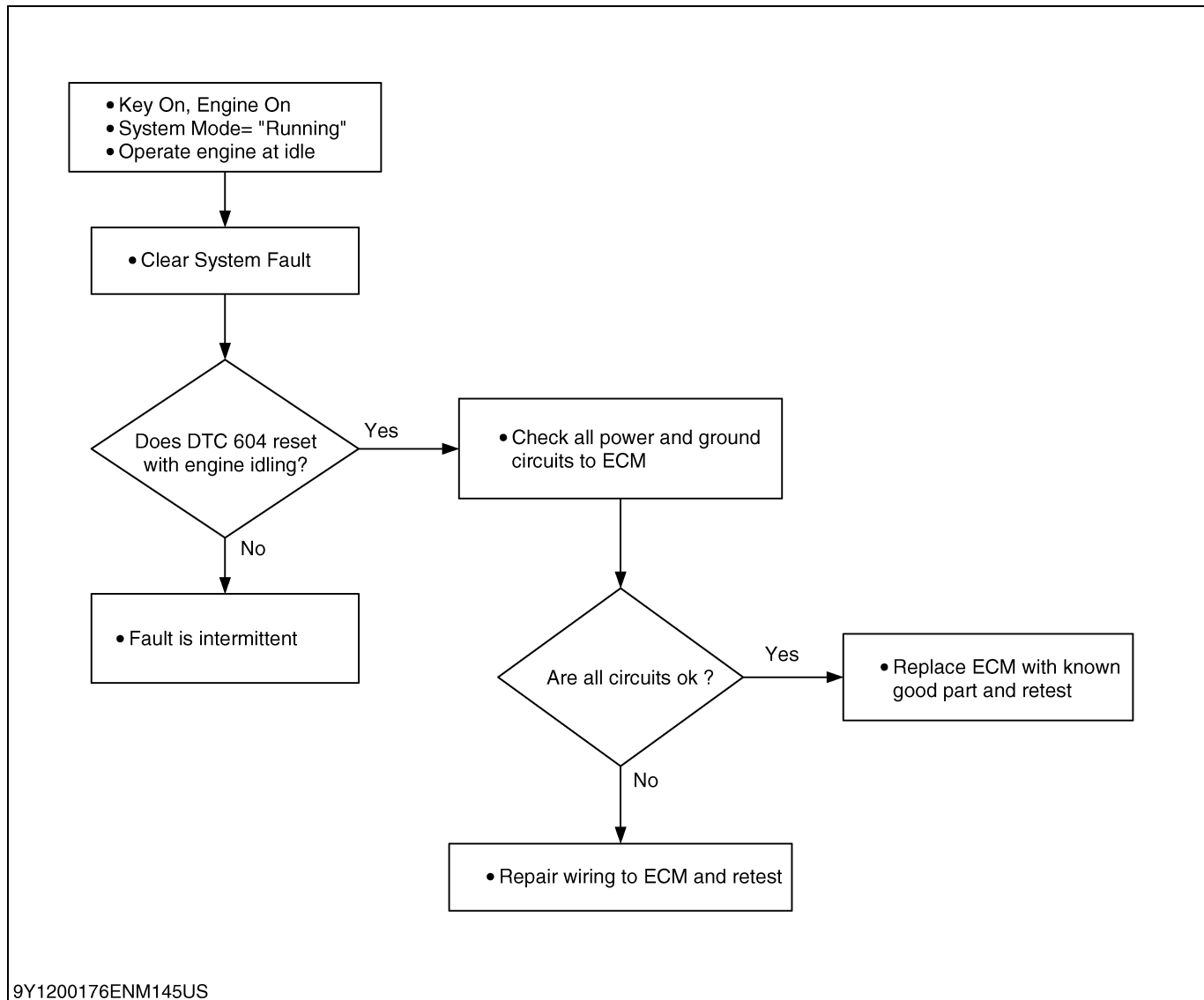
**DTC 601-Microprocessor Failure-FLASH**

**Diagnostic Aids Chart**



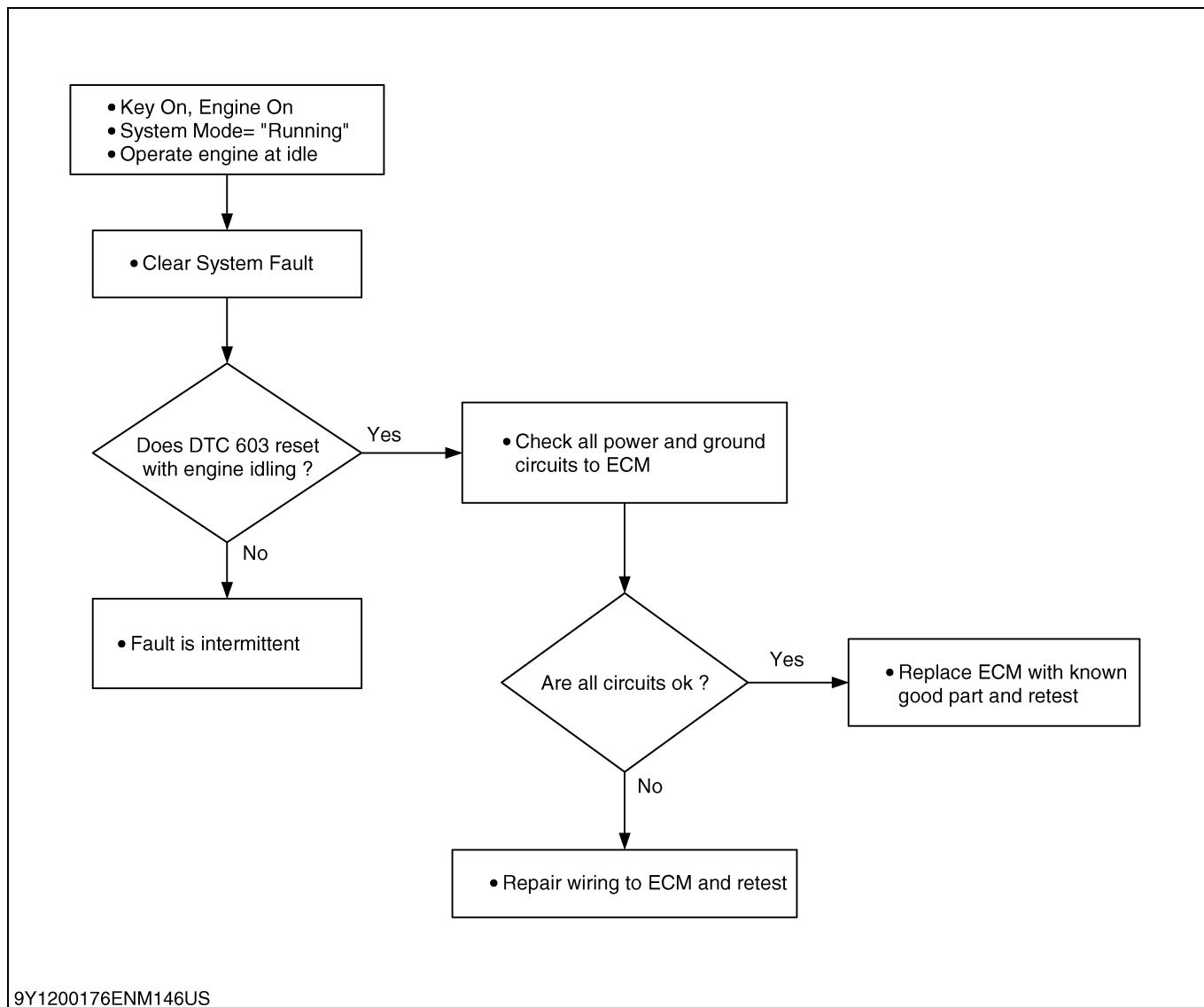
**DTC 604-Microprocessor Failure-RAM**

**Diagnostic Aids Chart**



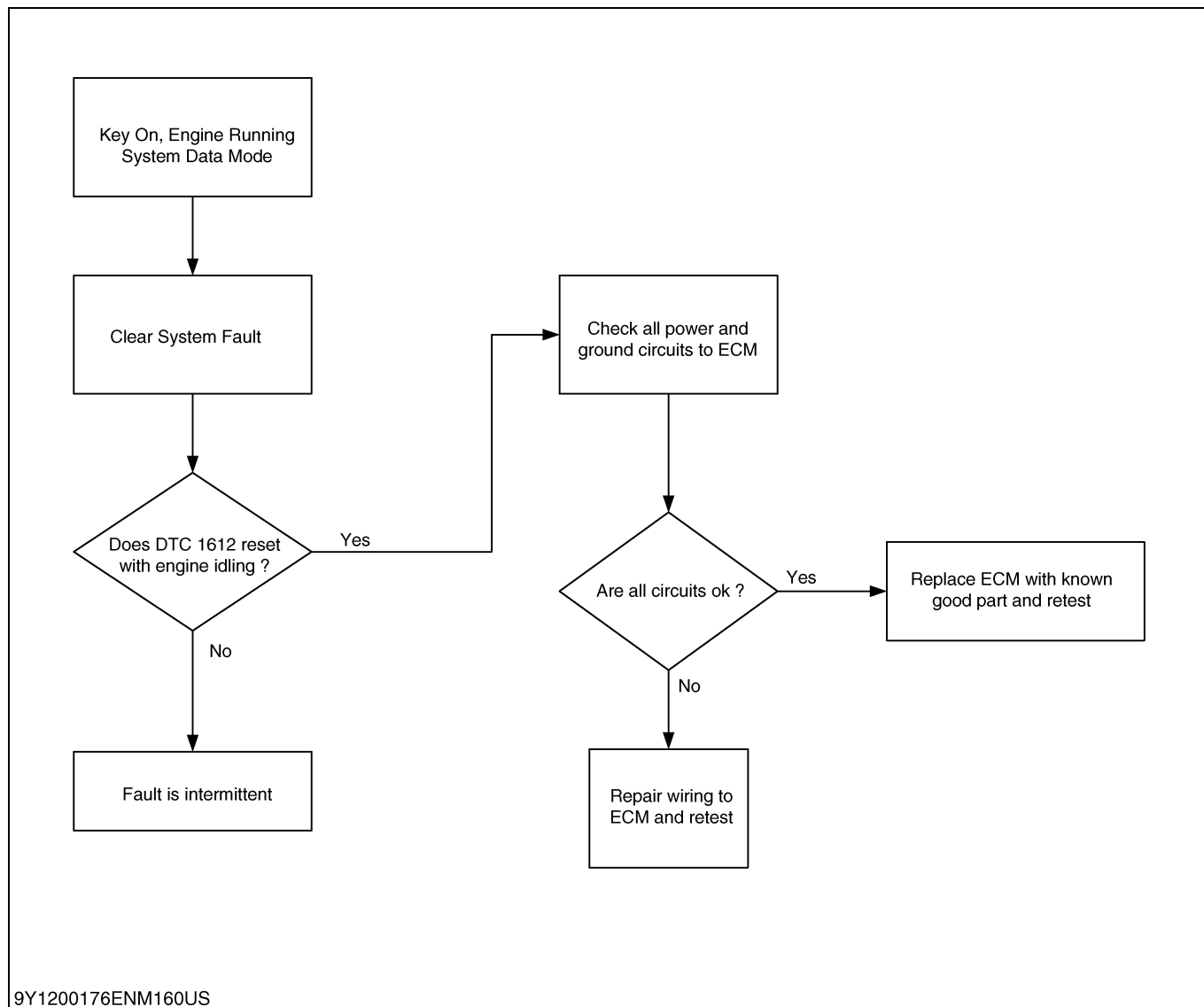
**DTC 606-Microprocessor Failure-COP**

**Diagnostic Aids Chart**



**DTC 1612-Microprocessor Failure-RTI 1**

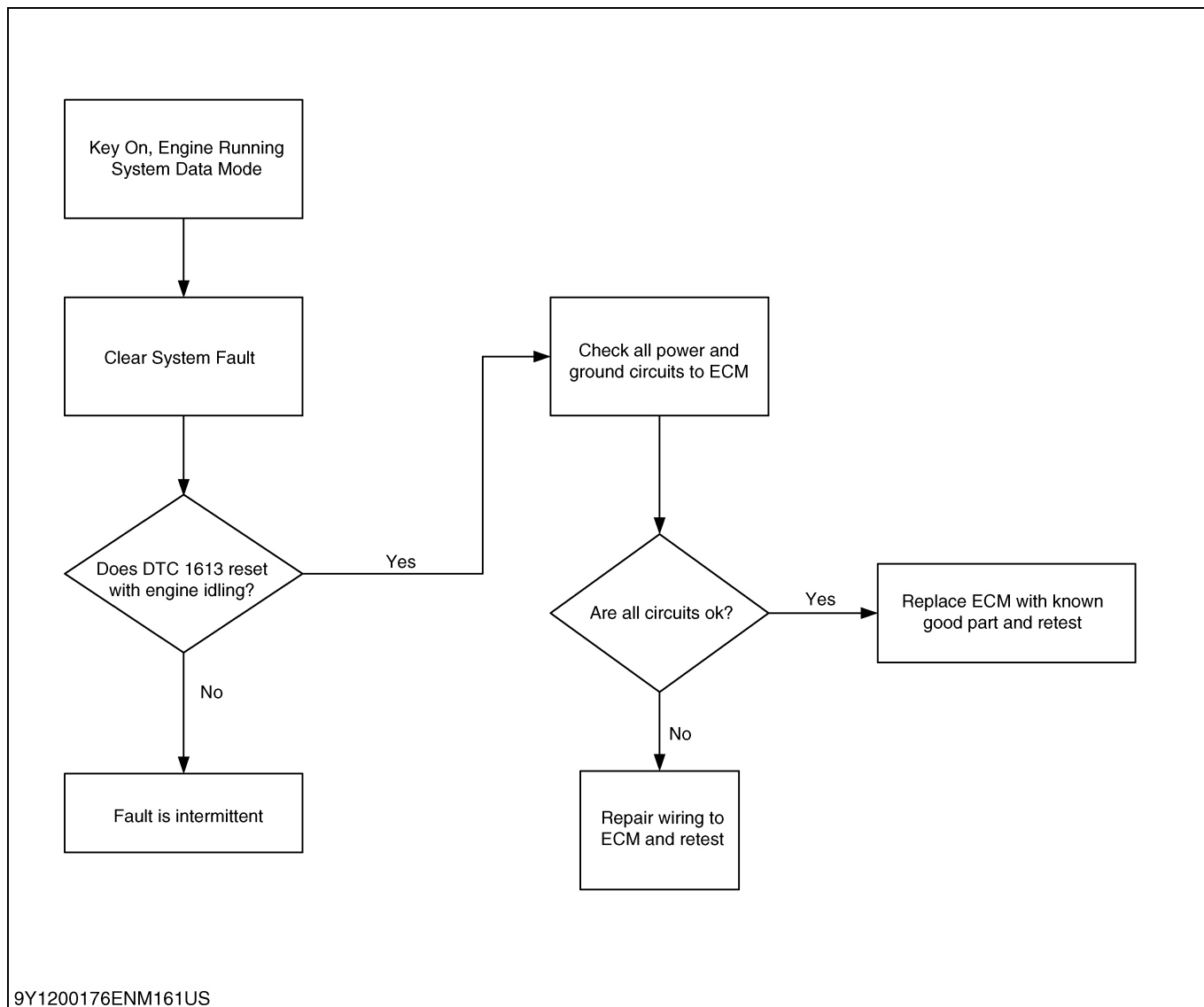
**Diagnostic Aids Chart**





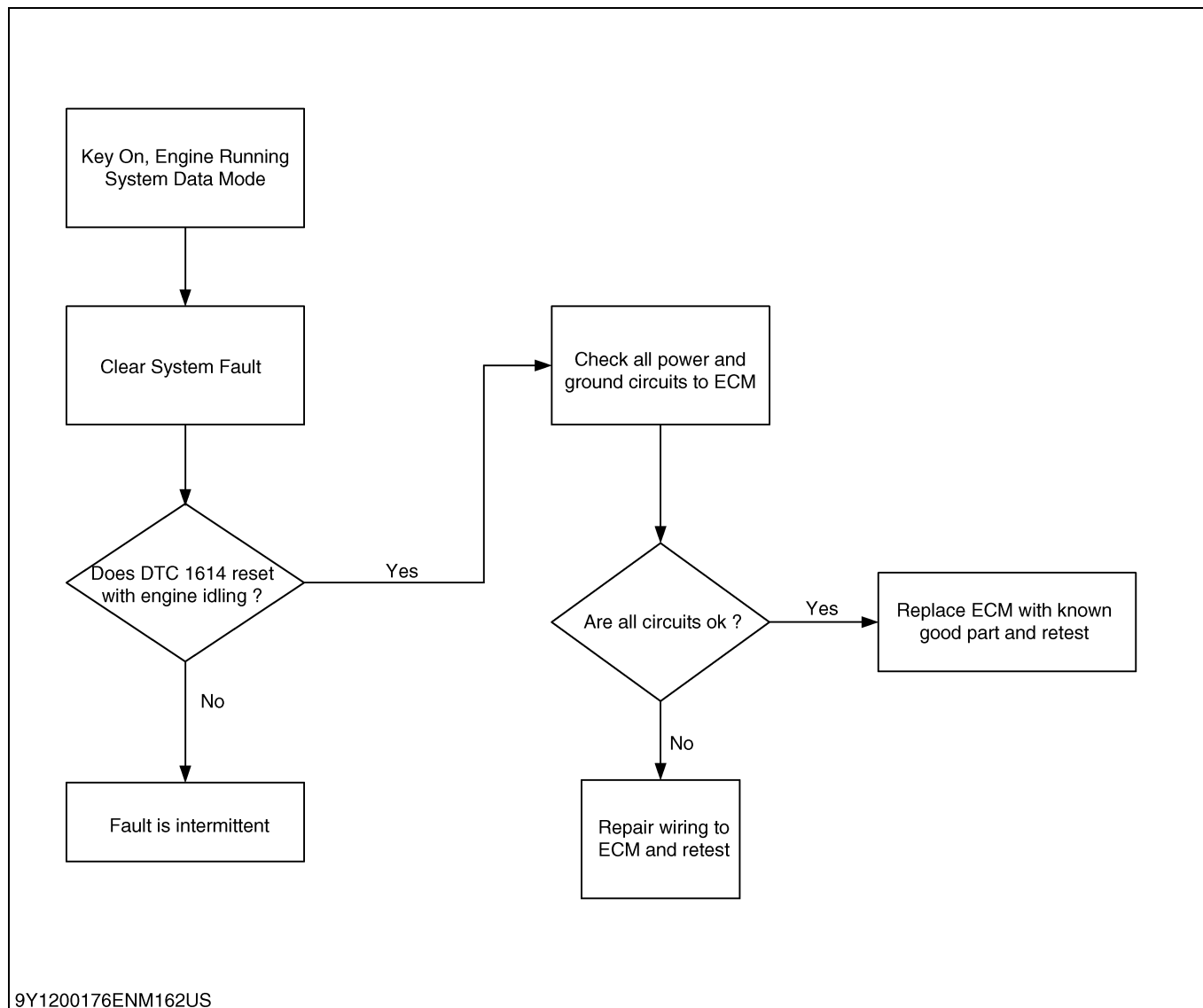
**DTC 1613-Microprocessor Failure-RTI 2**

**Diagnostic Aids Chart**



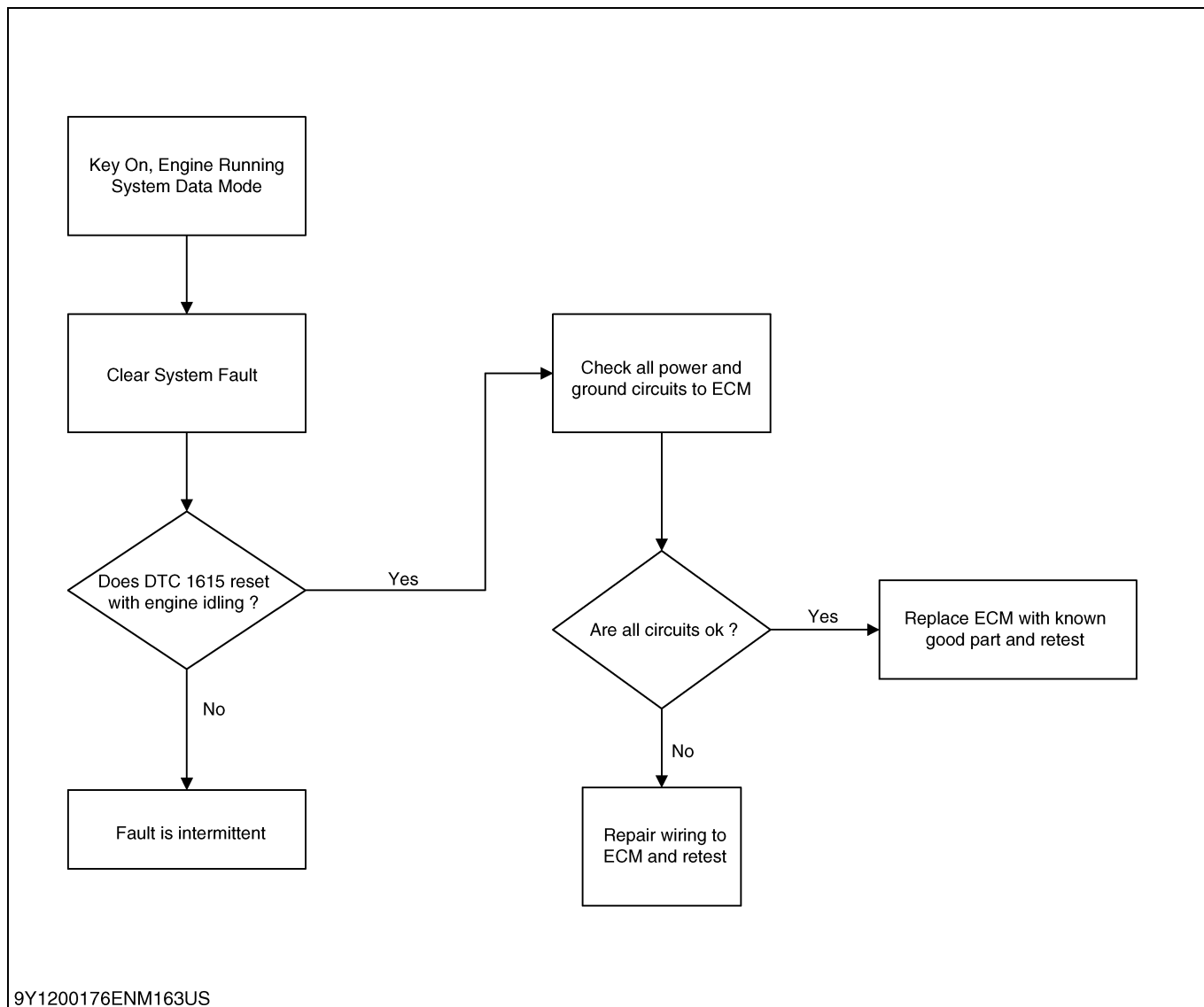
**DTC 1614-Microprocessor Failure-RTI 3**

**Diagnostic Aids Chart**



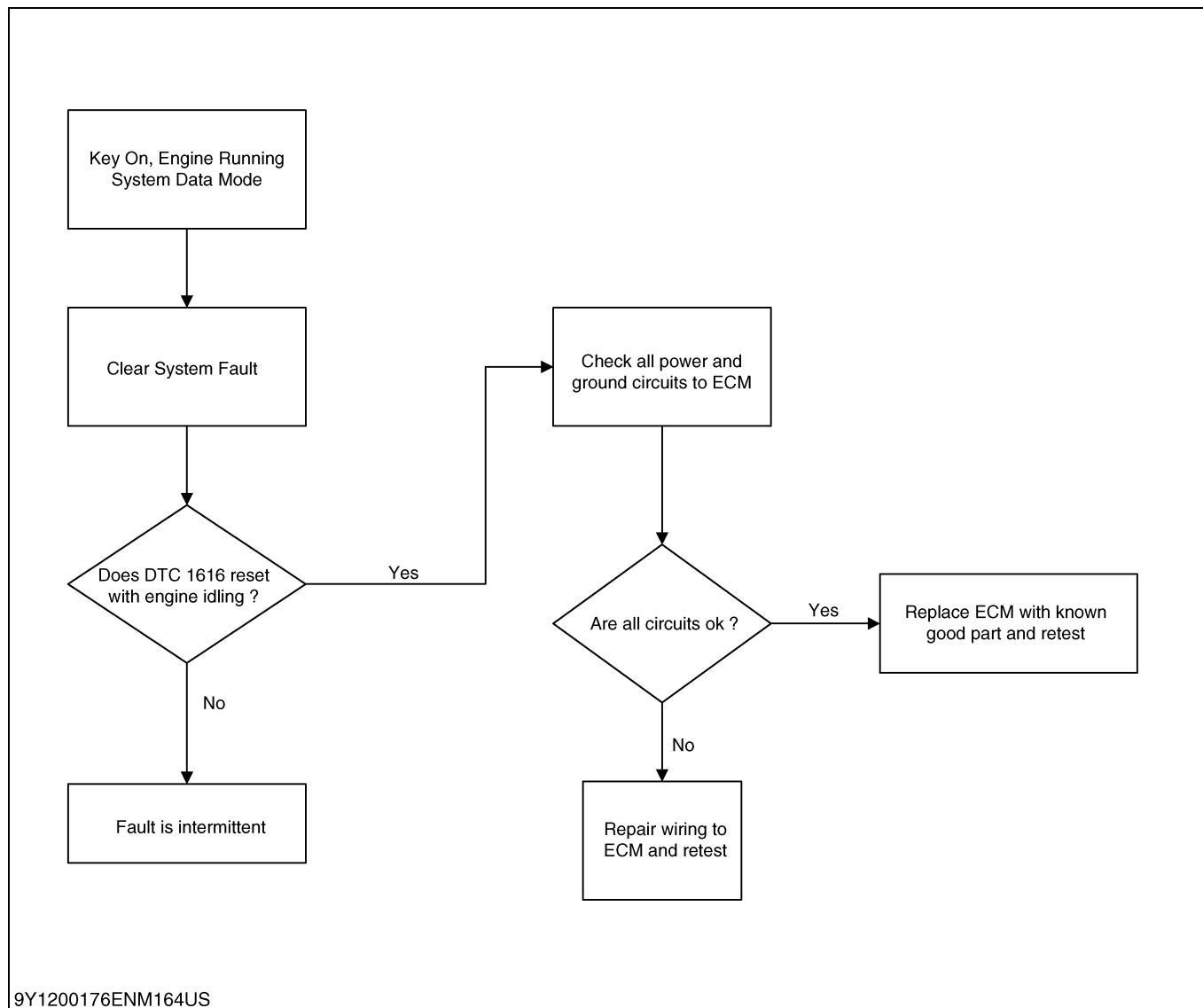
**DTC 1615-Microprocessor Failure-A/D**

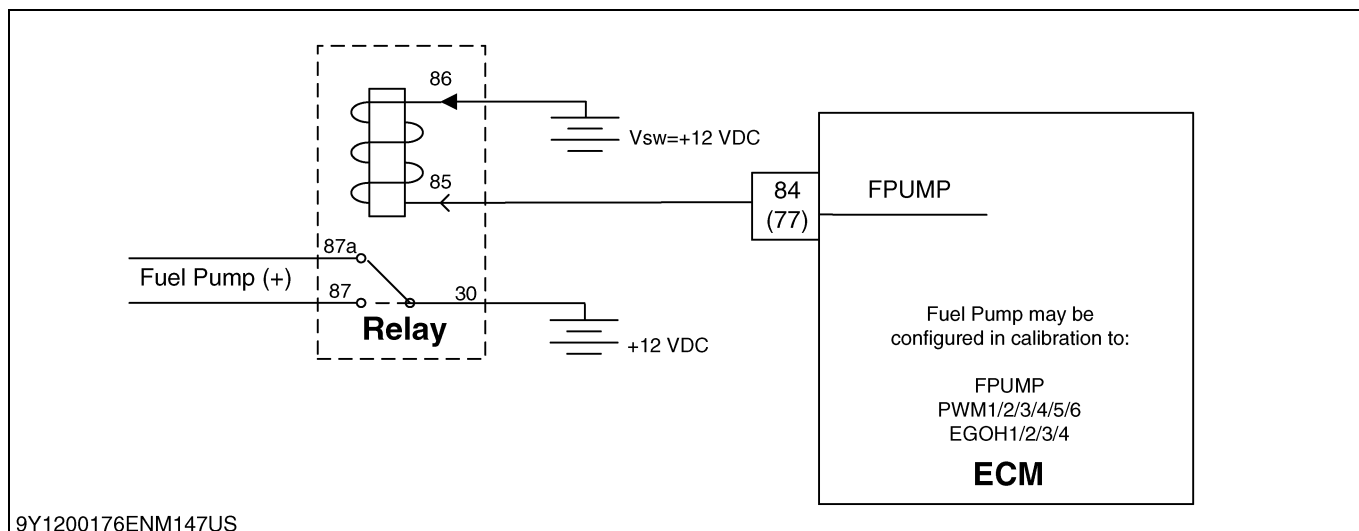
**Diagnostic Aids Chart**



### DTC 1616-Microprocessor Failure-nterrupt

#### Diagnostic Aids Chart



**(17) Fuel Pump Relay Control/Coil (DTC 627 to 629)****DTC 627-Fuel Pump Relay Coil Open**

- Hardware: Fuel Pump Relay Pull in Coil
- Enabling Conditions: Key On
- Set Conditions: Fuel Pump relay coil output open circuit for more than 10 samples of the circuit
- Corrective Action(s): Illuminate MIL
- Non-emissions related fault
- Possible Causes: Open coil in relay, Open in relay driver circuit in engine harness or faulty ECM

**DTC 628-Fuel Pump Relay Ground Short**

- J1939 SPN: 1348 FMI: 4
  - Hardware: Fuel Pump Relay Pull in Coil
  - Enabling Conditions: Engine Running
  - Set Conditions: Fuel Pump relay coil output shorted to ground for more than 10 samples of the circuit
  - Corrective Action(s): Illuminate MIL
  - Non-emissions related fault
  - Possible Causes: Relay pull in coil shorted internally, relay driver circuit shorted to ground in wire harness, faulty ECM
- 
- J1939 SPN: 1347 FMI: 5
  - Hardware: Fuel Pump Motor
  - Enabling Conditions: Engine Running
  - Set Conditions: Fuel pump motor high-side on-state < 4.0 volts, battery voltage > 8.0 volts
  - Corrective Action(s): Illuminate MIL
  - Non-emissions related
  - Possible Causes:

**DTC 629-Fuel Pump Relay Coil Short-To-Power**

- J1939 SPN: 1348 FMI: 3
  - Hardware: Fuel Pump Relay Pull in Coil
  - Enabling Conditions: Key On, Engine Off
  - Set Conditions: Fuel Pump relay coil output short to power/voltage
  - Corrective Action(s): Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp
  - Non-emissions related fault
  - Possible Causes: Shorted relay pull in coil, relay driver circuit shorted to voltage in wire harness
- 
- J1939 SPN: 1347 FMI: 6
  - Hardware: Fuel Pump Motor
  - Enabling Conditions: Engine Running
  - Set Conditions: Fuel pump motor high-side on-state < 4.0 volts, battery voltage < 16.0 volts
  - Corrective Action(s): Illuminate MIL
  - Non-emissions related
  - Possible Causes:

The ECM has auxiliary low-side drivers that can turn on warning devices or ground electromagnetic relay coils to control power to devices connected to the engine.

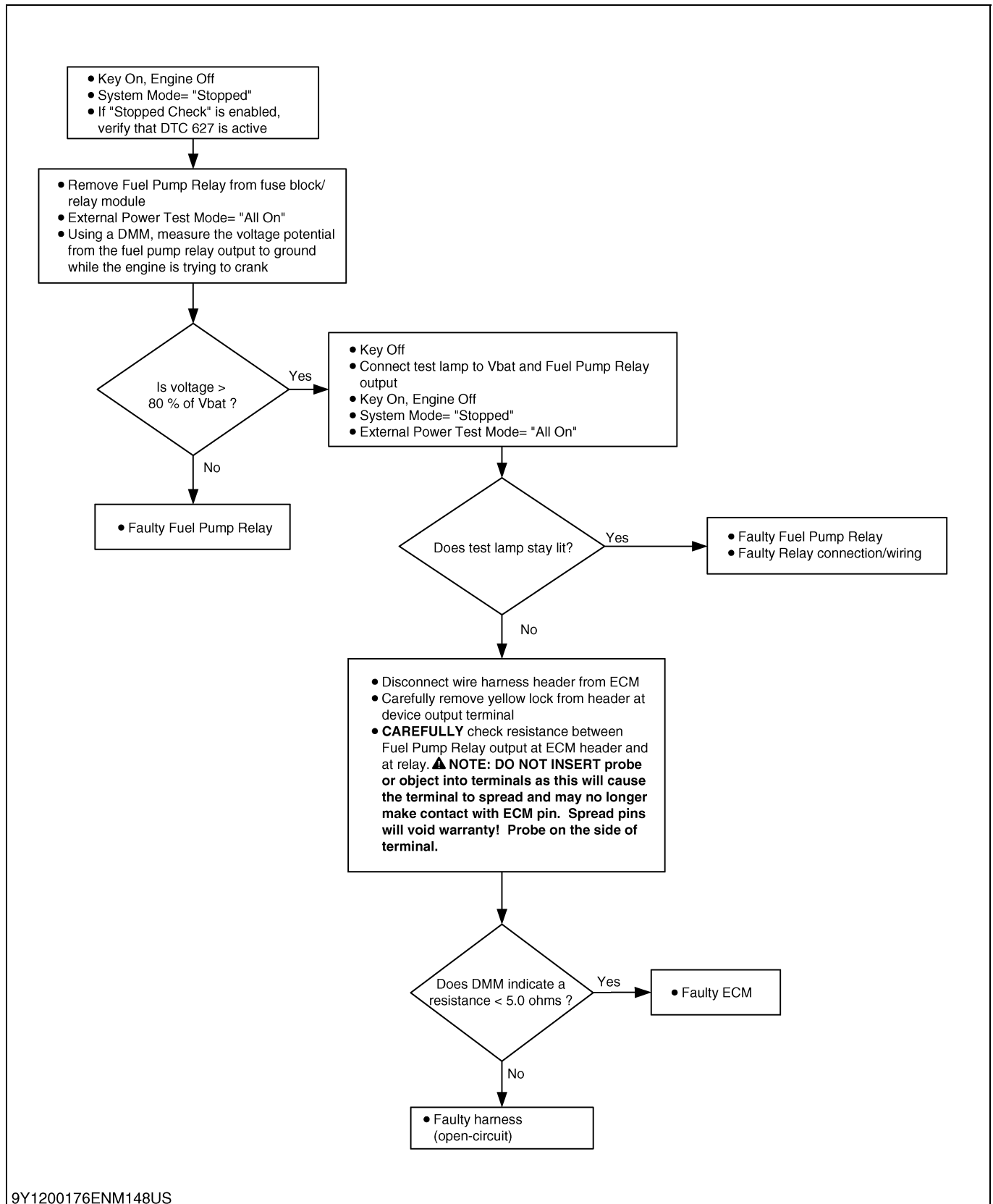
The fault of DTC 627 sets if the output for the fuel pump relay is detected as an open circuit. If this fault is active the fuel pump will not receive power and the engine will not run on gasoline.

The fault of DTC 628 sets if the output for the fuel pump relay is detected as being shorted to ground. If this fault is active and the high-side of the fuel pump relay is supplied, the fuel pump will run until the relay or high-side power is removed.

The fault of DTC 629 sets if the output for the fuel pump relay is detected as shorted to power. If this fault is active the fuel pump will not receive power and will not run.

**DTC 627-Fuel Pump Relay Coil Open**

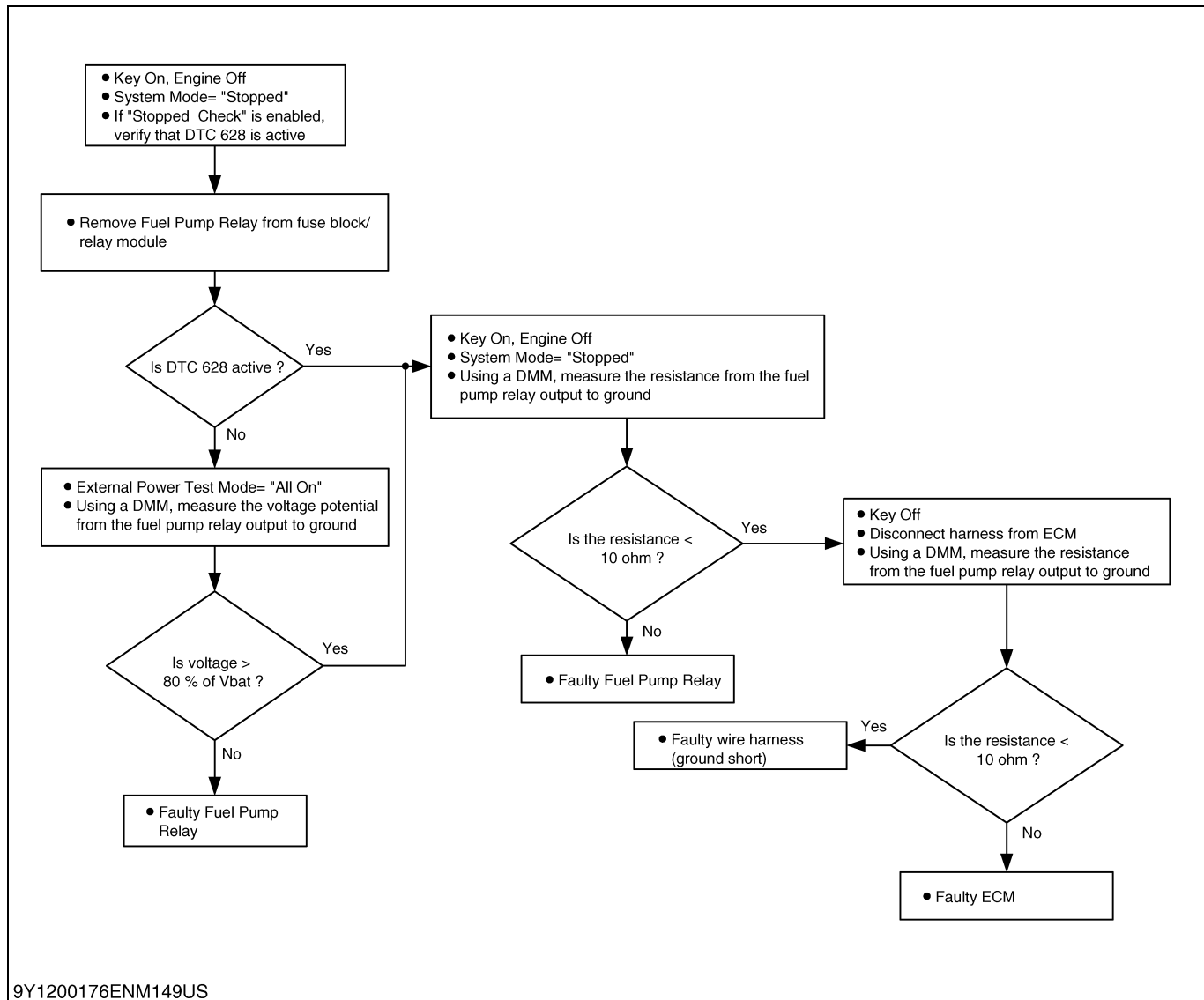
**Diagnostic Aids Chart**



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**DTC 628-Fuel Pump Relay Ground Short**

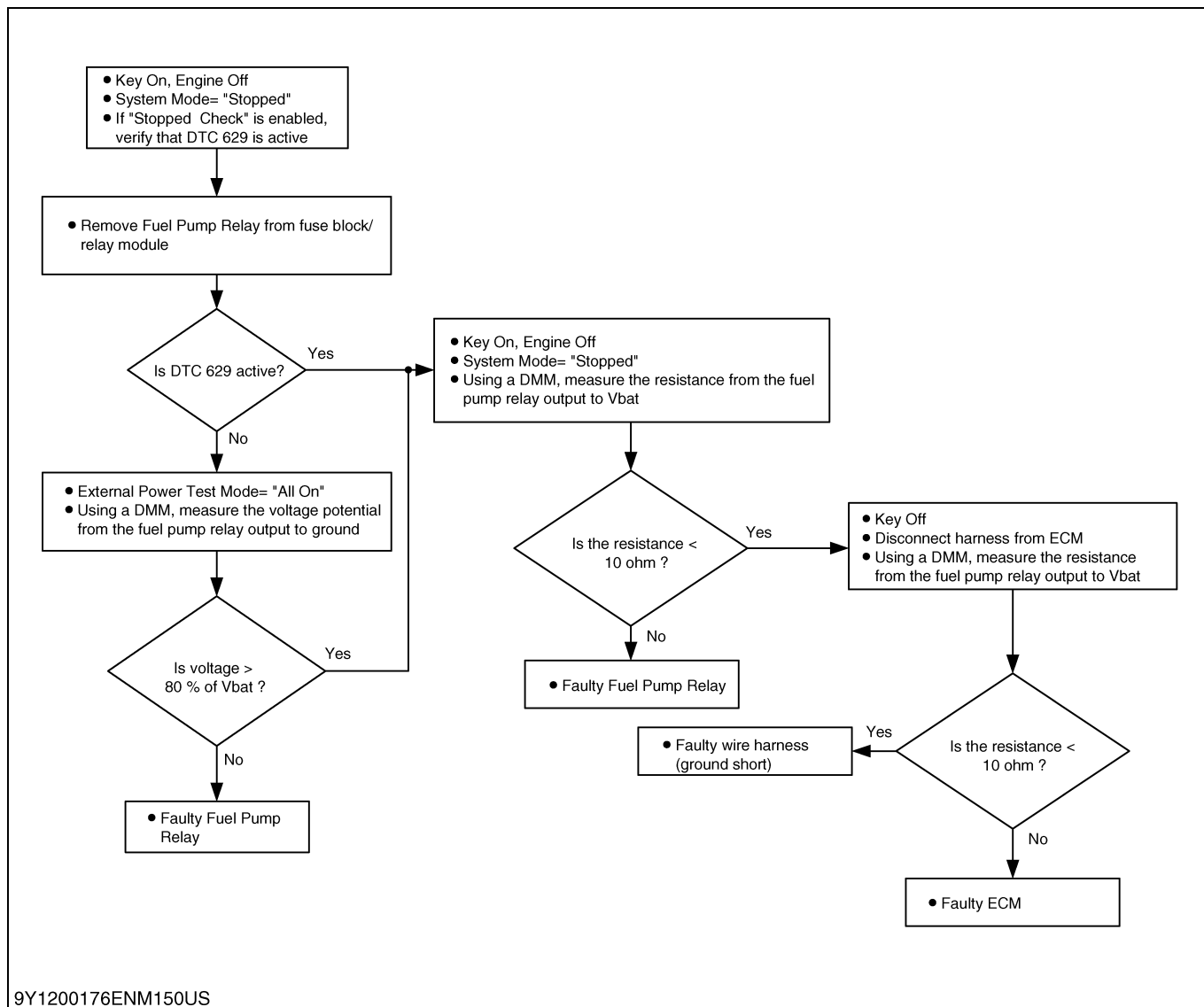
**Diagnostic Aids Chart**

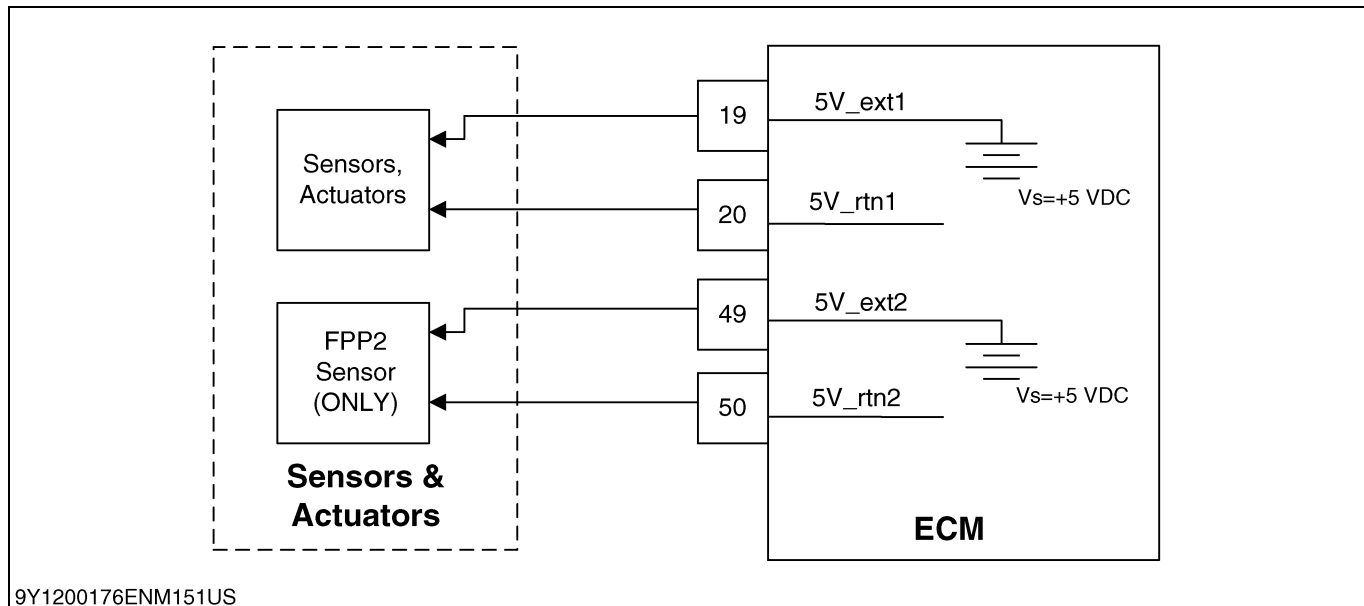




**DTC 629-Fuel Pump Relay Coil Short-To-Power**

**Diagnostic Aids Chart**



**(18) 5 V External (DTC 642, 643, 652, 653, 1611)****DTC 642-Sensor Supply Voltage 1 Low (5 Vext1)**

- Hardware: External Sensor Supply Voltage Regulator 1
- Enabling Conditions: Key On, Engine Off or Running
- Fault Condition- Voltage feedback on sensor supply circuit #1 below 4.60 V for longer than 1 second
- Corrective Action(s)- Illuminate MIL and disable fuel adaptive learn while code is active
- Non-emissions related fault
- Possible Causes: Internal short to ground in any sensor fed by 5 Vext1 supply, 5 Vext1 shorted to ground in wire harness, faulty ECM (no 5 V output on 5 Vext1)

**DTC 643-Sensor Supply Voltage 1 High (5 Vext1)**

- Hardware: External Sensor Supply Voltage Regulator 1
- Enabling Conditions: Key On, Engine Off and Running
- Set Conditions: Voltage feedback on sensor supply circuit #1 is greater than 5.40 V for longer than 1 second
- Corrective Action(s): Illuminate MIL and disable fuel adaptive learn while code is active
- Non-emissions related fault
- Possible Causes: 5 Vext1 circuit shorted to 12.0 V in wire harness

**DTC 652-Sensor Supply Voltage 2 Low (5 Vext2)**

- Hardware: External Sensor Supply Voltage Regulator 2
- Enabling Conditions: Key On, Engine Off or Running
- Fault Condition- Voltage feedback on sensor supply circuit #2 below 4.60 V for longer than 1 second
- Corrective Action(s)- Illuminate MIL and disable fuel adaptive learn while code is active
- Non-emissions related fault
- Possible Causes: Internal short to ground in any sensor fed by 5 Vext2 supply, 5 Vext2 shorted to ground in wire harness, faulty ECM (no 5 V output on 5 Vext2)

**DTC 653-Sensor Supply Voltage 2 High (5 Vext2)**

- Hardware: External Sensor Supply Voltage Regulator 2
- Enabling Conditions: Key On, Engine Off and Running
- Set Conditions: Voltage feedback on sensor supply circuit #2 is greater than 5.40 V for longer than 1 second
- Corrective Action(s): Illuminate MIL and disable fuel adaptive learn while code is active
- Non-emissions related fault
- Possible Causes: 5 Vext2 circuit shorted to 12.0 V in wire harness

**DTC 1611-Sensor Supply Voltage (5 Vext1/2) Simultaneous out-of-range**

- Hardware: External Sensor Supply Voltage Regulator 1/2
- Enabling Conditions: Engine On
- Fault Condition: Voltage feedback on sensor supply circuit #1 above 5.40 V or below 4.60 V for longer than 1 second, and Voltage feedback on sensor supply circuit #2 above 5.40 V or below 4.60 V for longer than 1 second
- Corrective Action (s): Illuminate MIL, AL disable, AL disable in key cycle, Power derate 2, Low rev limit, Forced idle
- Non-emissions related fault
- Possible Causes:

This fault indicates that both power supply feedback voltages are out-of-range as defined in the calibration. In configurations where the crank and/or camshaft position sensors are powered hall-effect sensors, the engine may stall due to loss of synchronization.

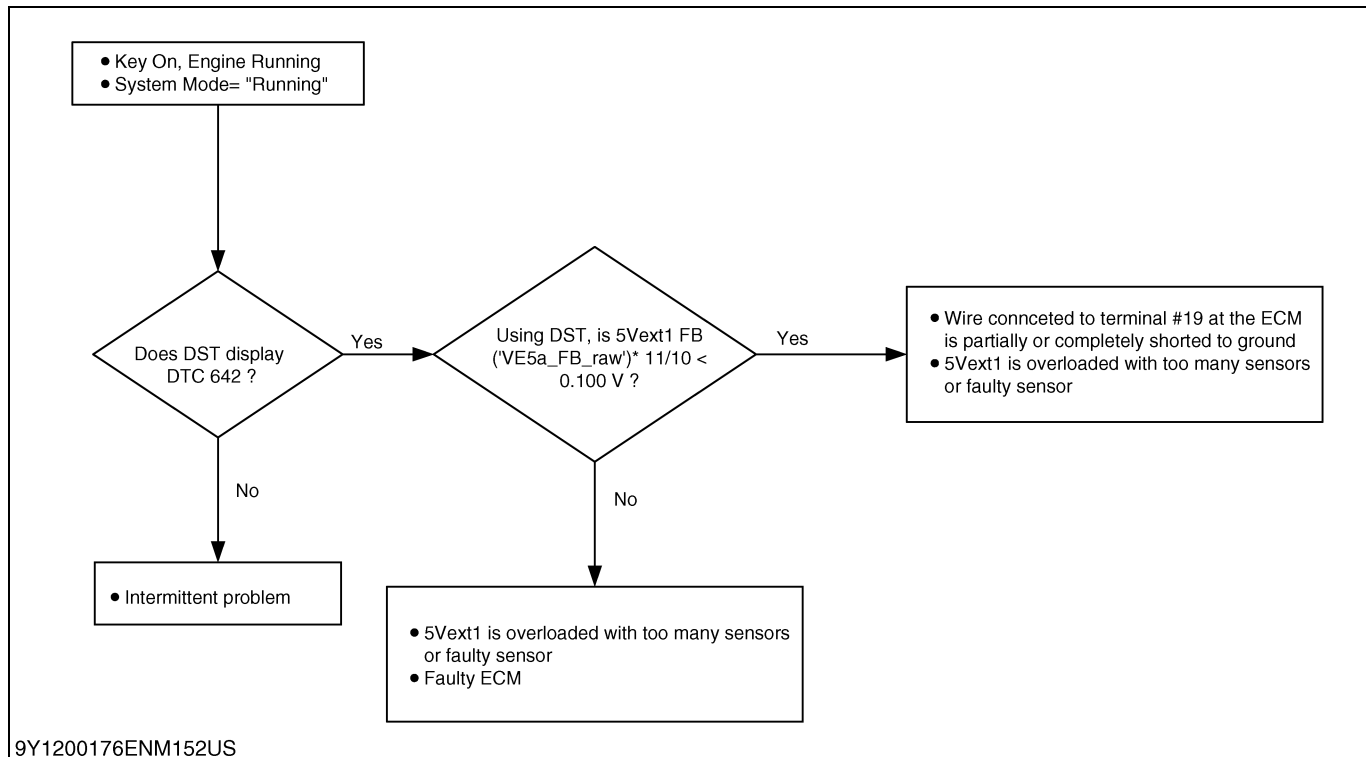
The external 5-volt supply powers sensors and other components in the engine control system. The accuracy of this supply is critical to the accuracy of the sensors' feedback, therefore, it is supplied from a precision regulator whose output is internally monitored by the ECM. The ECM monitors the 5-volt supply to ratio metrically correct sensor feedback and determine if the circuit is overloaded, shorted, or otherwise out of specification.

The fault of DTC 642 and DTC 652 will set if the internally measured voltage feedback of the regulator output is lower than the low voltage limit as defined in the diagnostic calibration anytime the engine is running or stopped at key-on (if applicable).

The fault of DTC 643 and DTC 653 will set if the internally measured voltage feedback of the regulator output is higher than the high voltage limit as defined in the diagnostic calibration anytime the engine is running or stopped at key-on (if applicable).

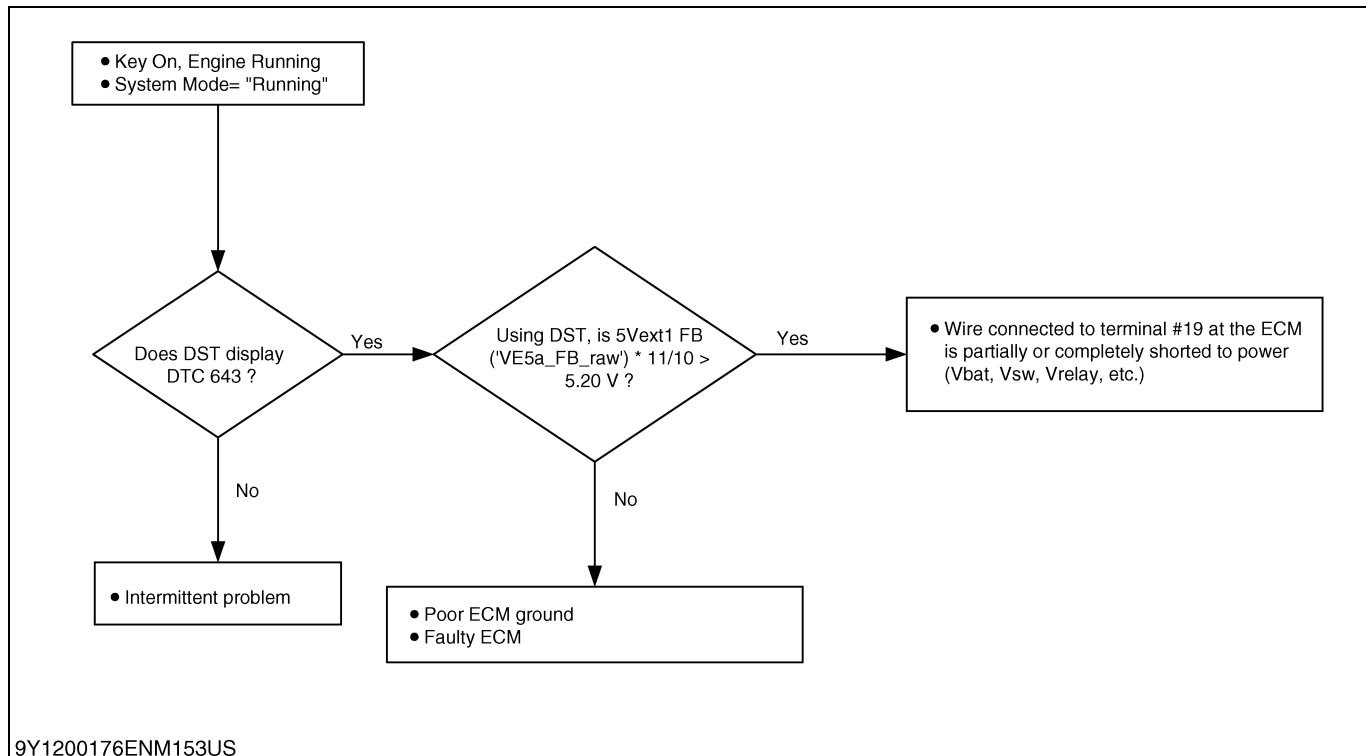
**DTC 642-Sensor Supply Voltage 1 Low (5 Vext1)**

**Diagnostic Aids Chart**



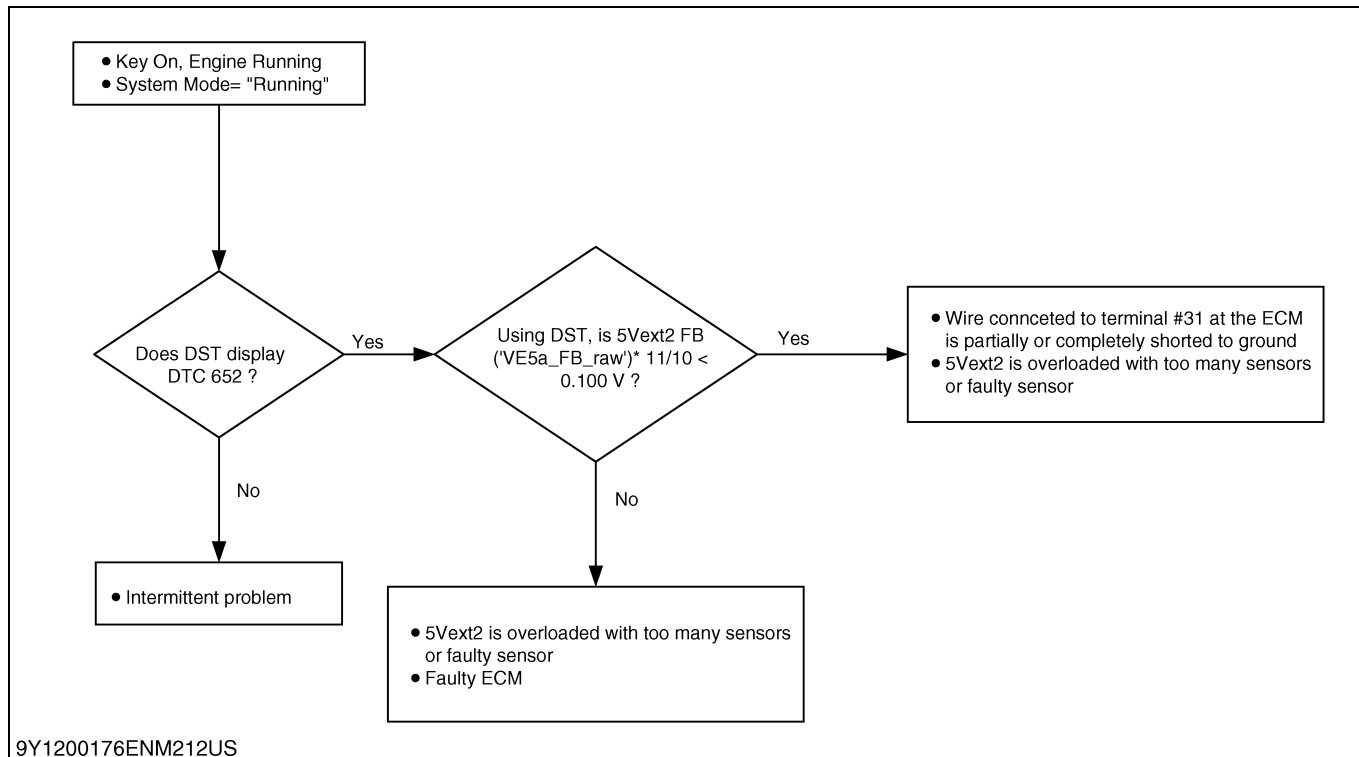
**DTC 643-Sensor Supply Voltage 1 High (5 Vext1)**

**Diagnostic Aids Chart**



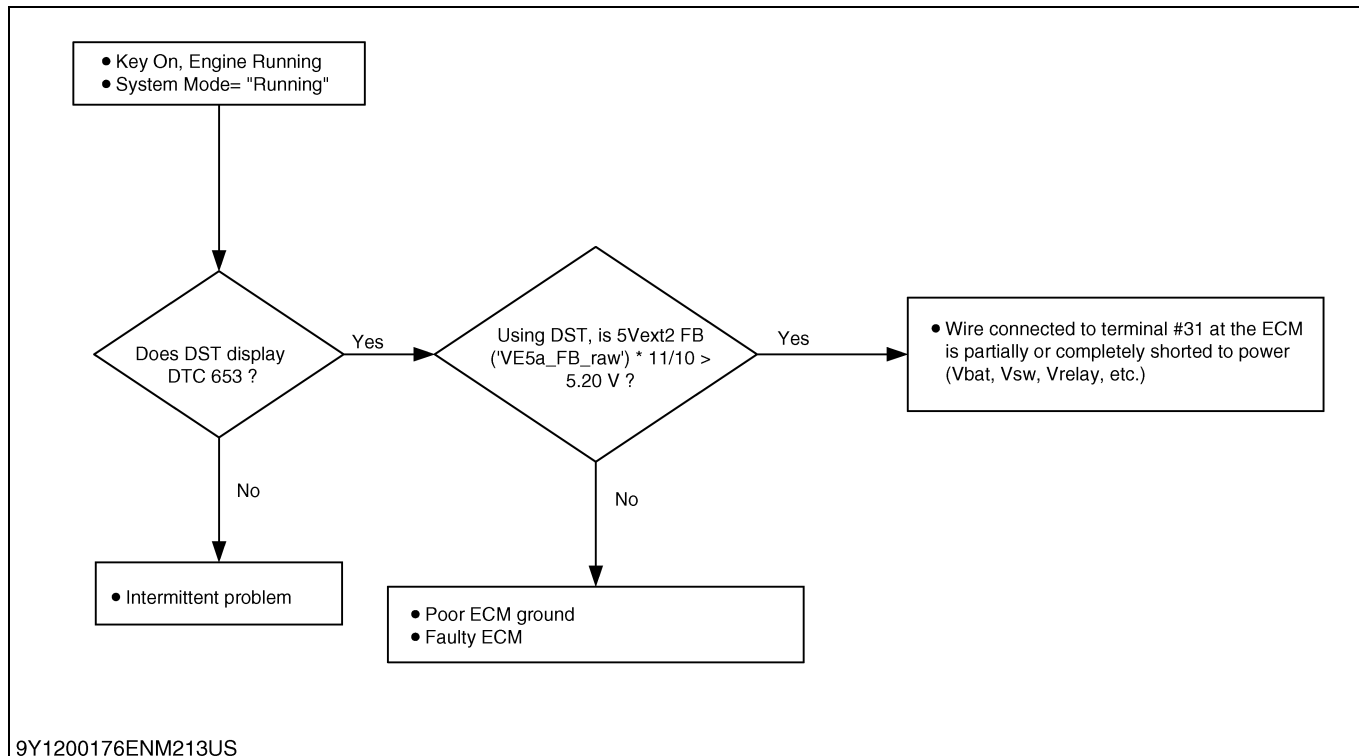
**DTC 652-Sensor Supply Voltage 2 Low (5 Vext2)**

**Diagnostic Aids Chart**



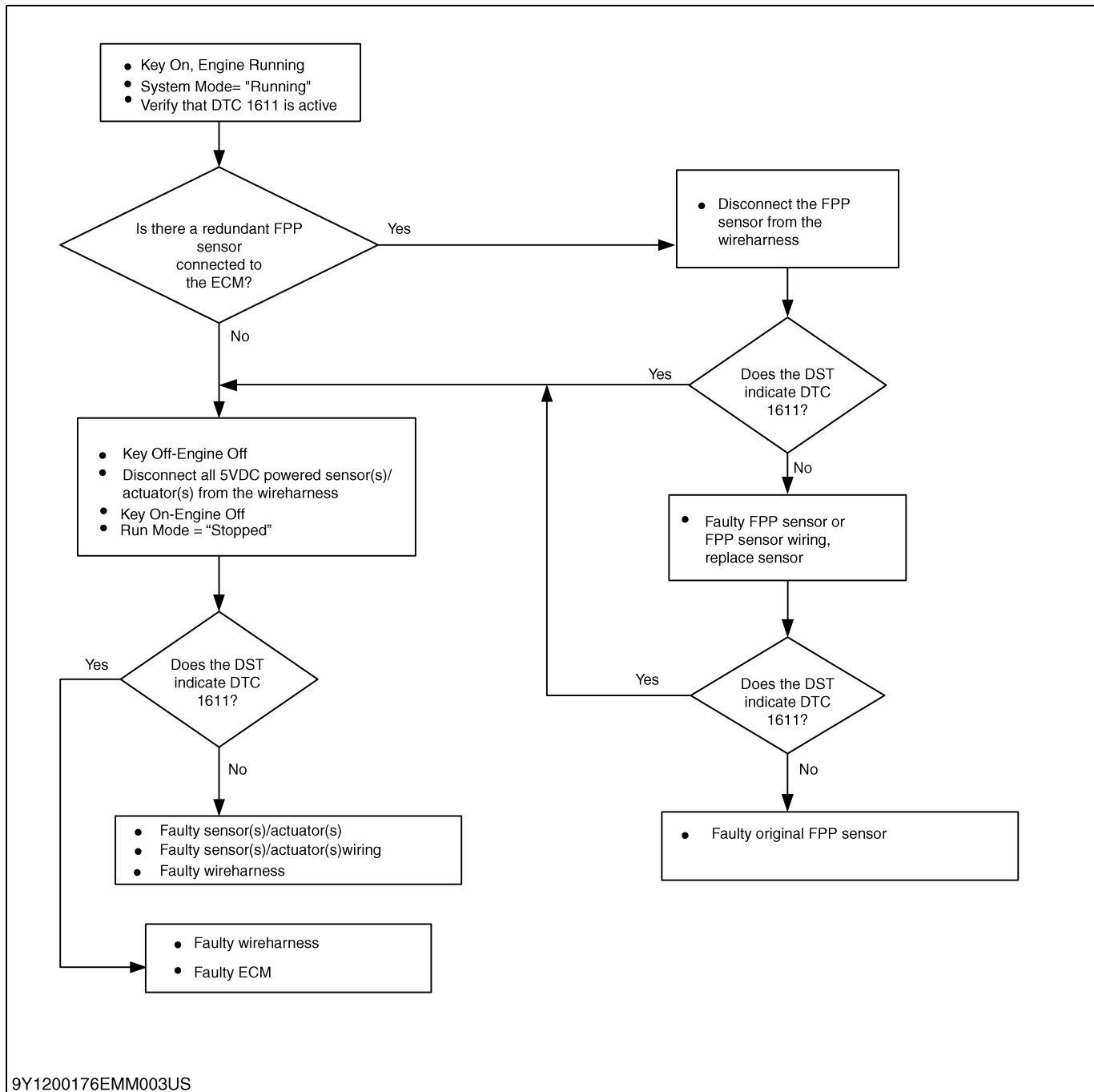
**DTC 653-Sensor Supply Voltage 2 High (5 Vext2)**

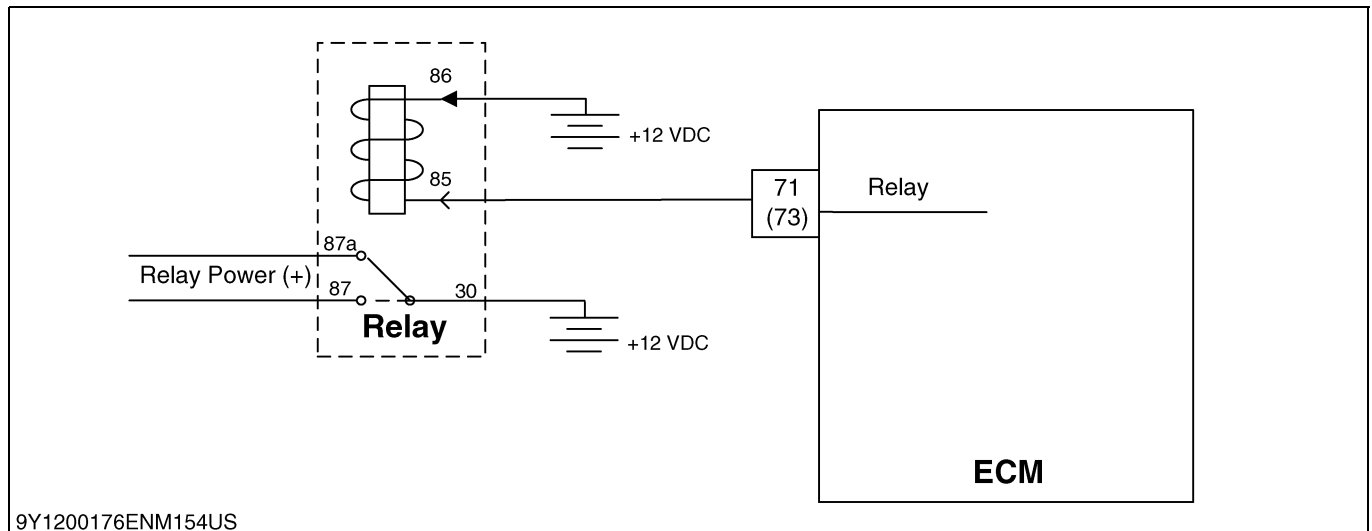
**Diagnostic Aids Chart**



**DTC 1611-Sensor Supply Voltage (5 Vext1/2) Simultaneous out-of-range**

**Daiganostic Aids Chart**



**(19) Power Relay Control / Coil (DTC 686, 687)****DTC 686-Power Relay Ground Short**

- Hardware: Power Relay Pull in Coil
- Enabling Conditions: Key On, Engine Off
- Set Conditions: Power relay coil output shorted to ground for more than 10 samples of circuit
- Corrective Action(s): Illuminate MIL
- Non-emissions related fault
- Possible Causes: Short to ground in relay pull in coil, short to ground in relay driver circuit in wire harness, faulty ECM

**DTC 687-Power Relay Coil Short-To-Power**

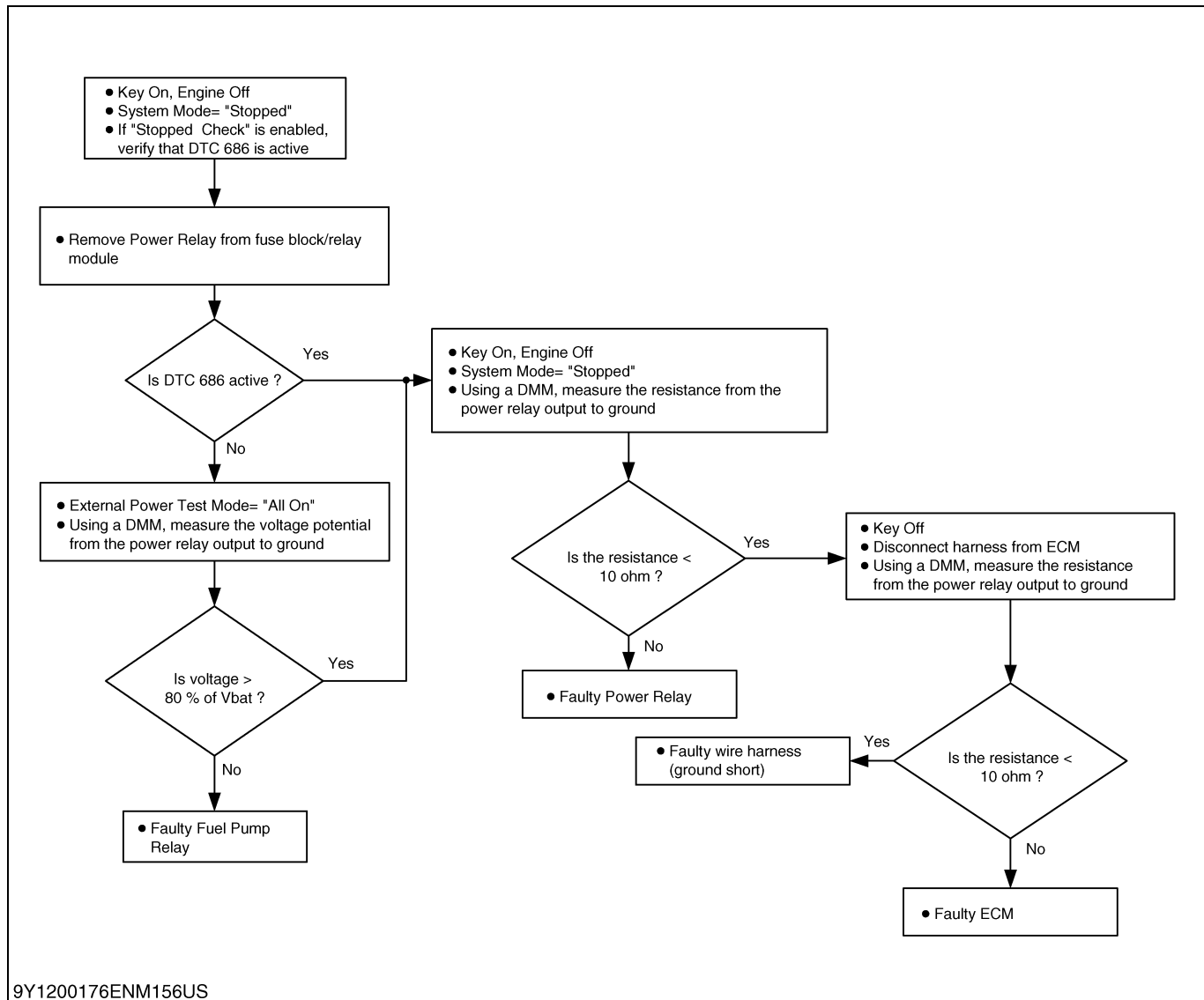
- Hardware: Power Relay Pull in Coil
- Enabling Conditions: Key On, Engine Off
- Set Conditions: Power relay coil output short to power/voltage
- Corrective Action(s): Illuminate MIL
- Non-emissions related fault
- Possible Causes: Shorted relay pull in coil, relay driver circuit shorted to voltage in wire harness

The fault of DTC 686 sets if the output for the power relay is detected as being shorted to ground. If this fault is active and the high-side of the power relay is supplied, the following components will have power until the relay or high-side power is removed: CMP sensor, CKP sensor, both O2 sensors, the DEPR (if attached) and all fuel injectors (gasoline engines).

The fault of DTC 687 sets if the output for the power relay is detected as shorted to power.

**DTC 686-Power Relay Ground Short**

**Diagnostic Aids Chart**

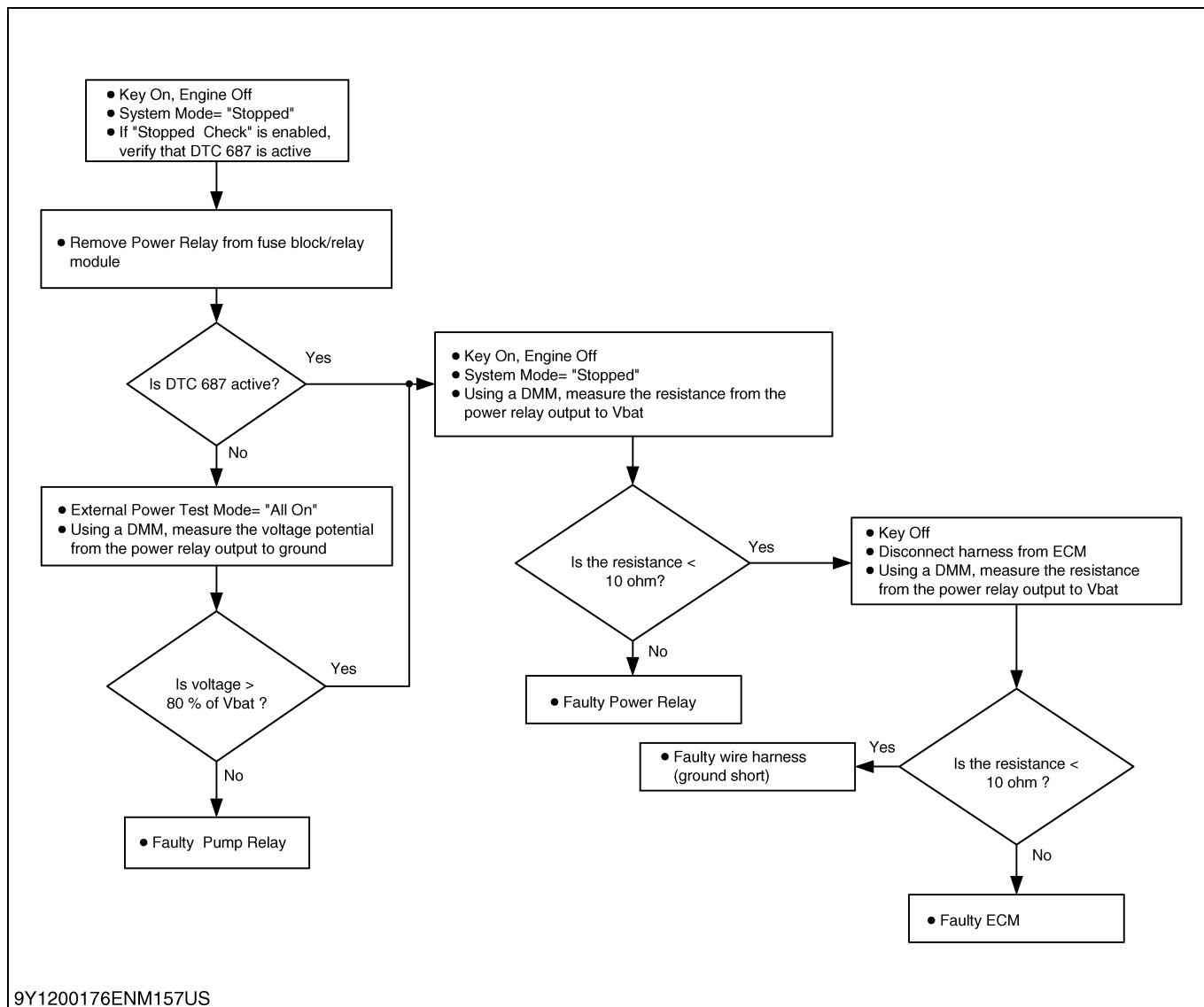


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### DTC 687-Power Relay Coil Short-To-Power

#### Diagnostic Aids Chart





The HEGO/HO<sub>2</sub>S sensor is a switching-type sensor around stoichiometry that measures the oxygen content present in the exhaust to determine if the fuel flow to the engine is correct. A UEGO sensor measures the exhaust content across a wide-range of air-fuel ratios with a linear output proportional to lambda/equivalence ratio/air-fuel ratio. In either case, if there is a deviation between the expected reading and the actual reading, fuel flow is precisely adjusted for each bank using the Closed Loop multiplier and then "learned" with the Adaptive multiplier. The multipliers only update when the system is in either "CL Active" or "CL + Adapt" control modes. The purpose of the closed loop fuel multiplier is to quickly adjust fuel flow due to variations in fuel composition, engine wear, engine-to-engine build variances, and component degradation prior to adaptive learn fueling correction "learning" the fueling deviation.

The fault of DTC 1151 and DTC 1153 sets if the Closed Loop multiplier exceeds the high limit of normal operation indicating that the engine is operating lean (excess oxygen) and requires more fuel than allowed by corrections. Often high positive fueling corrections are a function of one or more of the following conditions: 1) exhaust leaks upstream or near the HEGO sensor, 2) reduced fuel supply pressure to the gaseous fuel control system, 3) a fuel supply or manifold leak, 4) a non-responsive HEGO/UEGO sensor, and/or 5) a defective gaseous fuel control component (actuator/valve and/or mixer). These faults should be configured to disable adaptive learn for the remainder of the key-cycle to avoid improperly learning the adaptive learn table and may be configured to disable closed loop.

The fault of DTC 1152 and DTC 1154 sets if the Closed Loop multiplier exceeds the low limit of normal operation indicating that the engine is operating rich (excess fuel) and requires less fuel than allowed by corrections. Often high negative fueling corrections are a function of one or more of the following conditions: 1) high fuel supply pressure to the gaseous fuel control or faulty pressure regulator and/or 2) a non-responsive HEGO/UEGO sensor. These faults should be configured to disable adaptive learn for the remainder of the key-cycle to avoid improperly learning the adaptive learn table and may be configured to disable closed loop.

The fault of DTC 1155 sets if the closed loop multiplier exceeds the high limit of normal operation indicating that the engine is operating lean (excess oxygen) and requires more fuel than allowed by corrections. Often high positive fueling corrections are a function of one or more of the following conditions: 1) exhaust leaks upstream or near the HEGO sensor, 2) reduced fuel supply pressure to the fuel injection system, 3) a non-responsive HEGO/UEGO sensor, and/or 3) an injector that is stuck closed. This fault should be configured to disable adaptive learn for the remainder of the key-cycle to avoid improperly learning the adaptive learn table and may be configured to disable closed loop.

The fault of DTC 1156 sets if the closed loop multiplier exceeds the low limit of normal operation indicating that the engine is operating rich (excess fuel) and requires less fuel than allowed by corrections. Often high negative fueling corrections are a function of one or more of the following conditions: 1) high fuel supply pressure to the fuel injection system, 2) a non-responsive HEGO/UEGO sensor, and/or 3) an injector that is stuck open. This fault should be configured to disable adaptive learn for the remainder of the key-cycle to avoid improperly learning the adaptive learn table and may be configured to disable closed loop.

### **DTC 1151-Closed Loop High (LPG)**

### **DTC 1153-Closed Loop High (NG)**

#### **Diagnostic Aids**

#### **■ NOTE**

- **If any other DTCs are present, diagnose those first.**
- Oxygen Sensor Wire - Sensor may be mispositioned contacting the exhaust. Check for short to ground between harness and sensor sense signal.
- Vacuum Leaks - Large vacuum leaks and crankcase leaks can cause a lean exhaust condition at light load.
- Fuel Pressure - System will be lean if fuel pressure is too low. Ensure fuel tank pressure is not too low and that gaseous fuel control actuator/regulator has proper fuel pressure under all operating conditions.
- Exhaust Leaks - If there is an exhaust leak, outside air can be pulled into the exhaust and past the O<sub>2</sub> sensor causing a false lean condition.
- Fuel Quality - A drastic variation in fuel quality may cause the system to be lean including fuels with high inert gas content.
- System Grounding - ECM and engine must be grounded to the battery with very little resistance allowing for proper current flow. Faulty grounds can cause current supply issues resulting in many undesired problems.
- If all tests are OK, replace the HO<sub>2</sub>S or UEGO sensor with a known good part and retest.

**DTC 1152-Closed Loop Low (LPG)****DTC 1154-Closed Loop Low (NG)****Diagnostic Aids****■ NOTE**

- **If any other DTCs are present, diagnose those first.**
- Oxygen Sensor Wire - Sensor may be mispositioned contacting the exhaust. Check for short to ground between harness and sensor and on sensor harness
- Fuel Pressure - System will be rich if fuel delivery pressure is too high to gaseous control system. Check fuel pressure at the control actuator/valve under all operating conditions.
- System Grounding - ECM and engine must be grounded to the battery with very little resistance allowing for proper current flow. Faulty grounds can cause current supply issues resulting in many undesired problems.
- If all tests are OK, replace the HO<sub>2</sub>S or UEGO sensor with a known good part and retest.

**DTC 1155-Closed Loop Bank 1 High (Gasoline)****Diagnostic Aids****■ NOTE**

- **If any other DTCs are present, diagnose those first.**
- Oxygen Sensor Wire - Sensor may be mispositioned contacting the exhaust. Check for short to ground between harness and sensor and on sensor harness
- Vacuum Leaks - Large vacuum leaks and crankcase leaks can cause a lean exhaust condition at light load.
- Injectors - System will be lean if an injector driver or driver circuit fails. The system will also be lean if an injector fails in a closed manner or is dirty.
- Fuel Pressure - System will be lean if fuel pressure is too low. Check fuel pressure in the fuel rail during key-on, engine off and during normal operating conditions.
- Air in Fuel - If the fuel return hose/line is too close to the fuel supply pickup in the fuel tank, air may become entrapped in the pump or supply line causing a lean condition and driveability problems.
- Exhaust Leaks - If there is an exhaust leak, outside air can be pulled into the exhaust and past the O<sub>2</sub> sensor causing a false lean condition.
- Fuel Quality - A drastic variation in fuel quality may cause the system to be lean including oxygenated fuels.
- System Grounding - ECM and engine must be grounded to the battery with very little resistance allowing for proper current flow. Faulty grounds can cause current supply issues resulting in many undesired problems.
- If all tests are OK, replace the HO<sub>2</sub>S sensor with a known good part and retest.

**DTC 1156-Closed Loop Bank 1 Low (Gasoline)****Diagnostic Aids****■ NOTE**

- **If any other DTCs are present, diagnose those first.**
- Oxygen Sensor Wire - Sensor may be mispositioned contacting the exhaust. Check for short to ground between harness and sensor and on sensor harness
- Injectors - System will be rich if an injector driver or driver circuit fails shorted-to-ground. The system will also be rich if an injector fails in an open.
- Fuel Pressure - System will be rich if fuel pressure is too high. Check fuel pressure in the fuel rail during key-on, engine off and during normal operating conditions.
- System Grounding - ECM and engine must be grounded to the battery with very little resistance allowing for proper current flow. Faulty grounds can cause current supply issues resulting in many undesired problems.
- If all tests are OK, replace the HO<sub>2</sub>S sensor with a known good part and retest.

## **(21) EPR (HD EPR) or CFV (DTC 1171 to 1177)**

### **DTC 1171-EPR/CFV Regulation Pressure Higher than Expected**

- Hardware: EPR (HD EPR) or CFV
- Enabling Conditions: Engine Running
- Set Conditions: EPR (actual-commanded) pressure is higher than 2.5 in H<sub>2</sub>O for longer than 5 seconds
- Corrective Action(s): Illuminate MIL, AL disable
- Emissions related fault
- Possible Causes: Inlet pressure to DEPR is too high

This fault indicates that the device is at its minimum limit of authority and the pressure command cannot be achieved likely due to delivery/supply pressure being higher than expected. Adaptive fueling correction is disabled to avoid improper learning of the fuel correction table due to improper fuel supply pressure, and a Power Derate 1 condition is activated to reduce the possibility of engine damage.

The EPR is the second generation of EControls' Electronic Pressure Regulator found in many industrial and heavy-duty applications. The 2nd generation EPR is a "smart" actuator integrated with the primary stage regulator designed to control gaseous fuel pressure in the secondary stage regulator. The EPR receives fuel pressure commands from the ECM and quickly and precisely modulates fuel pressure to the gaseous fuel mixer. The EPR allows for fast and accurate gaseous fuel control to provide a combustible mixture to the engine.

The third generation of EControls' Electronic Pressure Regulator is the DEPR. The DEPR is a "smart" actuator that is fed supply pressure through a DSR (Dual Stage Regulator). The DSR is fully mechanical. The DEPR receives fuel pressure commands from the ECM and quickly and precisely modulates fuel pressure to the gaseous fuel mixer. The DEPR allows for very fast and very accurate gaseous fuel control to provide a combustible mixture to the engine.

The fourth generation of EControls' gaseous fuel control valve is the CFV. The CFV contains both a high-pressure Electronic Pressure Regulator and a precision Continuous Flow Valve. The inlet pressure to the CFV is typically 85 psig (586 kPa). The CFV receives mass flow commands from the ECM and quickly and precisely modulates both the fuel pressure and metering valve to achieve the desired mass flow. The CFV allows for very fast and very accurate gaseous fuel control to provide a combustible mixture to the engine.

### **DTC 1172-EPR/CFV Regulation Pressure Lower than Expected**

- Hardware: EPR (HD EPR) or CFV
- Enabling Conditions: Engine Running
- Set Conditions: EPR (actual-commanded) pressure is lower than -2.5 in H<sub>2</sub>O for longer than 5 seconds
- Corrective Action(s): Illuminate MIL, AL disable
- Emissions related fault
- Possible Causes: Inlet pressure to DEPR is too low  
Malfunctioning lock off valve, plugged fuel filter, closed manual valve or fuel tank out of fuel

This fault indicates that the device is at its minimum limit of authority and the pressure command cannot be achieved likely due to delivery/supply pressure being higher than expected. Adaptive fueling correction is disabled to avoid improper learning of the fuel correction table due to improper fuel supply pressure, and a Power Derate 1 condition is activated to reduce the possibility of engine damage.

### **DTC 1173-EPR/CFV Comm Lost**

- Hardware: EPR (HD EPR) or CFV
- Enabling Conditions: Engine Running
- Set Conditions: No EPR/CFV packets received within 500 ms
- Corrective Action(s): Illuminate MIL, AL disable, AL disable in key-cycle, power derate 2, Low rev limit
- Emissions related fault
- Possible Causes: Faulty CAN connection, CAN termination incorrect

**DTC 1174-EPR/CFV Voltage Supply High**

- Hardware: EPR (HD EPR) or CFV
- Enabling Conditions: Engine Running
- Set Conditions: Voltage supply to EPR is higher than 33.0 VDC for longer than 5 seconds.
- Corrective Action(s): Illuminate MIL, AL disable, AL disable in key-cycle, power derate 2, Low rev limit
- Emissions related fault
- Possible Causes: Wiring harness open,short or damage

**DTC 1175-EPR/CFV Voltage Supply Low**

- Hardware: EPR (HD EPR) or CFV
- Enabling Conditions: Engine Running
- Set Conditions: Voltage supply to EPR is lower than 18.0 VDC for longer than 5 seconds.
- Corrective Action(s): Illuminate MIL, AL disable, AL disable in key-cycle, power derate 2, Low rev limit
- Emissions related fault
- Possible Causes: Wiring harness open,short or damage, Faulty EPR power circuit

**DTC 1176-EPR/CFV Internal Actuator Fault Detection**

- Hardware: EPR (HD EPR) or CFV
- Enabling Conditions: Engine Running
- Set Conditions: Internal Actuator Fault detected
- Corrective Action(s): Illuminate MIL, AL disable
- Emissions related fault
- Possible Causes: Short or open circuit in actuator coil, Associated wiring, Overheating of actuator drive electronics

If the EPR/CFV does not trigger either 1171, 1172, or either of the CFV Flow fault code(s), there is no issue with the EPR/CFV. If one or more of these faults are triggered, refer to the appropriate section for diagnostic information.

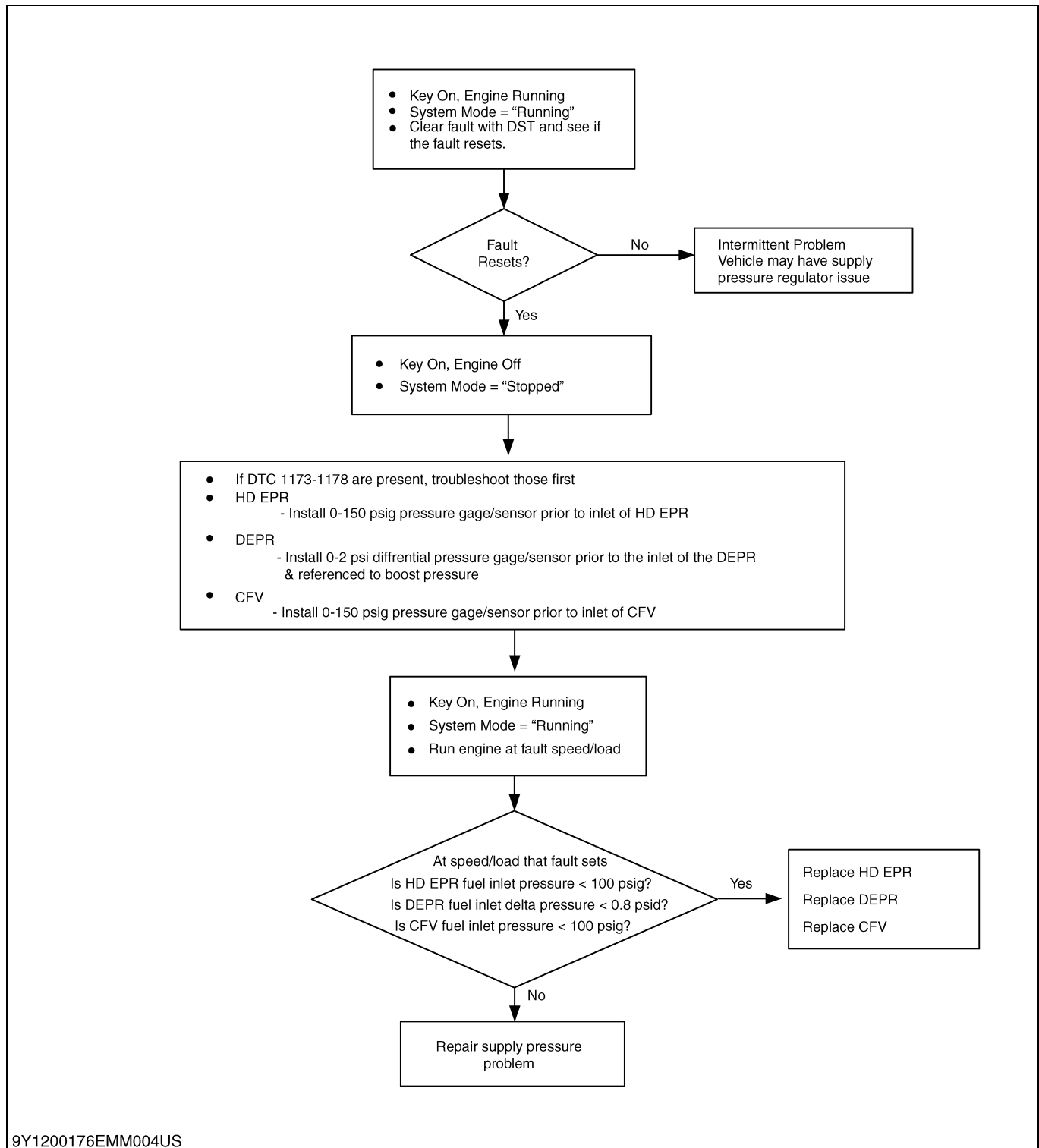
**DTC 1177-EPR/CFV Internal Circuitry Fault Detection**

- Hardware: EPR (HD EPR) or CFV
- Enabling Conditions: Engine Running
- Set Conditions: Internal circuitry fault detected
- Corrective Action(s): Illuminate MIL, AL disable
- Emissions related fault
- Possible Causes: DEPR internal microprocessor or memory failure, fuel temperature sensor failure

If the EPR/CFV does not trigger either 1171, 1172, or either of the CFV Flow fault code(s), there is no issue with the EPR/CFV. If one or more of these faults are triggered, refer to the appropriate section for diagnostic information.

**DTC 1171-EPR/CFV Regulation Pressure Higher than Expected**

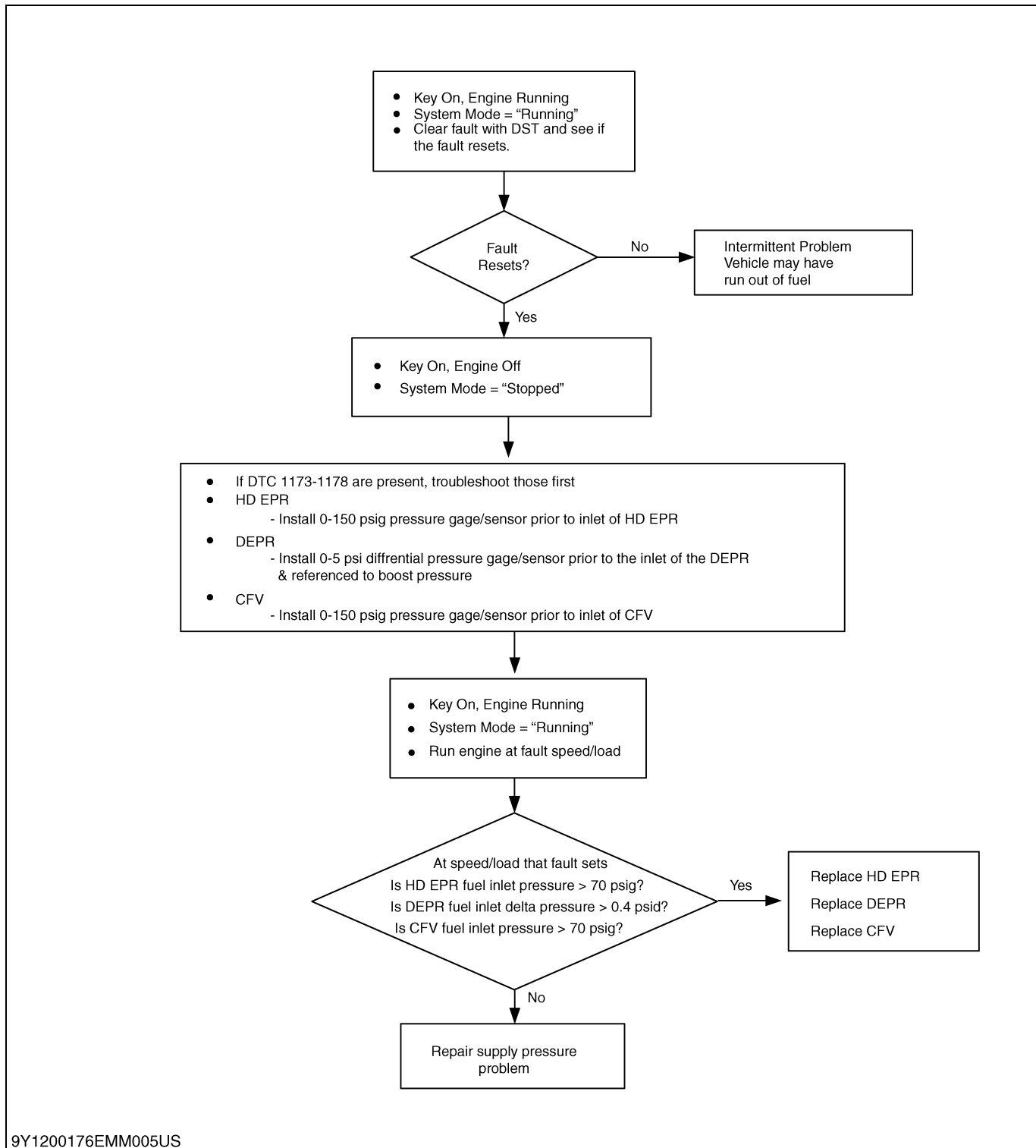
**Daiganostic Aids Chart**



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**DTC 1172-EPR/CFV Regulation Pressure Lower than Expected**

**Daiganostic Aids Chart**

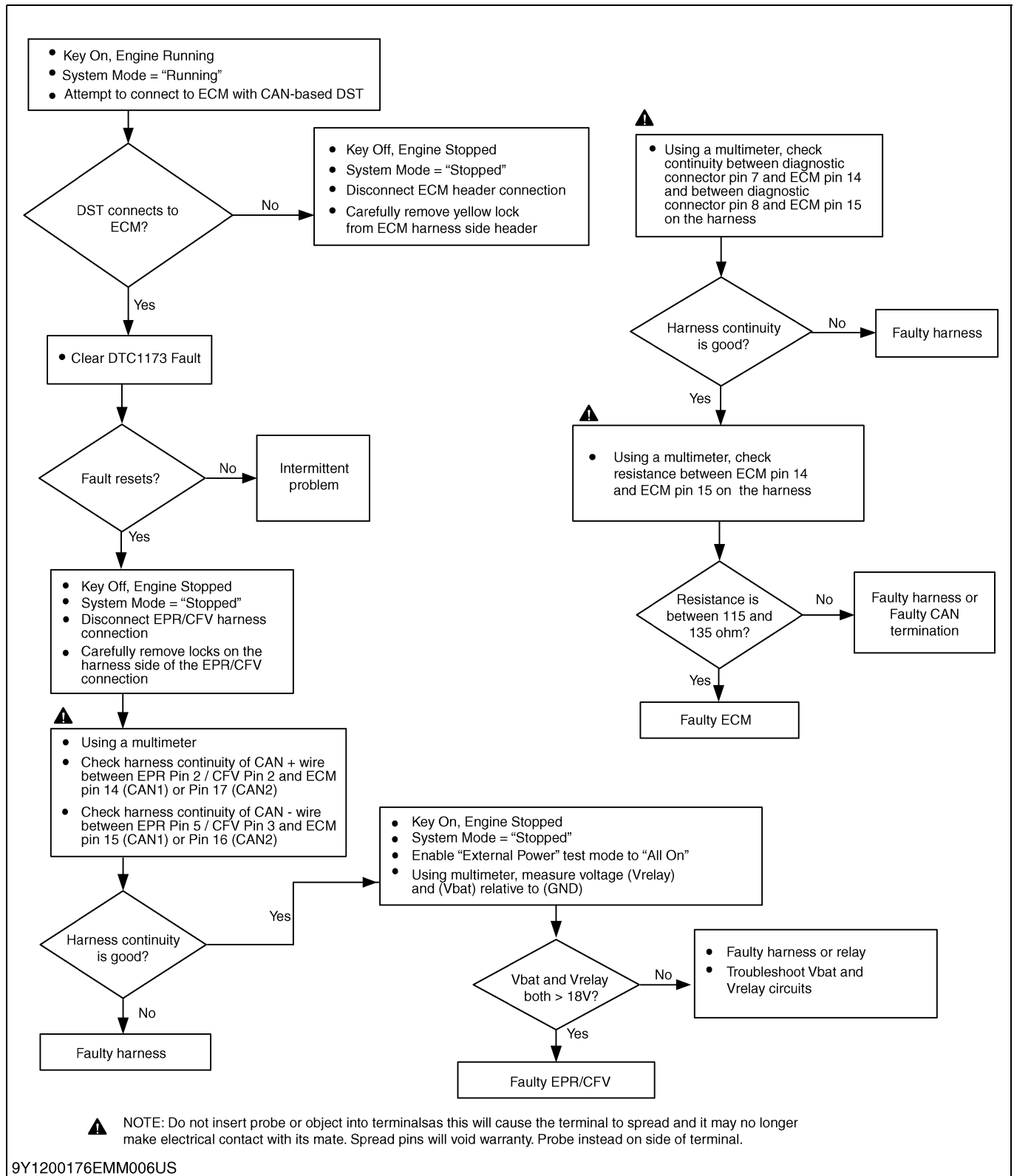


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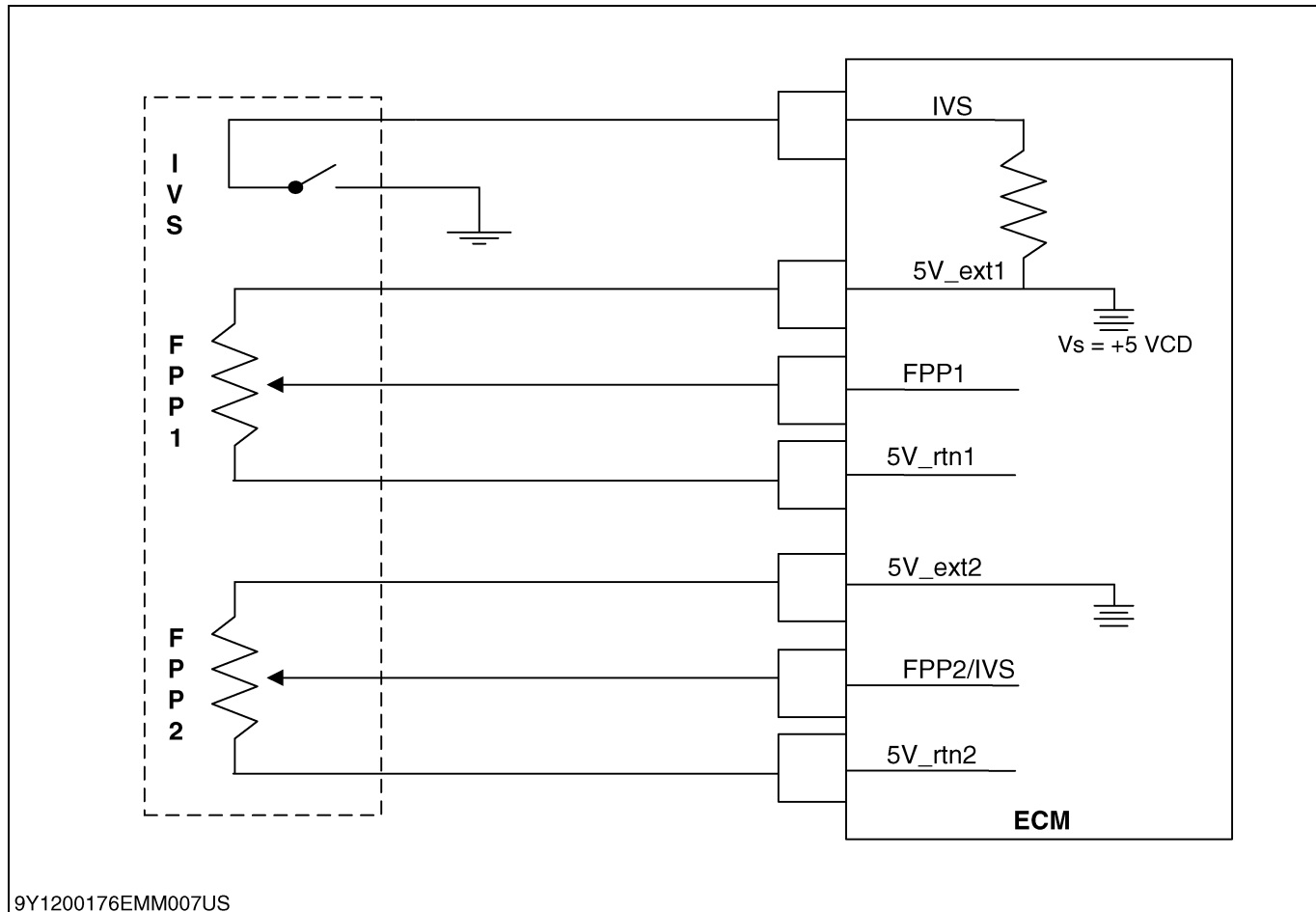


**DTC 1173-EPR/CFV Comm Lost**

**Daiganostic Aids Chart**



## (22) FPP (Foot Pedal Position Switch) (DTC 1121, 2121, 2126, 2122, 2123, 2127, 2128)



### DTC 1121-FPP1/2 Simultaneous Voltages Out-of-Range

- Hardware: Foot Pedal Position/Throttle control sensor
- Enabling Conditions: Key On, Engine Off
- Set Conditions: FPP voltage is higher than 4.80 V or lower than 0.20 V, and FPP voltage is higher than 4.80 V or lower than 0.20 V for longer than 0.5 second
- Corrective Action(s): Illuminate MIL, Power derate 2, Low rev limit, Forced idle
- Non-emissions related fault
- Possible Causes:
  - This fault is only applicable with sensors that incorporate dual potentiometer and indicates that FPP1 and FPP2 voltages are out-of-range resulting in a loss of redundancy.

### DTC 2121-FPP1 Lower Than FPP2

- Hardware: Foot Pedal Position /Throttle control sensor
- Enabling Conditions: Key On, Engine Off
- Set Conditions: (FPP1 % - FPP2 %) is lower than -20 for longer than 1.5 seconds
- Corrective Action(s): Illuminate MIL, Power derate 2, Low rev limit
- Non-emissions related fault
- Possible Causes:
  - This fault indicates that the measured % deflection of sensor 1 is less than sensor 2 by an amount defined in calibration.

**DTC 2126-FPP1 Higher Than FPP2**

- Hardware: Foot Pedal Position /Throttle control sensor
- Enabling Conditions: Key On, Engine Off
- Set Conditions: (FPP1 % - FPP2 %) is higher than 20 for longer than 1.5 seconds
- Corrective Action(s): Illuminate MIL, Power derate 2, Low rev limit
- Non-emissions related fault
- Possible Causes:  
This fault indicates that the measured % deflection of sensor 1 is greater than sensor 2 by an amount defined in calibration.

**DTC 2122-FPP1 Voltage High**

- Hardware: Electronic foot pedal/throttle control sensor
- Enabling Conditions: Key On, Engine Off
- Set Conditions: FPP1 voltage > 4.00 V for longer than 0.5 seconds
- Corrective Action(s): Illuminate MIL, activate low rev limit
- Non-emissions related fault
- Possible Causes: FPP signal shorted to voltage, 5 V\_rtn1 open to FPP, FPP open internally

**DTC 2127-FPP2 Voltage High**

- Hardware: Electronic foot pedal/throttle control sensor
- Enabling Conditions: Key On, Engine Off
- Set Conditions: FPP2 voltage > 4.00 V for longer than 0.5 seconds
- Corrective Action(s): Illuminate MIL, activate low rev limit
- Non-emissions related fault
- Possible Causes: FPP signal shorted to voltage, 5 V\_rtn1 open to FPP, FPP open internally

**DTC 2123-FPP1 Voltage Low**

- Hardware: Electronic foot pedal/throttle control sensor
- Enabling Conditions: Key On, Engine Off
- Set Conditions: FPP1 voltage < 0.300 V for longer than 0.5 seconds
- Corrective Action(s): Illuminate MIL, activate low rev limit
- Non-emissions related fault
- Possible Causes: Loss of 5 V supply, FPP1 signal circuit open or shorted to ground, faulty FPP, faulty ECM

**DTC 2128-FPP2 Voltage Low**

- Hardware: Electronic foot pedal/throttle control sensor
- Enabling Conditions: Key On, Engine Off
- Set Conditions: FPP2 voltage < 0.300 V for longer than 0.5 seconds
- Corrective Action(s): Illuminate MIL, activate low rev limit
- Non-emissions related fault
- Possible Causes: Loss of 5 V supply, FPP2 signal circuit open or shorted to ground, faulty FPP, faulty ECM

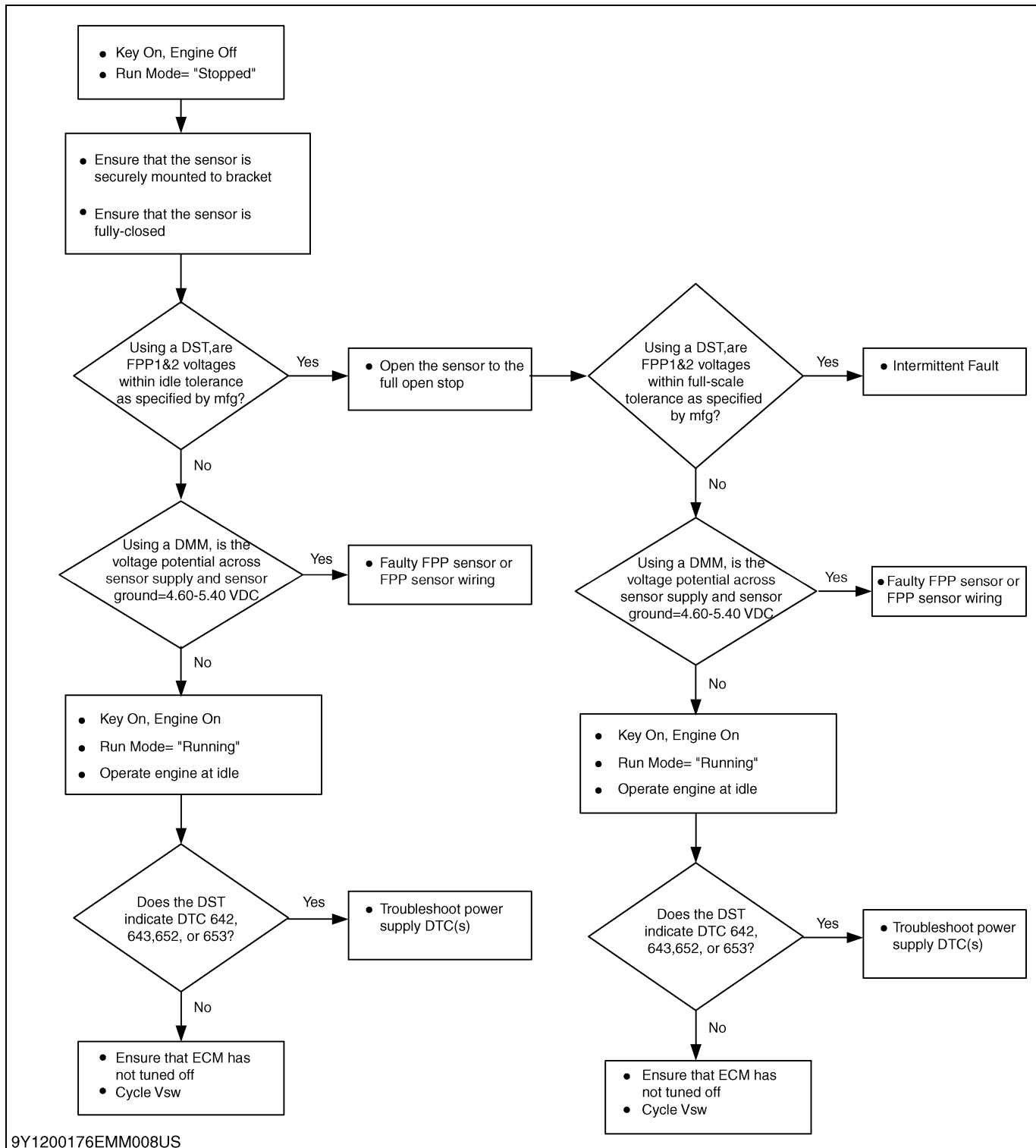
The FPP sensor is an electronic device that is coupled to a mechanically driven input as commanded by the vehicle/engine operator. The FPP sensor output is proportional to the commanded input. The ECM uses the FPP sensor input to control the throttle and adjust the engine's load in order to achieve the requested power. Since the FPP sensor inputs directly affect the engine's power output, redundant sensors are generally used to ensure safe, reliable operation. In electronic throttle control systems the foot pedal position/throttle control position sensor is used by the engine/equipment operator or system to command either throttle position or a governor speed target proportional to the input in order to achieve desired system behavior.

**DTC 1121-FPP1/2 Simultaneous Voltages Out-of-Range****Diagnostic Aids Chart**

- Troubleshoot according to FPP1 voltage out-of-range following DTC 2122 and 2123 procedures.
- Troubleshoot according to FPP2 voltage out-of-range following DTC 2127 and 2128 procedures.

**DTC 2121-FPP1 Lower Than FPP2**

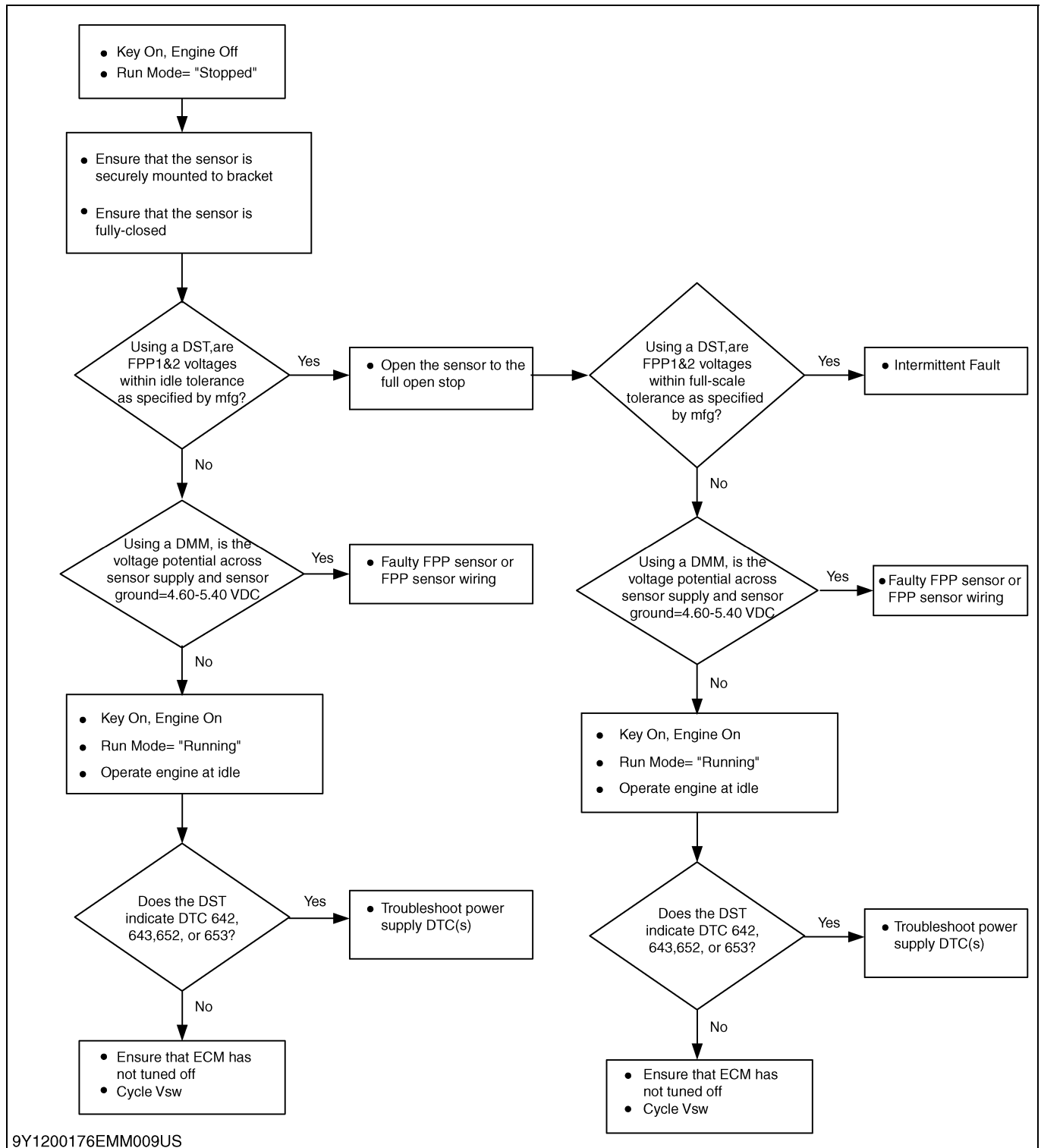
**Daiganostic Aids Chart**



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**DTC 2126-FPP1 Higher Than FPP2**

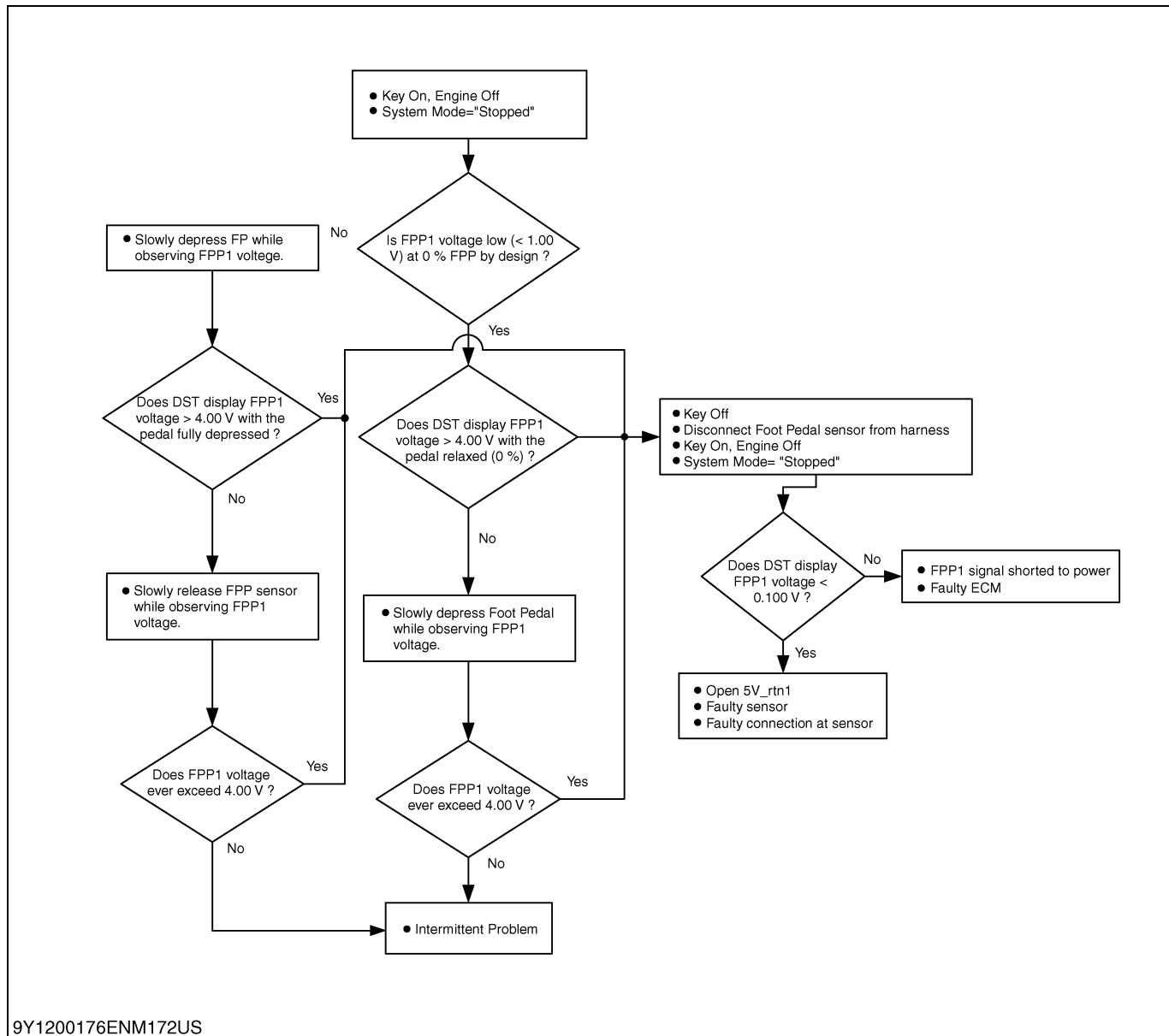
**Daiganostic Aids Chart**



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**DTC 2122-FPP1 Voltage High**

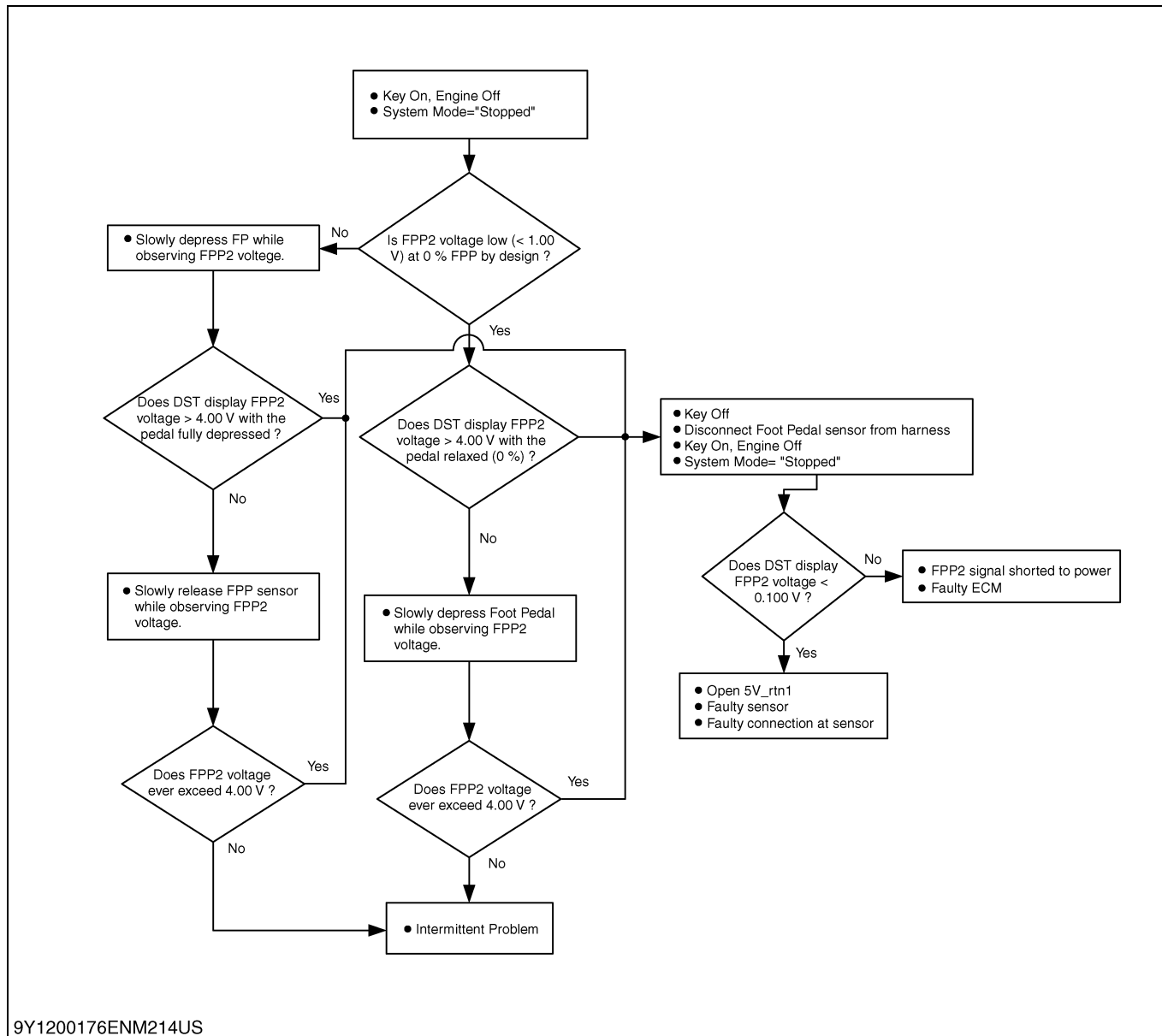
**Diagnostic Aids Chart**



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### DTC 2127-FPP1 Voltage High

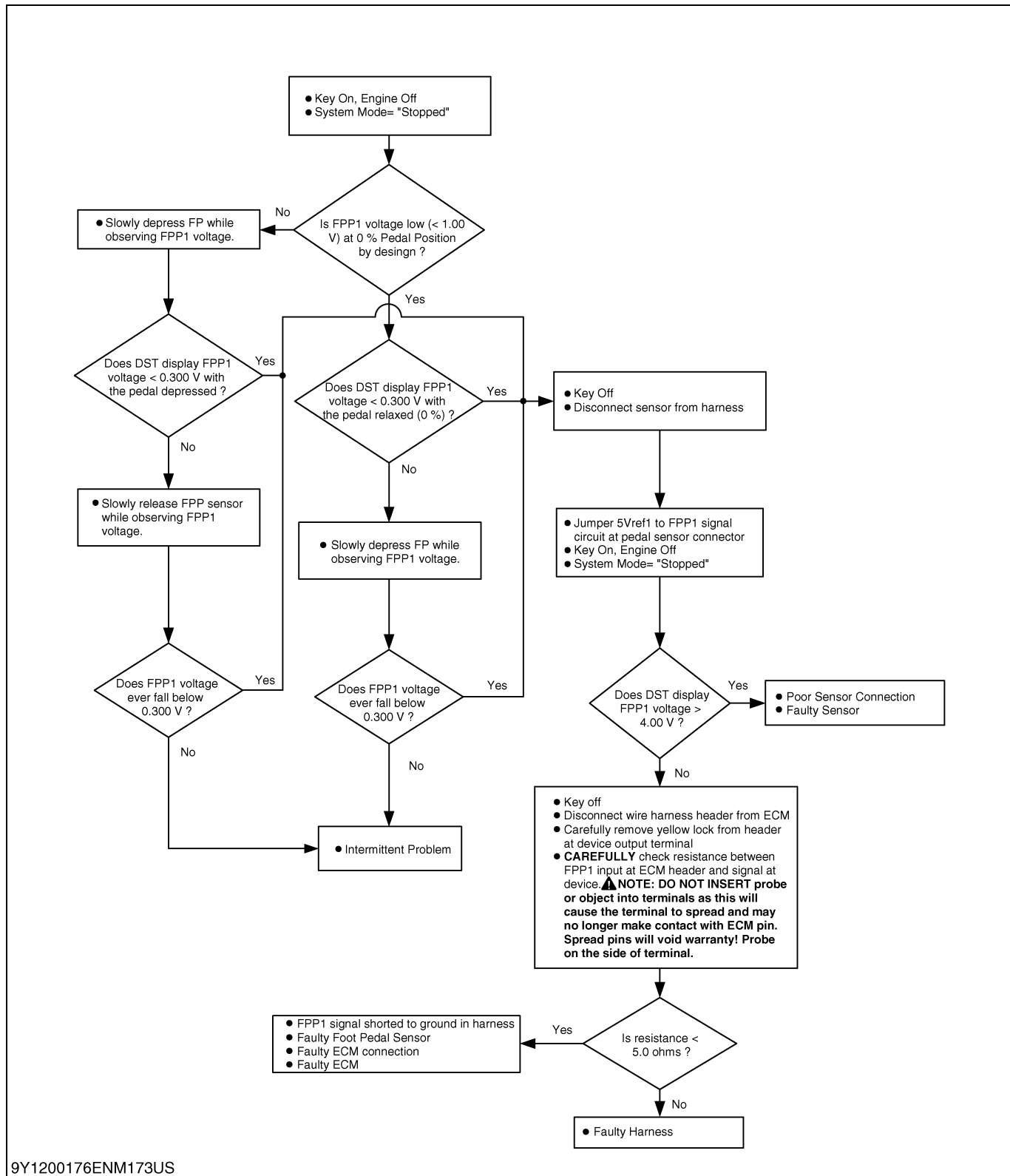
### Diagnostic Aids Chart



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**DTC 2123-FPP1 Voltage Low**

**Diagnostic Aids Chart**

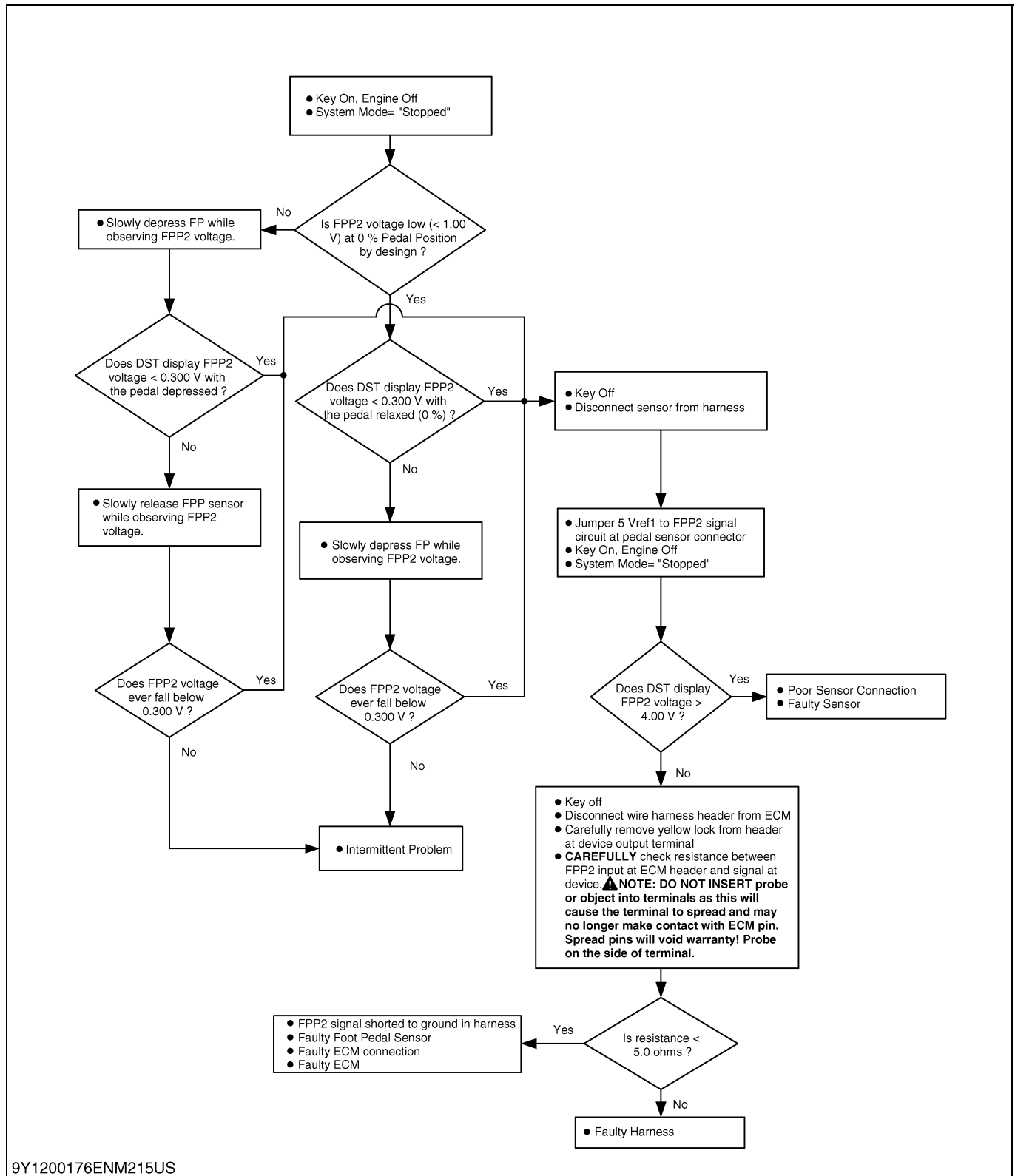


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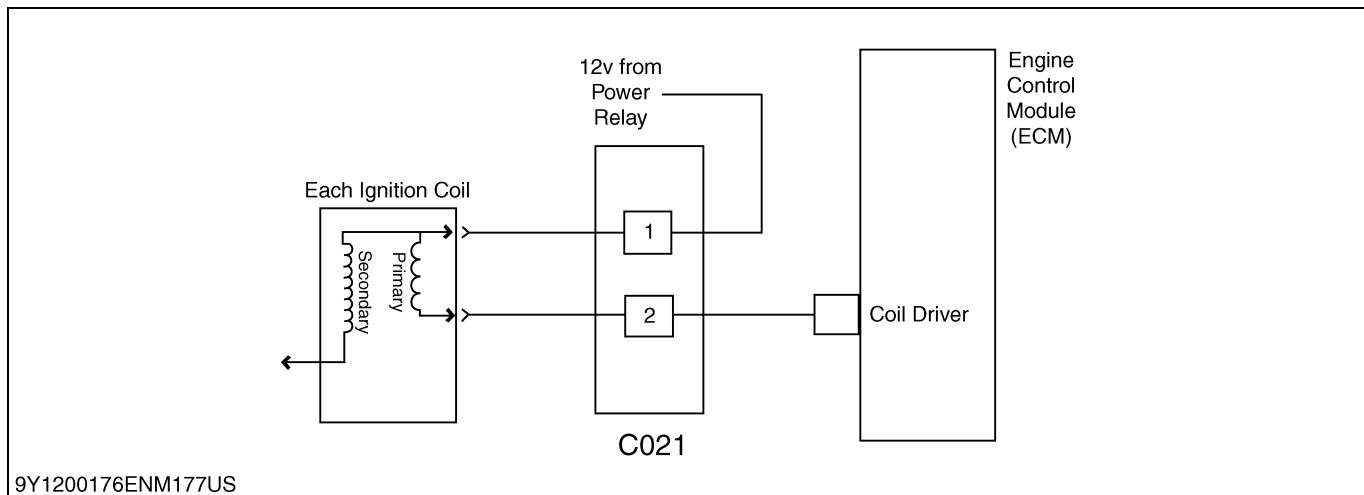


**DTC 2128-FPP2 Voltage Low**

**Diagnostic Aids Chart**



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**(23) Spark Coil Primary (DTC 2300, 2301, 2303, 2304, 2306, 2307, 2309, 2310)****DTC 2300-Spark Coil #1 Primary Open/Short-to-Ground****DTC 2303-Spark Coil #2 Primary Open/Short-to-Ground****DTC 2306-Spark Coil #3 Primary Open/Short-to-Ground****DTC 2309-Spark Coil #4 Primary Open/Short-to-Ground**

- Hardware: Ignition/Spark Coil (Dumb-coil ONLY)
- Enabling Conditions: Key On, Engine Running, Battery volts > 11.0
- Set Conditions: Primary circuitry of the ignition coil is an open circuit or shorted-to-ground
- Corrective Action(s): Illuminate MIL, disable closed-loop while code is active and disable fuel adaptive learn for the rest of the key cycle.
- Emissions related fault
- Possible Causes:

Each coil driver #1, #2, #3 and #4 fires the corresponding cylinder, the 1st, 2nd, 3rd and 4th cylinder each in the block order.

These faults will set if the ECM detects 10 coil firings in which the adaptive dwell adjustment is greater than 2 ms. or the total dwell is greater than 14 ms. and battery voltage is greater than 11.0 V.

The purpose of these faults is to detect a short-to-ground or open circuit in the harness or an open internal to the primary coil.

**DTC 2301-Spark Coil #1 Primary Short-to-Power****DTC 2304-Spark Coil #2 Primary Short-to-Power****DTC 2307-Spark Coil #3 Primary Short-to-Power****DTC 2310-Spark Coil #4 Primary Short-to-Power**

- Hardware: Ignition/Spark Coil (Dumb-coil ONLY)
- Enabling Conditions: Key On, Engine Running, Battery volts < 16.0
- Set Conditions: Primary circuitry of the ignition coil is shorted-to-power
- Corrective Action(s): Illuminate MIL, disable closed-loop while code is active and disable fuel adaptive learn for the rest of the key cycle.
- Emissions related fault
- Possible Causes:

Each coil driver #1, #2, #3 and #4 fires the corresponding cylinder, the 1st, 2nd, 3rd and 4th cylinder each in the block order.

These faults will set if the ECM detects 10 coil firings in which the adaptive dwell adjustment is less than -2 ms. or the total dwell is less than 4.0 ms. and battery voltage is less than 16.0 V.

The purpose of these faults is to detect a short-to-power in the harness or internal to the primary coil.

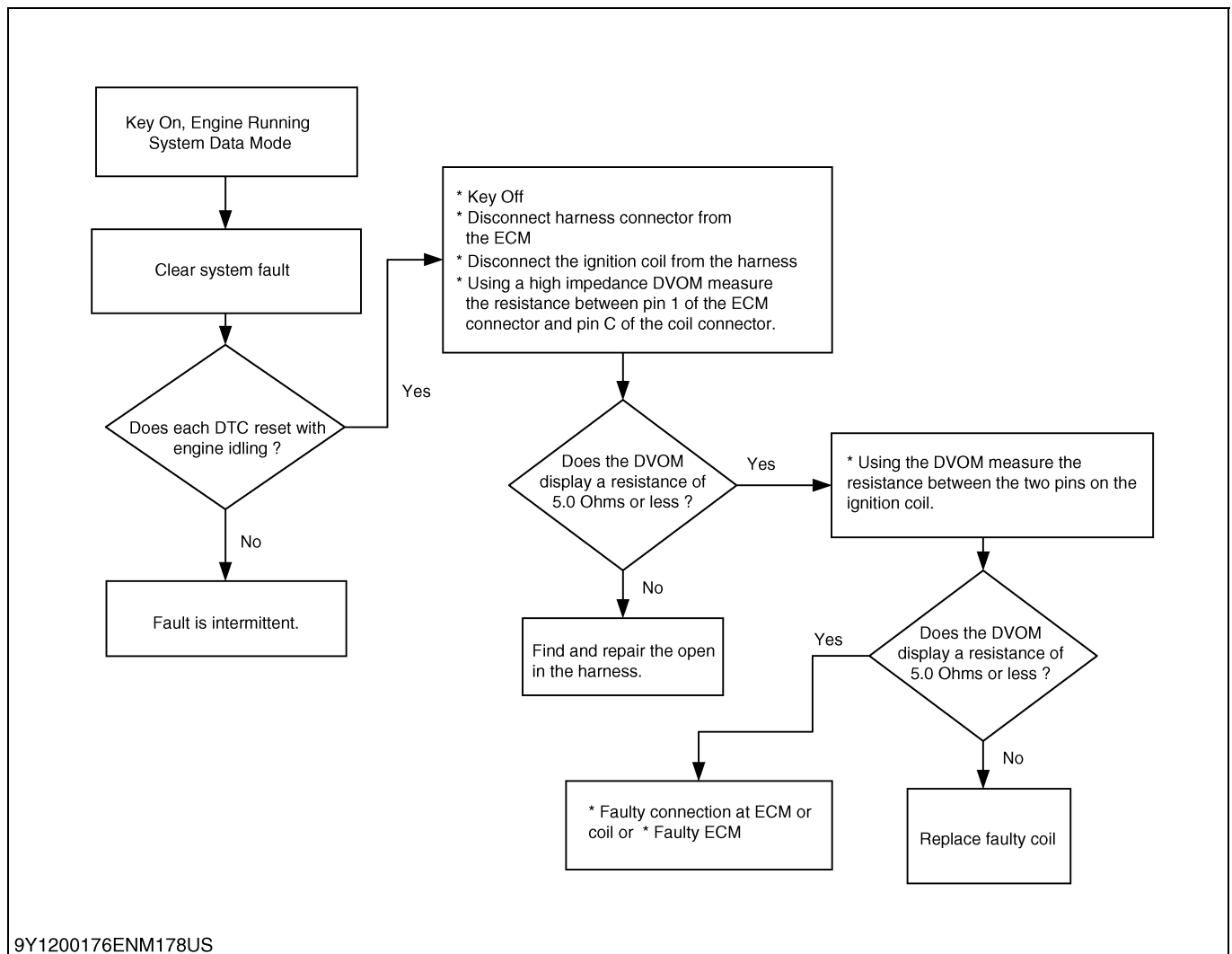
**DTC 2300-Spark Coil #1 Primary Open/Short-to-Ground**

**DTC 2303-Spark Coil #2 Primary Open/Short-to-Ground**

**DTC 2306-Spark Coil #3 Primary Open/Short-to-Ground**

**DTC 2309-Spark Coil #4 Primary Open/Short-to-Ground**

**Diagnostic Aids Chart**



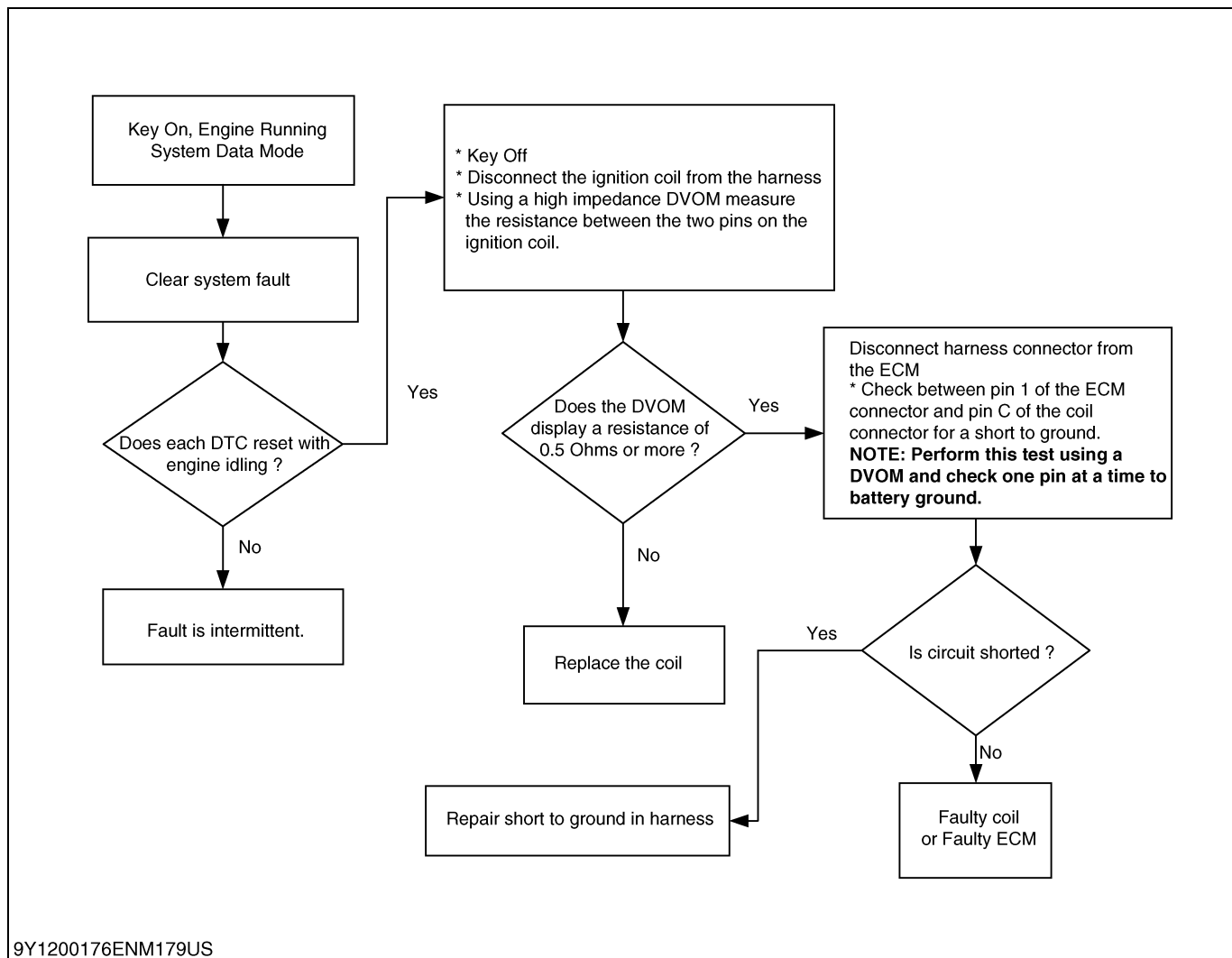
**DTC 2301-Spark Coil #1 Primary Short-to-Power**

**DTC 2304-Spark Coil #2 Primary Short-to-Power**

**DTC 2307-Spark Coil #3 Primary Short-to-Power**

**DTC 2310-Spark Coil #4 Primary Short-to-Power**

**Diagnostic Aids Chart**



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