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# Improving Automotive Troubleshooting Skills

Kevin C. Roner

*Utah State University*

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by

Kevin C. Roner

A Plan B project submitted in partial fulfillment
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of

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Approved:

Dr. Gary Stewardson
Major Professor

Dr. Ed Reeve
Committee Member

Dr. Brian Warnick
Committee Member

UTAH STATE UNIVERSITY
Logan, Utah

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# ABSTRACT

Improving Automotive Troubleshooting Skills

by

Kevin C. Roner, Master of Science

Utah State University, 2014

Major Professor: Dr. Gary Stewardson
Department: Technology and Engineering Education

This project gathered and analyzed data for two cohorts of students at Weber State University. The final performance exam data from the engine controls course and the Automotive Service Excellence certification results were gathered on each student from two cohorts. A skills survey was developed to determine each student's skill level. The survey was delivered to the students and their mentor technicians in the field. The data was analyzed to identify correlating items across the data sets. Those correlations were used to determine which lessons within the course in the content area of diagnostic troubleshooting required improvement. The project resulted in recommendations with examples for improving the diagnostic troubleshooting content of the Toyota Engine Controls course at Weber State University.

(147 pages)

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# CHAPTER I

# INTRODUCTION

Today's automotive technician requires a high level of diagnostic skill because of the increasing sophistication of the technology used in modern vehicle systems. The average vehicle may have 30 or more microprocessor-controlled devices (Motavalli, 2010). These electronic control units (ECU's) require various sensors to feed vehicle system information to each ECU. The Powertrain Control Module (PCM) controls the operation of the engine and receives input from sensors that measure the crankshaft position and speed to determine fuel injection and spark timing. Pressing the door unlock button on the key fob sends a radio transmission to the vehicle that must match the identification programmed into the Door Lock ECU before the doors will unlock.

The heating and air conditioning (A/C) system on the 2007 Toyota Tundra incorporates ECU's into the controlling the blending doors that control air flow and temperature (New Car Features - 2007 Toyota Tundra, 2007). The driver presses a switch to change the cabin air temperature which is an input and to the A/C ECU. The A/C ECU sends a pulse pattern signal out on a multiplex communication bus that consists of three wires which connect to all four actuators – five actuators if the vehicle has Automatic A/C. Each blending door actuator has an ECU built into the connector on the end of the harness and each actuator only operates when it recognizes a signal that matches its programming.

These automotive systems are very different from the automotive systems of thirty years ago. Today's automotive technicians require a large amount of education and training on each automotive system to develop the high-level diagnostic troubleshooting skills needed to work on today's automotive technologies.

**Purpose Statement**

The purpose of this project was to analyze data from two cohorts of students (2012 and 2013) at Weber State University (WSU) in the Department of Automotive Technology. These students completed the Automotive Service (AUSV) course 2060 for Toyota Engine Controls. The end result is improving the content area of diagnostic troubleshooting in the course curriculum. Data was gathered from the final performance exam results for each student, the Automotive Service Excellence (ASE) certification results for each student, and the skill levels for each student through surveying the students and their mentoring technicians. This data was gathered and analyzed to determine which lessons within the course in the area of diagnostic troubleshooting require improvement. The project resulted in recommendations with examples for improving the diagnostic troubleshooting content of the AUSV 2060 Toyota Engine Controls course.

**Needs Statement**

Customers depend on dealerships for vehicle maintenance, diagnosis, and repairs. The dealerships must be able to meet the customers' demands for reoccurring business with current customers and new business with new customers. Customer comments on Facebook, Yelp, and Twitter can make or break a business today which makes it so important for the dealership to fix the vehicle right the first time. To meet those needs, dealerships employ 4 different skill levels of technicians: the A Technician (Master/Diagnostic Technician), the B Technician (Repair Technician), the C Technician

(Apprentice/Trainee), and the D Technician (Lube Specialist). Each customer concern and vehicle goes to the technician with the appropriate skill level.

These skill levels result in different pay levels for technicians. For a D Technician to increase their income through promotion to a C Technician, they must increase their skill level. The same is for promotions from C Technician to B Technician and B Technician to A Technician. The A Technicians have the skills required to diagnose and repair any customer concern on today's vehicles and are the highest paid technicians. According to the 2013 Dealership Workforce Study by the National Automobile Dealers Association, the average B Technician in the Mountain Region earned $54,648, which is more than the all-industry median household income of $50,490. The average A Technician in the Mountain Region earned $61,599 in 2012 (DeltaTrends, 2013).

The difference in skill levels between B Technicians and A Technicians is the high level diagnostic skills that the post-secondary automotive education system should be delivering to their students as troubleshooting techniques. The difficulty in delivering these techniques to students lies in the complexity of vehicle systems and duplicating real-world scenarios in the laboratory. The skills that students retain after completing an engine controls course need to match those required by their customers' vehicles. This requires constant improvement in the quality and delivery of skills to students, including introducing new skills required by new technologies.

**Statement of Assumptions**

The following assumptions were inherent in this project:

1. All Mentor Technicians have honestly completed the survey

2. All Students have honestly completed the survey
3. The skill level of the 2012 cohort was different from the skill level of the 2013 cohort.

**Statement of Limitations**

The following limitations were inherent to this project:

1. Data collected was limited to WSU students in the students in the Toyota Technical Training and Education (T-TEN) Program.
2. Data collected was limited to ten students.
3. Data collected was limited to ten Mentor Technicians.

**Statement of Procedure**

This study gathered and analyzed student data from two cohorts of students that have completed the AUSV 2060 Engine Controls course at WSU. The data gathered includes the final performance exam data broken down by sections and the Automotive Service Excellence (ASE) certification exam pass rates. A survey was developed and delivered to those two cohorts of students and their Mentor Technicians to gather data on forty-seven tasks identified by the National Automotive Technicians Education Foundation (NATEF) for the engine performance courses and fourteen items identified in the T-TEN Instructor Community Instructional Planning Guide (Brownfield, Bramall, & Godson, 2013). The student final performance exam test scores, the ASE certification results, and the surveys were analyzed and correlations were determined between those areas to identify sections of the Engine Controls course that needed improvement. Example labsheets were developed according to the T-TEN Instructor Community Labsheet Templates to include in the curriculum to enhance the Engine Controls course.

**Definition of Acronyms and Terms**

Acronyms:

- ASE: Automotive Service Excellence
- AUSV: Automotive Service
- CAFE: Corporate Average Fuel Economy
- CAN: Controller Area Network
- CARB: California Air Research Board
- CEL: Check Engine Light
- DEF: Diesel Exhaust Fluid
- DTC: Diagnostic Trouble Code
- DVOM: Digital Volt-Ohm Meter
- ECU: Electronic Control Unit
- EPA: Environmental Protection Agency
- MIL: Malfunction Indicator Lamp
- MPX: Multiplex Communication
- NADA: National Automobile Dealers Association
- NATEF: National Automotive Technicians Education Foundation
- OBD: On-Board Diagnosis system
- OBD-II: On-Board Diagnosis system, generation 2
- PCM: Powertrain Control Module
- SAE: Society of Automotive Engineers
- T-TEN: Technician Training and Education Network

- VVT: Variable Valve Timing
- WSS: Wheel Speed Sensors
- WSU: Weber State University

Terms:

- Engine Control Systems
    - Emissions Controls – devices that capture and/or convert emissions from the vehicle
    - Engine Management System – computers, computer programming, sensors, and actuators that control how the engine operates
    - Fuel System – delivers fuel from the fuel tank to the engine cylinders
    - Ignition System– delivers spark to the engine cylinders
    - On-Board Diagnostics System – monitors engine systems for emissions failures
- Sensors:
    - AFS: Air/Fuel Ratio Sensor(s)
    - APPS: Accelerator Pedal Position Sensor
    - CKP: Crankshaft Position Sensor
    - CMP: Camshaft Position Sensor(s)
    - ECT: Engine Coolant Temperature Sensor
    - IAT: Intake Air Temperature Sensor
    - KNK: Knock Sensor(s)
    - MAF: Mass Air Flow Sensor
    - O2S: Oxygen Sensor(s)

- TPS: Throttle Position Sensor

- Technician Skill Levels
  - A Technician: Master Technician, Diagnostic Technician, Mentor Technician. Attributes include 5 years minimum tenure, completing all of the manufacturer certifications, passing ASE Certification exams, and demonstrating high levels of technical and diagnostic competencies. The A Technician is assigned to diagnose difficult problems and customer concerns, to mentor and coach C Technicians, and lead a team of B and C Technicians in the dealership.
  - B Technician: Technician that has completed some manufacturer training, may have completed a post-secondary training program, and has demonstrated competencies in repairing or replacing large components. The B Technician can handle some of the low-difficulty diagnostic situations such as "Malfunction Indicator Lamp" is on. If a diagnostic situation is above the B Technician's skill level, then the job goes to the A Technician.
  - C Technician: Apprentice/Trainee Technician. Attributes include working with a Mentor Technician, may be completing a post-secondary training program, and is learning the trade through observation and close coaching (on-the-job training).
  - D Technician: Lube Technician. Attributes include performing basic routine maintenance such as oil changes, tire rotations, and basic vehicle inspections.

# CHAPTER II

# REVIEW OF LITERATURE

Today's vehicles have very complex systems that are built to make them safer to operate, easier to operate, and be more enjoyable to drive. Vehicles are designed to get optimum power and fuel economy out of the engine while meeting federal regulations, such as emissions levels and Corporate Average Fuel Economy (CAFE), set by the Environmental Protection Agency (EPA) (National OBD Clearinghouse Genreal Information, n.d.).

The Tire Pressure Warning System monitors the tire pressures for tire failure and warns the driver in the event that a tire has low air pressure. The Anti-Lock Brake System (ABS) detects wheel slippage during low-traction brake application to enhance the effectiveness of the brakes by modulating brake hydraulic pressures. The Vehicle Stability Control System (VSC) compares the Steering Angle Sensor value to the Yaw Rate Sensor value to determine if the vehicle is on the intended course, in an under-steer condition, or an over-steer condition.

Some starting systems are designed with a Crank-Hold function so that the Powertrain Control Module (PCM) controls the starter and how long it cranks the engine. The driver needs to only turn the key to the "start" position momentarily, much like the push and release of a button on a keyboard, and the PCM continues cranking until the engine starts. The door lock system now detects a key in the driver's pocket, determines that it is the correct key for the vehicle, and unlocks the door upon the driver touching the door handle (New Car Features - 2004 Toyota Prius, 2004). Similarly, the PCM and

Smart Key System detects the key in the driver's pocket, verifies that it is the correct key for the vehicle, and then starts the engine at the push of the "Start" button (New Car Features - 2007 Toyota Camry, 2007).

The Heating and Air Conditioning (HVAC), Audio, Navigation, and Bluetooth Phone Systems all increase the occupants' comfort to enhance the experience. Now, drivers and passengers can listen to uninterrupted, static-free satellite radio as they drive across country in air conditioned or heated comfort. Incoming phone calls can be answered while the radio is automatically and simultaneously turned off without removing the driver's hands from the steering wheel.

The main function of the engine – to get fuel and air into an enclosed space, compress and combust the fuel and air mixture, absorb and convert the power from that combustion, exhaust the spent fuel and air, and repeat – has not changed since the inception of the engine. Systems that enhance that process have changed, though. Camshafts have moved from the cylinder block and into the cylinder head and then have become two or four instead of one. Valve timing can now be modulated through Variable Valve Timing (VVT) to increase performance at low and high engine speeds. The Evaporative Emissions System captures raw evaporated fuel and prevents that evaporated fuel from escaping to the atmosphere, thus reducing hydrocarbon emissions.

The PCM controls the fuel injection volume, fuel injection timing, and ignition timing for optimum engine power and fuel economy. To do this correctly and efficiently, the PCM requires specific information from sensors such as the Mass Air Flow (MAF), Intake Air Temperature (IAT), Engine Coolant Temperature (ECT), Throttle Position Sensor (TPS), Accelerator Pedal Position Sensor (APPS), Camshaft Position (CMP), Crankshaft Position (CKP), Knock (KNK) Sensor(s), Oxygen Sensors (O2S), and Air/Fuel Ratio Sensors (AFS). These sensor input signals are processed by the PCM to determine how the engine is operating, determine what the driver's demand is, and modify fuel injection volume, injection timing, and ignition timing to achieve the driver's desired output while still maintaining low emissions and high fuel economy.

Computer programming has much to do with how systems operate and perform self-diagnosis. Original Equipment Manufacturers (OEM) have been installing self-diagnosis systems in vehicles sold in California since 1988 due to the regulations set by the California Air Research Board (CARB). That was the birth of On-Board Diagnosis (OBD) systems. OBD incorporated a Malfunction Indicator Light (MIL), also known as a Check Engine Light (CEL), built into the system and located in the instrument cluster on the dash to alert the driver of faults in the vehicle engine and emissions control systems.

The second generation of automotive On-Board Diagnosis systems (OBD-II) was mandated in the United States by the 1990 Clean Air Act (National OBD Clearinghouse FAQ, n.d. ). OBD-II was required in all 1996 and newer model-year production vehicles. The OBD-II system monitors some engine control functions and all of the emissions control systems on the vehicle to detect failures within those systems.

The PCM contains all of the operational programming for the engine systems to function and the OBD-II system. Part of that programming contains a series of tests for specific systems called Monitors. Monitors are designed to observe systems for faults – some systems are monitored constantly and other systems only when certain operating conditions exist. When a Monitor detects a problem, the MIL in the Instrument Cluster is turned on to indicate to the driver that there is a problem in the system and the PCM stores a Diagnostic Trouble Code (DTC) for the fault detected.

During diagnosis of a customer's concern, the Technician can access that DTC with the use of a Scan Tool which communicates with the vehicle's on-board computer to access the OBD-II system. This is where the Technician can review history, pending, current, and permanent DTC's to determine whether the fault is occurring now, has occurred in the past, or has occurred recently. DTC's are then referenced in the Repair Manual for the vehicle and put the Technician on a diagnostic path where they will use other functions of the Scan Tool such as Data List, Active Test, Monitor, and Utilities. The Technician can review lists of data parameters (inputs and outputs); perform Active Tests to see immediate changes in different data parameters; review Monitor data to see what part of the series of tests failed; and the Utility Function for special functions that depend on the year, make, and model of the vehicle.

The Technician must be able to read and interpret this large amount data and use the functionality of the many diagnostic tools, such as Digital Volt-Ohm Meters (DVOM) or Oscilloscopes, to correctly identify the fault in the system. This can be overwhelming to the B, C, and D Automotive Technicians. The A Technician has years of experience and training to draw on and therefore is capable of tackling problems with higher levels of difficulty on sophisticated systems.

**Diagnostic Troubleshooting**

Modern automotive troubleshooting follows two methods: 1) Retrieve a DTC from the PCM and diagnose according to the steps in the repair manual or 2) Compare the customer's concern to the Problem-Symptoms Table and identify systems or components to inspect and inspect as per the repair manual (M. Montoya, personal communication, August 4, 2012). The repair manual contains specific steps for diagnosing every DTC that is associated with that particular vehicle which are very useful when the DTC is present. An A Technician in the field will not be reviewing the Problem-Symptoms Table at the beginning of a no-start diagnosis as their experience has taught them that the engine must have fuel, air, compression, and spark for the engine to start and remain running. The A Technician has a high level of knowledge of the vehicle systems and subsystems to make the correct diagnosis at decision points.

Automotive troubleshooting curriculum is broken down by the systems and subsystems. The textbook, Automotive Engine Performance (Pickerill, 2010), contains fourteen chapters and each chapter contains information on a system, what components are required for the system, where the system lives, how it functions properly, and how to troubleshoot faults in the system. These fourteen chapters can be grouped together as five curriculum modules that comprise of engine fundamentals, fuel systems, ignition systems, computer controls, and emissions controls.

The five curriculum modules are then broken into their subsidiary components for discussion and laboratory work on the location, operation, and diagnosis on each item in the system. The system components are brought back together to demonstrate how they function together to accomplish the objectives of the systems. Through this sequence, the students will gather knowledge and skills for working on customers' vehicles.

To deliver high level diagnostic skills to students, the curriculum must tie the various systems together (Roner, 2012). The A Technician in the field makes troubleshooting decisions based on knowledge and experience, such as identifying an ignition fault that may appear to the customer as a MIL illuminated and a fuel trim DTC. The curriculum should demonstrate the interconnectedness of the vehicle systems to deliver those high-level diagnostic troubleshooting skills.

# CHAPTER III

# METHODOLOGY

The purpose of this project was to analyze data from two cohorts of students (2012 and 2013) at Weber State University (WSU) in the Department of Automotive Technology. These students completed the Automotive Service (AUSV) course 2060 for Toyota Engine Controls. The end result is improving the content area of diagnostic troubleshooting in the course curriculum. Data was gathered from the final performance exam results for each student, the Automotive Service Excellence (ASE) certification results for each student, and the skill levels for each student through surveying the students and their mentoring technicians. This data was gathered and analyzed to determine which lessons within the course in the area of diagnostic troubleshooting require improvement. The project resulted in recommendations with examples for improving the diagnostic troubleshooting content of the AUSV 2060 Toyota Engine Controls course.

## Final Performance Exam

Final performance exam data was gathered from course records for the AUSV 2060 at WSU for the 2012 and 2013 cohorts of students. The data was organized to compare the cohorts and each student per each section of the final performance exam. Student names were deleted from the report for anonymity. See Appendix A for Final Performance Exam data.

**ASE Certification Data**

ASE Certification Data was gathered by contacting each individual student and inquiring whether they passed the ASE Certification Exam for Engine Performance. The Certification pass rate was determined by dividing the number of students that passed the certification exam by the total number of students that took the certification exam. Student names were deleted from the report for anonymity. See Appendix B for ASE Certification data.

**Survey**

Dealership Mentor Technicians completed a survey developed to assess the students' skill levels across sixty-one items on a zero-to-three point scale. Mentors assigned zero points for: no exposure – no information nor practice before. One point was assigned for: exposure only – general information only. Two points were assigned for: moderately skilled – was performed previously and more training is necessary. Mentors assigned three points for: skilled – can perform independently without any additional training. The students completed a survey as a self-assessment and assigned points on the same scale as the Mentor Technicians.

The survey addressed all of the tasks identified by the National Automotive Technicians Education Foundation (NATEF) (Foundation, 2013) and select items from the T-TEN Instructor Community Instructional Planning Guide (Brownfield, Bramall, & Godson, 2013) for an Automotive Engine Performance course delivered at the post-secondary level. Items from the T-TEN Instructor Community Instructional Planning Guide that overlapped the NATEF task list were omitted due to duplication. See Appendix C for the Survey and Appendix D for the Survey results.

## Analysis

The Final Performance Exam data was reviewed to identify the two areas in which the students scored lowest. The ASE Certification Data was analyzed to determine the ASE Certification exam pass rate. The Survey results were broken into three categories. Those categories are:

1. Needs improvement – scoring zero (0) to one and one-half (1.5) points
2. Acceptable – scoring one and one-half (1.5) to two (2) points
3. Performing as expected – scoring two (2) to three (3) points

Review of the final exam data, the ASE certification data, and the survey data revealed correlations between the data sets. These correlations identified content areas that required curriculum content improvement.

## Development

The Researcher developed recommendations and specific examples for content improvement. The curriculum content improvements are additional labsheets that were inserted in the current curriculum – see Appendix E for the AUSV 2060 Course Outline. The developed labsheets met the requirements set by the labsheet templates developed by the T-TEN Instructor Community (Brownfield, Bramall, & Godson, 2013). Those labsheet templates are:

1. System Basics – this labsheet is ideal for introducing a system and guiding the students through discovery-based learning of systems and their components.
2. Procedural – this labsheet is ideal for walking the students through a procedure or process such as an engine overhaul.

3. Diagnostic – this labsheet is ideal for delivering diagnostic sequences or skills and includes performing fault diagnosis on a vehicle.

# CHAPTER IV

# FINDINGS

The purpose of this project was to analyze data from two cohorts of students (2012 and 2013) at Weber State University (WSU) in the Department of Automotive Technology. These students completed the Automotive Service (AUSV) course 2060 for Toyota Engine Controls. The end result is improving the content area of diagnostic troubleshooting in the course curriculum. Data was gathered from the final performance exam results for each student, the Automotive Service Excellence (ASE) certification results for each student, and the skill levels for each student through surveying the students and their mentoring technicians. This data was gathered and analyzed to determine which lessons within the course in the area of diagnostic troubleshooting require improvement. The project resulted in recommendations with examples for improving the diagnostic troubleshooting content of the AUSV 2060 Toyota Engine Controls course.

In the Final Performance Exam, the students were tested on six sections of the engine controls course. Each section had a time limit of thirty minutes and the all of the students rotated through each of the sections on the assigned final exam day. Two areas were identified in the Final Performance Exam Data (see Table 4-1) as weak areas because the students averaged scores below twenty points out of the thirty points possible. Therefore, the weak areas targeted for improvement were Evaporative Emissions System Leaks and Misfire Diagnosis due to Fuel Trim.

Table 4-1: Final Performance Exam Data

| Toyota Engine Control Systems, AUSV 2060 Weber State University, Instructor: Kevin C. Roner | DTC Diagnosis due to Coolant Temperature Sensor | Cranks, No Start due to Fuel System | Evaporative Emissions Leak | DTC Diagnosis due to Ignition System | Misfire Diagnosis due to Fuel Trim | Misfire Diagnosis due to Ignition System | | |
|---|---|---|---|---|---|---|---|---|
| **Fall Semester, 2012** | **Vehicle 58** | **Vehicle 61** | **Vehicle 62** | **Vehicle 63** | **Vehicle 66** | **Vehicle 74** | **Sub-Total** | **Percentage** |
| Student 1 | 25 | 25 | 25 | 30 | 15 | 15 | 135 | 75% |
| Student 2 | 30 | 20 | 20 | 25 | 5 | 30 | 130 | 72% |
| Student 3 | 25 | 25 | 15 | 20 | 5 | 25 | 115 | 64% |
| Student 4 | 25 | 25 | 20 | 30 | 20 | 30 | 150 | 83% |
| Student 5 | 20 | 25 | 15 | 30 | 20 | 30 | 140 | 78% |
| Student 6 | 25 | 25 | 20 | 25 | 10 | 20 | 125 | 69% |
| Student 7 | 30 | 25 | 25 | 17.5 | 10 | 30 | 137.5 | 76% |
| Average Student | 25.71 | 24.29 | 20.00 | 25.36 | 12.14 | 25.71 | 133.21 | 74% |
| Points available per station | 30 | 30 | 30 | 30 | 30 | 30 | 180 | |
| | | | | | | | | |
| **Fall Semester, 2013** | **Vehicle 70** | **Vehicle 61** | **Vehicle 62** | **Vehicle 63** | **Vehicle 76** | **Vehicle 78** | **Sub-Total** | **Percentage** |
| Student 8 | 20 | 20 | 20 | 25 | 5 | 30 | 120 | 67% |
| Student 9 | 15 | 15 | 15 | 25 | 10 | 20 | 100 | 56% |
| Student 10 | 10 | 20 | 15 | 20 | 5 | 15 | 85 | 47% |
| Student 11 | 20 | 20 | 5 | 15 | 5 | 30 | 95 | 53% |
| Student 12 | 25 | 25 | 15 | 30 | 15 | 25 | 135 | 75% |
| Student 13 | 15 | 20 | 15 | 20 | 15 | 30 | 115 | 64% |
| Student 14 | 25 | 25 | 20 | 25 | 20 | 25 | 140 | 78% |
| Student 15 | 15 | 10 | 10 | 15 | 10 | 15 | 75 | 42% |
| Average Student | 18.13 | 19.38 | 14.38 | 21.88 | 10.63 | 23.75 | 108.13 | 60% |
| Points available per station | 30 | 30 | 30 | 30 | 30 | 30 | 180 | |
| | | | | | | | | |
| **Average Student Scores** | **DTC Diagnosis due to Coolant Temperature Sensor** | **Cranks, No Start due to Fuel System** | **Evaporative Emissions Leak** | **DTC Diagnosis due to Ignition System** | **Misfire Diagnosis due to Fuel Trim** | **Misfire Diagnosis due to Ignition System** | **Subtotal each Year** | **Percentage** |
| Cumulative Fall Semester, 2012 | 180.00 | 170.00 | 140.00 | 177.50 | 85.00 | 180.00 | 932.50 | 74.01% |
| Cumulative Fall Semester, 2013 | 145.00 | 155.00 | 115.00 | 175.00 | 85.00 | 190.00 | 865.00 | 68.65% |
| Average all years | 21.67 | 21.67 | 17.00 | 23.50 | 11.33 | 24.67 | | |

The ASE Certification Data (see Table 4-2) shows that of the seven students that attempted the ASE Certification exam, four students passed the exam, which is a fifty-seven percent passing rate. This indicates that the core of curriculum was working and that adjustments to that core curriculum were needed contrasted to a complete rewrite of the curriculum.

Table 4-2: ASE Certification Data

| Student | ASE Certification | Reason |
|---|---|---|
| A | yes | |
| B | no | did not attempt |
| C | yes | |
| D | yes | |
| E | no | did not attempt |
| F | failed | |
| G | yes | |
| H | no | did not attempt |
| I | failed | |
| J | failed | |
| Number of attempts | 7 | |
| Number passed | 4 | |
| Number failed | 3 | |
| Number not attempted | 3 | |

The Survey was delivered to ten students and their eight mentors. Two mentors had one student from each cohort. The Survey Data results were broken into three categories. Those categories were:

1. Needs improvement – scoring zero (0) to one and one-half (1.5) points
2. Acceptable – scoring one and one-half (1.5) to two (2) points
3. As expected – scoring two (2) to three (3) points

The Survey Data (see Table 4-3) identifies thirteen skill items that fell into the needs improvement category. Those thirteen items became the target for improvement and were shaded grey in Table 4-3. Forty-eight items fell into the acceptable or as expected categories.

Table 4-3: Survey Data

| **A. General: Engine Diagnosis** | **Subtotal** | **# of Surveys** | **Average** |
|---|---|---|---|
| 1. Identify and interpret engine performance concerns; determine necessary action. | 39 | 20 | 1.95 |
| 2. Research applicable vehicle and service information, vehicle service history, service precautions, and technical service bulletins. | 51 | 20 | 2.55 |
| 3. Diagnose abnormal engine noises or vibration concerns; determine necessary action. | 36 | 20 | 1.80 |
| 4. Diagnose the cause of excessive oil consumption, coolant consumption, unusual exhaust color, odor, and sound; determine necessary action. | 32 | 20 | 1.60 |
| 5. Perform engine absolute (vacuum/boost) manifold pressure tests; determine necessary action. | 27 | 20 | 1.35 |
| 6. Perform cylinder power balance test; determine necessary action. | 32 | 20 | 1.60 |
| 7. Perform cylinder cranking and running compression tests; determine necessary action. | 34 | 20 | 1.70 |
| 8. Perform cylinder leakage test; determine necessary action. | 30 | 20 | 1.50 |
| 9. Diagnose engine mechanical, electrical, electronic, fuel, and ignition concerns; determine necessary action. | 41 | 20 | 2.05 |
| 10. Verify engine operating temperature; determine necessary action. | 46 | 20 | 2.30 |
| 11. Verify correct camshaft timing. | 38 | 20 | 1.90 |

Table 4-3: Survey Data (continued)

| | | | |
|---|---|---|---|
| **B. Computerized Controls Diagnosis and Repair** | | | |
| 1. Retrieve and record diagnostic trouble codes, OBD monitor status, and freeze frame data; clear codes when applicable. | 57 | 20 | 2.85 |
| 2. Access and use service information to perform step-by-step (troubleshooting) diagnosis. | 49 | 20 | 2.45 |
| 3. Perform active tests of actuators using a scan tool; determine necessary action. | 47 | 20 | 2.35 |
| 4. Describe the importance of running all OBDII monitors for repair verification. | 43 | 20 | 2.15 |
| 5. Diagnose the causes of emissions or driveability concerns with stored or active diagnostic trouble codes; obtain, graph, and interpret scan tool data. | 37 | 20 | 1.85 |
| 6. Diagnose emissions or driveability concerns without stored diagnostic trouble codes; determine necessary action. | 27 | 20 | 1.35 |
| 7. Inspect and test computerized engine control system sensors, powertrain/engine control module (PCM/ECM), actuators, and circuits using a graphing multimeter (GMM)/digital storage oscilloscope (DSO); perform necessary action. | 28 | 20 | 1.40 |
| 8. Diagnose driveability and emissions problems resulting from malfunctions of interrelated systems (cruise control, security alarms, suspension controls, traction controls, A/C, automatic transmissions, non-OEM installed accessories, or similar systems); determine necessary action. | 22 | 20 | 1.10 |
| **C. Ignition System Diagnosis and Repair** | | | |
| 1. Diagnose (troubleshoot) ignition system related problems such as no-starting, hard starting, engine misfire, poor driveability, spark knock, power loss, poor mileage, and emissions concerns; determine necessary action. | 36 | 20 | 1.80 |
| 2. Inspect and test crankshaft and camshaft position sensor(s); perform necessary action. | 34 | 20 | 1.70 |

Table 4-3: Survey Data (continued)

| | | | |
|---|---|---|---|
| 3. Inspect, test, and/or replace ignition control module, powertrain/engine control module; reprogram as necessary. | 36 | 20 | 1.80 |
| 4. Remove and replace spark plugs; inspect secondary ignition components for wear and damage. | 53 | 20 | 2.65 |
| **D. Fuel, Air Induction, and Exhaust Systems Diagnosis and Repair** | | | |
| 1. Diagnose (troubleshoot) hot or cold no-starting, hard starting, poor driveability, incorrect idle speed, poor idle, flooding, hesitation, surging, engine misfire, power loss, stalling, poor mileage, dieseling, and emissions problems; determine necessary action. | 32 | 20 | 1.60 |
| 2. Check fuel for contaminants; determine necessary action. | 29 | 20 | 1.45 |
| 3. Inspect and test fuel pumps and pump control systems for pressure, regulation, and volume; perform necessary action. | 40 | 20 | 2.00 |
| 4. Replace fuel filter(s). | 42 | 20 | 2.10 |
| 5. Inspect, service, or replace air filters, filter housings, and intake duct work. | 56 | 20 | 2.80 |
| 6. Inspect throttle body, air induction system, intake manifold and gaskets for vacuum leaks and/or unmetered air. | 43 | 20 | 2.15 |
| 7. Inspect and test fuel injectors. | 35 | 20 | 1.75 |
| 8. Verify idle control operation. | 32 | 20 | 1.60 |
| 9. Inspect integrity of the exhaust manifold, exhaust pipes, muffler(s), catalytic converter(s), resonator(s), tail pipe(s), and heat shields; perform necessary action. | 44 | 20 | 2.20 |
| 10. Inspect condition of exhaust system hangers, brackets, clamps, and heat shields; repair or replace as needed. | 52 | 20 | 2.60 |
| 11. Perform exhaust system back-pressure test; determine necessary action. | 21 | 20 | 1.05 |
| 12. Check and refill diesel exhaust fluid (DEF). | 8 | 20 | 0.40 |

Table 4-3: Survey Data (continued)

| | | | |
|---|---|---|---|
| 13. Test the operation of turbocharger/supercharger systems; determine necessary action. | 8 | 20 | 0.40 |
| **E. Emissions Control Systems Diagnosis and Repair** | | | |
| 1. Diagnose oil leaks, emissions, and driveability concerns caused by the positive crankcase ventilation (PCV) system; determine necessary action. | 33 | 20 | 1.65 |
| 2. Inspect, test, and service positive crankcase ventilation (PCV) filter/breather cap, valve, tubes, orifices, and hoses; perform necessary action. | 35 | 20 | 1.75 |
| 3. Diagnose emissions and driveability concerns caused by the exhaust gas recirculation (EGR) system; determine necessary action. | 30 | 20 | 1.50 |
| 4. Diagnose emissions and driveability concerns caused by the secondary air injection and catalytic converter systems; determine necessary action. | 28 | 20 | 1.40 |
| 5. Diagnose emissions and driveability concerns caused by the evaporative emissions control system; determine necessary action. | 34 | 20 | 1.70 |
| 6. Inspect and test electrical/electronic sensors, controls, and wiring of exhaust gas recirculation (EGR) systems; perform necessary action. | 33 | 20 | 1.65 |
| 7. Inspect, test, service, and replace components of the EGR system including tubing, exhaust passages, vacuum/pressure controls, filters, and hoses; perform necessary action. | 31 | 20 | 1.55 |
| 8. Inspect and test electrical/electronically-operated components and circuits of air injection systems; perform necessary action. | 31 | 20 | 1.55 |
| 9. Inspect and test catalytic converter efficiency. | 33 | 20 | 1.65 |
| 10. Inspect and test components and hoses of the evaporative emissions control system; perform necessary action. | 35 | 20 | 1.75 |

Table 4-3: Survey Data (continued)

| | | | |
|---|---|---|---|
| 11. Interpret diagnostic trouble codes (DTCs) and scan tool data related to the emissions control systems; determine necessary action. | 41 | 20 | 2.05 |
| **F. T-TEN Instructor Community Skill Survey** | | | |
| Perform 5-gas Emissions Testing and Diagnosis | 28 | 20 | 1.40 |
| Inspect and Diagnose Ignition systems using an Oscilloscope (IGT and IGF) | 28 | 20 | 1.40 |
| Perform Diagnosis on LEV-2 and Key-Off Evaporative Emissions Systems | 33 | 20 | 1.65 |
| Save the Techstream data file and using Techstream functions | 46 | 20 | 2.30 |
| Inspect and diagnose vehicle concerns with the 6-step diagnostic process | 40 | 20 | 2.00 |
| Using Techstream for repair verification | 51 | 20 | 2.55 |
| Test the Evaporative System with the Smoke Tester | 38 | 20 | 1.90 |
| Using the Utilities function in Techstream | 43 | 20 | 2.15 |
| Perform the Permanent DTC erasure process | 33 | 20 | 1.65 |
| Using basic common sense | 51 | 20 | 2.55 |
| Identifying ECM terminals and circuits | 47 | 20 | 2.35 |
| Identify Learned Memory and the required resetting procedures | 33 | 20 | 1.65 |
| Differentiate between engine-caused and transmission-caused issues | 32 | 20 | 1.60 |
| Listen to the Customer and verify the Customer's concern | 42 | 20 | 2.10 |
| | | Group Subtotal | 111.30 |
| | | # of Tasks | 61 |
| | | Group Average | 1.82 |

The Survey Data was compared to the Final Performance Exam Data and several correlations between content in each data set were identified. Those correlations were as follows:

1. Four of the thirteen survey items aligned with two sections from the final performance exam.
2. Nine items on the survey did not align to a section from the final performance exam.
3. One item identified on the final performance exam was not identified by the survey.

The Correlations Data (see Table 4-4) linked the survey results to the students' performance on the Final Performance Exam. The labsheets that were added to the curriculum and the format of those labsheets are listed in the right-hand column.

Table 4-4: Correlations Data

| **Engine Controls Survey** | **Final Performance Exam** | **Labsheet Added (Format)** |
|---|---|---|
| NATEF VIII.A.5: Perform engine absolute (vacuum/boost) manifold pressure tests; determine necessary action. | none | Engine Sealing (Procedural) |
| NATEF VIII.A.8: Perform cylinder leakage test; determine necessary action. | none | Engine Sealing (Procedural) |
| NATEF VIII.B.6: Diagnose emissions or driveability concerns without stored diagnostic trouble codes; determine necessary action. | Misfire Diagnosis Due to Fuel Trim | Fuel Trim (Diagnostic) |

Table 4-4: Correlations Data (continued)

| | | |
|---|---|---|
| NATEF VIII.B.7: Inspect and test computerized engine control system sensors, powertrain/engine control module (PCM/ECM), actuators, and circuits using a graphing multimeter (GMM)/digital storage oscilloscope (DSO); perform necessary action. | Misfire Diagnosis Due to Fuel Trim | Fuel Trim (Diagnostic) |
| NATEF VIII.D.2: Check fuel for contaminants; determine necessary action. | Misfire Diagnosis Due to Fuel Trim | Fuel Trim (Diagnostic) |
| NATEF VIII.B.8: Diagnose driveability and emissions problems resulting from malfunctions of interrelated systems (cruise control, security alarms, suspension controls, traction controls, A/C, automatic transmissions, non-OEM installed accessories, or similar systems); determine necessary action. | none | Interrelated Systems (System Basics) |
| NATEF VIII.D.11: Perform exhaust system back-pressure test; determine necessary action. | none | Intake and Exhaust Systems (System Basics) |
| NATEF VIII.D.12: Check and refill diesel exhaust fluid (DEF). | none | Intake and Exhaust Systems (System Basics) |
| NATEF VIII.D.13: Test the operation of turbocharger/supercharger systems; determine necessary action. | none | Intake and Exhaust Systems (System Basics) |
| NATEF VIII.E.3: Diagnose emissions and driveability concerns caused by the exhaust gas recirculation (EGR) system; determine necessary action. | none | Exhaust Emissions (Diagnostic) |
| NATEF VIII.E.4: Diagnose emissions and driveability concerns caused by the secondary air injection and catalytic converter systems; determine necessary action. | none | Exhaust Emissions (Diagnostic) |
| T-TEN Instructor Community Skill Survey: Perform 5-gas Emissions Testing and Diagnosis | none | Exhaust Emissions (Diagnostic) |

Table 4-4: Correlations Data (continued)

| | | |
|---|---|---|
| T-TEN Instructor Community Skill Survey: Inspect and Diagnose Ignition systems using an Oscilloscope (IGT and IGF) | Misfire Diagnosis due to Ignition System | No-Start Ignition System (Diagnostic) |
| none | Evaporative Emissions System Leaks | Evaporative Emission System (Diagnostic) |

**Teach and Reflect**

Correlations identified seven labsheets that were created to address the improvements needed in the course. See Appendix F for the Correlation Chart and Appendix G for the Labsheets. Those labsheets were:

1. Engine Sealing
2. Fuel Trim
3. Interrelated Systems
4. Intake and Exhaust Systems
5. Exhaust Emissions
6. No-Start Ignition System
7. Evaporative Emission System

The survey identified two skills that indicated a need for a labsheet that covers Engine Sealing. This labsheet covers those tests that determine the integrity of the engine mechanical system. Those survey skills were:

1. NATEF VIII.A.5: Perform engine absolute (vacuum/boost) manifold pressure tests; determine necessary action.

2. NATEF VIII.A.8: Perform cylinder leakage test; determine necessary action.

The final performance exam data showed weaknesses in Misfire Diagnosis due to Fuel Trim which aligned to three survey skills. Those survey skills were:

1. NATEF VIII.B.6: Diagnose emissions or driveability concerns without stored diagnostic trouble codes; determine necessary action.
2. NATEF VIII.B.7: Inspect and test computerized engine control system sensors, powertrain/engine control module (PCM/ECM), actuators, and circuits using a graphing multimeter (GMM)/digital storage oscilloscope (DSO); perform necessary action.
3. NATEF VIII.D.2: Check fuel for contaminants; determine necessary action.

The Fuel Trim labsheet was written to address the weakness identified in the final performance exam. The labsheet is built around diagnosing fuel trim faults and incorporates the skills identified in the survey.

The survey revealed one skill that indicated a need for an Interrelated Systems labsheet. That skill was:

1. NATEF VIII.B.8: Diagnose driveability and emissions problems resulting from malfunctions of interrelated systems (cruise control, security alarms, suspension controls, traction controls, A/C, automatic transmissions, non-OEM installed accessories, or similar systems); determine necessary action.

The survey revealed three skills that identified a need for an Intake and Exhaust Systems labsheet. Those skills are:

1. NATEF VIII.D.11: Perform exhaust system back-pressure test; determine necessary action.
2. NATEF VIII.D.12: Check and refill diesel exhaust fluid (DEF).
3. NATEF VIII.D.13: Test the operation of turbocharger/supercharger systems; determine necessary action.

The survey revealed three skills that identified a need for an Exhaust Emissions labsheet. Those skills are:

1. NATEF VIII.E.3: Diagnose emissions and driveability concerns caused by the exhaust gas recirculation (EGR) system; determine necessary action.
2. NATEF VIII.E.4: Diagnose emissions and driveability concerns caused by the secondary air injection and catalytic converter systems; determine necessary action.
3. T-TEN Instructor Community Skill Survey: Perform 5-gas Emissions Testing and Diagnosis.

The final performance exam data showed weaknesses in Misfire Diagnosis due to Ignition System which aligned to one survey skill. That survey skill was:

1. T-TEN Instructor Community Skill Survey: Inspect and Diagnose Ignition systems using an Oscilloscope (IGT and IGF).

The final performance exam data showed a weakness in Evaporative Emissions System Leaks. The survey identified that Evaporative Emissions fell into the acceptable category. Therefore, the Evaporative Emission System (Diagnostic) labsheet was developed to improve skills to address the low scores on the final performance exam.

# CHAPTER V

# CONCLUSIONS

The purpose of this project was to analyze data from two cohorts of students (2012 and 2013) at Weber State University (WSU) in the Department of Automotive Technology. These students completed the Automotive Service (AUSV) course 2060 for Toyota Engine Controls. The end result is improving the content area of diagnostic troubleshooting in the course curriculum. Data was gathered from the final performance exam results for each student, the Automotive Service Excellence (ASE) certification results for each student, and the skill levels for each student through surveying the students and their mentoring technicians. This data was gathered and analyzed to determine which lessons within the course in the area of diagnostic troubleshooting require improvement. The project resulted in recommendations with examples for improving the diagnostic troubleshooting content of the AUSV 2060 Toyota Engine Controls course.

**Application to the Course**

The Researcher developed recommendations and specific examples for content improvement. The curriculum content improvements are additional labsheets that were inserted in the current curriculum – see Appendix A for the AUSV 2060 Course Outline. The developed labsheets met the requirements set by the labsheet templates developed by the T-TEN Instructor Community (Brownfield, Bramall, & Godson, 2013). Those labsheet templates are:

1. System Basics – this labsheet is ideal for introducing a system and guiding the students through discovery-based learning of systems and their components.
2. Procedural – this labsheet is ideal for walking the students through a procedure or process such as an engine overhaul.
3. Diagnostic – this labsheet is ideal for delivering diagnostic sequences or skills and includes performing fault diagnosis on a vehicle.

New content was developed and integrated into the course. The Engine Sealing (procedural) labsheet covers theory and procedures for testing the engine mechanical system. Those tests are Intake Manifold Vacuum, Cooling System Pressure, Compression Pressure, and Cylinder Leakage tests. These are normal engine mechanical diagnostic tests that the Technician in the field uses to determine that the engine is mechanically sound. This labsheet is inserted into the first module of the course to ensure that the students have a firm grasp on base engine functions.

The Fuel Trim (diagnostic) labsheet covers basics, theory, the diagnostic process walk-through, a diagnostic application, and a skill assessment for the Fuel Trim system. Basic fuel trim is based on engine speed, volume of air flowing into the engine, and the throttle position. It is optimized by the Powertrain Control Module (PCM) based on feedback from the Air-Fuel Ratio Sensors (AFS). This labsheet is inserted at the end of the fuel systems module.

The Interrelated Systems (system basic) labsheet covers the basic operations of systems such as cruise control, heating and air conditioning, security alarms, and immobilizer systems. These systems share information to enhance the operation of each system. This labsheet is inserted in the engine control systems and sensors module.

The Intake and Exhaust Systems (system basic) labsheet covers basic operation and theory of exhaust systems. This includes testing exhaust back-pressure, discussion on diesel exhaust systems and the application of Diesel Exhaust Fluid (DEF), testing turbochargers and testing superchargers. This labsheet is inserted in the engine control systems and sensors module.

The Exhaust Emissions (diagnostic) labsheet covers exhaust emission basics, combustion chemistry theory, a diagnostic process walk-through, a diagnostic application, and a skill assessment for the Exhaust Emissions system. This labsheet is inserted in the emissions control module.

The No-Start Ignition System (diagnostic) labsheet covers ignition system basics, theory, a diagnostic process walk-through, a diagnostic application, and a skill assessment of the Ignition system and the signals required for creating a spark. This labsheet is inserted in the ignition system module.

The Evaporative Emission System (diagnostic) labsheet covers evaporative emission system basics, theory, a diagnostic process walk-through, a diagnostic application, and a skill assessment. The skill assessment confirms that the student learned how to diagnose a faulty evaporative emissions system.

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# APPENDICES

Appendix A. Final Performance Exam Data

| Toyota Engine Control Systems, AUSV 2060 Weber State University, Instructor: Kevin C. Roner | DTC Diagnosis due to Coolant Temperature Sensor | Cranks, No Start due to Fuel System | Evaporative Emissions Leak | DTC Diagnosis due to Ignition System | Misfire Diagnosis due to Fuel Trim | Misfire Diagnosis due to Ignition System | | |
|---|---|---|---|---|---|---|---|---|
| **Fall Semester, 2012** | **Vehicle 58** | **Vehicle 61** | **Vehicle 62** | **Vehicle 63** | **Vehicle 66** | **Vehicle 74** | **Sub-Total** | **Percentage** |
| Student 1 | 25 | 25 | 25 | 30 | 15 | 15 | 135 | 75% |
| Student 2 | 30 | 20 | 20 | 25 | 5 | 30 | 130 | 72% |
| Student 3 | 25 | 25 | 15 | 20 | 5 | 25 | 115 | 64% |
| Student 4 | 25 | 25 | 20 | 30 | 20 | 30 | 150 | 83% |
| Student 5 | 20 | 25 | 15 | 30 | 20 | 30 | 140 | 78% |
| Student 6 | 25 | 25 | 20 | 25 | 10 | 20 | 125 | 69% |
| Student 7 | 30 | 25 | 25 | 17.5 | 10 | 30 | 137.5 | 76% |
| Average Student | 25.71 | 24.29 | 20.00 | 25.36 | 12.14 | 25.71 | 133.21 | 74% |
| Points available per station | 30 | 30 | 30 | 30 | 30 | 30 | 180 | |
| | | | | | | | | |
| **Fall Semester, 2013** | **Vehicle 70** | **Vehicle 61** | **Vehicle 62** | **Vehicle 63** | **Vehicle 76** | **Vehicle 78** | **Sub-Total** | **Percentage** |
| Student 8 | 20 | 20 | 20 | 25 | 5 | 30 | 120 | 67% |
| Student 9 | 15 | 15 | 15 | 25 | 10 | 20 | 100 | 56% |
| Student 10 | 10 | 20 | 15 | 20 | 5 | 15 | 85 | 47% |
| Student 11 | 20 | 20 | 5 | 15 | 5 | 30 | 95 | 53% |
| Student 12 | 25 | 25 | 15 | 30 | 15 | 25 | 135 | 75% |
| Student 13 | 15 | 20 | 15 | 20 | 15 | 30 | 115 | 64% |
| Student 14 | 25 | 25 | 20 | 25 | 20 | 25 | 140 | 78% |
| Student 15 | 15 | 10 | 10 | 15 | 10 | 15 | 75 | 42% |
| Average Student | 18.13 | 19.38 | 14.38 | 21.88 | 10.63 | 23.75 | 108.13 | 60% |
| Points available per station | 30 | 30 | 30 | 30 | 30 | 30 | 180 | |
| | | | | | | | | |
| **Average Student Scores** | **DTC Diagnosis due to Coolant Temperature Sensor** | **Cranks, No Start due to Fuel System** | **Evaporative Emissions Leak** | **DTC Diagnosis due to Ignition System** | **Misfire Diagnosis due to Fuel Trim** | **Misfire Diagnosis due to Ignition System** | **Subtotal each Year** | **Percentage** |
| Cumulative Fall Semester, 2012 | 180.00 | 170.00 | 140.00 | 177.50 | 85.00 | 180.00 | 932.50 | 74.01% |
| Cumulative Fall Semester, 2013 | 145.00 | 155.00 | 115.00 | 175.00 | 85.00 | 190.00 | 865.00 | 68.65% |
| Average all years | 21.67 | 21.67 | 17.00 | 23.50 | 11.33 | 24.67 | | |

# Appendix B. ASE Certification Data

| ASE Certification Data | | |
|---|---|---|
| Student | ASE A8 | Reason |
| A | yes | |
| B | no | did not attempt |
| C | yes | |
| D | yes | |
| E | no | did not attempt |
| F | failed | |
| G | yes | |
| H | no | did not attempt |
| I | failed | |
| J | failed | |
| Number of attempts | 7 | |
| Number passed | 4 | |
| Number failed | 3 | |
| Number not attempted | 3 | |

Appendix C. Survey

| VIII. ENGINE PERFORMANCE | Mentor: |
|---|---|
| | |
| This chart compiles every NATEF task for Engine Control Systems and select skills determined by a survey of Technicians. Please rate the T-TEN Student's **Skill Level** of each task on the following scale: | Student: |
| | |
| **0** - No Exposure - no information nor practice before | |
| **1** - Exposure Only - general information only | |
| **2** - Moderately Skilled - was performed previously and more training is necessary | |
| **3** - Skilled - can perform independently without any additional training | |
| | |
| **A. General: Engine Diagnosis** | **Rating** |
| 1. Identify and interpret engine performance concerns; determine necessary action. | |
| 2. Research applicable vehicle and service information, vehicle service history, service precautions, and technical service bulletins. | |
| 3. Diagnose abnormal engine noises or vibration concerns; determine necessary action. | |
| 4. Diagnose the cause of excessive oil consumption, coolant consumption, unusual exhaust color, odor, and sound; determine necessary action. | |
| 5. Perform engine absolute (vacuum/boost) manifold pressure tests; determine necessary action. | |
| 6. Perform cylinder power balance test; determine necessary action. | |
| 7. Perform cylinder cranking and running compression tests; determine necessary action. | |
| 8. Perform cylinder leakage test; determine necessary action. | |
| 9. Diagnose engine mechanical, electrical, electronic, fuel, and ignition concerns; determine necessary action. | |
| 10. Verify engine operating temperature; determine necessary action. | |
| 11. Verify correct camshaft timing. | |
| **B. Computerized Controls Diagnosis and Repair** | **Rating** |
| 1. Retrieve and record diagnostic trouble codes, OBD monitor status, and freeze frame data; clear codes when applicable. | |
| 2. Access and use service information to perform step-by-step (troubleshooting) diagnosis. | |
| 3. Perform active tests of actuators using a scan tool; determine necessary action. | |
| 4. Describe the importance of running all OBDII monitors for repair verification. | |

| | |
|---|---|
| 5. Diagnose the causes of emissions or driveability concerns with stored or active diagnostic trouble codes; obtain, graph, and interpret scan tool data. | |
| 6. Diagnose emissions or driveability concerns without stored diagnostic trouble codes; determine necessary action. | |
| 7. Inspect and test computerized engine control system sensors, powertrain/engine control module (PCM/ECM), actuators, and circuits using a graphing multimeter (GMM)/digital storage oscilloscope (DSO); perform necessary action. | |
| 8. Diagnose driveability and emissions problems resulting from malfunctions of interrelated systems (cruise control, security alarms, suspension controls, traction controls, A/C, automatic transmissions, non-OEM installed accessories, or similar systems); determine necessary action. | |
| **C. Ignition System Diagnosis and Repair** | **Rating** |
| 1. Diagnose (troubleshoot) ignition system related problems such as no-starting, hard starting, engine misfire, poor driveability, spark knock, power loss, poor mileage, and emissions concerns; determine necessary action. | |
| 2. Inspect and test crankshaft and camshaft position sensor(s); perform necessary action. | |
| 3. Inspect, test, and/or replace ignition control module, powertrain/engine control module; reprogram as necessary. | |
| 4. Remove and replace spark plugs; inspect secondary ignition components for wear and damage. | |
| **D. Fuel, Air Induction, and Exhaust Systems Diagnosis and Repair** | **Rating** |
| 1. Diagnose (troubleshoot) hot or cold no-starting, hard starting, poor driveability, incorrect idle speed, poor idle, flooding, hesitation, surging, engine misfire, power loss, stalling, poor mileage, dieseling, and emissions problems; determine necessary action. | |
| 2. Check fuel for contaminants; determine necessary action. | |
| 3. Inspect and test fuel pumps and pump control systems for pressure, regulation, and volume; perform necessary action. | |
| 4. Replace fuel filter(s). | |
| 5. Inspect, service, or replace air filters, filter housings, and intake duct work. | |
| 6. Inspect throttle body, air induction system, intake manifold and gaskets for vacuum leaks and/or unmetered air. | |
| 7. Inspect and test fuel injectors. | |
| 8. Verify idle control operation. | |
| 9. Inspect integrity of the exhaust manifold, exhaust pipes, muffler(s), catalytic converter(s), resonator(s), tail pipe(s), and heat shields; perform necessary action. | |

| | |
|---|---|
| 10. Inspect condition of exhaust system hangers, brackets, clamps, and heat shields; repair or replace as needed. | |
| 11. Perform exhaust system back-pressure test; determine necessary action. | |
| 12. Check and refill diesel exhaust fluid (DEF). | |
| 13. Test the operation of turbocharger/supercharger systems; determine necessary action. | |
| **E. Emissions Control Systems Diagnosis and Repair** | **Rating** |
| 1. Diagnose oil leaks, emissions, and driveability concerns caused by the positive crankcase ventilation (PCV) system; determine necessary action. | |
| 2. Inspect, test, and service positive crankcase ventilation (PCV) filter/breather cap, valve, tubes, orifices, and hoses; perform necessary action. | |
| 3. Diagnose emissions and driveability concerns caused by the exhaust gas recirculation (EGR) system; determine necessary action. | |
| 4. Diagnose emissions and driveability concerns caused by the secondary air injection and catalytic converter systems; determine necessary action. | |
| 5. Diagnose emissions and driveability concerns caused by the evaporative emissions control system; determine necessary action. | |
| 6. Inspect and test electrical/electronic sensors, controls, and wiring of exhaust gas recirculation (EGR) systems; perform necessary action. | |
| 7. Inspect, test, service, and replace components of the EGR system including tubing, exhaust passages, vacuum/pressure controls, filters, and hoses; perform necessary action. | |
| 8. Inspect and test electrical/electronically-operated components and circuits of air injection systems; perform necessary action. | |
| 9. Inspect and test catalytic converter efficiency. | |
| 10. Inspect and test components and hoses of the evaporative emissions control system; perform necessary action. | |
| 11. Interpret diagnostic trouble codes (DTCs) and scan tool data related to the emissions control systems; determine necessary action. | |
| **F. T-TEN Instructor Community Skill Survey** | **Rating** |
| Perform 5-gas Emissions Testing and Diagnosis | |
| Inspect and Diagnose Ignition systems using an Oscilloscope (IGT and IGF) | |
| Perform Diagnosis on LEV-2 and Key-Off Evaporative Emissions Systems | |
| Save the Techstream data file and using Techstream functions | |
| Inspect and diagnose vehicle concerns with the 6-step diagnostic process | |

| | |
|---|---|
| Using Techstream for repair verification | |
| Test the Evaporative System with the Smoke Tester | |
| Using the Utilities function in Techstream | |
| Perform the Permanent DTC erasure process | |
| Using basic common sense | |
| Identifying ECM terminals and circuits | |
| Identify Learned Memory and the required resetting procedures | |
| Differentiate between engine-caused and transmission-caused issues | |
| Listen to the Customer and verify the Customer's concern | |

Appendix D. Survey Results

| A. General: Engine Diagnosis | Subtotal | # of Surveys | Average |
|---|---|---|---|
| 1. Identify and interpret engine performance concerns; determine necessary action. | 39 | 20 | 1.95 |
| 2. Research applicable vehicle and service information, vehicle service history, service precautions, and technical service bulletins. | 51 | 20 | 2.55 |
| 3. Diagnose abnormal engine noises or vibration concerns; determine necessary action. | 36 | 20 | 1.80 |
| 4. Diagnose the cause of excessive oil consumption, coolant consumption, unusual exhaust color, odor, and sound; determine necessary action. | 32 | 20 | 1.60 |
| 5. Perform engine absolute (vacuum/boost) manifold pressure tests; determine necessary action. | 27 | 20 | 1.35 |
| 6. Perform cylinder power balance test; determine necessary action. | 32 | 20 | 1.60 |
| 7. Perform cylinder cranking and running compression tests; determine necessary action. | 34 | 20 | 1.70 |
| 8. Perform cylinder leakage test; determine necessary action. | 30 | 20 | 1.50 |
| 9. Diagnose engine mechanical, electrical, electronic, fuel, and ignition concerns; determine necessary action. | 41 | 20 | 2.05 |
| 10. Verify engine operating temperature; determine necessary action. | 46 | 20 | 2.30 |
| 11. Verify correct camshaft timing. | 38 | 20 | 1.90 |
| **B. Computerized Controls Diagnosis and Repair** | | | |
| 1. Retrieve and record diagnostic trouble codes, OBD monitor status, and freeze frame data; clear codes when applicable. | 57 | 20 | 2.85 |
| 2. Access and use service information to perform step-by-step (troubleshooting) diagnosis. | 49 | 20 | 2.45 |
| 3. Perform active tests of actuators using a scan tool; determine necessary action. | 47 | 20 | 2.35 |
| 4. Describe the importance of running all OBDII monitors for repair verification. | 43 | 20 | 2.15 |

| | | | |
|---|---|---|---|
| 5. Diagnose the causes of emissions or driveability concerns with stored or active diagnostic trouble codes; obtain, graph, and interpret scan tool data. | 37 | 20 | 1.85 |
| 6. Diagnose emissions or driveability concerns without stored diagnostic trouble codes; determine necessary action. | 27 | 20 | 1.35 |
| 7. Inspect and test computerized engine control system sensors, powertrain/engine control module (PCM/ECM), actuators, and circuits using a graphing multimeter (GMM)/digital storage oscilloscope (DSO); perform necessary action. | 28 | 20 | 1.40 |
| 8. Diagnose driveability and emissions problems resulting from malfunctions of interrelated systems (cruise control, security alarms, suspension controls, traction controls, A/C, automatic transmissions, non-OEM installed accessories, or similar systems); determine necessary action. | 22 | 20 | 1.10 |
| **C. Ignition System Diagnosis and Repair** | | | |
| 1. Diagnose (troubleshoot) ignition system related problems such as no-starting, hard starting, engine misfire, poor driveability, spark knock, power loss, poor mileage, and emissions concerns; determine necessary action. | 36 | 20 | 1.80 |
| 2. Inspect and test crankshaft and camshaft position sensor(s); perform necessary action. | 34 | 20 | 1.70 |
| 3. Inspect, test, and/or replace ignition control module, powertrain/engine control module; reprogram as necessary. | 36 | 20 | 1.80 |
| 4. Remove and replace spark plugs; inspect secondary ignition components for wear and damage. | 53 | 20 | 2.65 |
| **D. Fuel, Air Induction, and Exhaust Systems Diagnosis and Repair** | | | |
| 1. Diagnose (troubleshoot) hot or cold no-starting, hard starting, poor driveability, incorrect idle speed, poor idle, flooding, hesitation, surging, engine misfire, power loss, stalling, poor mileage, dieseling, and emissions problems; determine necessary action. | 32 | 20 | 1.60 |

| | | | |
|---|---|---|---|
| 2. Check fuel for contaminants; determine necessary action. | 29 | 20 | 1.45 |
| 3. Inspect and test fuel pumps and pump control systems for pressure, regulation, and volume; perform necessary action. | 40 | 20 | 2.00 |
| 4. Replace fuel filter(s). | 42 | 20 | 2.10 |
| 5. Inspect, service, or replace air filters, filter housings, and intake duct work. | 56 | 20 | 2.80 |
| 6. Inspect throttle body, air induction system, intake manifold and gaskets for vacuum leaks and/or unmetered air. | 43 | 20 | 2.15 |
| 7. Inspect and test fuel injectors. | 35 | 20 | 1.75 |
| 8. Verify idle control operation. | 32 | 20 | 1.60 |
| 9. Inspect integrity of the exhaust manifold, exhaust pipes, muffler(s), catalytic converter(s), resonator(s), tail pipe(s), and heat shields; perform necessary action. | 44 | 20 | 2.20 |
| 10. Inspect condition of exhaust system hangers, brackets, clamps, and heat shields; repair or replace as needed. | 52 | 20 | 2.60 |
| 11. Perform exhaust system back-pressure test; determine necessary action. | 21 | 20 | 1.05 |
| 12. Check and refill diesel exhaust fluid (DEF). | 8 | 20 | 0.40 |
| 13. Test the operation of turbocharger/supercharger systems; determine necessary action. | 8 | 20 | 0.40 |
| **E. Emissions Control Systems Diagnosis and Repair** | | | |
| 1. Diagnose oil leaks, emissions, and driveability concerns caused by the positive crankcase ventilation (PCV) system; determine necessary action. | 33 | 20 | 1.65 |
| 2. Inspect, test, and service positive crankcase ventilation (PCV) filter/breather cap, valve, tubes, orifices, and hoses; perform necessary action. | 35 | 20 | 1.75 |
| 3. Diagnose emissions and driveability concerns caused by the exhaust gas recirculation (EGR) system; determine necessary action. | 30 | 20 | 1.50 |

| | | | |
|---|---|---|---|
| 4. Diagnose emissions and driveability concerns caused by the secondary air injection and catalytic converter systems; determine necessary action. | 28 | 20 | 1.40 |
| 5. Diagnose emissions and driveability concerns caused by the evaporative emissions control system; determine necessary action. | 34 | 20 | 1.70 |
| 6. Inspect and test electrical/electronic sensors, controls, and wiring of exhaust gas recirculation (EGR) systems; perform necessary action. | 33 | 20 | 1.65 |
| 7. Inspect, test, service, and replace components of the EGR system including tubing, exhaust passages, vacuum/pressure controls, filters, and hoses; perform necessary action. | 31 | 20 | 1.55 |
| 8. Inspect and test electrical/electronically-operated components and circuits of air injection systems; perform necessary action. | 31 | 20 | 1.55 |
| 9. Inspect and test catalytic converter efficiency. | 33 | 20 | 1.65 |
| 10. Inspect and test components and hoses of the evaporative emissions control system; perform necessary action. | 35 | 20 | 1.75 |
| 11. Interpret diagnostic trouble codes (DTCs) and scan tool data related to the emissions control systems; determine necessary action. | 41 | 20 | 2.05 |
| **F. T-TEN Instructor Community Skill Survey** | | | |
| Perform 5-gas Emissions Testing and Diagnosis | 28 | 20 | 1.40 |
| Inspect and Diagnose Ignition systems using an Oscilloscope (IGT and IGF) | 28 | 20 | 1.40 |
| Perform Diagnosis on LEV-2 and Key-Off Evaporative Emissions Systems | 33 | 20 | 1.65 |
| Save the Techstream data file and using Techstream functions | 46 | 20 | 2.30 |
| Inspect and diagnose vehicle concerns with the 6-step diagnostic process | 40 | 20 | 2.00 |
| Using Techstream for repair verification | 51 | 20 | 2.55 |
| Test the Evaporative System with the Smoke Tester | 38 | 20 | 1.90 |
| Using the Utilities function in Techstream | 43 | 20 | 2.15 |

| | | | |
|---|---|---|---|
| Perform the Permanent DTC erasure process | 33 | 20 | 1.65 |
| Using basic common sense | 51 | 20 | 2.55 |
| Identifying ECM terminals and circuits | 47 | 20 | 2.35 |
| Identify Learned Memory and the required resetting procedures | 33 | 20 | 1.65 |
| Differentiate between engine-caused and transmission-caused issues | 32 | 20 | 1.60 |
| Listen to the Customer and verify the Customer's concern | 42 | 20 | 2.10 |
| | | Group Subtotal | 111.30 |
| | | # of Tasks | 61 |
| | | Group Average | 1.82 |

# Appendix E. AUSV 2060 Course Outline

**AUSV 2060 Course Outline:**

1. Introduction to Engine Control Systems
    a. Discussion of Engine Mechanical Condition Diagnostic Tests performed in Toyota Engine Mechanical course
        i. Vacuum Gauge Diagnosis
        ii. Compression Testing
        iii. Cylinder Leakage Testing
        iv. Cooling System Pressure Testing
    b. Fuel, ignition, and operating systems
    c. Why do we have the current systems on today's vehicles?
        i. Fuel economy requirements
        ii. Emission controls
        iii. Diagnostic capabilities
        iv. Customers' expectations
    d. 6-Step Troubleshooting Plan
2. Fuel Systems
    a. Components
    b. Delivery
        i. Fuel Pump
        ii. Fuel Filter
        iii. Fuel Lines
        iv. Fuel Pressure Regulator
    c. Distribution
        i. Injectors
        ii. Fuel Rail
    d. Diagnosis
        i. Misfire
        ii. Diagnostic Trouble Codes (DTC)
        iii. No-Start Condition
        iv. Fuel Trim
3. Ignition Systems
    a. Components
        i. Spark Plug
        ii. Ignition Coil
        iii. Spark Plug Wires
        iv. Distributor
    b. Operation
        i. Spark Generation
        ii. Spark Timing
        iii. Spark Duration
        iv. IGt signal
        v. IGf signal
    c. Diagnosis
        i. Misfire

ii. Diagnostic Trouble Codes (DTC)
iii. No-Start Condition

4. Engine Control System Sensors
    a. Sensors
        i. Intake Air Temperature Sensor
        ii. Engine Coolant Temperature Sensor
        iii. Throttle Position Sensor
        iv. Accelerator Pedal Position Sensor
        v. Mass Air Flow Meter
        vi. Manifold Absolute Pressure Sensor
        vii. Crankshaft Position Sensor
        viii. Camshaft Position Sensor
        ix. Knock Sensor
        x. Oxygen Sensor
        xi. Air-Fuel Ratio Sensor
        xii. Vapor Pressure Sensor
    b. Operation
    c. Diagnosis
5. Engine Control System Operation
    a. Techstream Scan Tool
    b. OBD Generations
        i. OBD1
        ii. OBD2
        iii. CAN OBD2
    c. Diagnostic Trouble Codes (DTC)
        i. Pending
        ii. Current
        iii. History
        iv. Permanent
    d. Freeze-Frame Data
        i. Diagnostic value
    e. Monitors and Modes
        i. Continuous
        ii. Non-Continuous
        iii. Diagnostic value
6. Emission Control Devices
    a. Positive Crankcase Ventilation
    b. Exhaust Gas Recirculation
    c. Secondary Air Injection
    d. Catalytic Converters
        i. Two way
        ii. Three way
    e. Evaporative Emission Control Systems
        i. Non-ECM Controlled System
        ii. Non-Intrusive (Early) System

iii. Intrusive (Late) System
iv. LEV2
v. LEV2 Key-Off

Appendix F. Correlations

| **Engine Controls Survey** | **Final Performance Exam** | **Labsheet Added (Format)** |
|---|---|---|
| NATEF VIII.A.5: Perform engine absolute (vacuum/boost) manifold pressure tests; determine necessary action. | none | Engine Sealing (Procedural) |
| NATEF VIII.A.8: Perform cylinder leakage test; determine necessary action. | none | Engine Sealing (Procedural) |
| NATEF VIII.B.6: Diagnose emissions or driveability concerns without stored diagnostic trouble codes; determine necessary action. | Misfire Diagnosis Due to Fuel Trim | Fuel Trim (Diagnostic) |
| NATEF VIII.B.7: Inspect and test computerized engine control system sensors, powertrain/engine control module (PCM/ECM), actuators, and circuits using a graphing multimeter (GMM)/digital storage oscilloscope (DSO); perform necessary action. | Misfire Diagnosis Due to Fuel Trim | Fuel Trim (Diagnostic) |
| NATEF VIII.D.2: Check fuel for contaminants; determine necessary action. | Misfire Diagnosis Due to Fuel Trim | Fuel Trim (Diagnostic) |
| NATEF VIII.B.8: Diagnose driveability and emissions problems resulting from malfunctions of interrelated systems (cruise control, security alarms, suspension controls, traction controls, A/C, automatic transmissions, non-OEM installed accessories, or similar systems); determine necessary action. | none | Interrelated Systems (System Basics) |
| NATEF VIII.D.11: Perform exhaust system back-pressure test; determine necessary action. | none | Intake and Exhaust Systems (System Basics) |
| NATEF VIII.D.12: Check and refill diesel exhaust fluid (DEF). | none | Intake and Exhaust Systems (System Basics) |
| NATEF VIII.D.13: Test the operation of turbocharger/supercharger systems; determine necessary action. | none | Intake and Exhaust Systems (System Basics) |
| NATEF VIII.E.3: Diagnose emissions and driveability concerns caused by the exhaust gas recirculation (EGR) system; determine necessary action. | none | Exhaust Emissions (Diagnostic) |

| | | |
|---|---|---|
| NATEF VIII.E.4: Diagnose emissions and driveability concerns caused by the secondary air injection and catalytic converter systems; determine necessary action. | none | Exhaust Emissions (Diagnostic) |
| T-TEN Instructor Community Skill Survey: Perform 5-gas Emissions Testing and Diagnosis | none | Exhaust Emissions (Diagnostic) |
| T-TEN Instructor Community Skill Survey: Inspect and Diagnose Ignition systems using an Oscilloscope (IGT and IGF) | Misfire Diagnosis due to Ignition System | No-Start Ignition System (Diagnostic) |
| none | Evaporative Emissions System Leaks | Evaporative Emission System (Diagnostic) |

Appendix G. Examples of Labsheets and Formats

# Engine Control Systems

# Interrelated Systems Basics

**Name ___________________**

## Learning Outcome

- Research and learn about interrelated systems

## Prerequisites

- 852 Toyota Engine Controls 1
- 652 Toyota Body and Electrical Controls
- 453 Toyota Suspension and Steering
- 553 Toyota Brake Systems

## Labsheet Objectives

- System Basics: Using this labsheet and the textbook, correctly answer questions regarding cruise control, security alarms, suspension controls, traction controls, A/C, automatic transmissions, non-OEM installed accessories, or similar systems
- Overall System Basics: Using this labsheet, the textbook and TIS, answer questions regarding cruise control, security alarms, suspension controls, traction controls, A/C, automatic transmissions, non-OEM installed accessories, or similar systems.
- Knowledge Assessment: Using this labsheet and the knowledge gained, correctly answer questions regarding interrelated systems.

## Skill Checks

- The student shall correctly answer questions regarding air intake and exhaust systems.

| Grading Criteria | Possible Points | Points Achieved |
|---|---|---|
| Correctly answer questions regarding cruise control, security alarms, suspension controls, traction controls, A/C, automatic transmissions, non-OEM installed accessories, or similar systems | 23 | |
| Correctly answer questions regarding cruise control, security alarms, suspension controls, traction controls, A/C, automatic transmissions, non-OEM installed accessories, or similar systems | 9 | |
| Correctly answer questions regarding interrelated systems. | 4 | |
| **Totals** | **36** | |

## NATEF Tasks

- NATEF VIII.B.8: Diagnose driveability and emissions problems resulting from malfunctions of interrelated systems (cruise control, security alarms, suspension controls, traction controls, A/C, automatic transmissions, non-OEM installed accessories, or similar systems); determine necessary action.

## Required Resources

- TIS
- Toyota 852 Handbook
- Automotive Engine Performance, Ken Pickerill, 5th Edition

## System Basics

Answer the following questions using TIS and the textbook. *Note: Do not proceed past the instructor review points until instructed to do so!*

1) There's no answer to this statement. Interrelated systems are defined as:
   a) Cruise Control,
   b) Security Alarms
   c) Suspension Controls
   d) Traction Controls
   e) Air Conditioning
   f) Automatic Transmissions
   g) Non-OEM Accessories
   h) Similar Systems

### Cruise Control Systems

2) What is the purpose of Cruise Control?

   ______________________________________________________________

   ______________________________________________________________

3) Cruise Control for today's Toyota, Lexus, and Scion vehicles is programmed into the PCM and is controlled by the Electronic ________________ Control System.

### Security Systems

4) What is the purpose of a security alarm?

   ______________________________________________________________

   ______________________________________________________________

5) Toyota uses a transponder __________ to identify it to the vehicle.

6) This system is called the __________________.

7) In the Immobilizer system, the radio signal from the key must ____________ the programming of the Certification ECU.

8) Additional or replacement keys can be __________________ to the vehicle.

**Suspension Control Systems**

9) Technician A says that today's high-tech suspension control systems may affect tire traction which may trigger Traction Control. Technician B says that Ride Height Control should be turned off before lifting a vehicle. Who is right?

   a) Technician A
   b) Technician B
   c) Both
   d) Neither

**Traction Control Systems**

10) The Toyota Supra had the first version for Toyota, Lexus and Scion. It killed engine power by closing a ______________ valve ahead of the throttle valve.

11) Traction Control helps to launch the vehicle in two ways:

   a) Killing engine power then applying brakes
   b) Applying brakes then killing engine power
   c) Applying brakes and shifting the automatic transmission into higher gear
   d) Applying brakes and shifting the automatic transmission into neutral

12) Slowing spinning wheels allows the tires to regain ______________ and then power is applied back to the wheels to move the vehicle.

**Air Conditioning Controls**

13) The vehicle air conditioning (A/C) compressor is drive by a drive belt off of the engine ________________.

14) The A/C compressor draws ______________ from the engine.

15) Today's A/C systems are communicating with the PCM. When the driver goes wide open throttle, the ____________ sends a signal to the A/C ECU to cut the compressor briefly for acceleration.

**Automatic Transmissions Systems**

16) Today's automatic transmission control (TCM) systems are communicating with the PCM. When the driver goes wide open throttle, the _____________ sends a signal to the TCM to downshift for acceleration.

17) The PCM and TCM must operate in concert with each other to maximize:

a) Power and performance
b) Fuel mileage and power
c) Performance and control
d) All of these

**Non-Original Equipment Manufacturer (OEM) Systems**

18) Today's vehicles are a product of huge amounts of time spent in research and ____________________.

19) Deviating from the OEM intended operation of vehicle systems ay __________________ that system's performance.

**Similar Systems**

20) The Anti-Lock Brake System (ABS) is designed to help bring the vehicle to a stop during times of low _________________

21) The Vehicle Stability Control (VSC) is designed to assist the driver in keeping the vehicle on the road during _________________.

22) Brake Override is a system built into the ABS controller to give the brake pedal higher authority over the accelerator _____________.

23) ABS, VSC, and Brake Override are ____________________ built into the functionality of the Skid Control ECU.

## Overall System Basic Operation

1) Problems with the Cruise Control system are diagnosed by connecting Techstream to the vehicle and retrieving:

   a) Diagnostic Trouble Codes
   b) Reviewing the Data List
   c) Performing Active Tests
   d) All of the above

2) Technician A says that a vehicle with a no-start condition should have the immobilizer system checked for DTC's and matching keys before troubleshooting the fuel, ignition, and PCM systems. Technician B says that the fuel, ignition, and PCM systems will not function with the wrong key. Who is right?

   a) Technician A
   b) Technician B
   c) Both
   d) Neither

3) Technician A says that today's high-tech suspension control systems have the ability to cut engine power when the tires loose traction. Technician B says that the brake system does that as Traction Control. Who is right?

   a) Technician A
   b) Technician B
   c) Both
   d) Neither

4) Technician A says that a low tire may trigger the Traction Control system. Technician B says that a doughnut tire may trigger the Traction Control system. Who is right?

   a) Technician A
   b) Technician B
   c) Both
   d) Neither

5) Customer states that the engine nearly dies at idle when the A/C is on. Technician A says that the compressor may be seizing. Technician B says that the air blower motor is drawing too many amps from the alternator. Who is right?

   a) Technician A
   b) Technician B
   c) Both
   d) Neither

6) Shift schedules are programmed into the TCM. Technician A says that a customer's concern may be remedied by reprogramming the TCM. Technician B says that some customer concerns are remedied by replacing the TCM. Who is right?

   a) Technician A
   b) Technician B
   c) Both
   d) Neither

7) A customer is concerned about fuel mileage after installing different tire sizes on their 2012 Toyota Tundra. Technician A says that this is not normal and must be investigated. Technician B says that this is inherent when changing any factory settings on any vehicle. Who is right?

   a) Technician A
   b) Technician B
   c) Both
   d) Neither

8) The Anti-Lock Brake System (ABS) is designed to help bring the vehicle to a stop. Technician A says that if the ABS is malfunctioning, the ABS light will illuminate and the engine performance will be affected. Technician B says that the ABS is used in every braking event. Who is right?

   a) Technician A
   b) Technician B
   c) Both
   d) Neither

9) The Vehicle Stability Control (VSC) is designed to assist the driver in keeping the vehicle on the road. Technician A says that if there is a problem with the VSC, the system will illuminate the VSC light and the system will shut down. Technician B says that ABS, VSC, and Traction Control will all illuminate a light and then shut down when a fault is detected. Who is right?

   a) Technician A
   b) Technician B
   c) Both
   d) Neither

STOP

Stop here after completing all the related activities and answering the questions. Inform your instructor that you are ready to review this section.
**Instructor Signature:**

____________________________________

## Knowledge Assessment

1) Technician A says that if there is a problem with the VSC, the problem may appear to the customer as an engine control problem. Technician B says that a transmission problem may appear to the customer as an engine control problem. Who is right?

   a) Technician A
   b) Technician B
   c) Both
   d) Neither

2) A customer is concerned about a surge that happens during acceleration up to freeway speeds. Technician A says that this may be the A/C compressor kicking off during wide open throttle acceleration. Technician B says to test drive according to how the customer drives to confirm the concern. Who is right?

   a) Technician A
   b) Technician B
   c) Both
   d) Neither

3) Customer states that the engine loses power on acceleration. Technician A says that this may be the Traction Control kicking in. Technician B says that this may be caused by a weak fuel pump. Who is right?

   a) Technician A
   b) Technician B
   c) Both
   d) Neither

4) Customer states that the engine tachometer in the dash surges to 6,000 RPMs during normal acceleration from a stop in city streets. Technician A says that the engine is developing too much power. Technician B says that the transmission may be slipping. Who is right?

    a) Technician A
    b) Technician B
    c) Both
    d) Neither

Labsheet is complete. Report to your Instructor.

# Engine Control Systems

# Interrelated Systems Basics – Instructor

**Name ___________________**

## Learning Outcome

- Research and learn about interrelated systems

## Prerequisites

- 852 Toyota Engine Controls 1
- 652 Toyota Body and Electrical Controls
- 453 Toyota Suspension and Steering
- 553 Toyota Brake Systems

## Labsheet Objectives

- System Basics: Using this labsheet and the textbook, correctly answer questions regarding cruise control, security alarms, suspension controls, traction controls, A/C, automatic transmissions, non-OEM installed accessories, or similar systems
- Overall System Basics: Using this labsheet, the textbook and TIS, answer questions regarding cruise control, security alarms, suspension controls, traction controls, A/C, automatic transmissions, non-OEM installed accessories, or similar systems.
- Knowledge Assessment: Using this labsheet and the knowledge gained, correctly answer questions regarding interrelated systems.

## Skill Checks

- The student shall correctly answer questions regarding air intake and exhaust systems.

| Grading Criteria | Possible Points | Points Achieved |
|---|---|---|
| Correctly answer questions regarding cruise control, security alarms, suspension controls, traction controls, A/C, automatic transmissions, non-OEM installed accessories, or similar systems | 23 | |
| Correctly answer questions regarding cruise control, security alarms, suspension controls, traction controls, A/C, automatic transmissions, non-OEM installed accessories, or similar systems | 9 | |
| Correctly answer questions regarding interrelated systems. | 4 | |
| **Totals** | **36** | |

## NATEF Tasks

- NATEF VIII.B.8: Diagnose driveability and emissions problems resulting from malfunctions of interrelated systems (cruise control, security alarms, suspension controls, traction controls, A/C, automatic transmissions, non-OEM installed accessories, or similar systems); determine necessary action.

## Required Resources

- TIS
- Toyota 852 Handbook
- Automotive Engine Performance, Ken Pickerill, 5th Edition

## System Basics

Answer the following questions using TIS and the textbook. *Note: Do not proceed past the instructor review points until instructed to do so!*

1) There is no answer to this statement. Interrelated systems are defined as:
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   c) Suspension Controls
   d) Traction Controls
   e) Air Conditioning
   f) Automatic Transmissions
   g) Non-OEM Accessories
   h) Similar Systems

### Cruise Control Systems

2) What is the purpose of Cruise Control?

   ______________________________________________________________

   To manage and maintain a set vehicle speed for the driver

3) Cruise Control for today's Toyota, Lexus, and Scion vehicles is programmed into the PCM and is controlled by the Electronic __Throttle____ Control System.

### Security Systems

4) What is the purpose of a security alarm?

   ______________________________________________________________

   To deter theft

5) Toyota uses a transponder __Key____ to identify it to the vehicle.

6) This system is called the __Immobilizer____.

7) In the Immobilizer system, the radio signal from the key must __match____ the programming of the Certification ECU.

8) Additional or replacement keys can be __programmed____ to the vehicle.

**Suspension Control Systems**

9) Technician A says that today's high-tech suspension control systems may affect tire traction which may trigger Traction Control. Technician B says that Ride Height Control should be turned off before lifting a vehicle. Who is right?

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15) Today's A/C systems are communicating with the PCM. When the driver goes wide open throttle, the __PCM____ sends a signal to the A/C ECU to cut the compressor briefly for acceleration.

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16) Today's automatic transmission control (TCM) systems are communicating with the PCM. When the driver goes wide open throttle, the __PCM____ sends a signal to the TCM to downshift for acceleration.

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c) Performance and control
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**Similar Systems**

20) The Anti-Lock Brake System (ABS) is designed to help bring the vehicle to a stop during times of low __traction____

21) The Vehicle Stability Control (VSC) is designed to assist the driver in keeping the vehicle on the road during __cornering____.

22) Brake Override is a system built into the ABS controller to give the brake pedal higher authority over the accelerator __pedal____.

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1) Problems with the Cruise Control system are diagnosed by connecting Techstream to the vehicle and retrieving:

   e) Diagnostic Trouble Codes
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   h) <u>All of the above</u>

2) Technician A says that a vehicle with a no-start condition should have the immobilizer system checked for DTC's and matching keys before troubleshooting the fuel, ignition, and PCM systems. Technician B says that the fuel, ignition, and PCM systems will not function with the wrong key. Who is right?

   a) Technician A
   b) Technician B
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3) Technician A says that today's high-tech suspension control systems have the ability to cut engine power when the tires loose traction. Technician B says that the brake system does that as Traction Control. Who is right?

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   c) <u>Both</u>
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5) Customer states that the engine nearly dies at idle when the A/C is on. Technician A says that the compressor may be seizing. Technician B says that the air blower motor is drawing too many amps from the alternator. Who is right?

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   b) Technician B
   c) Both
   d) Neither

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   c) Both
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   b) Technician B
   c) Both
   d) Neither


Stop here after completing all the related activities and answering the questions. Inform your instructor that you are ready to review this section.
**Instructor Signature:**

______________________________________

## Knowledge Assessment

1) Technician A says that if there is a problem with the VSC, the problem may appear to the customer as an engine control problem. Technician B says that a transmission problem may appear to the customer as an engine control problem. Who is right?

   a) Technician A
   b) Technician B
   c) <u>Both</u>
   d) Neither

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   b) Technician B
   c) <u>Both</u>
   d) Neither

4) Customer states that the engine tachometer in the dash surges to 6,000 RPMs during normal acceleration from a stop in city streets. Technician A says that the engine is developing too much power. Technician B says that the transmission may be slipping. Who is right?

   a) Technician A
   b) <u>Technician B</u>
   c) Both
   d) Neither

Labsheet is complete. Report to your Instructor.

# Engine Control Systems

# Engine Sealing Procedural

**Name:** ___________________________

## Learning Outcome

- Perform engine sealing inspection tests to determine integrity of the engine mechanical systems

## Prerequisites

- Toyota Course 151

## Labsheet Objectives

- System Basics: Using this labsheet, Toyota Information System (TIS), and the textbook, correctly answer questions about Intake Manifold Vacuum, Cooling System Pressure, Compression Pressure, and Cylinder Leakage tests.
- Practical Procedure: Using this labsheet and an assigned vehicle, correctly perform engine sealing tests and report the integrity of the engine to your Instructor
- Knowledge Assessment: Using this labsheet, correctly answer questions about vacuum testing, compression testing, cylinder leakage testing, and cooling system pressure tests.

## Skill Checks

- Student will correctly answer questions about vacuum testing, compression testing, cylinder leakage testing, and cooling system pressure tests without the assistance of the labsheet.

| Grading Criteria | Points Possible | Points Achieved |
|---|---|---|
| Correctly answer questions about engine sealing tests | 20 | |
| Correctly perform engine mechanical tests and report findings to your Instructor | 20 | |
| Correctly answer questions about vacuum testing, compression testing, cylinder leakage testing, and cooling system pressure tests | 5 | |
| **Total** | **45** | |

## NATEF Tasks

- NATEF VIII.A.5: Perform engine absolute (vacuum/boost) manifold pressure tests; determine necessary action.
- NATEF VIII.A.8: Perform cylinder leakage test; determine necessary action.

## Required Resources

- 2010 Toyota Camry with 2AR-FE Engine
- Toyota Technician Handbook Course 151
- Automotive Engine Performance, Ken Pickerill, 5$^{th}$ Edition
- Cooling system pressure tester
- Vacuum gauge
- Compression tester
- Cylinder leakage tester
- Techstream unit (to clear codes at the end)

## System Basics

Answer the following questions using TIS and the training materials.
*Note: Do not proceed past the evaluation points until instructed to do so!*

**Vehicle Application**

| **Make** | **Model** | **Year** | **Engine** |
|---|---|---|---|
| Toyota | Camry | 2012 | 2AR-FE |
| **Transmission** | **Vin** | **Catalyst** | **Build Location** |
| | | | |

### Cooling System Pressure Testing

1) Engine coolant is a mixture of water and ______________.

2) What happens to the boiling point of the engine coolant when pressure is added by the radiator cap?

______________________________________________________________

______________________________________________________________

3) The engine cooling system is a closed system with a radiator cap. What is the purpose of the overflow bottle?

______________________________________________________________

______________________________________________________________

______________________________________________________________

______________________________________________________________

______________________________________________________________

______________________________________________________________

4) What is indicated by a cooling system that will not hold pressure?

______________________________________________________________

______________________________________________________________

5) If a cooling system is leaking, does it always leak externally? Explain:

______________________________________________________________

______________________________________________________________

______________________________________________________________

______________________________________________________________

**Vacuum Testing**

6) Define Intake Manifold Vacuum and what creates it:

______________________________________________________________
______________________________________________________________
______________________________________________________________
______________________________________________________________
______________________________________________________________
______________________________________________________________
______________________________________________________________
______________________________________________________________
______________________________________________________________

7) Refer to the repair manual: What is the specification for vacuum on a 2010 Toyota Camry at idle?

   a) 18 inches of Hg
   b) 26 inches of Hg
   c) 12 inches of Hg
   d) 2 inches of Hg

8) What is indicated by intake manifold vacuum being too low?

   a) ______________________________________________
   b) ______________________________________________
   c) ______________________________________________

9) What tool is used for measuring manifold vacuum?

   a) Techstream
   b) Vacuum Gauge
   c) Vacuum Pump

10) Inspect the engine compartment on your vehicle.  What is a good place to measure intake manifold vacuum?

______________________________________________________________

______________________________________________________________

______________________________________________________________

**Compression Testing**

11) The 4-stroke engine moves air and fuel through the _____________ to create power through combustion.

12) The compression pressure specifications can be found in the _____________ manual.

13) Technician A says that a compression test is necessary to identify a cylinder that is not contributing to the engine power.  Technician B says that a compression test compares the pressure results between each cylinder.  Who is right?

a) Technician A
b) Technician B
c) Both
d) Neither

14) The Technician measures compression and compares the readings to specification to determine which of the following?

a) Determine if the piston rings are sealing
b) Determine if the valves are sealing
c) Determine if the cylinder head gaskets are sealing
d) Determine that there is a leak and additional testing is necessary

15) What is the set-up procedure for a compression test?

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

**Cylinder Leakage Testing**

16) The cylinder leakage test injects air into the _____________ through the spark plug hole.

17) The cylinder being tested must be on ___________________________ on the compression stroke so that the valves are closed.

18) The volume of air passing through is measured and compared to each cylinder reading. The cylinder with the _____________ compression will have the most leakage.

19) The cylinder leakage test is used when determining which of the following? Select all that apply.

a) Determine if the piston rings are sealing
b) Determine if the valves are sealing
c) Determine if the cylinder head gaskets are sealing
d) Determine that there is a leak and additional testing is necessary

20) If the piston rings are leaking, air will be heard escaping from the:
a) Oil filler cap
b) Exhaust tailpipe
c) Intake air cleaner
d) Externally

Stop here after completing all the related activities and answering the questions. Inform your instructor that you are ready to review this section.

**Instructor Signature:**

_______________________________________

## Practical Procedure

**Customer concern: Engine seems to lack power. Please check and advise.**

**Vehicle Application**

| **Make** | **Model** | **Year** | **Engine** |
|---|---|---|---|
| Toyota | Camry | 2010 | 2AR-FE |
| **Transmission** | **Vin** | **Catalyst** | **Build Location** |
| | | | |

1) Briefly start the engine and determine if you can confirm the concern. Did you confirm customer's concern?

   a) Yes
   b) No

2) Stop the engine.

3) Connect cooling system pressure tester and perform cooling system pressure test.

4) Pressurize the system to 15 psi and observe pressure reading in 5 minutes. What did you observe?

   a) Pressure increased
   b) Pressure remained steady
   c) Pressure decreased 1-5 psi
   d) Pressure decreased 5+ psi

5) What do your results tell you about the cooling system of this vehicle?

   ______________________________________________

   ______________________________________________

6) Could a cooling system internal leak cause the customer's concern? Explain:

   ______________________________________________

   ______________________________________________

7) Remove cooling system pressure tester.

8) Connect a vacuum gauge to a service port

9) Start the engine and observe the vacuum gauge. What did you observe?
______________________________________________________________
______________________________________________________________
______________________________________________________________

10) Did the vacuum test reveal a fault? ________

11) Stop the engine.

12) Prepare the engine for a compression test:
   a) Connect a battery charger to maintain the battery
   b) Disable the fuel system (fuse, circuit opening relay, etc.)
   c) Remove all of the spark plugs
   d) Inspect condition of the compression tester tool
   e) Create chart on the repair order to record readings (see below)

13) Install the compression tester in cylinder #1

14) Crank the engine until the pressure does not increase anymore (this may be 15-20 revolutions of the crankshaft).

15) Record the readings in the following chart:

| Cylinder #1 | Cylinder #2 | Cylinder #3 | Cylinder #4 | Cylinder #5 | Cylinder #6 | Cylinder #7 | Cylinder #8 |
|---|---|---|---|---|---|---|---|
| | | | | | | | |

16) Remove the tool and repeat for each cylinder. Record readings for each cylinder in the chart above.

17) Leave engine disabled.

18) What is the specification for this engine? ______________

19) Were any cylinders below the specification?

_______________________________________________________________________
_______________________________________________________________________

20) Subtract the lowest measurement from the highest measurement. Compare that number to 10% of the highest measurement. Were all of the cylinders within 10% of each other?

_______________________________________________________________________
_______________________________________________________________________

21) Did the test identify a weak cylinder?

_______________________________________________________________________
_______________________________________________________________________

22) Is further testing required? __________

23) Explain:

_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________

24) What is that test? ___________________________

25) Prepare the engine for a cylinder leakage test:
   a) Remove the battery charger
   b) Turn the key off
   c) Remove the Schrader valve from the compression tester hose
   d) Install the hose (alone) in cylinder #1
   e) Use a wrench to turn the crankshaft until air starts escaping from the compression tester hose
   f) Observe the crankshaft timing marks and place engine at TDC
   g) Inspect the cylinder leakage tester condition

26) Connect cylinder leakage tester
   a) Connect the hose to the cylinder through the spark plug hole
   b) Connect the tool to the hose
   c) Connect shop air to the tool
   d) Adjust the regulator to the pressure specified in the operator's manual

27) Observe the percentage of air leaking on the gauge. Create chart on the repair order to record readings for each cylinder (see below).

| Cylinder #1 | Cylinder #2 | Cylinder #3 | Cylinder #4 | Cylinder #5 | Cylinder #6 | Cylinder #7 | Cylinder #8 |
|---|---|---|---|---|---|---|---|
| | | | | | | | |

28) Remove shop air.

29) Remove the hose from the cylinder.

30) Refer to New Car Features to determine firing order.

31) Move the hose to the next cylinder in the firing order.

32) Rotate the crankshaft with a wrench to TDC for the next cylinder.
   a) Note: An inline 4-cylinder engine requires 180 degrees of rotation to go to TDC of the next cylinder

33) Connect cylinder leakage tester
   a) Connect the hose to the cylinder through the spark plug hole
   b) Connect the tool to the hose
   c) Connect shop air to the tool
   d) Record readings

34) Repeat the step above for each cylinder and document your findings in the chart.

35) Refer to the repair manual. What is the leakage specification? ____________

36) Were any cylinders above the specification?

_______________________________________________

_______________________________________________

37) Reconnect to the cylinder that leaked the most.

38) Do you hear air leaking? It will appear as a whistle noise or a drone from the intake or exhaust.

_______________________________________________

_______________________________________________

39) Where is the source of the noise?

_______________________________________________

_______________________________________________

40) What does this tell you?

_______________________________________________

_______________________________________________

41) Is further testing required? ________

42) Explain:

______________________________________________________________________
______________________________________________________________________
______________________________________________________________________
______________________________________________________________________
______________________________________________________________________
______________________________________________________________________

43) Return the vehicle to normal:
   a) Remove tools from the vehicle
   b) Reinstall spark plugs
   c) Enable the fuel system
   d) Start engine
   e) Clear any DTC's that may have appeared during testing


Stop here after completing all the related activities and answering the questions. Inform your instructor that you are ready to review this section.
**Instructor Signature:**

________________________________________

## Knowledge Assessment

Answer the following questions without the assistance of previous sections on this labsheet, the repair manual, or the Instructor.

1) Technician A says that if the compression test results are normal, there is no need to perform a cylinder leakage test. Technician B says that if vacuum test results indicate a compression test is needed but the compression test passed, then you need to inspect the intake and exhaust systems. Who is right?

   a) Technician A
   b) Technician B
   c) Both
   d) Neither

2) The compression test results failed for cylinder #1. Leakage testing passes. Technician A says to inspect for air flow blockage to cylinder #1. Technician B says to inspect to see if the valves are opening for cylinder #1. Who is right?

   a) Technician A
   b) Technician B
   c) Both
   d) Neither

3) Air is heard leaking from the intake manifold. Which of the following is the probable cause?

   a) Exhaust valves
   b) Intake valves
   c) Cylinder walls
   d) Hole in the piston

4) Air is heard leaking from the exhaust manifold. Which of the following is the probable cause?

   a) Exhaust valves
   b) Intake valves
   c) Cylinder walls
   d) Hole in the piston

5) Air is heard leaking from the oil filler cap. Which of the following is the probable cause?

   a) Exhaust valves
   b) Intake valves
   c) Cylinder walls
   d) Hole in the piston

STOP

Stop here after completing all the related activities and answering the questions. Inform your instructor that you are ready to review this section.
**Instructor Signature:**
____________________________________

# Engine Control Systems

# Engine Sealing Procedural – <u>Instructor</u>

**Name:** ______________________________

## Learning Outcome

- Perform engine sealing inspection tests to determine integrity of the engine mechanical systems

## Prerequisites

- Toyota Course 151

## Labsheet Objectives

- System Basics: Using this labsheet, Toyota Information System (TIS), and the textbook, correctly answer questions about Intake Manifold Vacuum, Cooling System Pressure, Compression Pressure, and Cylinder Leakage tests.
- Practical Procedure: Using this labsheet and an assigned vehicle, correctly perform engine sealing tests and report the integrity of the engine to your Instructor
- Knowledge Assessment: Using this labsheet, correctly answer questions about vacuum testing, compression testing, cylinder leakage testing, and cooling system pressure tests.

## Skill Checks

- Student will correctly answer questions about vacuum testing, compression testing, cylinder leakage testing, and cooling system pressure tests without the assistance of the labsheet.

| Grading Criteria | Points Possible | Points Achieved |
|---|---|---|
| Correctly answer questions about engine sealing tests | 20 | |
| Correctly perform engine mechanical tests and report findings to your Instructor | 20 | |
| Correctly answer questions about vacuum testing, compression testing, cylinder leakage testing, and cooling system pressure tests | 5 | |
| **Total** | **45** | |

## NATEF Tasks

- NATEF VIII.A.5: Perform engine absolute (vacuum/boost) manifold pressure tests; determine necessary action.
- NATEF VIII.A.8: Perform cylinder leakage test; determine necessary action.

## Required Resources

- 2010 Toyota Camry with 2AR-FE Engine
- Toyota Technician Handbook Course 151
- Automotive Engine Performance, Ken Pickerill, 5th Edition
- Cooling system pressure tester
- Vacuum gauge
- Compression tester
- Cylinder leakage tester
- Techstream unit (to clear codes at the end)

## System Basics

Answer the following questions using TIS and the training materials.
*Note: Do not proceed past the evaluation points until instructed to do so!*

**Vehicle Application**

| **Make** | **Model** | **Year** | **Engine** |
|---|---|---|---|
| Toyota | Camry | 2012 | 2AR-FE |
| **Transmission** | **Vin** | **Catalyst** | **Build Location** |
| | | | |

### Cooling System Pressure Testing

1) Engine coolant is a mixture of water and __antifreeze____.

2) What happens to the boiling point of the engine coolant when pressure is added by the radiator cap?

   The boiling point increases

3) The engine cooling system is a closed system with a radiator cap. What is the purpose of the overflow bottle?

   The overflow bottle receives and contains coolant that escapes the cooling system when pressure exceeds the pressure limited by the radiator cap. Coolant can then flow back into the engine when the engine cools.

4) What is indicated by a cooling system that will not hold pressure?

   This indicates that the system is leaking.

5) If a cooling system is leaking, does it always leak externally? Explain:

   No, it does not always leak externally. The coolant can leak into the engine at any sealing point or through cracks in hard components.

**Vacuum Testing**

6) Define Intake Manifold Vacuum and what creates it:

____________________________________________________________________________________________

____________________________________________________________________________________________

____________________________________________________________________________________________

____________________________________________________________________________________________

Intake Manifold Vacuum is created when the piston moved down on the intake stroke of a four-stroke/cycle engine. Vacuum will be high when the throttle plate is closed and low when the throttle plate is open. An engine that exhibits low engine vacuum at idle indicates wear on the piston rings or leaking valves.

7) Refer to the repair manual: What is the specification for vacuum on a 2010 Toyota Camry at idle?

a) 18 inches of Hg
b) 26 inches of Hg
c) 12 inches of Hg
d) 2 inches of Hg

8) What is indicated by intake manifold vacuum being too low?

a) Wear on the cylinder walls or the piston rings
b) Valves out of adjustment
c) Valves worn

9) What tool is used for measuring manifold vacuum?

a) Techstream
b) Vacuum Gauge
c) Vacuum Pump

10) Inspect the engine compartment on your vehicle. What is a good place to measure intake manifold vacuum?

______________________________________________________________

______________________________________________________________

Hose that goes to the Brake Booster

**Compression Testing**

11) The 4-stroke engine moves air and fuel through the __engine____ to create power through combustion.

12) The compression pressure specifications can be found in the __repair____ manual.

13) Technician A says that a compression test is necessary to identify a cylinder that is not contributing to the engine power. Technician B says that a compression test compares the pressure results between each cylinder. Who is right?

a) Technician A
b) Technician B
c) Both
d) Neither

14) The Technician measures compression and compares the readings to specification to determine which of the following?

a) Determine if the piston rings are sealing
b) Determine if the valves are sealing
c) Determine if the cylinder head gaskets are sealing
d) Determine that there is a leak and additional testing is necessary

15) What is the set-up procedure for a compression test?

______________________________________________________________________
______________________________________________________________________
______________________________________________________________________

Remove all spark plugs, install a battery charger to maintain the battery, disable the fuel supply, confirm that the compression tester tool is in working condition, document all readings on the repair order.

**Cylinder Leakage Testing**

16) The cylinder leakage test injects air into the __cylinder____ through the spark plug hole.

17) The cylinder being tested must be on __Top-Dead-Center (TDC)____ on the compression stroke so that the valves are closed.

18) The volume of air passing through is measured and compared to each cylinder reading. The cylinder with the __lowest____ compression will have the most leakage.

19) The cylinder leakage test is used when determining which of the following? Select all that apply.

a) Determine if the piston rings are sealing
b) Determine if the valves are sealing
c) Determine if the cylinder head gaskets are sealing
d) Determine that there is a leak and additional testing is necessary

20) If the piston rings are leaking, air will be heard escaping from the:
a) Oil filler cap
b) Exhaust tailpipe
c) Intake air cleaner
d) Externally


Stop here after completing all the related activities and answering the questions. Inform your instructor that you are ready to review this section.

**Instructor Signature:**

______________________________________________

## Practical Procedure

**Customer concern: Engine seems to lack power. Please check and advise.**

**Vehicle Application**

| **Make** | **Model** | **Year** | **Engine** |
|---|---|---|---|
| Toyota | Camry | 2010 | 2AR-FE |
| **Transmission** | **Vin** | **Catalyst** | **Build Location** |
| | | | |

1) Briefly start the engine and determine if you can confirm the concern. Did you confirm customer's concern?

   a) Yes
   b) No

2) Stop the engine.

3) Connect cooling system pressure tester and perform cooling system pressure test.

4) Pressurize the system to 15 psi and observe pressure reading in 5 minutes. What did you observe?

   a) Pressure increased
   b) Pressure remained steady
   c) Pressure decreased 1-5 psi
   d) Pressure decreased 5+ psi

5) What do your results tell you about the cooling system of this vehicle?

   ______________________________________________

   No problem found

6) Could a cooling system internal leak cause the customer's concern? Explain:

   ______________________________________________

   Possibly, if the coolant was leaking internally.

7) Remove cooling system pressure tester.

8) Connect a vacuum gauge to a service port

9) Start the engine and observe the vacuum gauge. What did you observe?

______________________________________________________________

______________________________________________________________

Gauge was low at 15 inches of vacuum. Needle was steady.

10) Did the vacuum test reveal a fault? __No____

11) Stop the engine.

12) Prepare the engine for a compression test:
   a) Connect a battery charger to maintain the battery
   b) Disable the fuel system (fuse, circuit opening relay, etc.)
   c) Remove all of the spark plugs
   d) Inspect condition of the compression tester tool
   e) Create chart on the repair order to record readings (see below)

13) Install the compression tester in cylinder #1

14) Crank the engine until the pressure does not increase anymore (this may be 15-20 revolutions of the crankshaft).

15) Record the readings in the following chart:

| Cylinder #1 | Cylinder #2 | Cylinder #3 | Cylinder #4 | Cylinder #5 | Cylinder #6 | Cylinder #7 | Cylinder #8 |
|---|---|---|---|---|---|---|---|
| | | | | | | | |

16) Remove the tool and repeat for each cylinder. Record readings for each cylinder in the chart above.

17) Leave engine disabled.

18) What is the specification for this engine? ______________

19) Were any cylinders below the specification?

_________________________________________________________________

Identified cylinder

20) Subtract the lowest measurement from the highest measurement. Compare that number to 10% of the highest measurement. Were all of the cylinders within 10% of each other?

_________________________________________________________________

No

21) Did the test identify a weak cylinder?

_________________________________________________________________

Yes

22) Is further testing required? __Yes____

23) Explain:

_________________________________________________________________

_________________________________________________________________

The compression test identified a weak cylinder. We now must test to see why it is weak.

24) What is that test? __Cylinder Leakage Test____

25) Prepare the engine for a cylinder leakage test:
    a) Remove the battery charger
    b) Turn the key off
    c) Remove the Schrader valve from the compression tester hose
    d) Install the hose (alone) in cylinder #1
    e) Use a wrench to turn the crankshaft until air starts escaping from the compression tester hose
    f) Observe the crankshaft timing marks and place engine at TDC
    g) Inspect the cylinder leakage tester condition

26) Connect cylinder leakage tester
    a) Connect the hose to the cylinder through the spark plug hole
    b) Connect the tool to the hose
    c) Connect shop air to the tool
    d) Adjust the regulator to the pressure specified in the operator's manual

27) Observe the percentage of air leaking on the gauge. Create chart on the repair order to record readings for each cylinder (see below).

| Cylinder #1 | Cylinder #2 | Cylinder #3 | Cylinder #4 | Cylinder #5 | Cylinder #6 | Cylinder #7 | Cylinder #8 |
|---|---|---|---|---|---|---|---|
| | | | | | | | |

28) Remove shop air.

29) Remove the hose from the cylinder.

30) Refer to New Car Features to determine firing order.

31) Move the hose to the next cylinder in the firing order.

32) Rotate the crankshaft with a wrench to TDC for the next cylinder.
   a) Note: An inline 4-cylinder engine requires 180 degrees of rotation to go to TDC of the next cylinder

33) Connect cylinder leakage tester
   a) Connect the hose to the cylinder through the spark plug hole
   b) Connect the tool to the hose
   c) Connect shop air to the tool
   d) Record readings

34) Repeat the step above for each cylinder and document your findings in the chart.

35) Refer to the repair manual. What is the leakage specification? ____________

36) Were any cylinders above the specification?

   ______________________________________________________________

   Identified cylinder

37) Reconnect to the cylinder that leaked the most.

38) Do you hear air leaking? It will appear as a whistle noise or a drone from the intake or exhaust.

   ______________________________________________________________

   Yes

39) Where is the source of the noise?

   ______________________________________________________________

   Exhaust

40) What does this tell you?

   ______________________________________________________________

   That the exhaust valve for this cylinder is leaking

41) Is further testing required? __No____

42) Explain:

The cylinder leakage test identified the cause for the weak cylinder. We now must remove the valve cover to inspect valve clearance and may need to remove the cylinder head to inspect and repair the valves.

43) Return the vehicle to normal:

a) Remove tools from the vehicle
b) Reinstall spark plugs
c) Enable the fuel system
d) Start engine
e) Clear any DTC's that may have appeared during testing


Stop here after completing all the related activities and answering the questions. Inform your instructor that you are ready to review this section.
**Instructor Signature:**

________________________________________

## Knowledge Assessment

Answer the following questions without the assistance of previous sections on this labsheet, the repair manual, or the Instructor.

1) Technician A says that if the compression test results are normal, there is no need to perform a cylinder leakage test. Technician B says that if vacuum test results indicate a compression test is needed but the compression test passed, then you need to inspect the intake and exhaust systems. Who is right?

   a) Technician A
   b) Technician B
   c) <u>Both</u>
   d) Neither

2) The compression test results failed for cylinder #1. Leakage testing passes. Technician A says to inspect for air flow blockage to cylinder #1. Technician B says to inspect to see if the valves are opening for cylinder #1. Who is right?

   a) Technician A
   b) Technician B
   c) <u>Both</u>
   d) Neither

3) Air is heard leaking from the intake manifold. Which of the following is the probable cause?

   a) Exhaust valves
   b) <u>Intake valves</u>
   c) Cylinder walls
   d) Hole in the piston

4) Air is heard leaking from the exhaust manifold.  Which of the following is the probable cause?

    a) Exhaust valves
    b) Intake valves
    c) Cylinder walls
    d) Hole in the piston

5) Air is heard leaking from the oil filler cap.  Which of the following is the probable cause?

    a) Exhaust valves
    b) Intake valves
    c) Cylinder walls
    d) Hole in the piston


Stop here after completing all the related activities and answering the questions. Inform your instructor that you are ready to review this section.
**Instructor Signature:**
____________________________________

# Engine Control Systems

# Fuel Trim Diagnosis

**Name: _________________________**

## Learning Outcome

- Perform Fuel Trim diagnostic procedure and determine fault on a vehicle

## Prerequisites

- 852 Fuel Systems

## Objectives

- System Basics: Using the repair manual found in the Toyota Information System (TIS), research vehicle information and correctly answer questions associated with Fuel Systems
- Theoretical Diagnosis: Using the repair manual for a given vehicle, correctly answer the Theoretical Diagnosis questions.
- Vehicle fault diagnostics – diagnostic walk through: Use the assigned vehicle and this labsheet to correctly perform a fuel system diagnostic procedure
- On-Car Fault Diagnostics: Using the assigned vehicle, TIS, and tools, correctly diagnose the fault on the vehicle and report to the Instructor
- Skill Checks: Using the assigned vehicle, TIS, and tools, correctly diagnose the fault on the vehicle and report to the Instructor

## Skill Checks

- The student will be required to correctly diagnose a Fuel Trim condition without help from the labsheet or instructor.

| Grading Criteria | Possible Points | Points Achieved |
|---|---|---|
| Correctly answer basic questions associated with Fuel Trim | 8 | |
| Correctly answer the Theoretical Diagnosis questions | 8 | |
| Correctly perform a fuel trim diagnostic procedure | 16 | |
| Correctly diagnose the On-Car Fault on the vehicle and report to the Instructor | 11 | |
| Correctly diagnose the Skill Check Fault on the vehicle and report to the Instructor | 4 | |
| **Totals** | **47** | |

## NATEF Tasks

- NATEF VIII.B.6: Diagnose emissions or driveability concerns without stored diagnostic trouble codes; determine necessary action.
- NATEF VIII.B.7: Inspect and test computerized engine control system sensors, powertrain/engine control module (PCM/ECM), actuators, and circuits using a graphing multimeter (GMM)/digital storage oscilloscope (DSO); perform necessary action.
- NATEF VIII.D.2: Check fuel for contaminants; determine necessary action.

## Required Resources

- 2012 Toyota Avalon with 2GR-FE engine
- 2013 Toyota Camry with 2GR-FE engine
- 2012 Toyota Highlander with 2GR-FE engine
- DVOM
- Techstream unit
- TIS
- Toyota 852 Handbook
- Automotive Engine Performance, Ken Pickerill, 5th Edition

## System Basics

Answer the following questions using the repair manual in TIS, the Toyota 852 training manual, the textbook, and provided training materials. *Note: Do not continue past the evaluation points until instructed to do so!*

**Vehicle Application**

| **Make** | **Model** | **Year** | **Engine** |
|---|---|---|---|
| Toyota | Avalon | 2012 | 2GR-FE |
| **Transmission** | **Vin** | **Catalyst** | **Build Location** |
| | | | |

1) The fuel system consists of the following items:

    a) ______________________________
    b) ______________________________
    c) ______________________________
    d) ______________________________
    e) ______________________________
    f) ______________________________
    g) ______________________________
    h) ______________________________

2) The base fuel injected into the cylinders is calculated by the PCM with these basic inputs:
    a) ______________________________
    b) ______________________________

3) The PCM calculates a feedback compensation value known to Toyota, Lexus, and Scion Technicians as ___________________.

4) The fuel trim is calculated by the PCM with these inputs:
   a) ______________________________
   b) ______________________________
   c) ______________________________
   d) ______________________________
   e) ______________________________
   f) ______________________________
   g) ______________________________
   h) ______________________________

5) What is the difference between Long-Term Fuel Trim and Short-Term Fuel Trim?

| Short-Term Fuel Trim | Long-Term Fuel Trim |
|---|---|
| | |

6) Techstream can display both short and long fuel trim. It can also show fuel trims for each bank. Identify the following acronyms:

| STFT #1 | STFT #2 |
|---|---|
| | |
| LTFT #1 | LTFT #2 |
| | |
| Total | Total |
| | |

7) What DTC's have to do with fuel trim issues? Fill in the chart below:

| DTC Code | Description |
|---|---|
| | |
| | |
| | |
| | |

8) What do Bank 1 and Bank 2 refer to?

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___

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___

## Theoretical Diagnostics

1) A customer comes in with DTC P0175 set on their 2012 Toyota Avalon with 2GR-FE engine. Technician A says that Bank 2 fuel trim is excessively rich. Technician B says that the PCM is past the limits of normal adjustment. Who is right?

   a) Technician A
   b) Technician B
   c) Both
   d) Neither

2) A customer comes in with DTC P0175 set on their 2012 Toyota Avalon with 2GR-FE engine. Technician A says that Bank 2 is referring to the bank farthest from the front of the vehicle. Technician B says that Bank 1 is the bank farthest from the front of the engine.. Who is right?

   a) Technician A
   b) Technician B
   c) Both
   d) Neither

3) A customer comes in with DTC P0175 set on their 2012 Toyota Avalon with 2GR-FE engine. Technician A says that only things that affect Bank 2 can cause this code to set. Technician B says that a faulty MAF would affect both banks. Who is right?

   a) Technician A
   b) Technician B
   c) Both
   d) Neither

4) While diagnosing a 2012 Toyota Avalon with 2GR-FE engine, the Technician notices that the MAF meter is reading 6.0 gm/sec of air entering the vehicle. Technician A says that this is normal. Technician B says to perform a "Airflow-Free VG Check" to know for sure that the MAF is ok. Who is right?

   a) Technician A
   b) Technician B
   c) Both
   d) Neither

Refer to the Repair Manual for P0171, P0172, P0174, and P0175 to answer the following questions.

5) For DTC's P0171/P0174, which of these items will affect one bank or both banks? Complete the chart below:

| **Item** | **One** | **Both** |
|---|---|---|
| Air induction system | | |
| Injector blockage | | |
| Mass Air Flow (MAF) meter | | |
| Engine Coolant Temperature (ECT) sensor | | |
| Fuel pressure | | |
| Gas leakage from exhaust system | | |
| Open or short in A/F sensor (bank 1, 2 sensor 1) circuit | | |
| A/F sensor (bank 1, 2 sensor 1) | | |
| PCV valve and hose | | |
| PCV hose connections | | |
| Wire harness or connector | | |
| ECM | | |

6) For DTC's P0172/P0175, which of these items will affect one bank or both banks? Complete the chart below:

| **Item** | **One** | **Both** |
|---|---|---|
| Injector leakage or blockage | | |
| MAF meter | | |
| ECT sensor | | |
| Ignition system | | |
| Fuel pressure | | |
| Gas leakage from exhaust system | | |
| Open or short in A/F sensor (bank 1, 2 sensor 1) circuit | | |
| A/F sensor (bank 1, 2 sensor 1) | | |
| Wire harness or connector | | |
| ECM | | |

7) Two Technicians are discussing fuel contaminants. Technician A says that particulate contaminants could block the fuel filter. Technician B says that the engine would not run correctly with the wrong fuel. Who is right?

   a) Technician A
   b) Technician B
   c) Both
   d) Neither

8) Technician A says that water is a contaminant for gasoline. Technician B says that diesel is a contaminant for gasoline. Who is right?

   a) Technician A
   b) Technician B
   c) Both
   d) Neither


Stop here after completing all the related activities and answering the questions. Inform your instructor that you are ready to review this section.
**Instructor Signature:**

________________________________________

# Vehicle Fault Diagnostics – Diagnostic Walk Through

**Customer concern: Customer states that the MIL is on and DTC P0174 is present. Please check and advise.**

**Vehicle Application**

| Make | Model | Year | Engine |
|---|---|---|---|
| Toyota | Avalon | 2012 | 2GR-FE |
| **Transmission** | **Vin** | **Catalyst** | **Build Location** |
| | | | |

1) Start the engine and bring it to operating temperature.

2) Connect Techstream and retrieve codes. Can you confirm Customer's concern? List details found:

 ______________________________________________

 ______________________________________________

3) Review freeze frame data. What did you observe?

 ______________________________________________

 ______________________________________________

4) Review data list. Which bank is affected?

 ______________________________________________

 ______________________________________________

5) What are the suspected areas that could cause this condition (refer to the chart on the previous page)?

 ______________________________________________

 ______________________________________________

 ______________________________________________

 ______________________________________________

 ______________________________________________

 ______________________________________________

6) Go to Active Tests on the Techstream.

7) Select Control Injection Volume for A/F Sensor Test.

8) If this test passes, what items from the list on #5 above are confirmed OK?

_______________________________________________

_______________________________________________

_______________________________________________

_______________________________________________

9) If the test passes, what should the technician focus on for the fault?

_______________________________________________

_______________________________________________

10) If the test fails, what does it confirm is bad?

_______________________________________________

_______________________________________________

_______________________________________________

_______________________________________________

11) Perform the Control Injection Volume for A/F Sensor Test. Did the Air/Fuel Ratio sensors react according to the chart in the repair manual for P0171, P0172, P0174, and P0175? Explain:

_______________________________________________

_______________________________________________

_______________________________________________

_______________________________________________

_______________________________________________

_______________________________________________

12) What are the suspected fault areas?

a) ____________________________

b) ____________________________

13) Inspect the exhaust system for leaks.  Findings: ________________________

14) What is the target for diagnosis? ____________________________________

15) Perform the Injection Volume active test and monitor the misfire data.  What did you observe?

________________________________________________________________

________________________________________________________________

________________________________________________________________

________________________________________________________________

16) What is your diagnosis?

________________________________________________________________

________________________________________________________________


Stop here after completing all the related activities and answering the questions. Inform your instructor that you are ready to review this section.
**Instructor Signature:**

____________________________________

# On Car Fault Diagnosis

**Customer concern: Customer states that the MIL is on and DTC P0172 is present. Please check and advise.**

**Vehicle Application**

| **Make** | **Model** | **Year** | **Engine** |
|---|---|---|---|
| Toyota | Camry | 2013 | 2GR-FE |
| **Transmission** | **Vin** | **Catalyst** | **Build Location** |
| | | | |

1) Start the engine and bring it to operating temperature.

2) Connect Techstream and retrieve codes. Can you confirm Customer's concern? List details found:

3) Review freeze frame data. What did you observe?

4) Review data list. Which bank is affected?

5) What are the suspected areas that could cause this condition (refer to the chart page 6)?

6) Review the data list and complete the following chart:

| **Data Parameter** | **Test** | **Results** |
|---|---|---|
| MAF | Air Flow Free VG check? | |
| ECT | Is temperature correct? | |
| Ignition | Misfire codes or data? | |

7) How could fuel pressure cause the customer's concern?

____________________________________________________________

____________________________________________________________

8) Inspect fuel pressure:
   a) Specification: ______________
   b) Measurement: ______________
   c) Pass/Fail? ______________

9) Select Control Injection Volume for A/F Sensor Test.

10) Manipulate the air fuel ratio and observe Fuel Trim readings. What do you observe?

____________________________________________________________

____________________________________________________________

11) What sensor could be lying to the PCM to cause this?

____________________________________________________________

____________________________________________________________


Stop here after completing all the related activities and answering the questions. Inform your instructor that you are ready to review this section.
**Instructor Signature:**

______________________________________

## Labsheet Skill Assessment

**Customer concern: Customer states that the MIL is on and a DTC is present. Please check and advise.**

**Vehicle Application**

| **Make** | **Model** | **Year** | **Engine** |
|---|---|---|---|
| Toyota | Camry | 2013 | 2GR-FE |
| **Transmission** | **Vin** | **Catalyst** | **Build Location** |
| | | | |

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*INVOICE*

ANYTOWN TOYOTA
TOYOTA / SCION

BOB JONES
123 MAIN STREET
ANYTOWN, VA 00000
HOME: 555-555-1234     BUS: 555-555-4321

PAGE 1

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ANYTOWN, VA 00000
(555) 555-1099

SERVICE ADVISOR:

| COLOR | YEAR | MAKE/MODEL | VIN | LICENSE | MILEAGE IN/OUT | TAG |
|---|---|---|---|---|---|---|
| | | | | | | |

| DEL DATE | PRDO DATE | WARR EXP | PROMISED | PO NO. | RATE | PAYMENT | INV DATE |
|---|---|---|---|---|---|---|---|
| | | | | | | | |

| R.O. OPENED | READY | OPTIONS: |
|---|---|---|
| | | |

LINE OPCODE TECH TYPE HOURS     LIST     NET     TOTAL

1. Were you able to duplicate the concern?

   ______________________________________

2. What steps were taken to diagnose the fault?

   ______________________________________

3. What was the root cause of the fault?

   ______________________________________

4. What is the correct repair for this concern?

   ______________________________________

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Thank You! for allowing us to service your vehicle

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CUSTOMER SIGNATURE

| DESCRIPTION | TOTALS |
|---|---|
| LABOR AMOUNT | 0.00 |
| PARTS AMOUNT | 0.00 |
| GAS, OIL, LUBE | 0.00 |
| SUBLET AMOUNT | 0.00 |
| ENVIRONMENTAL FEES | 0.00 |
| TOTAL CHARGES | 0.00 |
| LESS AMOUNT | 0.00 |
| SALES TAX | 0.00 |
| PLEASE PAY THIS AMOUNT | 0.00 |

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Labsheet is complete. Report to your Instructor.

# Engine Control Systems

# Fuel Trim Diagnosis – Instructor

**Name:** ___________________________

## Learning Outcome

- Perform Fuel Trim diagnostic procedure and determine fault on a vehicle

## Prerequisites

- 852 Fuel Systems

## Objectives

- System Basics: Using the repair manual found in the Toyota Information System (TIS), research vehicle information and correctly answer questions associated with Fuel Systems
- Theoretical Diagnosis:  Using the repair manual for a given vehicle, correctly answer the Theoretical Diagnosis questions.
- Vehicle fault diagnostics – diagnostic walk through: Use the assigned vehicle and this labsheet to correctly perform a fuel system diagnostic procedure
- On-Car Fault Diagnostics: Using the assigned vehicle, TIS, and tools, correctly diagnose the fault on the vehicle and report to the Instructor
- Skill Checks: Using the assigned vehicle, TIS, and tools, correctly diagnose the fault on the vehicle and report to the Instructor

## Skill Checks

- The student will be required to correctly diagnose a Fuel Trim condition without help from the labsheet or instructor.

| Grading Criteria | Possible Points | Points Achieved |
|---|---|---|
| Correctly answer basic questions associated with Fuel Trim | 8 | |
| Correctly answer the Theoretical Diagnosis questions | 8 | |
| Correctly perform a fuel trim diagnostic procedure | 16 | |
| Correctly diagnose the On-Car Fault on the vehicle and report to the Instructor | 11 | |
| Correctly diagnose the Skill Check Fault on the vehicle and report to the Instructor | 4 | |
| **Totals** | **47** | |

## NATEF Tasks

- NATEF VIII.B.6: Diagnose emissions or driveability concerns without stored diagnostic trouble codes; determine necessary action.
- NATEF VIII.B.7: Inspect and test computerized engine control system sensors, powertrain/engine control module (PCM/ECM), actuators, and circuits using a graphing multimeter (GMM)/digital storage oscilloscope (DSO); perform necessary action.
- NATEF VIII.D.2: Check fuel for contaminants; determine necessary action.

## Required Resources

- 2012 Toyota Avalon with 2GR-FE engine
- 2013 Toyota Camry with 2GR-FE engine
- 2012 Toyota Highlander with 2GR-FE engine
- DVOM
- TIS
- Techstream unit
- Toyota 852 Handbook
- Automotive Engine Performance, Ken Pickerill, 5th Edition

## System Basics

Answer the following questions using the repair manual in TIS, the Toyota 852 training manual, the textbook, and provided training materials. *Note: Do not continue past the evaluation points until instructed to do so!*

**Vehicle Application**

| **Make** | **Model** | **Year** | **Engine** |
|---|---|---|---|
| Toyota | Avalon | 2012 | 2GR-FE |
| **Transmission** | **Vin** | **Catalyst** | **Build Location** |
| | | | |

1) The fuel system consists of the following items:

    a) Fuel Tank
    b) Fuel Pump
    c) Fuel Filter
    d) Fuel Lines
    e) Injector Rail
    f) Injectors
    g) Pressure Regulator
    h) Pulsation Dampener

2) The base fuel injected into the cylinders is calculated by the PCM with these basic inputs:
    a) Mass Air Flow (MAF)
    b) NE (Engine RPM)

3) The PCM calculates a feedback compensation value known to Toyota, Lexus, and Scion Technicians as __Fuel Trim____.

4) The fuel trim is calculated by the PCM with these inputs:
   a) Voltage corrections
   b) Oxygen sensor values
   c) Air/Fuel Ratio Sensor Values
   d) THW (Engine Coolant Temperature)
   e) THA (Intake Air Temperature)
   f) VTA (Throttle Angle)
   g) APPS (Accelerator Pedal Position Sensor)
   h) Long Term Fuel Trim

5) What is the difference between Long-Term Fuel Trim and Short-Term Fuel Trim?

| Short-Term Fuel Trim | Long-Term Fuel Trim |
|---|---|
| Immediate, what is happening right now, based on immediate sensor feedback | Fuel trim over a large period of time |

6) Techstream can display both short and long fuel trim. It can also show fuel trims for each bank. Identify the following acronyms:

| STFT #1 | STFT #2 |
|---|---|
| Short Term Fuel Trim Bank #1 | Short Term Fuel Trim Bank #2 |
| LTFT #1 | LTFT #2 |
| Long Term Fuel Trim Bank #1 | Long Term Fuel Trim Bank #2 |
| Total | Total |
| Total Term Fuel Trim Bank #1 | Total Term Fuel Trim Bank #1 |

7) What DTC's have to do with fuel trim issues? Fill in the chart below:

| DTC Code | Description |
|---|---|
| P0171 | System too Lean (bank 1) |
| P0172 | System too Rich (bank 1) |
| P0174 | System too Lean (bank 2) |
| P0175 | System too Rich (bank 2) |

8) What do Bank 1 and Bank 2 refer to?

The cylinders on the left side of the V are in a bank and the cylinders on the other side of the V are in the other bank. Bank 1 refers to the bank with cylinder #1. Bank 2 refers to the opposite bank.

## Theoretical Diagnostics

1) A customer comes in with DTC P0175 set on their 2012 Toyota Avalon with 2GR-FE engine.  Technician A says that Bank 2 fuel trim is excessively rich.  Technician B says that the PCM is past the limits of normal adjustment.  Who is right?

    a) Technician A
    b) Technician B
    c) <u>Both</u>
    d) Neither

2) A customer comes in with DTC P0175 set on their 2012 Toyota Avalon with 2GR-FE engine.  Technician A says that Bank 2 is referring to the bank farthest from the front of the vehicle.  Technician B says that Bank 1 is the bank farthest from the front of the engine..  Who is right?

    a) Technician A
    b) <u>Technician B</u>
    c) Both
    d) Neither

3) A customer comes in with DTC P0175 set on their 2012 Toyota Avalon with 2GR-FE engine.  Technician A says that only things that affect Bank 2 can cause this code to set.  Technician B says that a faulty MAF would affect both banks.  Who is right?

    a) Technician A
    b) Technician B
    c) <u>Both</u>
    d) Neither

4) While diagnosing a 2012 Toyota Avalon with 2GR-FE engine, the Technician notices that the MAF meter is reading 6.0 gm/sec of air entering the vehicle. Technician A says that this is normal. Technician B says to perform a “Airflow-Free VG Check” to know for sure that the MAF is ok. Who is right?

   a) Technician A
   b) Technician B
   c) Both
   d) Neither

Refer to the Repair Manual for P0171, P0172, P0174, and P0175 to answer the following questions.

5) For DTC’s P0171/P0174, which of these items will affect one bank or both banks? Complete the chart below:

| **Item** | **One** | **Both** |
|---|---|---|
| Air induction system | | X |
| Injector blockage | X | |
| Mass Air Flow (MAF) meter | | X |
| Engine Coolant Temperature (ECT) sensor | | X |
| Fuel pressure | | X |
| Gas leakage from exhaust system | X | |
| Open or short in A/F sensor (bank 1, 2 sensor 1) circuit | X | |
| A/F sensor (bank 1, 2 sensor 1) | X | |
| PCV valve and hose | | X |
| PCV hose connections | | X |
| Wire harness or connector | X | X |
| ECM | X | X |

6) For DTC's P0172/P0175, which of these items will affect one bank or both banks? Complete the chart below:

| Item | One | Both |
|---|---|---|
| Injector leakage or blockage | X | |
| MAF meter | | X |
| ECT sensor | | X |
| Ignition system | X | X |
| Fuel pressure | | X |
| Gas leakage from exhaust system | X | |
| Open or short in A/F sensor (bank 1, 2 sensor 1) circuit | X | |
| A/F sensor (bank 1, 2 sensor 1) | X | |
| Wire harness or connector | X | X |
| ECM | X | X |

7) Two Technicians are discussing fuel contaminants. Technician A says that particulate contaminants could block the fuel filter. Technician B says that the engine would not run correctly with the wrong fuel. Who is right?

a) Technician A
b) Technician B
c) Both
d) Neither

8) Technician A says that water is a contaminant for gasoline. Technician B says that diesel is a contaminant for gasoline. Who is right?

a) Technician A
b) Technician B
c) Both
d) Neither


Stop here after completing all the related activities and answering the questions. Inform your instructor that you are ready to review this section.
**Instructor Signature:**

______________________________________

# Vehicle Fault Diagnostics – Diagnostic Walk Through

**Customer concern: Customer states that the MIL is on and DTC P0174 is present. Please check and advise. Block one injector (details below)**

**Vehicle Application**

| **Make** | **Model** | **Year** | **Engine** |
|---|---|---|---|
| Toyota | Avalon | 2012 | 2GR-FE |
| **Transmission** | **Vin** | **Catalyst** | **Build Location** |
| | | | |

1) Start the engine and bring it to operating temperature.

2) Connect Techstream and retrieve codes. Can you confirm Customer's concern? List details found:

   Check engine light was on, DTC P0174 was retrieved.

3) Review freeze frame data. What did you observe?

   Bank 2 Fuel Trim was positive, confirming that the system was too lean

4) Review data list. Which bank is affected?

   Bank 2 alone

5) What are the suspected areas that could cause this condition (refer to the chart on the previous page)?

   Injector blockage, Gas leakage from exhaust system, Open or short in A/F sensor (bank 1, 2 sensor 1) circuit, A/F sensor (bank 1, 2 sensor 1), wire harness, ECM

6) Go to Active Tests on the Techstream.

7) Select Control Injection Volume for A/F Sensor Test.

8) If this test passes, what items from the list on #5 above are confirmed OK?

______________________________________________________________

______________________________________________________________

Open or short in A/F sensor (bank 1, 2 sensor 1) circuit, A/F sensor (bank 1, 2 sensor 1), wire harness, ECM

9) If the test passes, what should the technician focus on for the fault?

______________________________________________________________

Injector blockage or exhaust leaks

10) If the test fails, what does it confirm is bad?

______________________________________________________________

______________________________________________________________

Open or short in A/F sensor (bank 1, 2 sensor 1) circuit, A/F sensor (bank 1, 2 sensor 1), wire harness, ECM

11) Perform the Control Injection Volume for A/F Sensor Test. Did the Air/Fuel Ratio sensors react according to the chart in the repair manual for P0171, P0172, P0174, and P0175? Explain:

______________________________________________________________

______________________________________________________________

______________________________________________________________

Yes, it reacted as it should have according to the chart in the repair manual. This indicates that the air/fuel ratio sensors are functioning, that the wiring harness is OK, and that the PCM is functioning correctly.

12) What are the suspected fault areas?

a) Injector blockage
b) Exhaust leaks

13) Inspect the exhaust system for leaks. Findings: __sealed________________

14) What is the target for diagnosis? __Injector blockage____________________

15) Perform the Injection Volume active test and monitor the misfire data. What did you observe?

____________________________________________________________________

____________________________________________________________________

Reviewing misfire data while manipulating the Injection Volume with an active test should revealed a cylinder that misfired during test

16) What is your diagnosis?

____________________________________________________________________

Plugged injector for cylinder #4


Stop here after completing all the related activities and answering the questions. Inform your instructor that you are ready to review this section.
**Instructor Signature:**
______________________________________

## On Car Fault Diagnosis

**Customer concern: Customer states that the MIL is on and DTC P0172 is present. Please check and advise. Tape MAF.**

**Vehicle Application**

| **Make** | **Model** | **Year** | **Engine** |
|---|---|---|---|
| Toyota | Camry | 2013 | 2GR-FE |
| **Transmission** | **Vin** | **Catalyst** | **Build Location** |
| | | | |

1) Start the engine and bring it to operating temperature.

2) Connect Techstream and retrieve codes. Can you confirm Customer's concern? List details found:

   Check engine light was on, DTCs P0172 and P0175 were retrieved.

3) Review freeze frame data. What did you observe?

   Both Banks Fuel Trim was negative, confirming that the system was too rich

4) Review data list. Which bank is affected?

   Both

5) What are the suspected areas that could cause this condition (refer to the chart page 6)?

   MAF meter, ECT Sensor, Ignition system, fuel pressure, wire harness, ECM

6) Review the data list and complete the following chart:

| Data Parameter | Test | Results |
|---|---|---|
| MAF | Air Flow Free VG check? | OK |
| ECT | Is temperature correct? | OK |
| Ignition | Misfire codes or data? | None |

7) How could fuel pressure cause the customer's concern?

Excessive fuel pressure could cause the system to run rich.

8) Inspect fuel pressure:
   a) Specification: ______________
   b) Measurement: ______________
   c) Pass/Fail? __PASS______

9) Select Control Injection Volume for A/F Sensor Test.

10) Manipulate the air fuel ratio and observe Fuel Trim readings. What do you observe?

The engine seems to run better when driven lean

11) What sensor could be lying to the PCM to cause this?

MAF sensor while engine is running


Stop here after completing all the related activities and answering the questions. Inform your instructor that you are ready to review this section.
**Instructor Signature:**

______________________________________

## Labsheet Skill Assessment

**Customer concern: Customer states that the MIL is on and a DTC is present. Please check and advise. <u>Vacuum leak.</u>**

**Vehicle Application**

| **Make** | **Model** | **Year** | **Engine** |
|---|---|---|---|
| Toyota | Camry | 2013 | 2GR-FE |
| **Transmission** | **Vin** | **Catalyst** | **Build Location** |
| | | | |

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*INVOICE*

BOB JONES
123 MAIN STREET
ANYTOWN, VA 00000
HOME: 555-555-1234 BUS: 555-555-4321

PAGE 1

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ANYTOWN, VA 00000
(555) 555-1099

SERVICE ADVISOR:

| COLOR | YEAR | MAKE/MODEL | VIN | LICENSE | MILEAGE IN/OUT | TAG |
|---|---|---|---|---|---|---|
| | | | | | | |

| DEL DATE | PRDO DATE | WARR EXP | PROMISED | PO NO. | RATE | PAYMENT | INV DATE |
|---|---|---|---|---|---|---|---|
| | | | | | | | |

| R.O. OPENED | READY | OPTIONS: |
|---|---|---|
| | | |

LINE OPCODE TECH TYPE HOURS LIST NET TOTAL

1. Were you able to duplicate the concern?

   ________________________________________

2. What steps were taken to diagnose the fault?

   ________________________________________

3. What was the root cause of the fault?

   ________________________________________

4. What is the correct repair for this concern?

   ________________________________________

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CUSTOMER SIGNATURE

| DESCRIPTION | TOTALS |
|---|---|
| LABOR AMOUNT | 0.00 |
| PARTS AMOUNT | 0.00 |
| GAS, OIL, LUBE | 0.00 |
| SUBLET AMOUNT | 0.00 |
| ENVIRONMENTAL FEES | 0.00 |
| TOTAL CHARGES | 0.00 |
| LESS AMOUNT | 0.00 |
| SALES TAX | 0.00 |
| PLEASE PAY THIS AMOUNT | 0.00 |

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Labsheet is complete. Report to your Instructor.

**Instructor's Fault Installation Instructions:**

- Vehicle Fault Diagnostics – Diagnostic Walk Through
    - Customer concern: Customer states that the MIL is on and DTC P0174 is present.  Please check and advise.
    - Block one injector
        - Remove an injector from a spare engine,
        - Block the injector by partially filling the fuel supply side of the injector with JB Weld.
        - Reinstall
- On Car Fault Diagnosis
    - Customer concern: Customer states that the MIL is on and DTC P0172 is present.  Please check and advise.
    - Tape MAF.
        - Remove MAF
        - Apply packing tape
        - Form it to funnel more air through the sensor
        - Reinstall
- Labsheet Skill Assessment
    - Customer concern: Customer states that the MIL is on and a DTC is present.  Please check and advise.
    - Vacuum leak.
        - Connect an 8 foot length of vacuum line to the vacuum source for the EVAP system
        - Thread line through to the bottom of the engine
        - Insert into the cross member to eliminate vacuum leak noise