MODULE 13:
Fuel Supply Line & Installation

State of Oklahoma
College of the Desert
West Virginia University

MODULE 13: FUEL SUPPLY LINE & INSTALLATION

CONTENTS

MODULE 13: FUEL SUPPLY LINE & INSTALLATION

OBJECTIVES

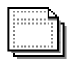
At the completion of this module, the technician will be able to:

- Inspect the tank valves and gauges, and discuss their characteristics and considerations per the application.
- Discuss the fuel line layout and its considerations.
- Properly install the fuel lines and components.
- Fabricate lines and fittings.
- Critique the fuel line and component installation.
- Perform fuel line leak testing.

INSTRUCTOR NOTES

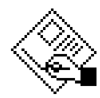
INSTRUCTOR MATERIALS/MEDIA NEEDED

Overhead projector or LCD panel/projection equipment
Overhead transparency masters or Microsoft PowerPoint 4.0 presentation file Mod13.ppt

Note: Slides correspond to text as indicated by icon 

VCR with TV or projection unit

Laboratory Activities:
Activity 13-1: Hose & Fitting Assembly

Note: Lab activities correspond to text as indicated by icon 

STUDENT MATERIALS/MEDIA NEEDED

Module 13: Fuel Supply Line & Installation

MODULE REVIEW ITEMS

The Module Review Items (MRI) are designed to allow for flexibility in their use. The exam may be utilized as a post-module review, pre/post test, part of a term examination, or it may be used by the student if the module is used as a self study text.

OVERHEAD TRANSPARENCY MASTERS

The printouts enclosed with this module are taken from the Microsoft PowerPoint 4.0 presentation file Mod13.ppt . Instructors planning to use overhead projectors should make transparencies from these printouts on a copier (or laser printer designed to safely print to acetate.

Note: Please review Module 25: Training of Trainers for more hints on instructional needs and strategies.

Liquefied Petroleum Gas

MODULE 13: FUEL SUPPLY LINE & INSTALLATION

TANK PLUMBING

Descriptions of tank guard, fill valve, automatic stop fill, liquid level gauge, and relief valve are covered in Module 2.

13-1 Typical tank valve and gauge layout – plumbing not connected.

1. Inspect the filler valve, automatic stop fill valve, manual liquid shutoff valve, fixed liquid level gauge, relief valve, and fuel gauge on the fuel tank. These components are installed by the tank manufacturer at the factory but should be double-checked to assure correct installation, including float alignment, valve clearance, thread sealant application, component operation and orientation.

13-2 Backside of remote fill fixture. **Inset** Front side of remote fill fixture

Key Points & Notes

13-3

13-2

13-5

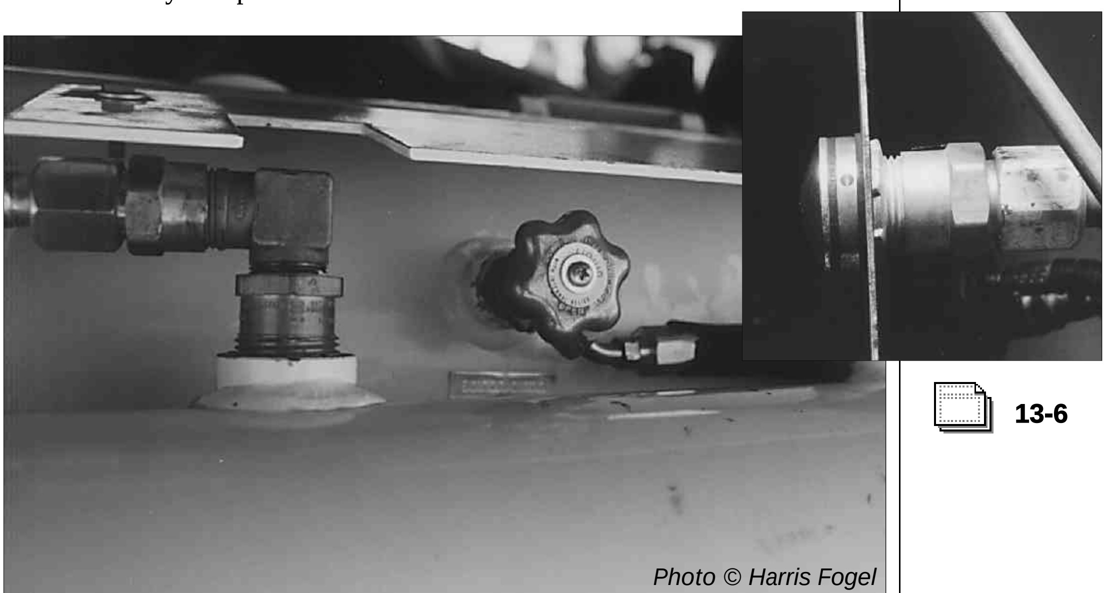
13-4

2. For tank installations that employ a remote fill fixture, a back-flow check valve (single or double) must be permanently installed outside the vehicle in addition to the double back-flow check valve mounted in the tank. Likewise, a #54 drill size liquid level gauge orifice fitting must be permanently mounted outside the vehicle in addition to the #54 drill size orifice fitting in the tank.

3. For tank installations that require a remote relief valve, the point of discharge must be directed upward or downward within 45^{o} of vertical. This is intended to prevent direct discharge of propane on the vehicle or any adjacent vehicle. Further, the relief valve outlet must be protected by a rain cap or a dust cover. Refer to Figure 13-3. The valve must also have a break-away adapter at the tank opening that meets manufacturer's specifications, with a melting point not less than 1500^{o} F (816^{o} C). The hose connecting the tank and remote discharge vent should be non-metallic and have an internal diameter not less than that capable of discharging the rated volume of the valve and its recommended breakaway adapter.

Key Points & Notes

13-7



13-6

13-3 Relief valve remote pipe-away. **Inset** Rain/dust cap for relief valve pipe-away.

FUEL LINE LAYOUT, ASSEMBLY AND INSTALLATION PROCEDURE

LINE ROUTING

13-8

Refer to the system manual. Observe how the components are laid out and interconnected. The fuel lines will usually run along the underside of the vehicle and are fastened to the frame. The first step is to estimate the required length for the shortest and simplest routing, including bends and anticipating conflicts. Review the planned route for the lines. Look for suitable surfaces for mounting line clamps and ties. Check the locations of planned alternations in the vehicle body. Make sure the structural integrity of the frame is not defeated with modifications to it.

Keep the following considerations in mind when planning.

- Allow for the rotational torque of the drive train and frame flex which can shear off a tight fuel line.
- Keep the fuel lines protected by using the form of the vehicle's frame by running the fuel line inside a channel or fold in the frame. Refer to Figure 13-4.

13-4 Liquid supply line routed and clamped along frame rail.

- Make sure hoses are not kinked (use elbows and other fittings if necessary).
- Keep hoses at least 8" away from hot exhaust components, or provide shielding if necessary.
- Keep lines at least 3" away from spark ignition wires (electrical noise may be carried by the lines into sensitive electronic components).
- Keep lines at least 3" away from moving vehicle parts.
- Keep the lines at least 1" away from closed hoods and trunks.
- Keep the lines from chaffing by shielding them with heat hose, springs, or coils.

BULKHEADS

Wherever the fuel line passes through a floor or wall panel, steel or brass sleeves or bulkhead fittings should be used to protect the line from possible damage. Before making the first cut, verify what is on the other side of the surface. Then drill the hole and install the appropriate connector. Refer to Figure 13-5.

FUEL LOCKS

The following considerations should be followed when installing propane fuel locks:

1. The fuel lock should be installed according to manufacturer's instructions. Install as close to the converter as possible so that fuel is supplied quickly to the converter during cold starts.

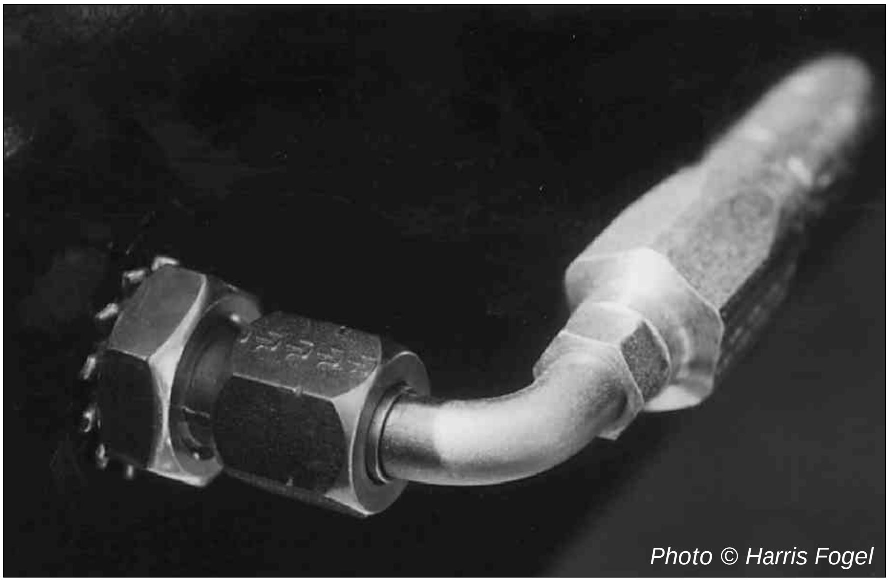
Key Points & Notes

13-9

13-10

13-11

13-13



13-5 Bulkhead fitting.

2. As mentioned in previous chapters, electric fuel locks should be installed using either a vacuum safety switch or an oil pressure switch. Refer to Figure 13-6. This ensures positive shut off when the ignition is switched off or the engine is not running. The power wire for the fuel lock should not be connected to the ignition coil, because it can rob the coil of primary voltage necessary to provide a good secondary ignition voltage spark. One volt drop in the primary circuit to the coil will cause a 5000 volt drop in secondary iginition output.

   Many newer computer controlled engines are equipped with safety lockout circuits for their gasoline fuel pumps which perform the same function as vacuum and oil pressure safety switches. These computer actuated circuits can be used to shut off fuel in the event of an engine failure and will satisfy NFPA 58.

13-6 Two types of electric fuel locks.

Key Points & Notes

13-12

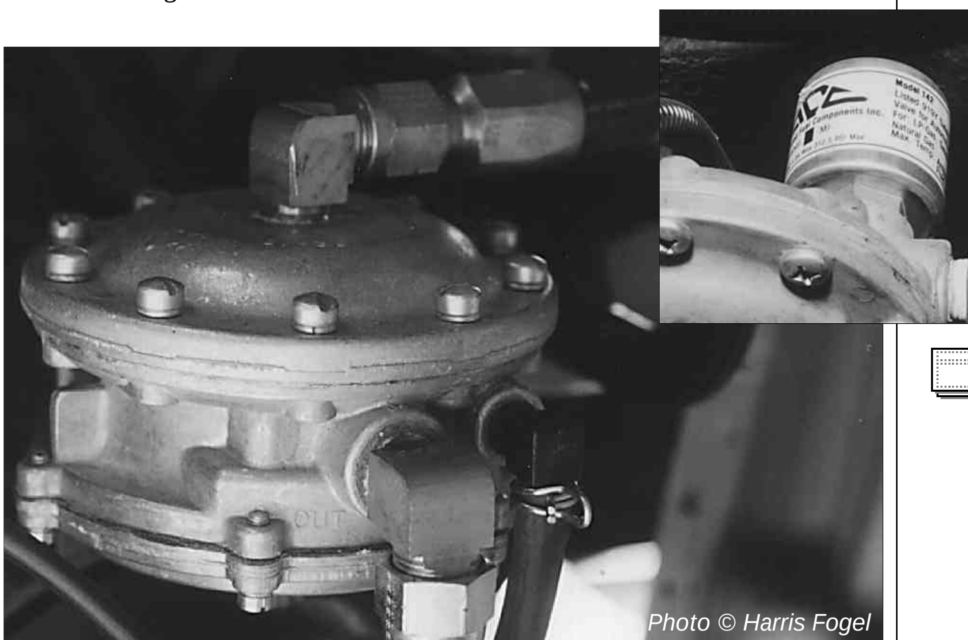
13-14

13-15

3. If the fuel lock incorporates a filter element, it should be positioned so that the filter can be easily serviced.

4. The fuel lock should be mounted securely in a protected place such as inside the frame rail or rear corner of the engine compartment. Mount the fuel lock using as few fittings as possible to minimize leak points and with the shortest length of hose possible.

NOTE: School buses may require additional consideration. Refer to local regulations and NFPA 58.



13-7 Vacuum filter fuel lock. **Inset** Electric fuel lock mounted on filter.

MEASURING, CUTTING, AND CUSTOMIZING LINES AND FITTINGS

Measure the planned route and then measure and cut a length of hose. Slightly extra lengths of hose can be used; it is always easier to cut off excess amounts. Allow a little extra hose for bends. Test run the hose to get an idea of its final fit. If the hose is not to be immediately used in the vehicle, it should be labeled for its purpose and location so it is not used for other purposes.

Remember the following guidelines for hose work:

- Always deburr the line inside and out after cutting it.
- Blow out the line before its installation.
- Keep the installation design as professional-looking as you can (i.e., straight, level, etc.).

To install fittings on hoses, follow the manufacturer's specific instructions whenever possible. A general overview of common assembly procedures follows.

FUEL SUPPLY HOSE AND FITTING INSTALLATION

Install the fuel line in sections between the components one at a time. Clean the area around the fittings and component ports and

Key Points & Notes

13-17

13-16

13-18

13-19

remove any protective caps and covers. For non-flared pipe fittings high quality Teflon pipe compound or tape must be used on the male fitting. Attach the nut of the fitting and hand tighten, watching for adverse movements in the component or the hose. Torque the nut according to the specified foot-pounds; don't overtighten it.

Observe the following practices:

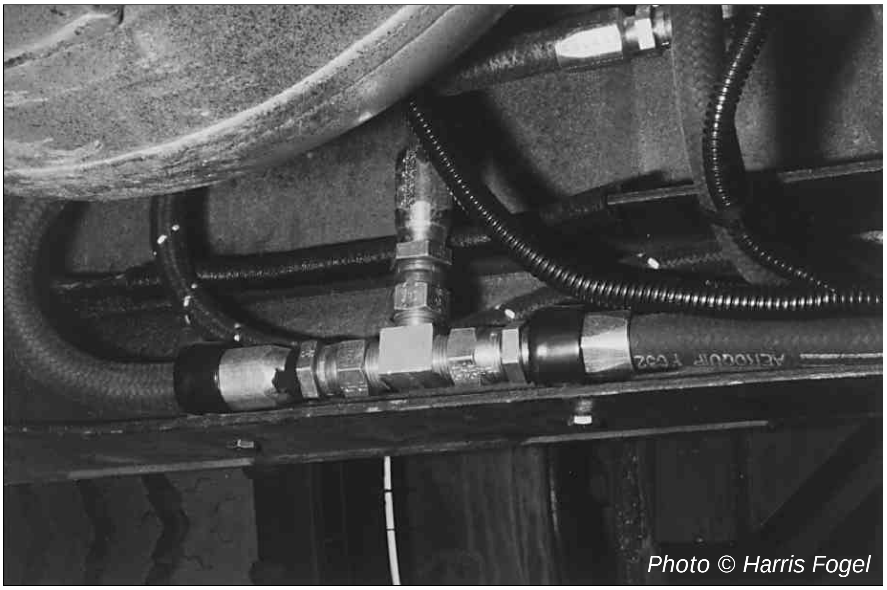
- Always use flat wrenches to tighten fittings.
- Don't use the barbed fitting end to torque or tighten or prevent fitting rotation during tightening.
- Always use the proper tools for installations.
- Don't clamp or apply leverage to the components during tightening.

After installing one end of the hose, run the line to its destination. Ties or similar hangers can be used to hold the line temporarily while it is being fitted and connected.

Again, keep these considerations in mind when installing the lines:

- Make sure the hoses are not kinked (use elbows and other fittings if necessary).
- Keep hoses at least 8" away from hot exhaust components, or provide shielding if necessary.
- Keep lines at least 3" away from spark ignition wires.
- Keep lines at least 3" away from moving vehicle parts.
- Keep the lines at least 1" away from closed hoods and trunks.
- Keep the lines from chaffing by shielding them with heat hose, springs, or coils.

Secure the lines permanently every 18" minimum with corrosion resistant hangers, clips, ties, or metal or nylon strap clamps. Refer to Figure 13-8.



13-8 Fuel line installation.

Key Points & Notes

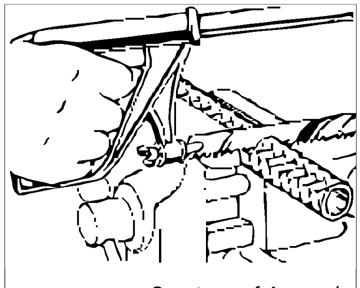
13-20

13-21

HOSE ASSEMBLY

HOSE END PREPARATION

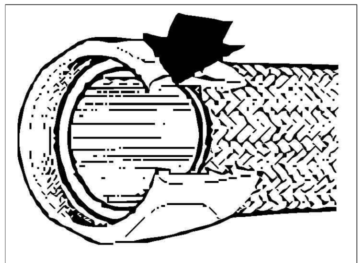
1. Clamp the hose in a vise, or secure it otherwise to prohibit movement during the cutting process. Ensure that the hose is not compressed by the vise, damaging the reinforcement braids. Cut the hose squarely and straight using a hacksaw, hose cut pliers, or powered cutting blade. Clean all debris off the cut ends of the hose, and blow out the center. Refer to Figure 13-9.


Courtesy of Aeroquip

13-9 Cut hose squarely.

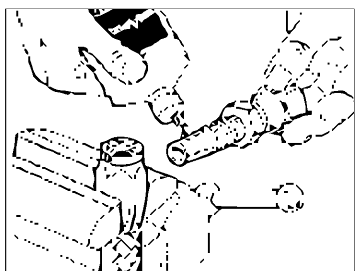
2. Screw the hose end ferrule on to the hose with the ferrule secured in a vise if necessary. Screw the hose in all the way until it bottoms on the ferrule lip.

3. Mark the bottom edge of the ferrule when fully on hose. Unscrew the ferrule one half (1/2) turn to expose the end of the hose. Refer to Figure 13-10.


Courtesy of Aeroquip

13-10 Back off 1/2 turn.

4. Apply lubricant to the hose insertion nipple. Refer to Figure 13-11. Use a manufacturer approved hose assembly lubricant or petroleum based oil only. Never use a lube containing silicone, solvents, or penetrating additives. Spread lubricant evenly around the nipple. Insert firmly into hose until threads engage.


Courtesy of Aeroquip

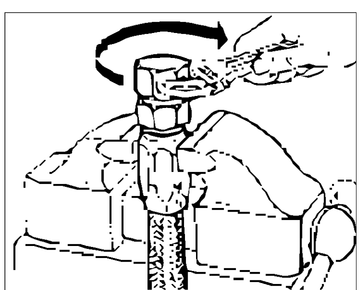
13-11 Lube end of nipple or mandrel.

5. Screw nipple into the ferrule until tight. Tighten the nipple until it contacts the edge of the ferrule. Do not tighten further. If the fitting is a 45^o or 90^o, ensure that the final assembly will allow the hose to be installed without kinking.

MANDREL TYPE HOSE END INSTALLATION

1. Screw the mandrel assembly tool into the hose end flare and tighten both ends securely. Refer to Figure 13-12. Apply lubricant and follow the directions outlined in step 4.

2. Secure the hose end ferrule in a vise and start the threads into the hose fitting. Tighten the hose nipple into the ferrule as previously directed.


Courtesy of Aeroquip

13-12 Screw mandrel

Key Points & Notes

13-22

13-23

Activity 13-1: Hose & Fitting Assembly

13-24

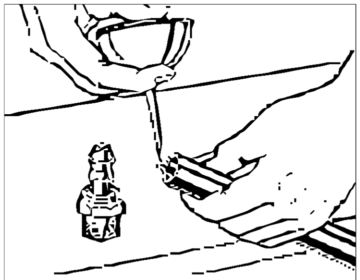
13-25

13-26

13-27

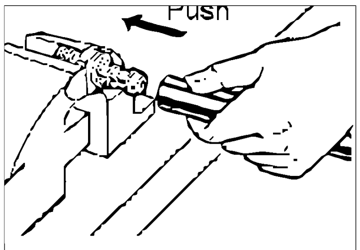
PUSH-ON HOSE END INSTALLATION

1. Cut the push-on hose to length as required by the application, ensuring that the edge is square. Apply lubricant to the inner diameter of the hose with an OEM approved product. Refer to Figure 13-13. Never use any type of lube containing silicone, solvents or penetrating additives.
2. Secure the hose end in a vise, being careful not to compress the flare end. Slide the hose onto the nipple end and push it all the way on until it bottoms on the lip of the hose end. The edge of the hose should be covered by the hose barb cup. Refer to Figure 13-14.



Courtesy of Aeroquip

13-13 Push lube.

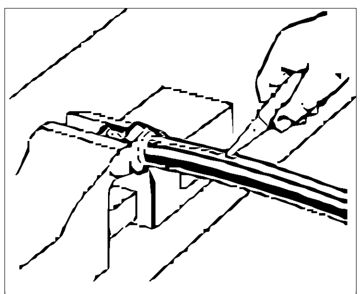


Courtesy of Aeroquip

13-14 Push on.

REMOVING RE-USEABLE HOSE ENDS

1. Secure the hose end in a vise. Make a linear cut from the hose barb lip back along the hose for about two inches using a utility razor. Ensure that the cut starts at the edge of the hose. Refer to Figure 13-15.
2. Pull the hose back sharply at a ninety degree angle from the hose end. Tear the hose off of the barb when it comes free. Hose ends may be re-used as long as the fitting is not damaged during removal. Refer to Figure 13-16.



Courtesy of Aeroquip

13-15 Push cut.

CRIMPED FERRULE HOSE PREPARATION & INSTALLATION

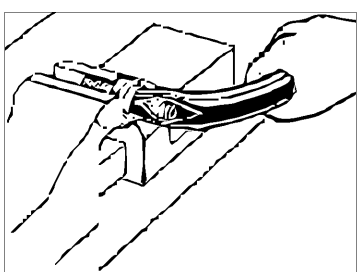
The following steps apply to hoses, fittings, and ferrules unique to one manufacturer:

[For the following steps, the term "fitting" applies to fittings, Y-connecters (splitters) and spray nozzle fittings.]

1. Cut hoses to lengths required to provide proper routing as described previously.
2. Slide the ferrule over the hose.

3 Lay the fitting next to the hose and ferrule.

4. Position the barb at the center of the ferrule and mark the fitting at the end of the hose.



Courtesy of Aeroquip

13-16 Push tear.

Key Points & Notes

13-28

13-29

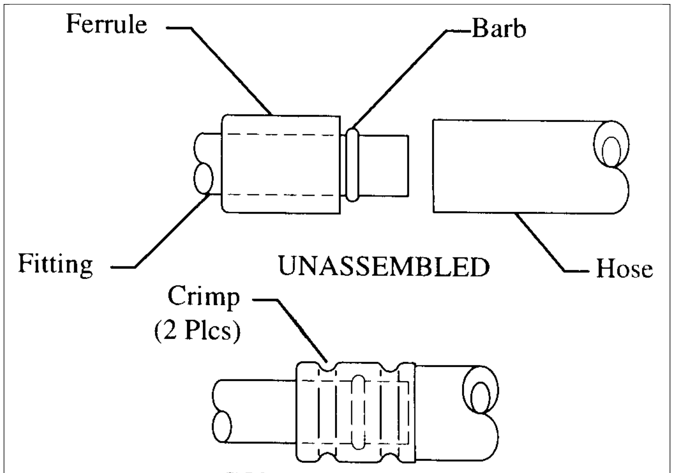
13-30

13-31

13-32

13-34

13-33



Courtesy of GFI

13-17 Crimp hose assembly.

5. Insert the fitting into the hose up to the mark made in step 4 and crimp.

   CAUTION: Use only crimping tool recommended by manufacturer.

6. Repeat steps 2 through 5 for other end of hose.

- Route hose so that there is a minimum clearance of 1" when the hood is closed.
- Secure all hoses with clips and/or ties.

INVERTED FLARE LOW-PRESSURE HOSE INSTALLATION

1. Determine the proper routing and prepare hose as described above.
2. Thoroughly inspect and clean any dirt and debris from threads of fitting and sealing surface.

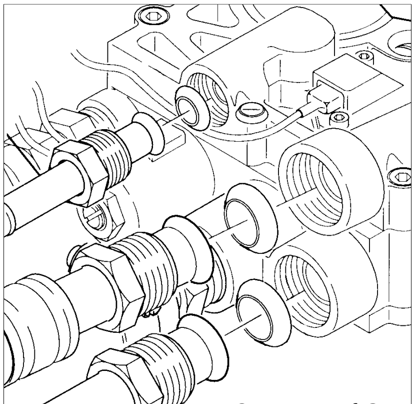
   CAUTION: Do not scratch or mar sealing surfaces. Scratches can cause poor seals and subsequent fuel leaks.

3. Insert new copper sealing washer in fitting port. Refer to Figure 13-18.

   NOTE: NEVER REUSE COPPER WASHERS. If a fitting is removed or loosened, ALWAYS replace existing washer with a new washer. This is to ensure a good seal. Refer to manufacturer's instructions.

4. Engage fitting nut into port threads and position hose as desired. Hand tighten nut.

   NOTE: When tightening nut, fitting and hose may "travel" clockwise. Position hose and fitting a few degrees counter-clockwise from desired position before tightening.



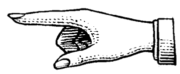
Courtesy of GFI

13-18 Hose assembly with copper washers.

Key Points & Notes

13-35

13-36



13-37

Key Points & Notes

5. Torque nut between 25 to 30 ft-lbs. Do not over tighten.
   - Always use wrench flats to tighten.
   - Always use proper tools. Do not use pliers.
   - Do not clamp or apply leverage to vaporizer, compuvalve, solenoids, or injectors.
   - Do not overtighten or otherwise damage the filter.
6. Pressure test system and check for leaks. DO NOT tighten fittings to stop leaks; proper torque is sufficient if threads are clean and new copper washer are used.

FILTERINSTALLATION

13-38

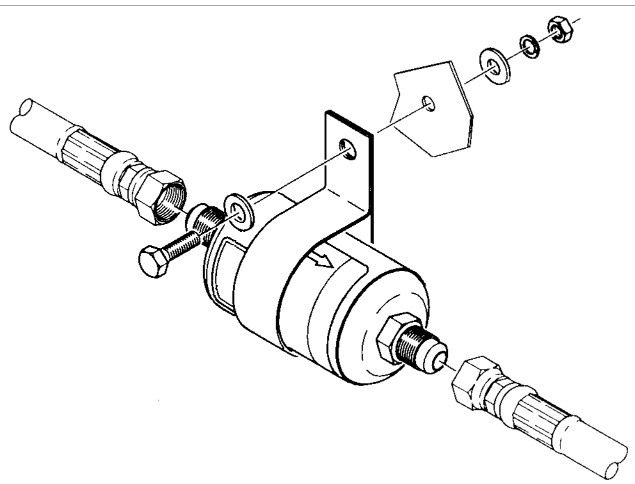
The fuel filter is mounted between the fuel tank and vaporizer and should be located to minimize hose routing and access for maintenance. Refer to Figure 13-19. The criteria for hose routing applies to determining the filter location.

CAUTION: Propane fuel filters are not interchangeable with gasoline filters.

1. Determine the best location for the fuel filter.
2. Drill and deburr mounting hole in desired location. Size of hole is dependent on type of attaching hardware used.
3. Attach filter using appropriate hardware; self tapping metal screw, washer and lock washer may be used when backside of mounting surface is unreachable.

CAUTION: The fuel flow through the filter is directional. Ensure that mounting allows that IN is from the fuel tank and OUT is to the vaporizer.

13-39



Courtesy of GFI

13-19 Filter and mounting bracket.

GASOLINE (CARBURETED) LOCK-OFF INSTALLATION

13-40

Install gasoline lock-off in the fuel line between the mechanical fuel pump and carburetor, as close to carburetor as possible without interfering with mixer installation. If the vehicle has an electric fuel pump, the pump can be disabled when the engine runs on propane by intercepting the power wire to the pump and wiring it through the fuel selector switch or relay.

1. Determine the best location for the fuel shutoff solenoid, then cut the gasoline fuel line with a tubing cutter or hacksaw. Deburr the fuel line, removing any debris or filings from the line.
2. Install the fuel shutoff solenoid so that it is mounted securely with adequate clearance around it. Compression fittings are recommended for connection to gasoline service lines. Barbed fittings, fuel hose, and clamps are also acceptable. All wiring connections should be soldered, heat shrink wrapped, and sealed from moisture.

   CAUTION: Anywhere the flow of gasoline has been interrupted, such as where a fuel line has been spliced, is a potential leak point and fire hazard. Make fittings leak proof and inspect regularly.

POST INSTALLATION

Be sure to inspect the fuel lines closely on a regular basis and replace or repair them as needed. Tears and pin pricks in hoses do not necessarily mean they need be replaced but note the problem for future maintenance checks.

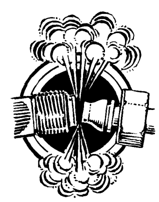
TESTING THE LINES

Fully pressurize the system using air or an inert gas such as CO_2, N_2, or both. Check each hose and connection for leaks by pressurizing up to 140 psi for at least 10 minutes. If there is a leak, isolate it using a liquid leak detector and watch for escaping bubbles. An electronic LPG detector can also be used. Repair any leaks and re-run the pressurization testing procedure until there are no leaks left. Leaks are often caused by incorrect fitting-to-hose assembly.

Key Points & Notes

13-41

13-42



Key Points & Notes

MODULE REVIEW ITEMS

Note to Technician: Consider all choices carefully and select the best answer to each.

1. Why is it important to inspect the tank components installed by the tank manufacturer?
A. To become familiar with the tank.
B. To make sure they were installed correctly.
C. To make sure the components operate correctly.
D. All of the above.

2. For tank installations that employ a remote fill fixture, what kind of valve must be permanently installed outside the vehicle?
A. Filler valve.
B. Back-flow check valve.
C. Stop fill valve.
D. None of the above.

3. For tank installations that require a remote relief valve, the point of discharge must be directed upward or downward within _____ degrees of vertical.
A. 15.
B. 30.
C. 45.
D. 90.

4. The relief valve must be protected by a _____.
A. Rain cap.
B. Liquid level gauge orifice.
C. Dust cover.
D. A or C.

5. The relief valve must have a break-away adapter at the tank opening with a melting point not less than _____.
A. 150° F
B. 500° F
C. 1500° F
D. 2500° F

6. Which step is not a part of the planning to route a fuel lines?
A. Estimate the required length for the shortest routing.
B. Estimate the required length for the longest routing.
C. Look for suitable surfaces to mount the fuel lines.
D. Ensure the structural integrity of the frame the lines are to be mounted to.

7. Which of the following could shear off a tight fuel line?
A. Rotational torque of the drive train.
B. Tight clamps.
C. Frame flex.
D. A & C

8. Keep the fuel line protected by using the form of the vehicle's frame by running the fuel line outside a channel or fold in the frame.
A. True.
B. False.

9. Use elbows and other fittings if necessary to make sure hoses are not _____.
A. Too tight
B. Sheared off.
C. Kinked.
D. All of the above.

10. Keep hoses at least _____ inches away from hot exhaust components.
A. 1-3.
B. 3-5.
C. 6-8.
D. 9-11.

11. Keep lines at least _____ inches away from spark ignition wires and moving vehicle parts
A. 1.
B. 3.
C. 5.
D. 7.

12. What can you use to keep lines from chaffing?
A. Shield them with heat hoses.
B. Shield them with springs.
C. Shield them with coils.
D. All of the above.

13. When a fuel line passes through a floor or wall panel, what should be used to protect the line from damage?
A. Steel or brass sleeves.
B. Heat hoses.
C. Bulkhead fittings.
D. A or C.

14. When installing the propane fuel lock, it should be installed as close to the _____ as possible.
A. Converter.
B. Ignition coil.
C. Remote relief valve.
D. Backflow check valve.

15. Why should you never connect the power wire to the ignition coil?
A. It could raise the secondary ignition output.
B. It can rob the coil of primary voltage.
C. It may cause the gasoline fuel pumps to malfunction.
D. None of the above.

16. Which of the following provides the fuel lock with the most protection?
A. Outside the frame rail.
B. On the gasoline fuel pump.
C. The rear corner of the engine compartment.
D. All of the above.

17. Which of the following does not belong regarding hose work?
A. Always deburr the line after cutting it.
B. Blow out the line before its installation.
C. Keep the installation design as professional as you can.
D. Never cut a hose any longer than its exact measurement.

18. Always use flat wrenches to tighten fittings.
A. True.
B. False.

19. A general checklist of hose requirements and locations can include the following:
A. Automatic lockoff to fuel filter.
B. Regulator to vaporizer.
C. Fuel filter to regulator.
D. All of the ahove.

20. Hose lines can be tested for leakage by which of the following methods?
A. Pressurizing the system using air.
B. Using a liquid leak detector.
C. Using an electronic LPG detector.
D. All of the above.

MRI SCORING KEY

1. D
2. B
3. C
4. D
5. C
6. B
7. D
8. B
9. C
10. C
11. B
12. D
13. D
14. A
15. B
16. C
17. D
18. A
19. D
20. D

ACTIVITY 13-1: HOSE & FITTING ASSEMBLY

OBJECTIVE

To properly fabricate hose lines and various fittings.

MATERIALS NEEDED

Hose

Fittings

Tools (vise, hacksaw, hose cut pliers, utility knife, powered cutting blade, hose assembly lubricant, shop air)

Module 13: Fuel Supply Line & Installation, pages 13-7 - 13-9

METHOD

This exercise provides practice for assembling different types of fittings to hose lines.

Refer to Module 13, pages 13-7 through 13-9. Identify which type of fitting is to be installed. Know the proper length of hose to be used before installing fittings. Proceed with the installation procedure for your fitting type.

Later the hose and fitting will be leak tested.

QUESTIONS

What type of fitting did you assemble? How is it different than other types of fittings? How is its installation procedure different than that of other fittings?

What considerations were there for your fitting installation? Can you detect any problems now before the hose and fitting are leak tested? If there are problems, what should be done to correct them?

COMMENTS

1 **MODULE 13:**
Fuel Supply Line & Installation

2 **TANK PLUMBING**

- Inspect all components before installation
- Install back-flow check valve if needed
- Protect relief valve by rain cap or dust cover
  - Direct upward or downward within 45^{o} of vertical
- Relief valve must have break-away adapter at tank opening

3 **13-1 TANK VALVE AND GAUGE LAYOUT**

4 **13-2 REMOTE FILL FIXTURE BACKSIDE**

5 **13-2A REMOTE FILL FIXTURE**

6 **13-3 RELIEF VALVE REMOTE PIPE-AWAY**

7 **13-3A RAIN/DUST CAP**

8 **FUEL LINE LAYOUT, ASSEMBLY AND INSTALLATION PROCEDURE - LINE ROUTING**

- Estimate length for shortest and simplest routing
- Review planned route for lines
- Identify surfaces for mounting line clamps and ties
- Check location of planned alterations in vehicle body
- Ensure structural integrity of frame is not defeated

9 **LINE ROUTING**

Considerations:

- Allow for rotational torque and frame flex
- Use vehicle frame to protect fuel lines
- Don't kink hoses
- Keep hoses 8" away from heat sources
- Keep lines 3" away from spark ignition wires and moving parts
- Keep lines 1" away from closed hoods and trunks
- Keep lines shielded from chaffing

10 **13-4 LIQUID SUPPLY LINE ROUTE**

11 **BULKHEADS**

- Protect line from possible damage when going through floors or walls

12 **13-5 BULKHEAD FITTING**

13 **FUEL LOCKS**

- Install as close to converter as possible
- Install electric fuel locks using either vacuum safety or oil pressure switch
- Ensure fuel lock can be easily serviced
- Install fuel lock securely in protected place

14 **13-6 ELECTRIC FUEL LOCKS**

15 **13-6A ELECTRIC FUEL LOCKS**

16 **13-7 VACUUM FILTER FUEL LOCK**

17 **13-7A ELECTRIC FUEL LOCK ON FILTER**

18 **MEASURING, CUTTING, AND CUSTOMIZING LINES AND FITTINGS**

- Measure planned route, then measure and cut hose
- Deburr line after cutting it
- Blow out line before installation
- Follow manufacturer's instructions to install fittings

19 **FUEL SUPPLY HOSE AND FITTING INSTALLATION**

- Install fuel line in sections between components

– One at a time
- Clean fitting area and component ports
- Attach nut; hand tighten; watch hose movements; torque to correct ft-lbs.
- After installing one end of hose, run line to its destination
- Secure lines every 18"

20 **FUEL SUPPLY HOSE AND FITTING INSTALLATION**

Correct practices:
- Use flat wrenches
- Don't use barbed fitting end to tighten
- Don't clamp or leverage components during tightening

21 **13-8 FUEL LINE INSTALLATION**

22 **HOSE ASSEMBLY - HOSE END PREPARATION**
- Clamp or secure hose, undamaged
- Cut hose squarely, clean out debris
- Screw hose end ferrule on
- Mark ferrule bottom edge when fully on hose, then back off 1/2 turn
- Apply lube to hose insertion nipple evenly
- Insert firmly into hose until threads engage
- Screw nipple into ferrule edge until tight

23 **13-9 CUT HOSE SQUARELY**

24 **13-10 BACK OFF 1/2 TURN**

25 **13-11 LUBE END OF MANDREL OR NIPPLE**

26 **MANDREL TYPE HOSE END INSTALLATION**
- Screw mandrel tool into hose end flare and tighten both ends
- Apply lube to hose insertion nipple evenly
- Insert firmly into hose until threads engage
- Secure hose end ferrule in vise and start threads into fitting
- Screw nipple into ferrule edge until tight

27 **13-12 SCREW MANDREL**

28 **PUSH-ON HOSE END INSTALLATION**
- Cut hose to desired length
- Apply lube to inner hose
- Secure hose in vise, don't compress flare end
- Slide hose onto nipple end all the way up

29 **13-13 PUSH LUBE**

30 **13-14 PUSH ON**

31 **REMOVING RE-USEABLE HOSE ENDS**
- Secure hose end in vise
- Make linear cut from hose barb lip along hose
- Cut starts at end of hose
- Pull hose back at an angle
- Tear hose off barb

32 **13-15 PUSH CUT**

33 **13-16 PUSH TEAR**

34 **CRIMPED FERRULE HOSE PREPARATION & INSTALLATION**
- Cut hose to length and prep
- Slide ferrule over hose
- Lay fitting next to hose and ferrule
- Position barb at ferrule center and mark fitting at hose end

- Insert fitting into hose up to mark and crimp
- Repeat for other end of hose

35 **13-17 CRIMP HOSE ASSEMBLY**

36 **INVERTED FLARE LOW-PRESSURE HOSE INSTALLATION**

- Determine routing and prep hose
- Inspect, clean dirt from fitting threads & sealing surface
- Insert new copper sealing washer in fitting port
- Engage fitting nut into port threads & position hose
- Hand tighten nut
- Torque nut 25-30 ft-lbs without overtightening
- Pressure test system, check for leaks

37 **13-18 HOSE ASSEMBLY WITH COPPER WASHERS**

38 **FILTER INSTALLATION**

- Mount between fuel tank and vaporizer
- Do not interchange with gasoline filters
- Install in best location
- Drill & deburr mounting hole
- Attach filter with correct hardware
- Ensure correct direction of fuel flow into filter

39 **13-19 FILTER AND MOUNTING BRACKET**

40 **GASOLINE (CARBURETED) LOCK-OFF INSTALLATION**

- Install between mechanical fuel pump and carburetor
- Determine location for fuel shutoff solenoid
- Cut gasoline fuel line and deburr
- Install fuel shutoff solenoid
- Make fittings leak proof and inspect regularly

41 **POST INSTALLATION**

- Close periodic inspection
- Note tears and pin pricks in hose

42 **TESTING THE LINES**

- Fully pressurize the system to check for leaks
- Use a leak detector or an electronic LPG detector
- Make sure the fitting instructions were followed precisely

MODULE 13:
Fuel Supply Line & Installation

TANK PLUMBING

- Inspect all components before installation
- Install back-flow check valve if needed
- Protect relief valve by rain cap or dust cover
  - Direct upward or downward within 45^{o} of vertical
- Relief valve must have break-away adapter at tank opening

13-1 TANK VALVE AND GAUGE LAYOUT

Photo Copyright Harris Fogel

13-2 REMOTE FILL FIXTURE BACKSIDE

Photo Copyright Harris Fogel

13-2A REMOTE FILL FIXTURE

Photo Copyright Harris Fogel

13-3 RELIEF VALVE REMOTE PIPE-AWAY

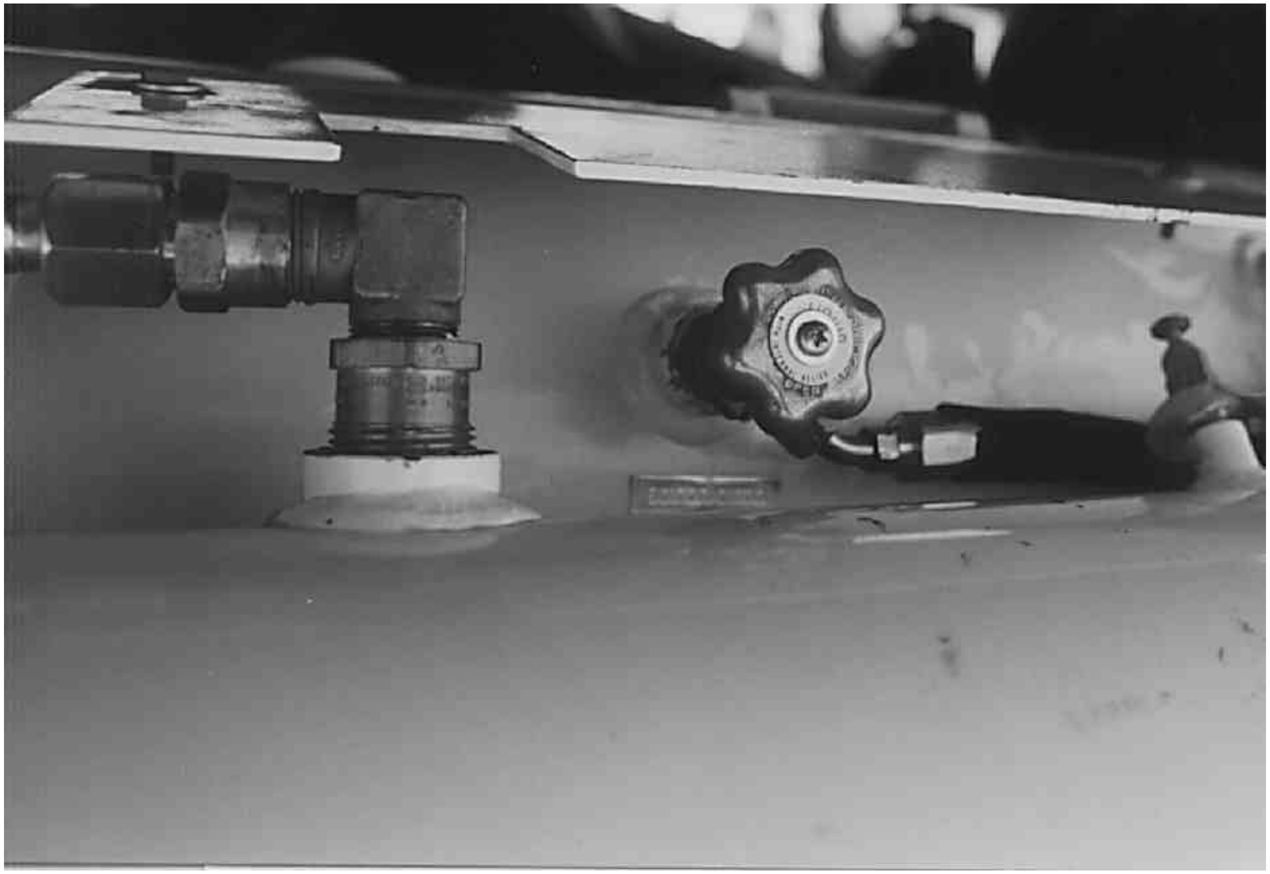


Photo Copyright Harris Fogel

13-3A RAIN/DUST CAP

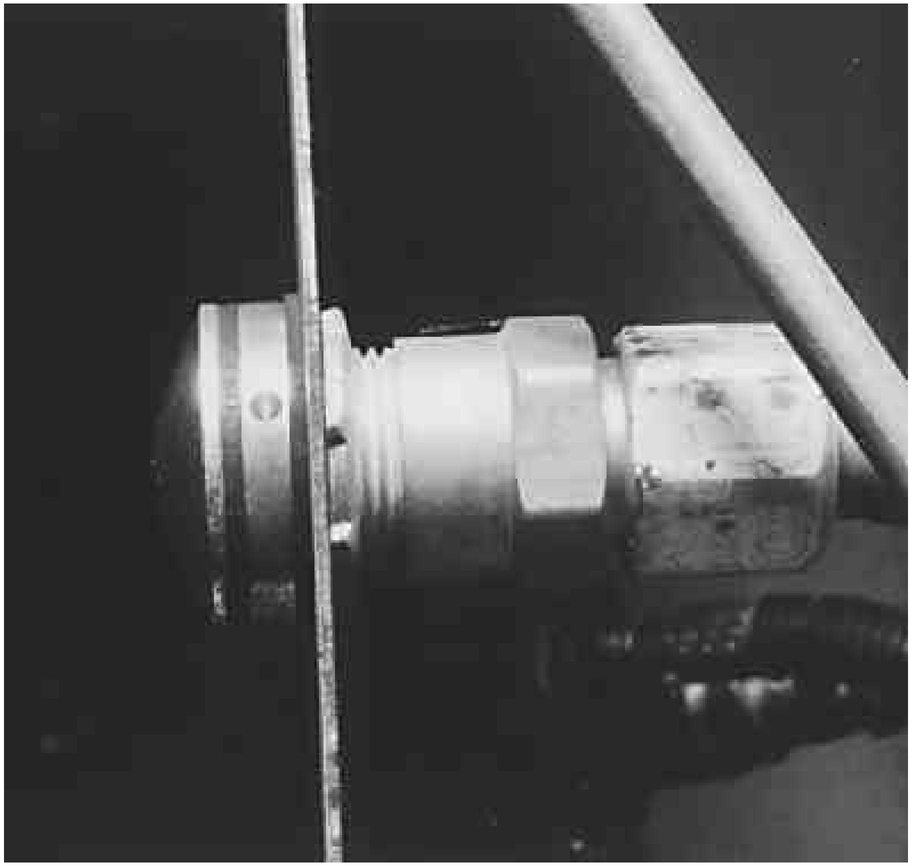


Photo Copyright Harris Fogel

FUEL LINE LAYOUT, ASSEMBLY AND INSTALLATION PROCEDURE - LINE ROUTING

- Estimate length for shortest and simplest routing
- Review planned route for lines
- Identify surfaces for mounting line clamps and ties
- Check location of planned alterations in vehicle body
- Ensure structural integrity of frame is not defeated

LINE ROUTING

Considerations:

- Allow for rotational torque and frame flex
- Use vehicle frame to protect fuel lines
- Don't kink hoses
- Keep hoses 8" away from heat sources
- Keep lines 3" away from spark ignition wires and moving parts
- Keep lines 1" away from closed hoods and trunks
- Keep lines shielded from chaffing

13-4 LIQUID SUPPLY LINE ROUTE

Photo Copyright Harris Fogel

BULKHEADS

- Protect line from possible damage when going through floors or walls

13-5 BULKHEAD FITTING

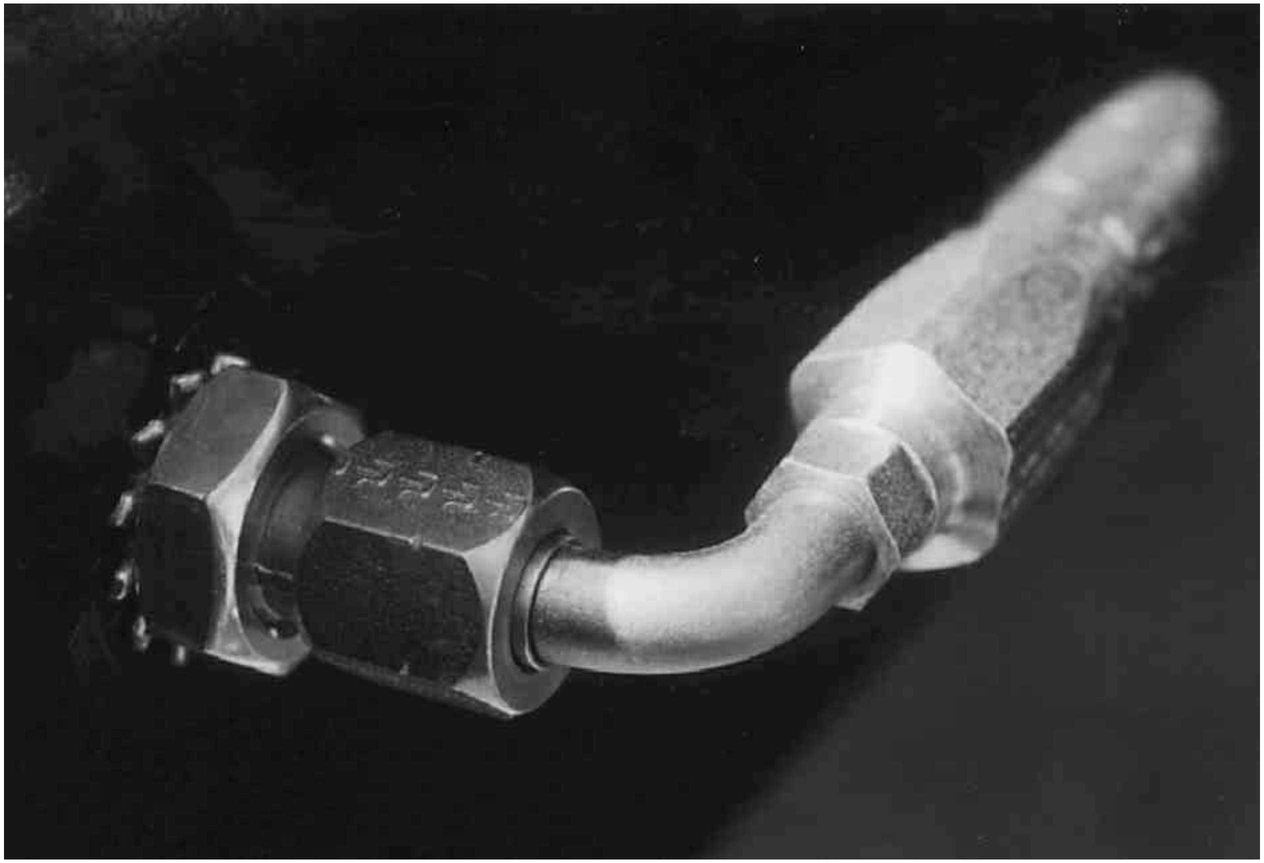


Photo Copyright Harris Fogel

FUEL LOCKS

- Install as close to converter as possible
- Install electric fuel locks using either vacuum safety or oil pressure switch
- Ensure fuel lock can be easily serviced
- Install fuel lock securely in protected place

13-6 ELECTRIC FUEL LOCKS

Photo Copyright Harris Fogel

13-6A ELECTRIC FUEL LOCKS

Photo Copyright Harris Fogel

13-7 VACUUM FILTER FUEL LOCK

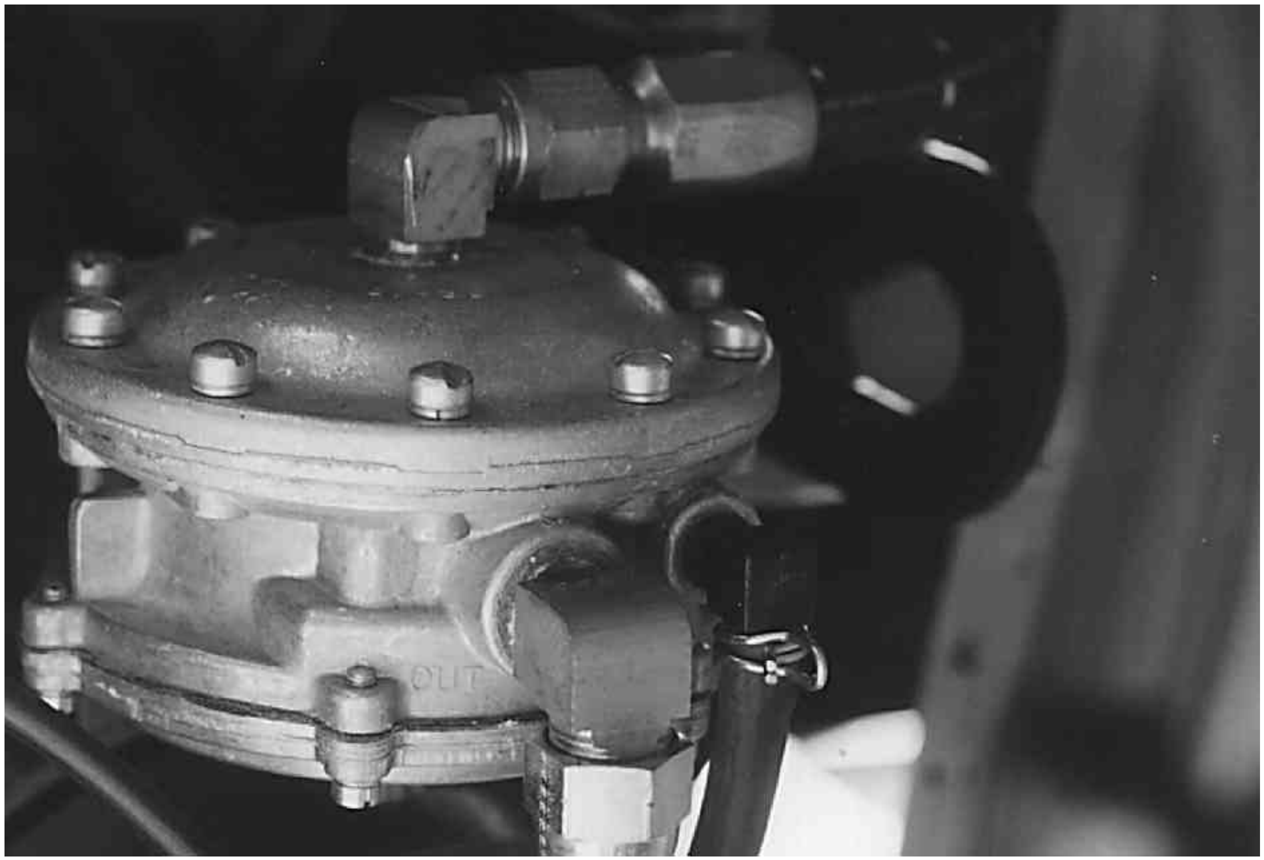


Photo Copyright Harris Fogel

13-7A ELECTRIC FUEL LOCK ON FILTER

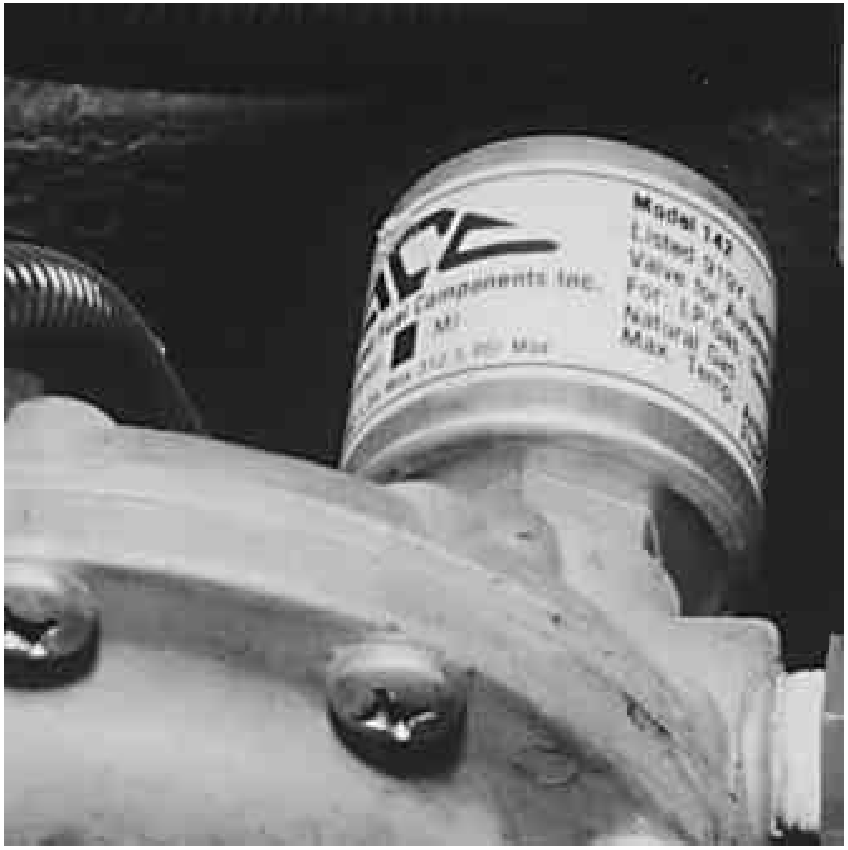


Photo Copyright Harris Fogel

MEASURING, CUTTING, AND CUSTOMIZING LINES AND FITTINGS

- Measure planned route, then measure and cut hose
- Deburr line after cutting it
- Blow out line before installation
- Follow manufacturer's instructions to install fittings

FUEL SUPPLY HOSE AND FITTING INSTALLATION

- Install fuel line in sections between components
  - One at a time
- Clean fitting area and component ports
- Attach nut; hand tighten; watch hose movements; torque to correct ft-lbs.
- After installing one end of hose, run line to its destination
- Secure lines every 18"

FUEL SUPPLY HOSE AND FITTING INSTALLATION

Correct practices:

- Use flat wrenches
- Don't use barbed fitting end to tighten
- Don't clamp or leverage components during tightening

13-8 FUEL LINE INSTALLATION

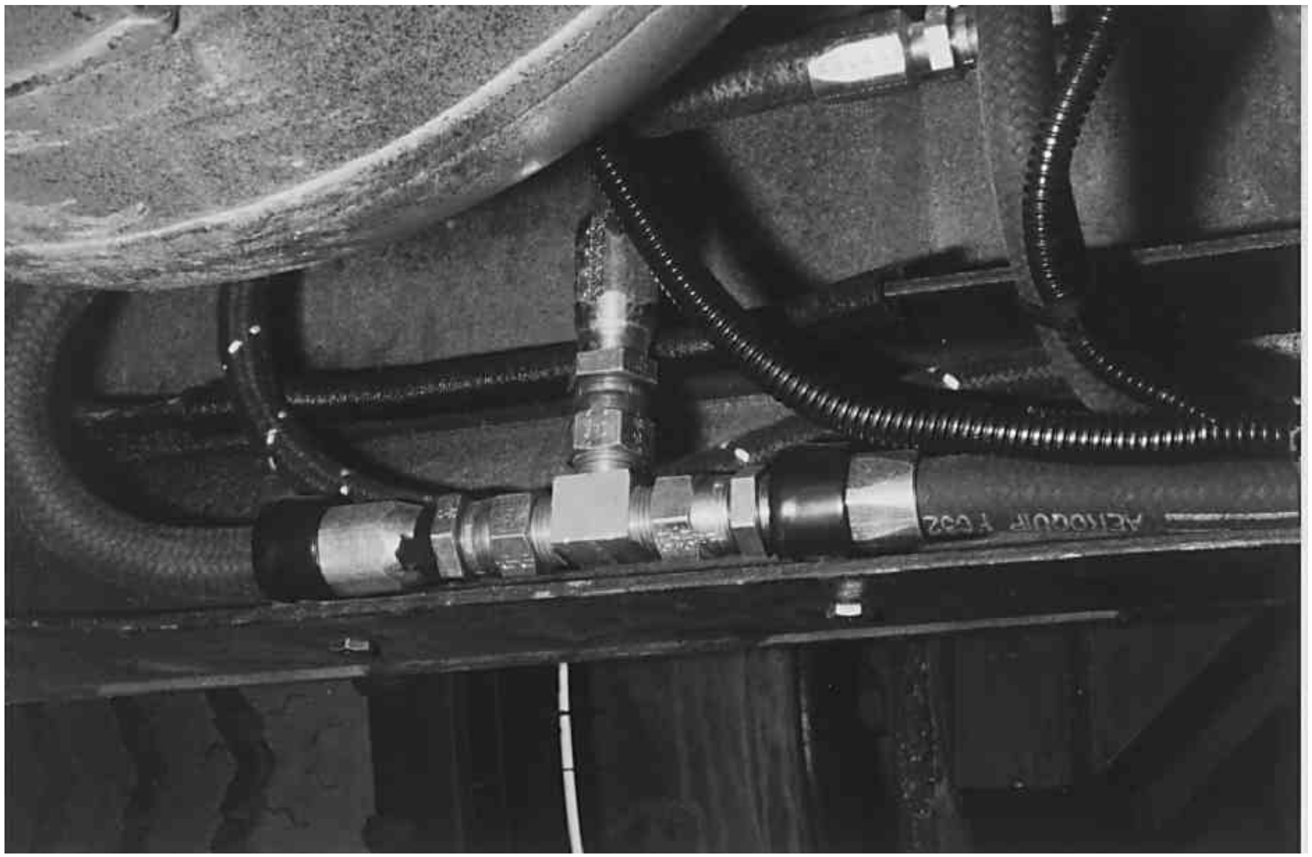
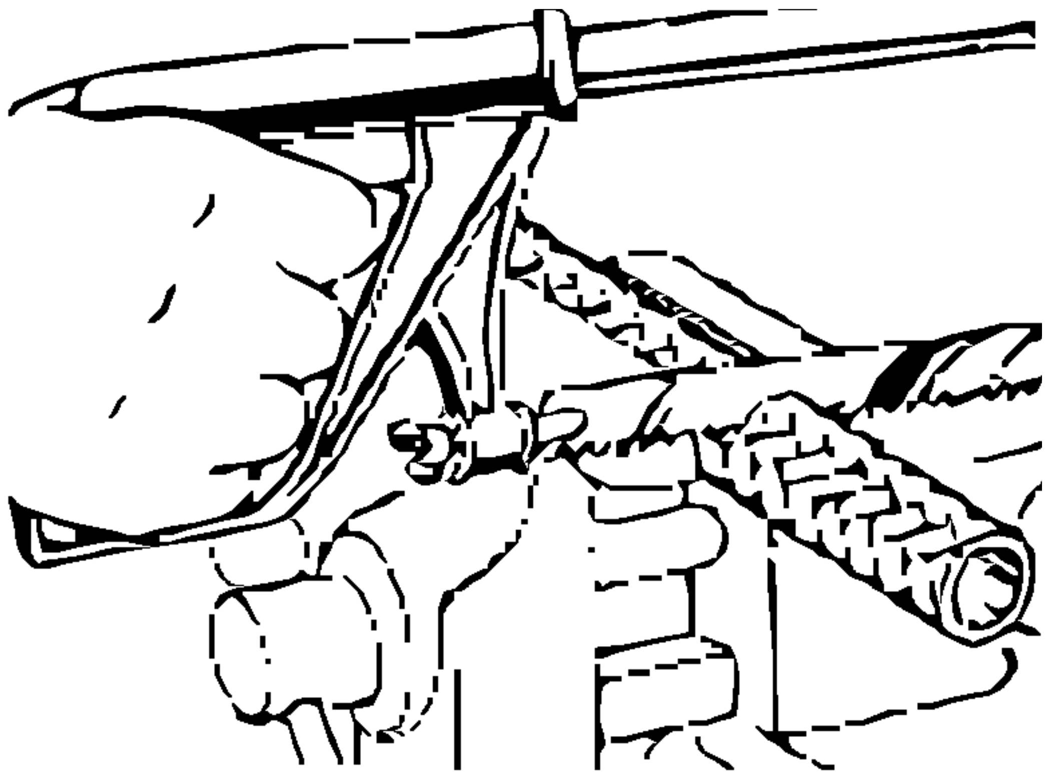


Photo Copyright Harris Fogel

HOSE ASSEMBLY - HOSE END PREPARATION

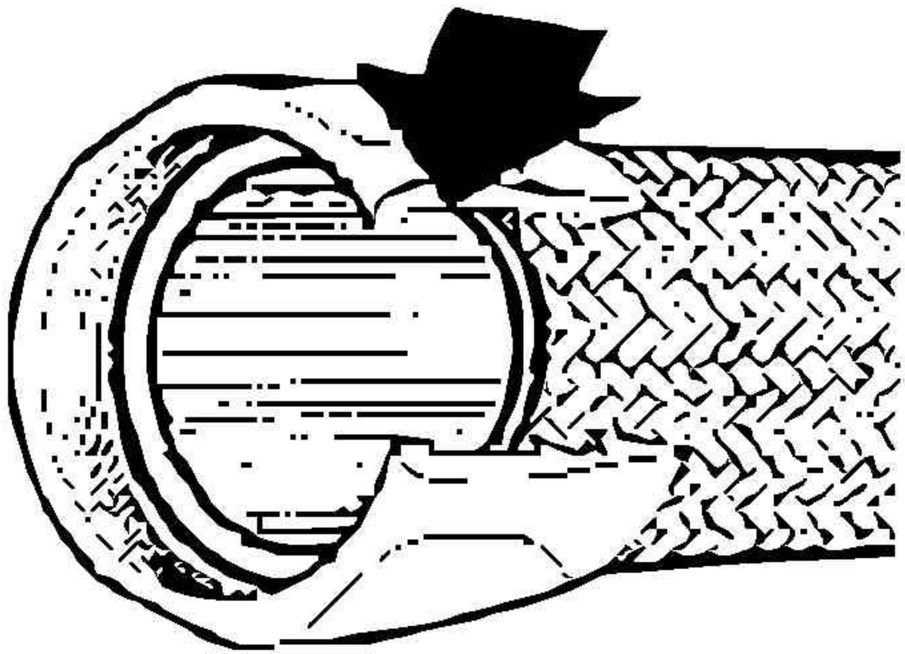
- Clamp or secure hose, undamaged
- Cut hose squarely, clean out debris
- Screw hose end ferrule on
- Mark ferrule bottom edge when fully on hose, then back off 1/2 turn
- Apply lube to hose insertion nipple evenly
- Insert firmly into hose until threads engage
- Screw nipple into ferrule edge until tight

13-9 CUT HOSE SQUARELY



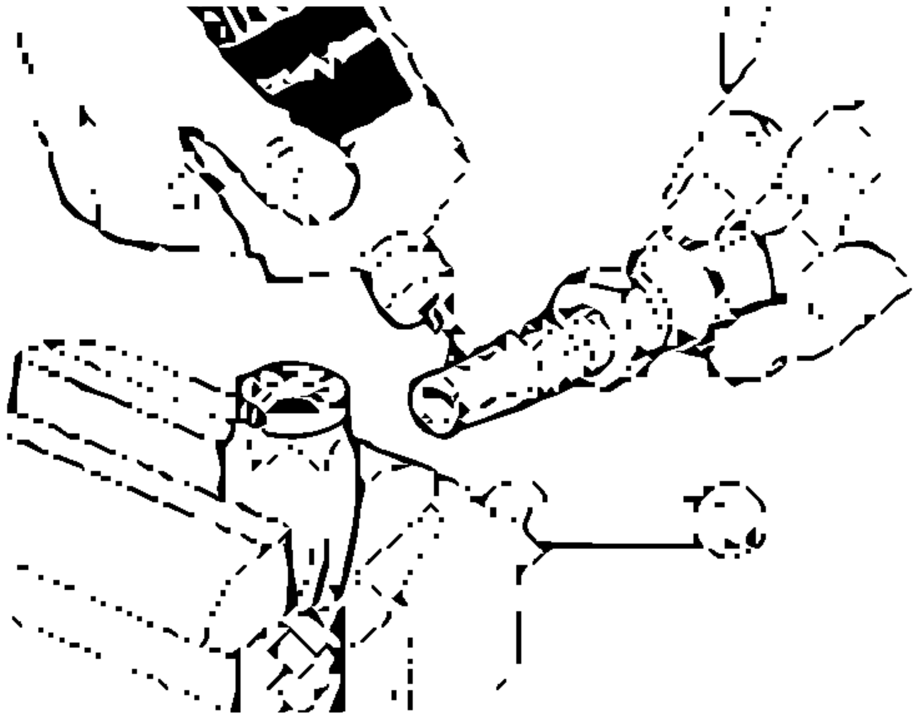
Courtesy of Aeroquip

13-10 BACK OFF 1/2 TURN



Courtesy of Aeroquip

13-11 LUBE END OF MANDREL OR NIPPLE

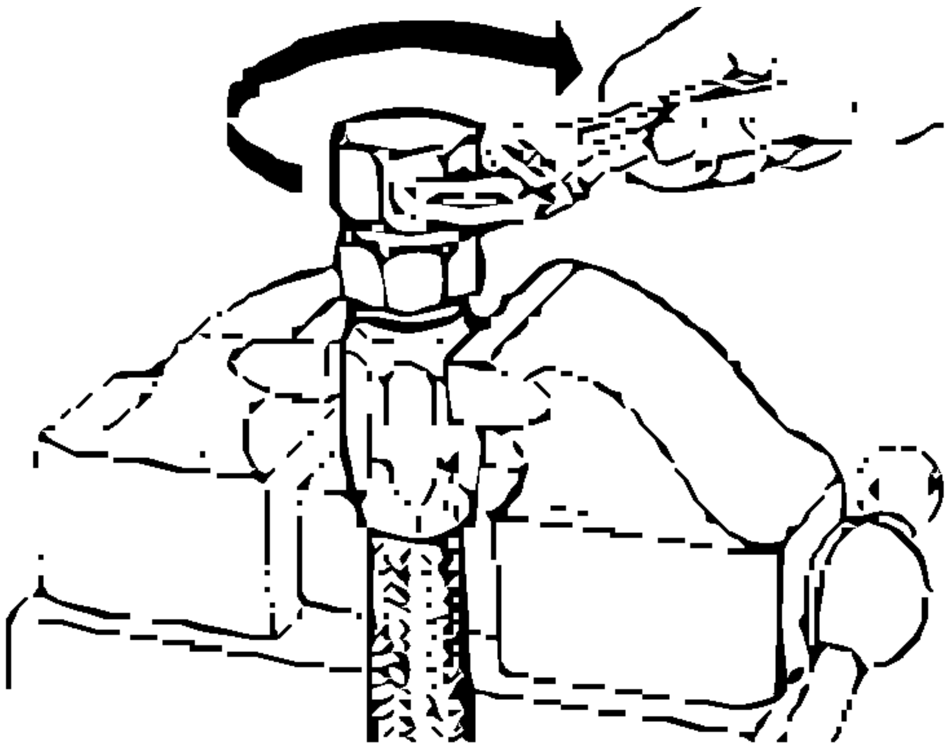


Courtesy of Aeroquip

MANDREL TYPE HOSE END INSTALLATION

- Screw mandrel tool into hose end flare and tighten both ends
- Apply lube to hose insertion nipple evenly
- Insert firmly into hose until threads engage
- Secure hose end ferrule in vise and start threads into fitting
- Screw nipple into ferrule edge until tight

13-12 SCREW MANDREL

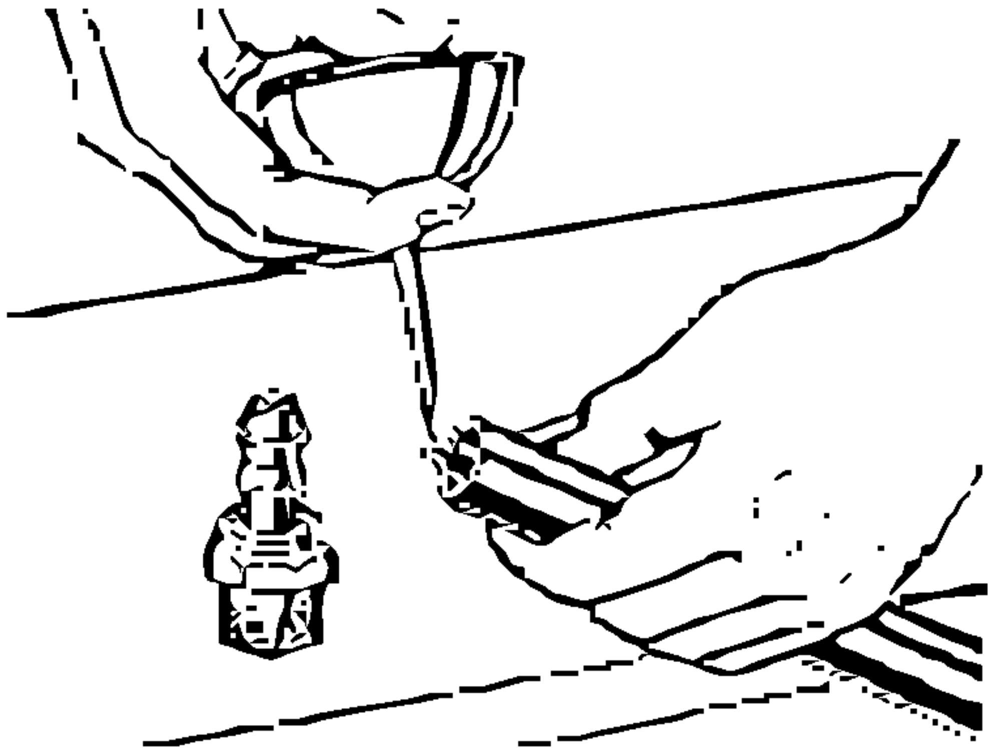


Courtesy of Aeroquip

PUSH-ON HOSE END INSTALLATION

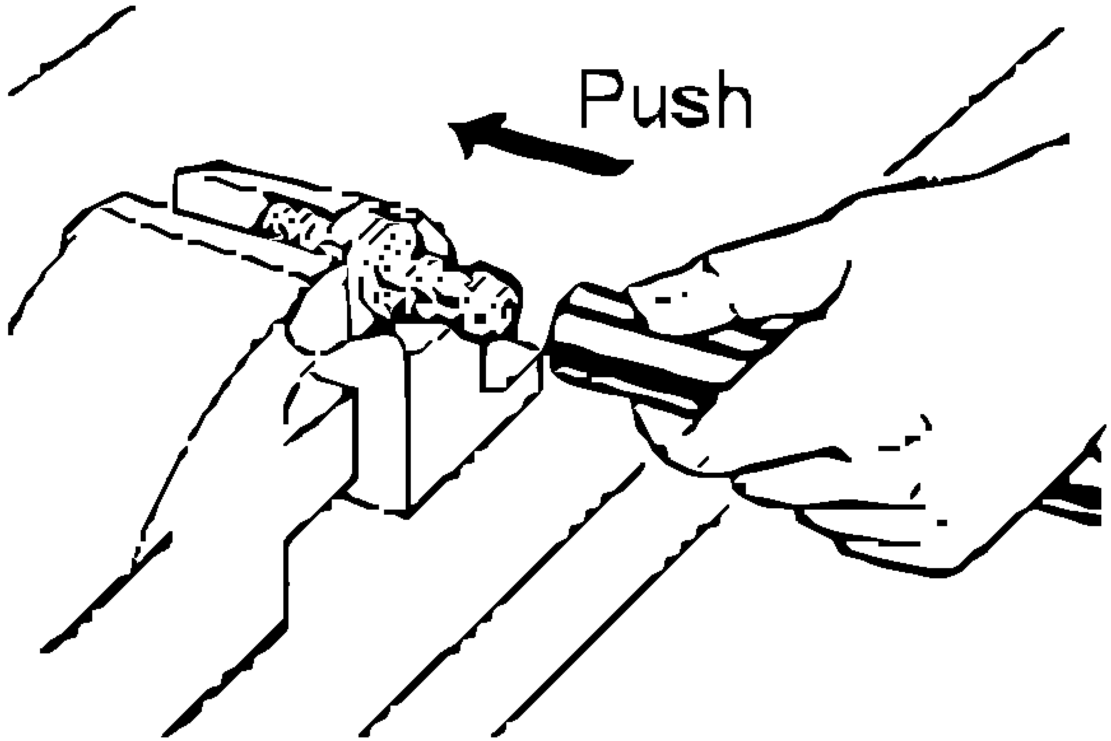
- Cut hose to desired length
- Apply lube to inner hose
- Secure hose in vise, don't compress flare end
- Slide hose onto nipple end all the way up

13-13 PUSH LUBE



Courtesy of Aeroquip

13-14 PUSH ON

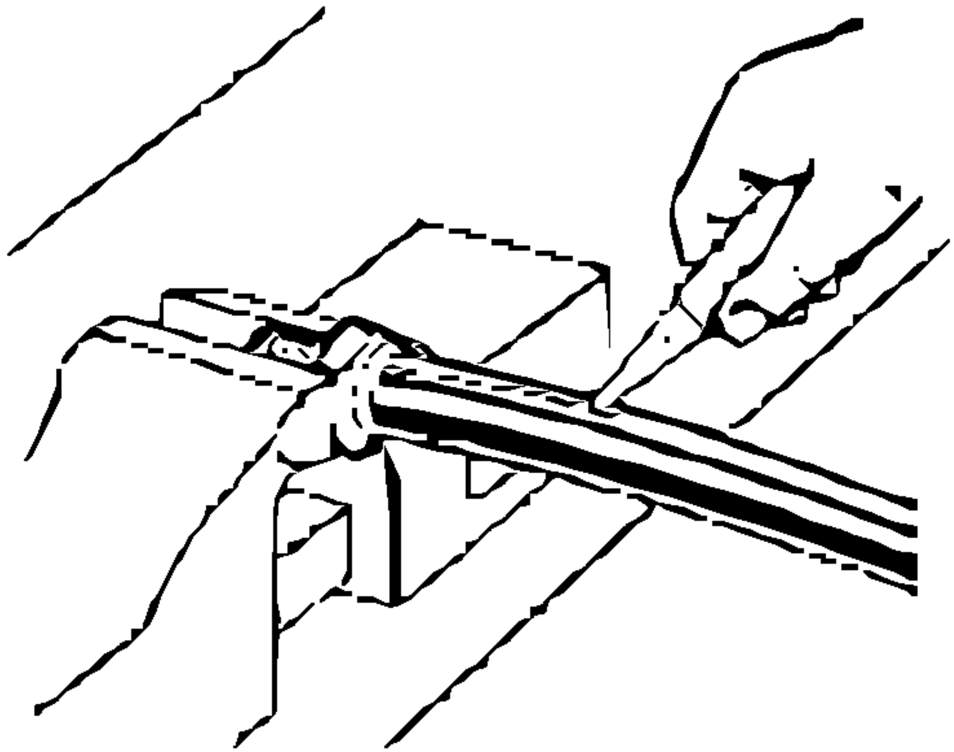


Courtesy of Aeroquip

REMOVING RE-USEABLE HOSE ENDS

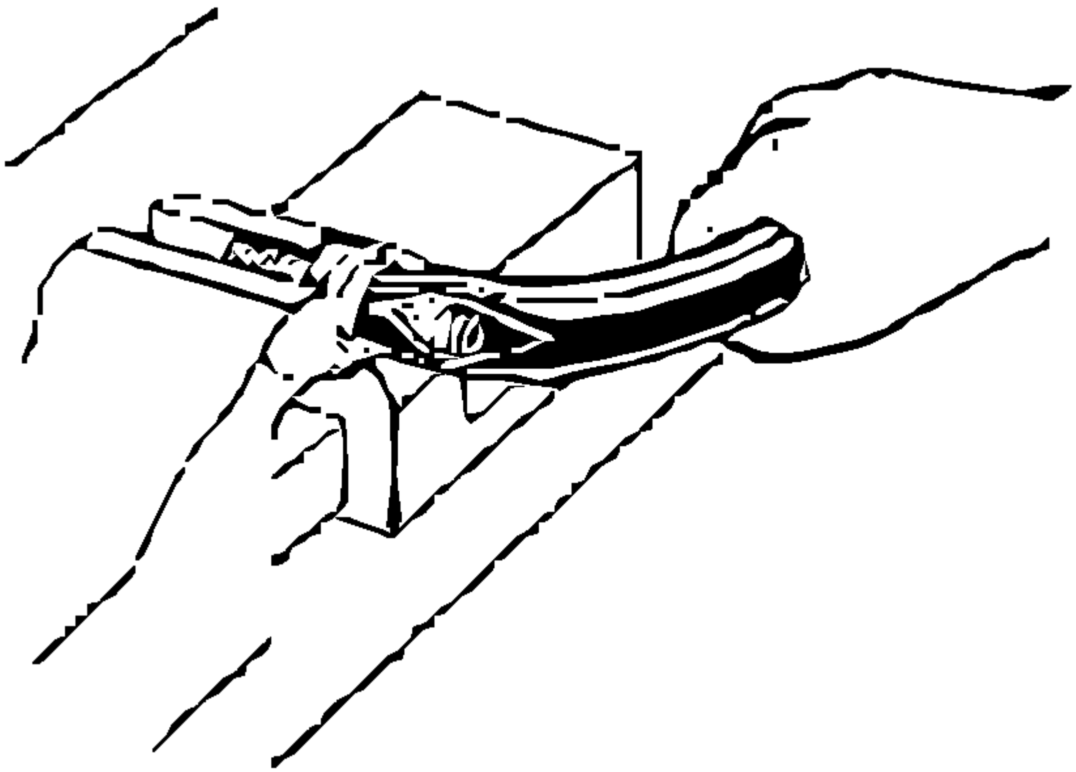
- Secure hose end in vise
- Make linear cut from hose barb lip along hose
- Cut starts at end of hose
- Pull hose back at an angle
- Tear hose off barb

13-15 PUSH CUT



Courtesy of Aeroquip

13-16 PUSH TEAR

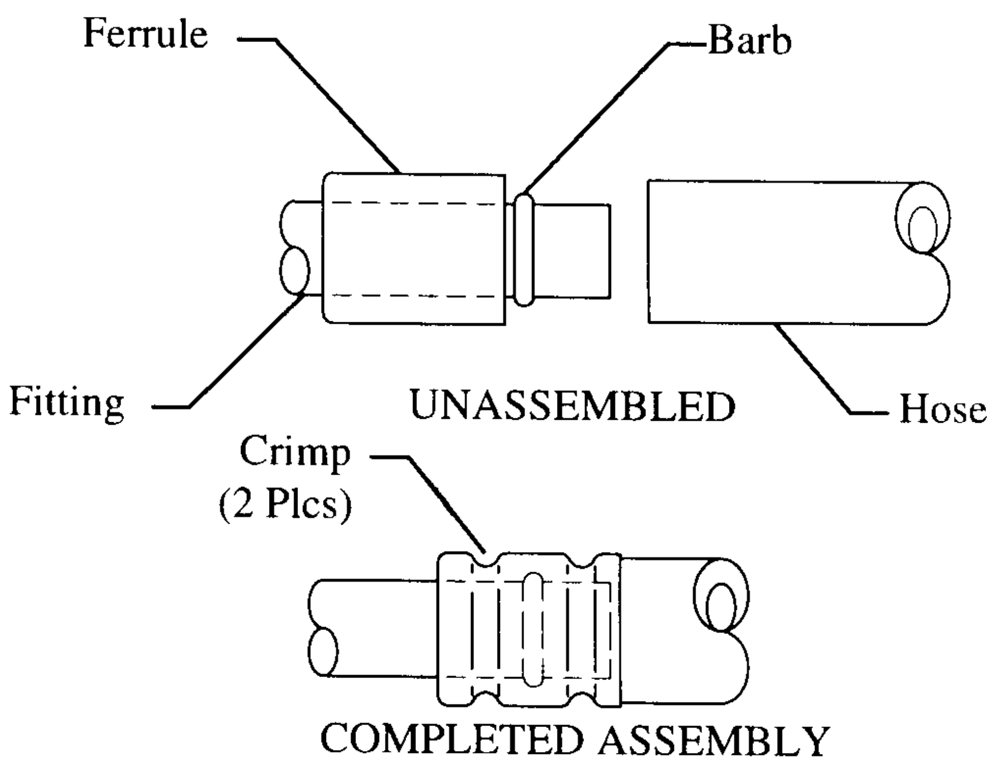


Courtesy of Aeroquip

CRIMPED FERRULE HOSE PREPARATION & INSTALLATION

- Cut hose to length and prep
- Slide ferrule over hose
- Lay fitting next to hose and ferrule
- Position barb at ferrule center and mark fitting at hose end
- Insert fitting into hose up to mark and crimp
- Repeat for other end of hose

13-17 CRIMP HOSE ASSEMBLY

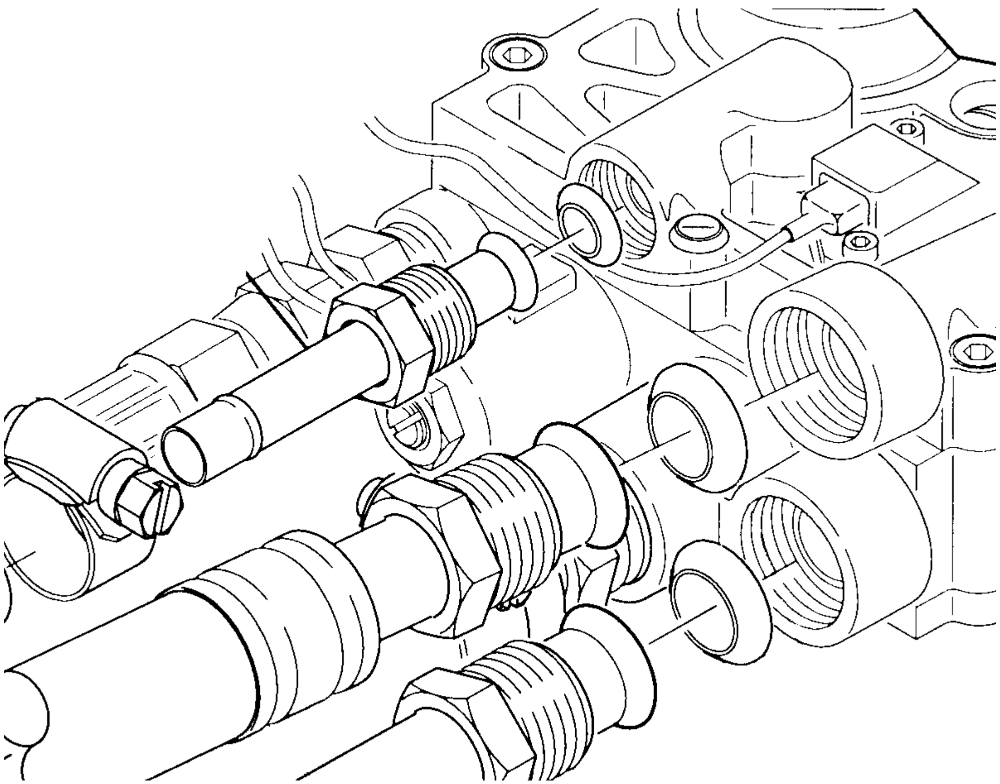


Courtesy of GFI

INVERTED FLARE LOW-PRESSURE HOSE INSTALLATION

- Determine routing and prep hose
- Inspect, clean dirt from fitting threads & sealing surface
- Insert new copper sealing washer in fitting port
- Engage fitting nut into port threads & position hose
- Hand tighten nut
- Torque nut 25-30 ft-lbs without overtightening
- Pressure test system, check for leaks

13-18 HOSE ASSEMBLY WITH COPPER WASHERS

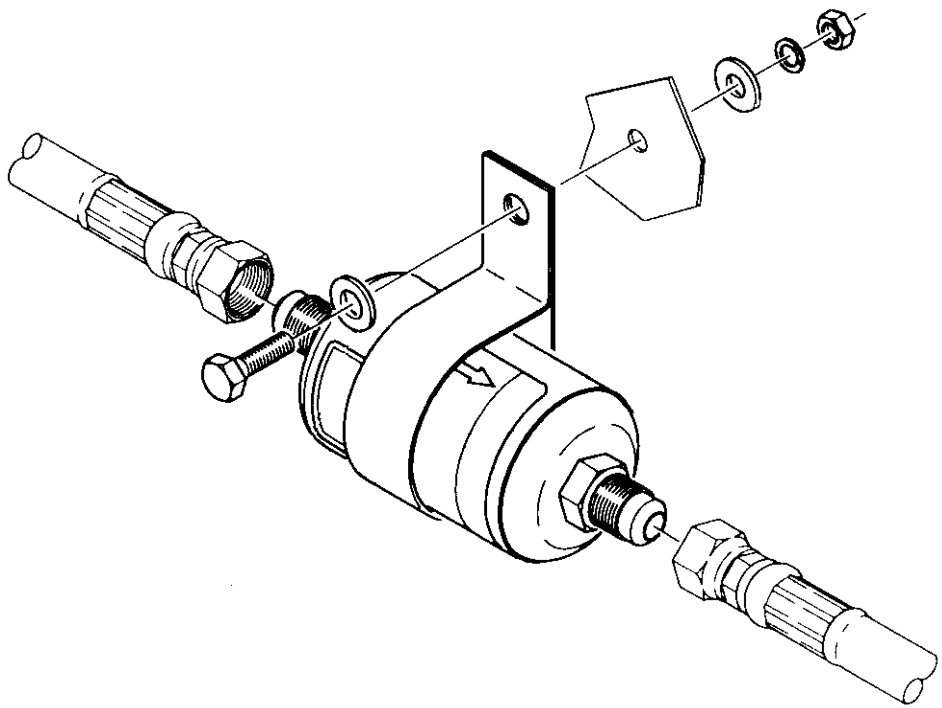


Courtesy of GFI

FILTER INSTALLATION

- Mount between fuel tank and vaporizer
- Do not interchange with gasoline filters
- Install in best location
- Drill & deburr mounting hole
- Attach filter with correct hardware
- Ensure correct direction of fuel flow into filter

13-19 FILTER AND MOUNTING BRACKET



Courtesy of GFI

GASOLINE (CARBURETED) LOCK-OFF INSTALLATION

- Install between mechanical fuel pump and carburetor
- Determine location for fuel shutoff solenoid
- Cut gasoline fuel line and deburr
- Install fuel shutoff solenoid
- Make fittings leak proof and inspect regularly

POST INSTALLATION

- Close periodic inspection
- Note tears and pin pricks in hose

TESTING THE LINES

- Fully pressurize the system to check for leaks
- Use a leak detector or an electronic LPG detector
- Make sure the fitting instructions were followed precisely

MODULE 14:
Converter Installation

State of Oklahoma
College of the Desert
West Virginia University

MODULE 14: CONVERTER INSTALLATION

CONTENTS

MODULE 14: CONVERTER INSTALLATION

OBJECTIVES

At the completion of this module, the technician will be able to:

- Select the proper converter for installation.
- Determine the best location to mount the converter.
- Trial fit the converter with other components.
- Properly install mounting brackets for the converter.
- Properly install the converter unit.
- Properly connect water lines, fuel lines, and the vent hose.
- Properly charge the system with coolant.
- Identify and correct problems with the installation.

INSTRUCTOR NOTES

INSTRUCTOR MATERIALS/MEDIA NEEDED

Overhead projector or LCD panel/projection equipment
Master overhead transparencies or Microsoft PowerPoint 4.0 presentation file Mod14.ppt

Note: Slides correspond to text as indicated by icon

STUDENT MATERIALS/MEDIA NEEDED

Module 14: Converter Installation

MODULE REVIEW ITEMS

The Module Review Items (MRI) are designed to allow for flexibility in their use. The exam may be utilized as a post-module review, pre/post test, part of a term examination, or it may be used by the student if the module is used as a self study text.

OVERHEAD TRANSPARENCY MASTERS

The printouts enclosed with this module are taken from the Microsoft PowerPoint 4.0 presentation file Mod14.ppt . Instructors planning to use overhead projectors should make transparencies from these printouts on a copier (or laser printer designed to safely print to acetate.

Note: Please review Module 25: Training of Trainers for more hints on instructional needs and strategies.

Liquefied Petroleum Gas

MODULE 14: CONVERTER INSTALLATION

CONVERTER

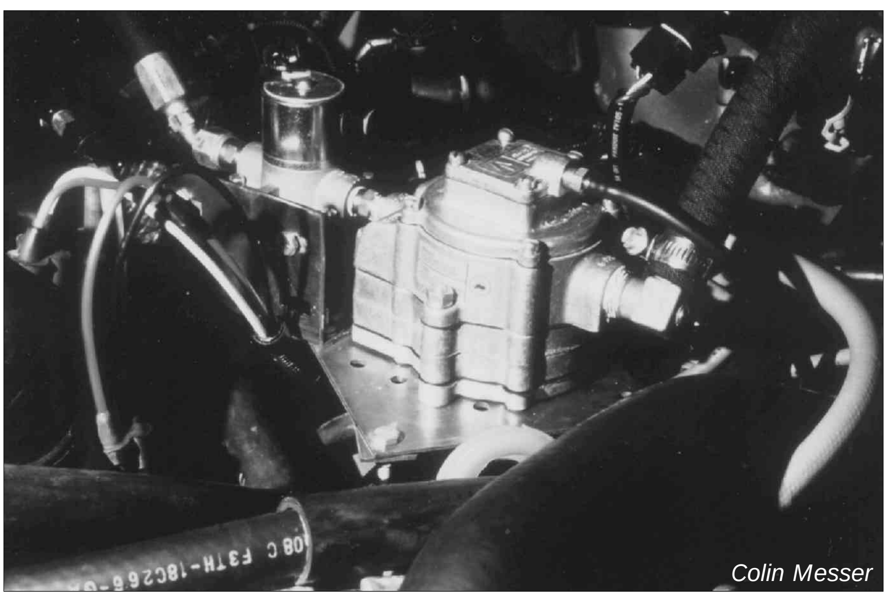
The vaporizer and regulator are typically combined in one unit known as a converter. Many system providers supply converters with prefabricated bracket assemblies to simplify the installation.

LOCATION CONSIDERATIONS

1. Select and install the correct converter for the application according to the manufacturer's specification.
2. Determine the best location for the converter in the engine compartment. The converter must be mounted away from the exhaust system or other sources of external heat. It should be installed securely in a place where it won't be damaged in the event of a collision and where it can be easily adjusted.

MOUNTING BRACKET CONSIDERATIONS

Some systems may not include mounting brackets, in which case they must be made by the installer. Use strong and rust-free materials. It may be necessary to move or relocate components such as the battery, windshield washer reservoir, or the engine coolant reservoir. Be sure to know what is on the other side of the mounting location before drilling. Select a stable mounting surface to prevent the converter from being held in place by the fuel lines. Refer to Figure 14-1.



14-1 Typical converter fuel lock mounting.

- Locate away from OEM mechanical operation or where motions such as engine rock or hood closing endanger the unit.
- Locate away from areas where routine service operations are performed.
- Locate away from potential areas of damage by vehicle operation or collision. If possible, locate back toward the bulkhead (fire wall) for added protection in case of accident.

Key Points & Notes

14-2

14-3

14-5

14-4

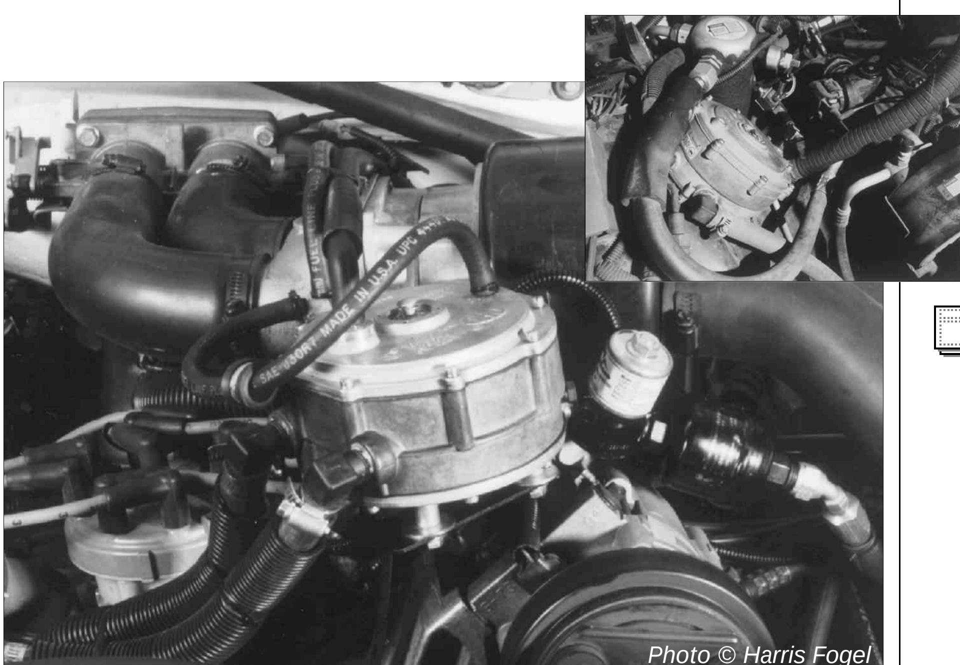
14-6

- Locate at least 2” away from belts or pulleys.
- Locate sufficiently away from the engine block and the radiator tank.
- Locate away from the frontal sheet metal.
- Locate away from the splash path.
- Locate away from areas that may cause hoses to be crimped or chafed.

3. Make a trial fit of the converter to see how it lines up with the fuel lock and mixer. Install the mounting brackets and bolt the converter in place. Use large fender washers where necessary to prevent the bracket from pulling loose. Ideally, the vapor hose outlet should be at the lowest point of the converter so any oil that may be present in the fuel will not accumulate inside the unit. Also, mount the converter below the top tank of the radiator to assure good coolant flow through the heat exchanger and eliminate air pockets. Consider the following:

- allow 6” for hose fittings and hose flex from the converter;
- locate the converter with the diaphragm parallel to the length of the vehicle to prevent surges caused by vehicle stop-and-go motions;
- locate below the top tank of the radiator to assure good coolant flow through the heat exchanger and to eliminate air pockets;
- locate as close as possible to the mixer, the fuel lockoff, and filter. Refer to Figure 14-2. If they must be separated, use appropriate sized and correct pressure hoses.

4. Fabricate and assemble converter mounting brackets.



14-2 Converter mounted to mixer. **Inset** Converter mounted on fender wall.

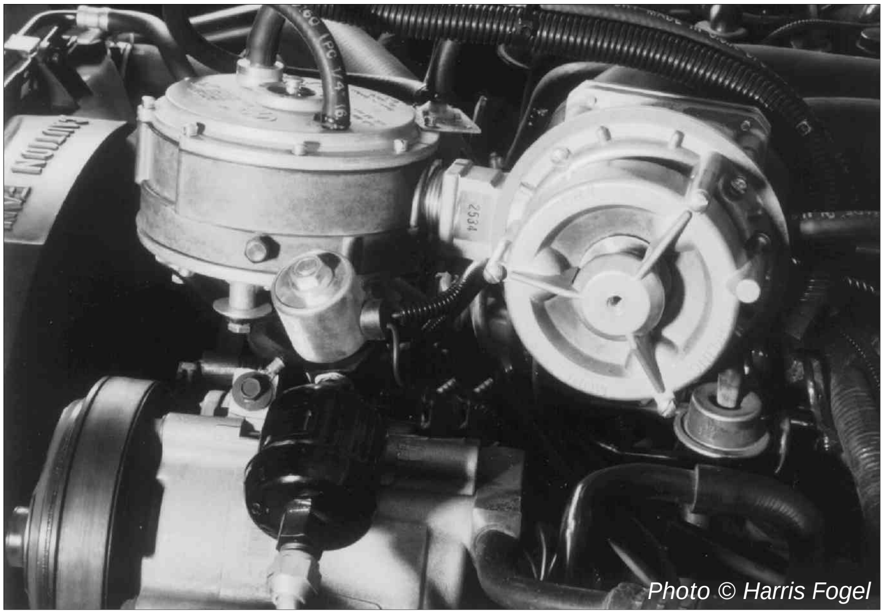
Key Points & Notes

14-7

14-8

14-10

14-9



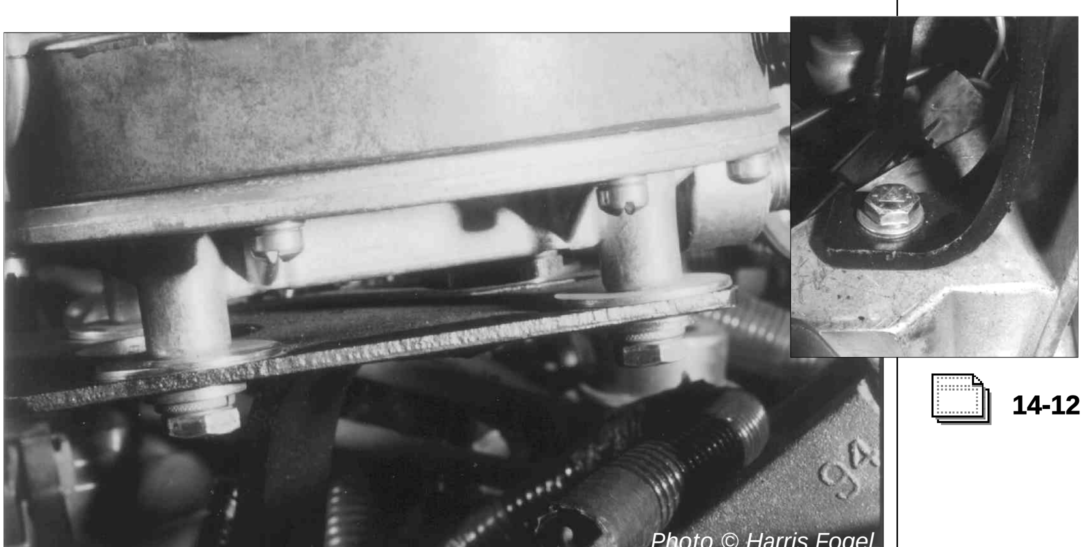
14-3 Filter and fuel lockoff connected directly to converter.

Converters are typically drilled and tapped for mounting bolt attachment. Ensure that the bolts are properly sized taking into account washers and mounting bracket thickness. Mark and drill bracket to match mounting bolt pattern.

Fabricate a bracket support, if necessary. Use existing brackets, holes, and fasteners when available. The support should be fabricated from sturdy, rust-free steel or aluminum. Refer to Figure 14-4.

5. Connect the water lines.

The lines must be connected in parallel with the heater – not in series with it. Use "H", "T" or "Y" connectors to tap into the heater inlet and return hoses. Refer to Figures 14-5 and 14-6. The



14-4 Converter mounted to bracket. **Inset** Detail of mounting foot.

Key Points & Notes

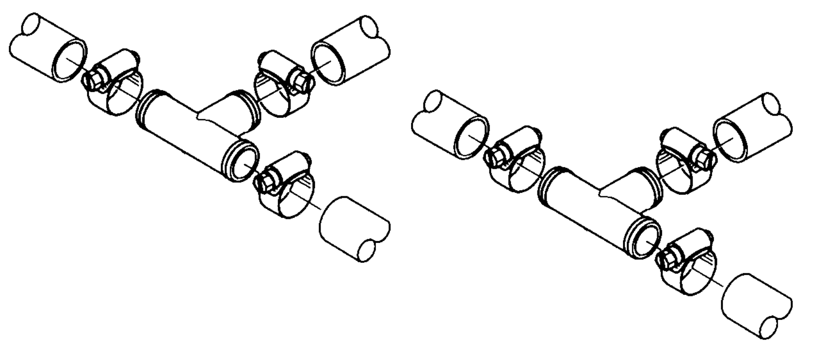
14-11

14-14

14-13

14-12

MODULE 14: CONVERTER INSTALLATION



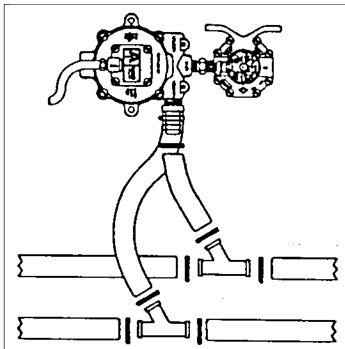
Courtesy of GFI

14-5 Typical T connecters.

converter "IN" port should be connected to the inlet or hot side heater hose. The converter "OUT" port should be connected to the return or cold side heater hose. Use only brass or plastic fittings on aluminum or soft metal vaporizers to prevent corrosion. Do not use steel or iron fittings.

Caution: Before installing the coolant lines to the converter, refer to cooling system service procedures in vehicle service manual.

- Install the water side fittings and hoses only when the engine is cold.
- Avoid cutting water hoses when they are under pressure as there is a danger of being scalded.
- Refill the cooling system with coolant as recommended by vehicle manufacturer, ensuring a proper ratio of coolant to water. Use ethyl glycol type coolant.



Courtesy of Algas Carburetion

14-6 Typical Y connecters.

6. Connect the fuel line from the fuel lock to the converter using the shortest hose length possible. If possible, make a direct connection with a hexagonal brass pipe nipple.
   - Make sure no dirt or debris enters the converter during the installation.
   - Keep ports and openings tightly capped until the hoses are connected.
   - Use stainless steel or plated steel screws with flat washers and lock washers. Use large fender washers if necessary.

PROBLEMS

The following are situations where improper installations can cause problems.

- If the vapor outlet is mounted at the top, compressor oil and contaminates collect inside the converter. Mount it with the vapor outlet down or on its back.

Key Points & Notes

14-15

14-16

14-17

14-18

14-19

- If the converter or fuel line is mounted near the exhaust manifold or the exhaust pipe, the converter temperature could increase from lack of coolant flow after the engine is shut down when hot. This will cause LPG to vaporize in the high pressure fuel line or the converter, causing a problem in regulating fuel flow. It could also damage the converter's primary diaphragm and decrease performance and mileage.
- If the converter water inlet and outlets are both connected to either pressure or suction ports, they could prevent water from circulating through the converter. For proper coolant flow the piping to the converter should be connected as closely to the water pump as possible. The converter should warm quickly if water circulation is correctly installed.
- If steel fittings are used for water fittings for the converter, electrolysis could occur which could result in leakage between the fuel and water passages. Use only brass or plastic fittings.

Key Points & Notes

14-20

Key Points & Notes

MODULE REVIEW ITEMS

Note to Technician: Consider all choices carefully and select the best answer to each.

1. A vaporizer and regulator, if combined, may be called a:
A. Converter.
B. Convexor.
C. Compuvalve.
D. Compuserve.

2. Which is not a step in the installation of the converter?
A. Determine the best location for it in the engine compartment.
B. Connect the water lines.
C. Connect the fuel lines.
D. Select and install the most cost efficient converter for the application.

3. Which location should be avoided when determining a location for the converter?
A. Mount near external sources of heat.
B. Mount away from exhaust system.
C. Mount near areas secure from possible damage.
D. Mount away from interfering moving parts.

4. Which location should be avoided when determining a location for the converter?
A. Mount securely on the frontal sheet metal.
B. Mount near areas from the splash path.
C. Mount at least 2" from belts or pulleys.
D. Mount away from areas that might crimp a hose.

5. Which location should be avoided when determining a location for the converter?
A. Mount in areas not routinely serviced.
B. Mount below the radiator's top tank to eliminate air pockets.
C. Mount equally spaced in-line to the mixer, fuel lockoff, and filter.
D. Mount with the diaphragm parallel to the length of the vehicle.

6. When trial fitting the converter, perform the following:
A. Line it up with the fuel lock and regulator.
B. Use fender washers only if available.
C. Place vapor hose outlet at the lowest point of the converter.
D. Place the converter above the top tank of the radiator for good clearance.

7. When the water lines are connected,
A. The lines must be in series (not parallel) with the heater.
B. Use "T" connectors to tap into the heater inlet and return hoses.
C. The converter "IN" should be connected to the cold side heater.
D. Use only brass or plastic fittings.

8. Avoid performing which of the following:
A. Use caution when installing hoses when the engine is hot.
B. Install water side fittings only when the engine is cold.
C. Cut hoses when they are not under pressure.
D. Keep ports capped until the hoses are ready to be connected.

MODULE 14: CONVERTER INSTALLATION

9. The correct orientation of the water lines is:
A. Converter "IN" to hot side; converter "OUT" to inlet.
B. Converter "IN" to inlet; converter "OUT" to cold side.
C. Converter "IN" to cold side; converter "OUT" to inlet.
D. Converter "IN" to cold side; converter "OUT" to hot side.

10. When working with the coolant lines, do not:
A. Use steel or iron fittings where called for.
B. Refer to the vehicle's manual for cooling system service procedures.
C. Refill the cooling system as recommended by the OEM.
D. Use the proper ratio of coolant to water.

11. Which is not good practice when mounting brackets?
A. Mount the brackets so the converter is not held in place by the fuel lines.
B. Locate a dry, cool, unobstructive place to mount the brackets.
C. Make your own if the system didn't come with any.
D. According to the layout design nothing is on the other side of the mounting surface.

12. Install the converter:
A. With the oil drain plug facing down.
B. With stainless steel screws.
C. With two faces as an absolute minimum.
D. All of the above.

13. Which cannot be a problem, and why?
A. Fittings leak- Electrolysis occurs because brass fittings were used.
B. LPG vaporizes in the high pressure fuel line- converter or fuel line mounted near hot exhaust areas.
C. Improper coolant flow- piping to converter should be connected closer to water pump.
D. Compressor oil and gunk collects in converter- mount vapor outlet down or on its back.

MRI SCORING KEY

1. C
2. D
3. A
4. A
5. C
6. C
7. D
8. A
9. B
10. A
11. D
12. D
13. A

1 **MODULE 14:**
Converter Installation

2 **CONVERTER**

- Vaporizer + Regulator

3 **LOCATION CONSIDERATIONS**

- Select/install correct converter
- Determine best, safest location

4 **14-1 CONVERTER FUEL LOCK MOUNTING**

5 **MOUNTING BRACKET CONSIDERATIONS**

- May have to fabricate brackets
- Components might need moved
- Have a stable mounting surface

6 **MOUNTING BRACKET CONSIDERATIONS**

Keep away from:

- Operations and movements
- Service areas
- Damage-prone areas
- Belts and pulleys
- Engine block and radiator

7 **MOUNTING BRACKET CONSIDERATIONS**

Keep away from:

- Frontal sheet metal
- Splash path
- Areas where hoses may be crimped or chafed

8 **MOUNTING BRACKET CONSIDERATIONS**

- Trial fit the converter
- Vapor hose outlet should be at lowest point of converter
- Place converter below top tank of radiator
- Allow 6" for hose flex
- Align converter with diaphragm parallel to length of vehicle
- Locate as close as possible to mixer, lockoff, filter
- Fabricate and assemble brackets

9 **14-2 CONVERTER NEXT TO MIXER**

10 **14-2A CONVERTER ON FENDER WALL**

11 **14-3 FILTER AND LOCKOFF ON CONVERTER**

12 **14-4 CONVERTER MOUNTED TO BRACKET**

13 **14-4A MOUNTING FOOT**

14 **MOUNTING BRACKET CONSIDERATIONS**

- Connect water lines
- Parallel with heater, not in series with it
- Use H, T, or Y tap connectors
- Converter IN to inlet or hot side hose
- Converter OUT to return or cold side hose
- Do not use steel or iron fittings

15 **14-5 T CONNECTORS**

16 **14-6 Y CONNECTORS**

17 **MOUNTING BRACKET CONSIDERATIONS**

- Install while engine is cold

- Don't cut pressurized hoses
- Refill cooling system with ethyl glycol coolant

18 **MOUNTING BRACKET CONSIDERATIONS**

- Connect fuel line from fuel lock to converter
- Shortest hose length possible
- Keep dirt and debris free
- Keep ports and openings capped until connected to

19 **PROBLEMS**

- Compressor oil and contaminates inside converter-
  - Mount converter with vapor outlet down or on back
- Converter temperature increases, LPG vaporizes in high pressure fuel line, affects regulating fuel flow-
  - Reroute fuel line or move converter away from heat source

20 **PROBLEMS**

- Water not circulating through converter-
  - Connect lines properly to water inlet and outlet ports
- Electrolysis occuring; leakage between fuel and water passages-
  - Use brass or plastic instead of steel fittings

MODULE 14:
Converter Installation

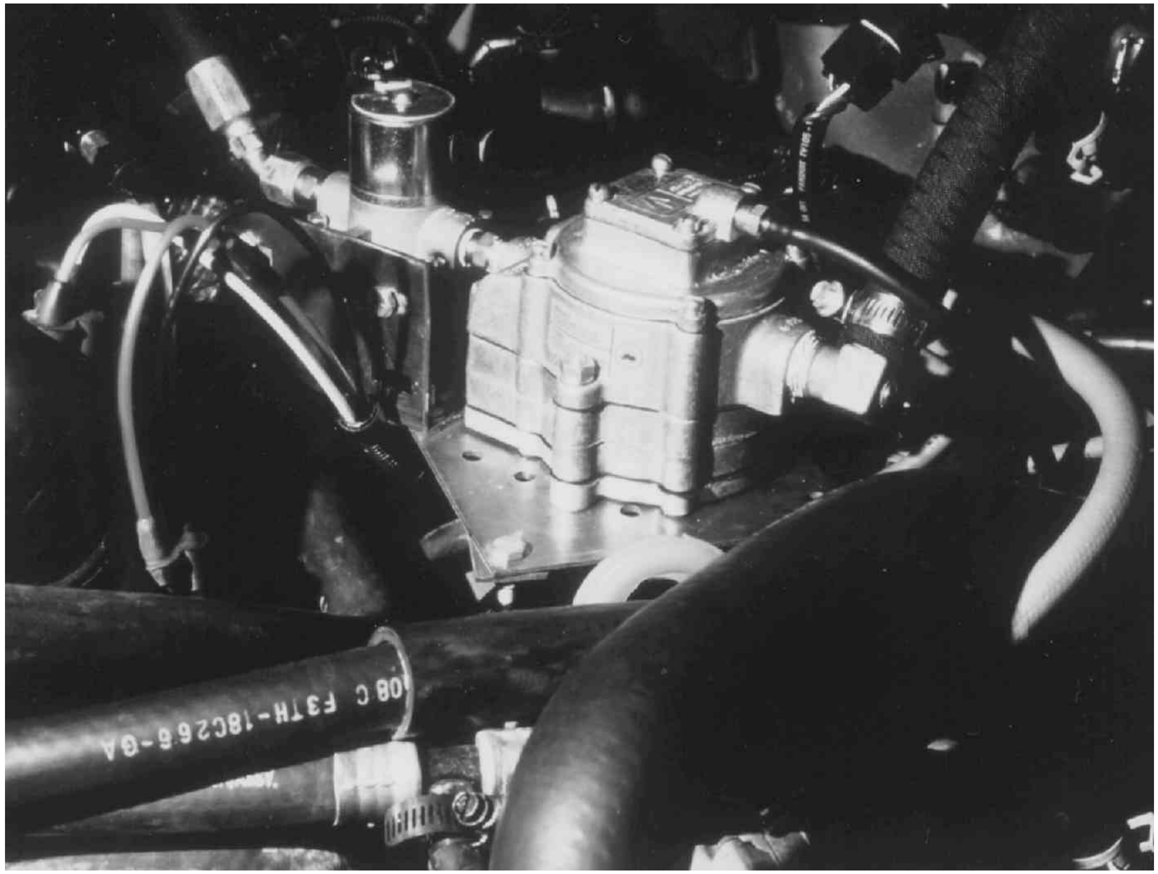
CONVERTER

- Vaporizer + Regulator

LOCATION CONSIDERATIONS

- Select/install correct converter
- Determine best, safest location

14-1 CONVERTER FUEL LOCK MOUNTING



Colin Messer

MOUNTING BRACKET CONSIDERATIONS

- May have to fabricate brackets
- Components might need moved
- Have a stable mounting surface

MOUNTING BRACKET CONSIDERATIONS

Keep away from:

- Operations and movements
- Service areas
- Damage-prone areas
- Belts and pulleys
- Engine block and radiator

MOUNTING BRACKET CONSIDERATIONS

Keep away from:

- Frontal sheet metal
- Splash path
- Areas where hoses may be crimped or chafed

MOUNTING BRACKET CONSIDERATIONS

- Trial fit the converter
- Vapor hose outlet should be at lowest point of converter
- Place converter below top tank of radiator
- Allow 6" for hose flex
- Align converter with diaphragm parallel to length of vehicle
- Locate as close as possible to mixer, lockoff, filter
- Fabricate and assemble brackets

14-2 CONVERTER NEXT TO MIXER

Photo Copyright Harris Fogel

14-2A CONVERTER ON FENDER WALL

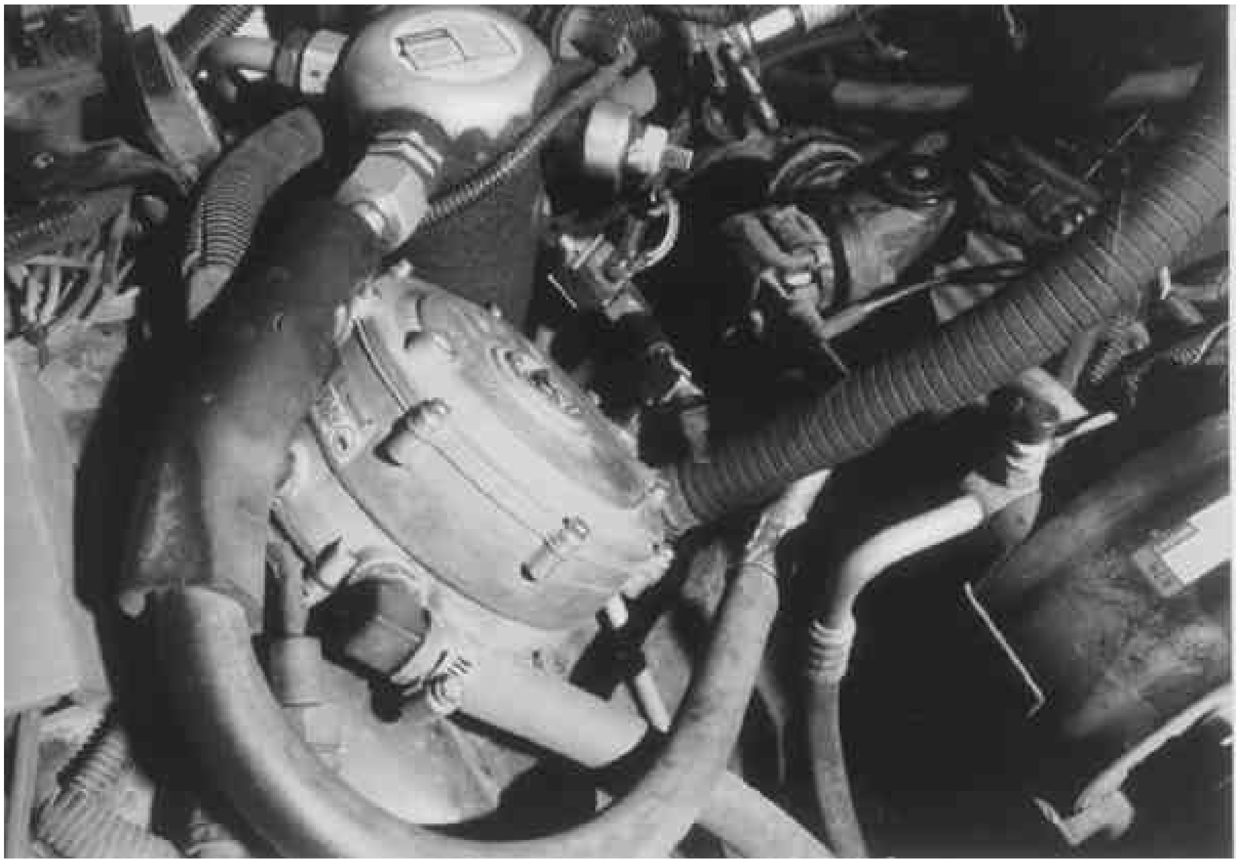


Photo Copyright Harris Fogel

14-3 FILTER AND LOCKOFF ON CONVERTER

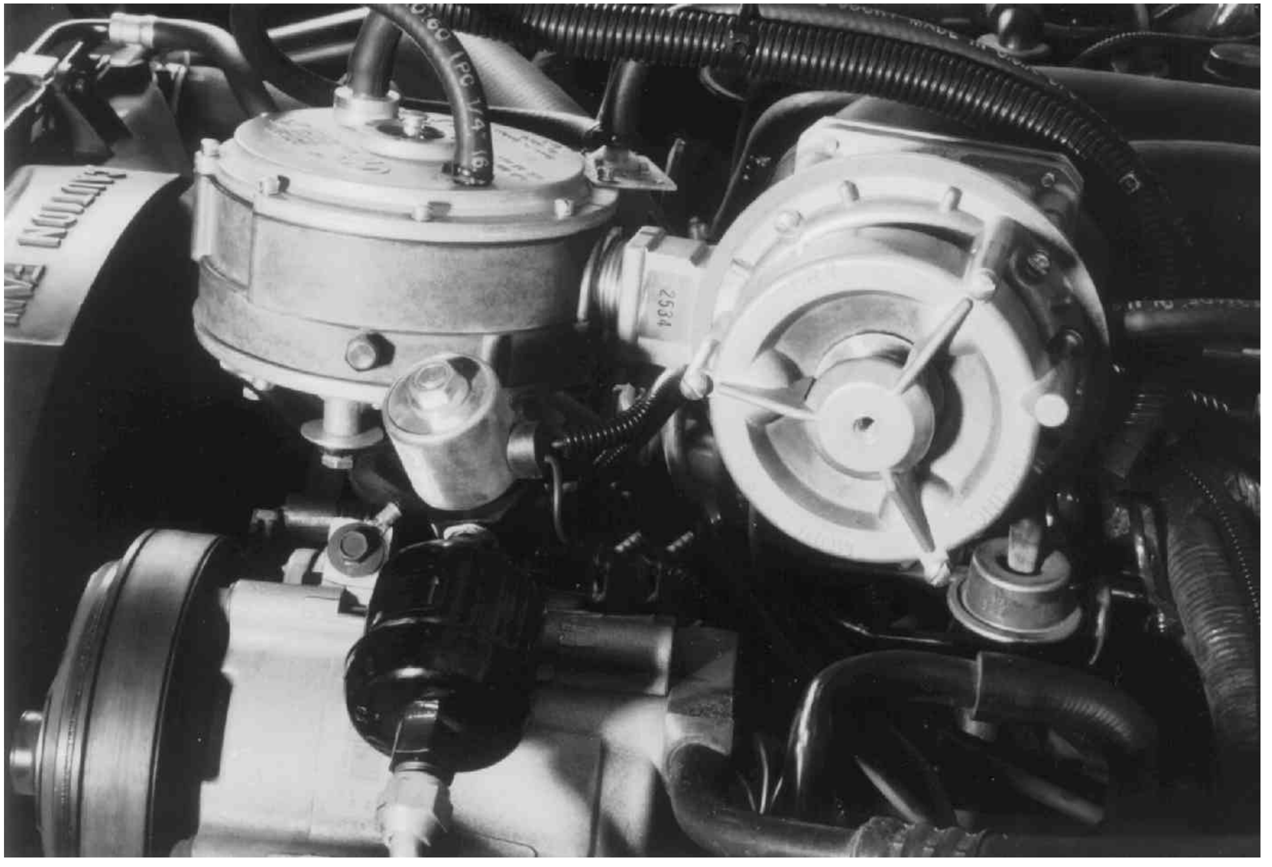


Photo Copyright Harris Fogel

14-4 CONVERTER MOUNTED TO BRACKET

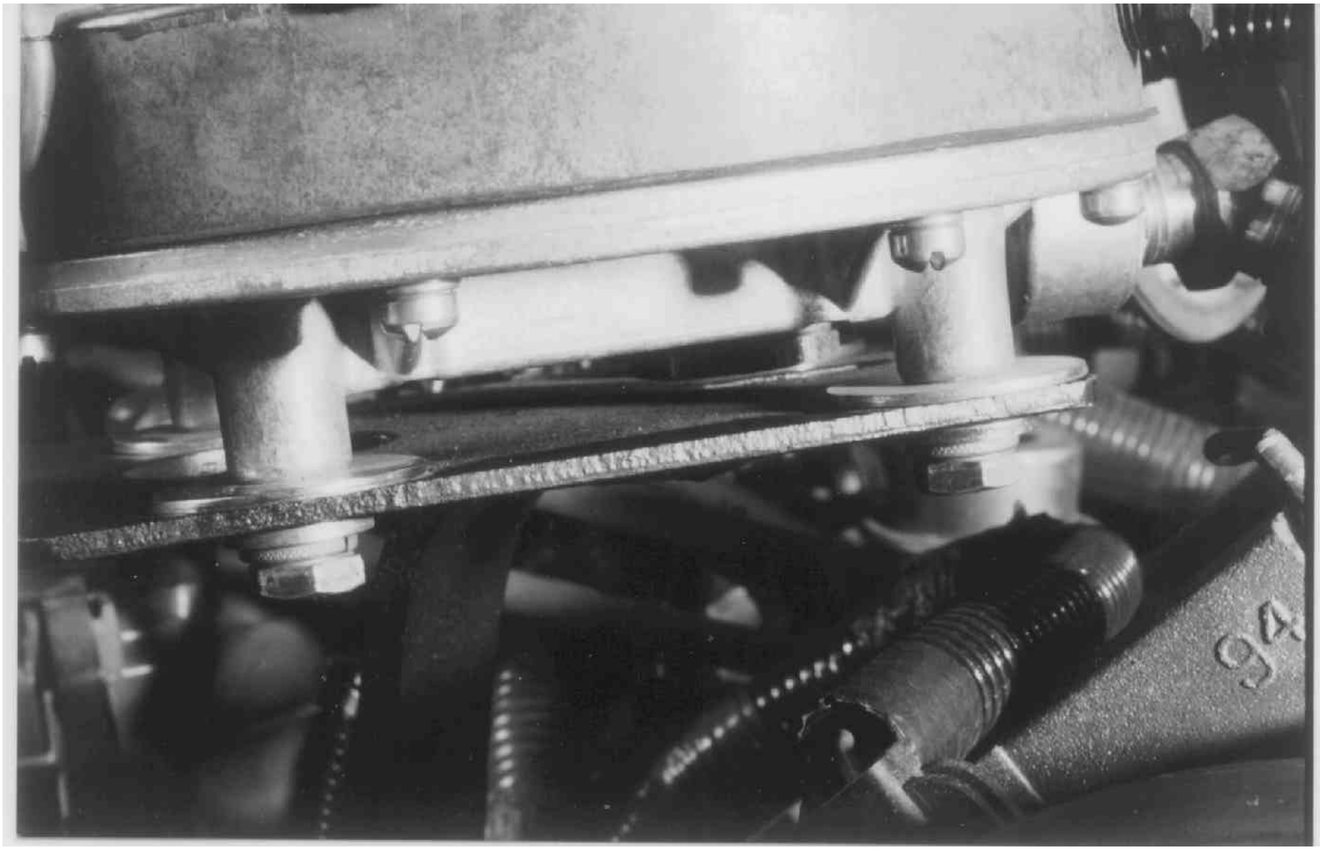


Photo Copyright Harris Fogel

14-4A MOUNTING FOOT

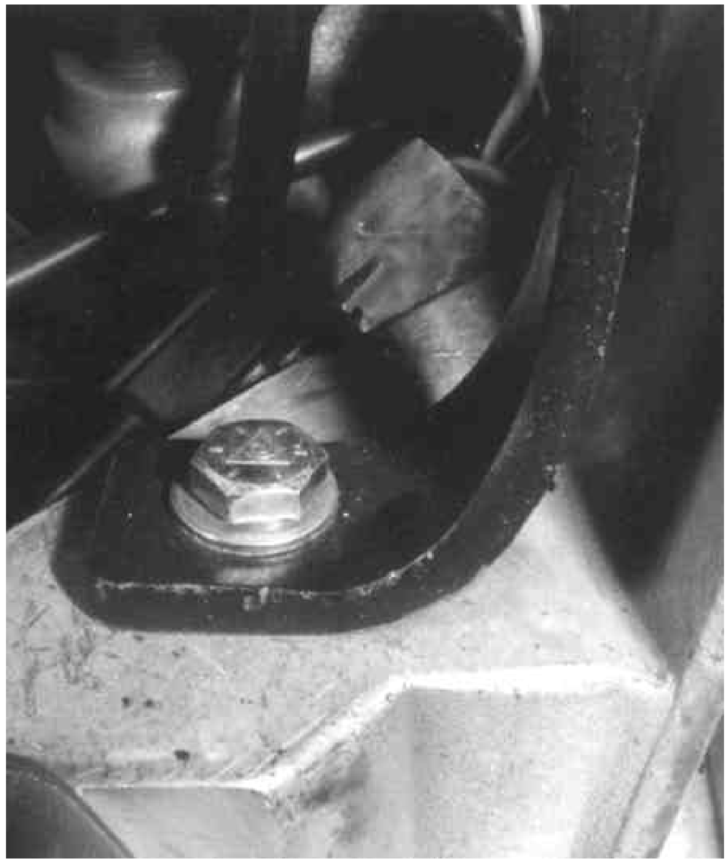
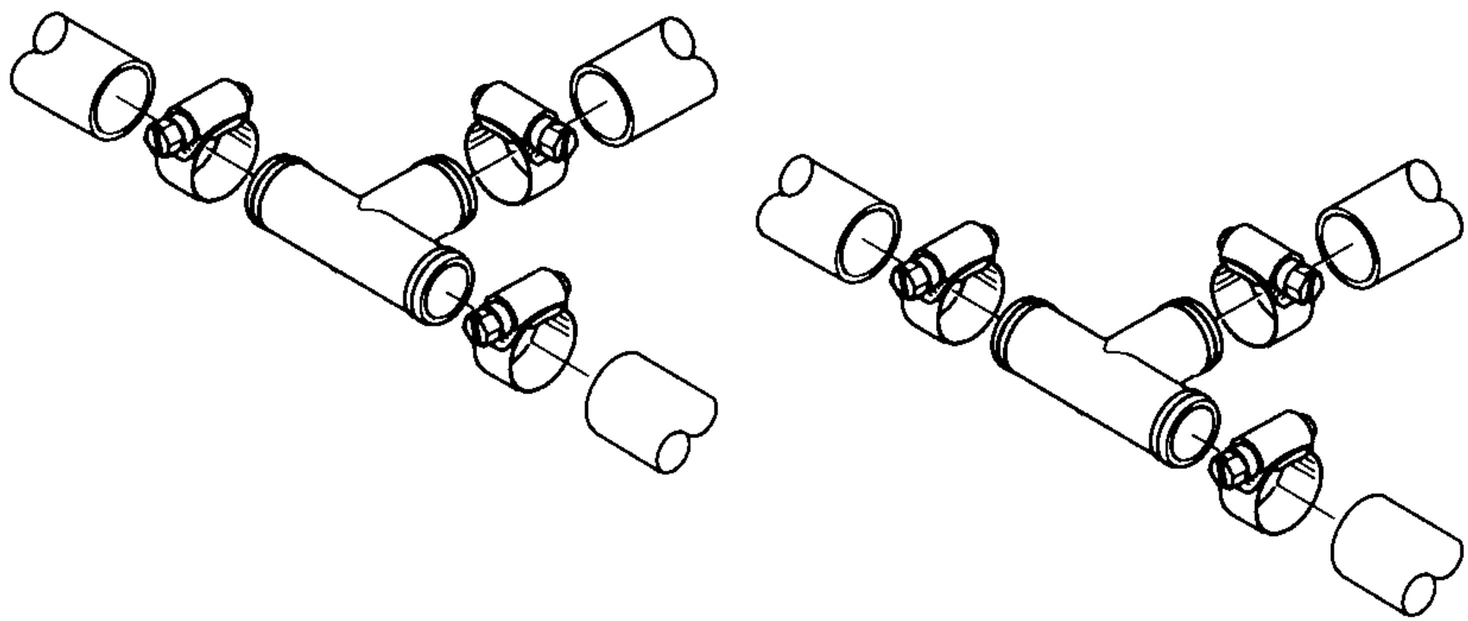


Photo Copyright Harris Fogel

MOUNTING BRACKET CONSIDERATIONS

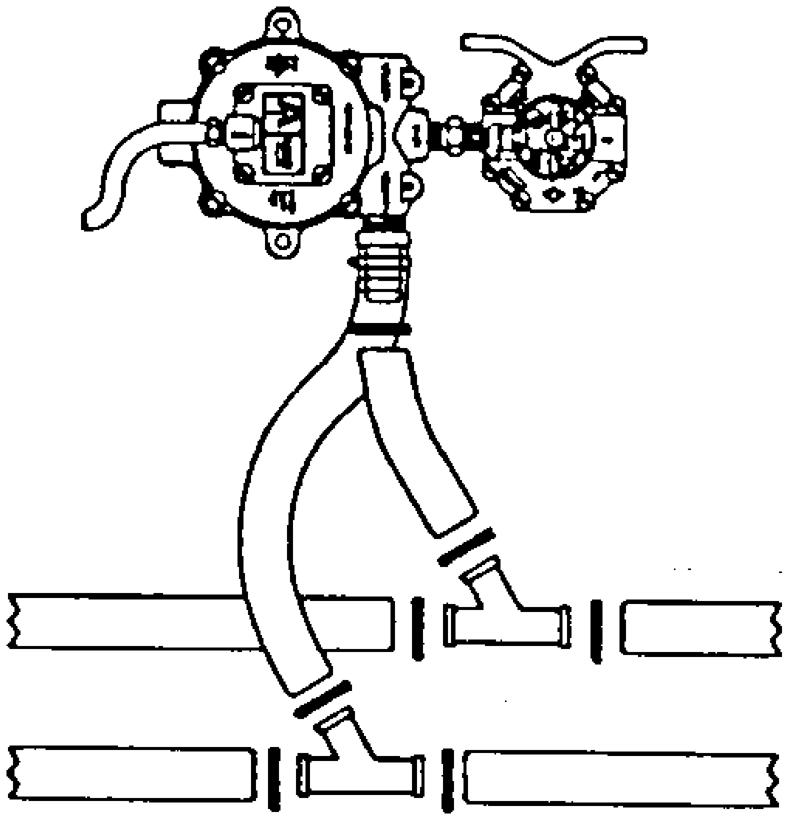
- Connect water lines
- Parallel with heater, not in series with it
- Use H, T, or Y tap connectors
- Converter IN to inlet or hot side hose
- Converter OUT to return or cold side hose
- Do not use steel or iron fittings

14-5 T CONNECTORS



Courtesy of GFI

14-6 Y CONNECTORS



Courtesy of Algas Carburetion

MOUNTING BRACKET CONSIDERATIONS

- Install while engine is cold
- Don't cut pressurized hoses
- Refill cooling system with ethyl glycol coolant

MOUNTING BRACKET CONSIDERATIONS

- Connect fuel line from fuel lock to converter
- Shortest hose length possible
- Keep dirt and debris free
- Keep ports and openings capped until connected to

PROBLEMS

- Compressor oil and contaminates inside converter-
  - Mount converter with vapor outlet down or on back
- Converter temperature increases, LPG vaporizes in high pressure fuel line, affects regulating fuel flow-
  - Reroute fuel line or move converter away from heat source

PROBLEMS

- Water not circulating through converter-
  - Connect lines properly to water inlet and outlet ports
- Electrolysis occuring; leakage between fuel and water passages-
  - Use brass or plastic instead of steel fittings

MODULE 15:

Air Valve Mixer & Fuel Injection Installation

State of Oklahoma
College of the Desert
West Virginia University

MODULE 15: AIR VALVE MIXER & FUEL INJECTION INSTALLATION

CONTENTS

MODULE 15: AIR VALVE MIXER & FUEL INJECTION INSTALLATION

OBJECTIVES

At the completion of this module, the technician will be able to:

- Discuss the procedures for installing a propane air-fuel mixer in mono-fuel carbureted and fuel injected engines.
- Properly install a propane air-fuel mixer in mono-fuel and bi-fuel carbureted and fuel injected engines.
- Compare and contrast the differences between a mono-fuel versus a bi-fuel conversion.
- Identify the differences in mono-fuel applications versus bi-fuel application in fuel injected engines.
- Properly install a fuel injection metering valve.
- Properly install the Manifold Absolute Pressure (MAP) sensor takeoff.
- Locate and properly install a fuel discharge nozzle.

INSTRUCTOR NOTES

INSTRUCTOR MATERIALS/MEDIA NEEDED

Overhead projector or LCD panel/projection equipment
Master overhead transparencies or Microsoft PowerPoint 4.0 presentation file Mod15.ppt

Note: Slides correspond to text as indicated by icon

STUDENT MATERIALS/MEDIA NEEDED

Module 15: Air Valve Mixer & Fuel Injection Installation

MODULE REVIEW ITEMS

The Module Review Items (MRI) are designed to allow for flexibility in their use. The exam may be utilized as a post-module review, pre/post test, part of a term examination, or it may be used by the student if the module is used as a self study text.

OVERHEAD TRANSPARENCY MASTERS

The printouts enclosed with this module are taken from the Microsoft PowerPoint 4.0 presentation file Mod15.ppt . Instructors planning to use overhead projectors should make transparencies from these printouts on a copier (or laser printer designed to safely print to acetate.

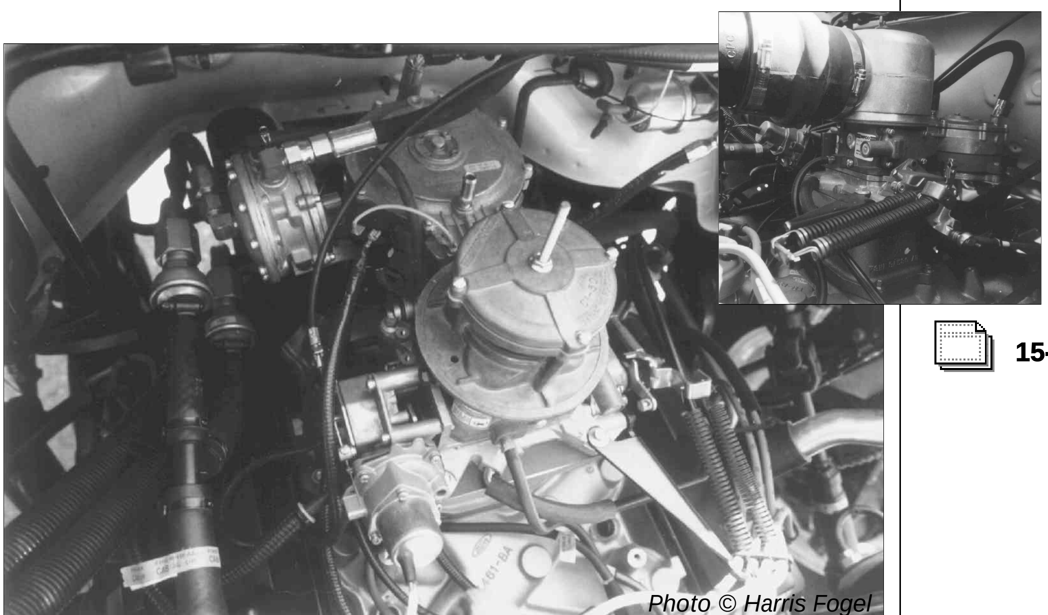
Note: Please review Module 25: Training of Trainers for more hints on instructional needs and strategies.

MODULE 15: AIR VALVE MIXER & FUEL INJECTION INSTALLATION

CARBURETOR AND AIR-FUEL MIXER

MONO-FUEL APPLICATIONS – CARBURETED ENGINES

In dedicated propane conversions, the gasoline carburetor is removed and replaced by the propane air-fuel mixer. Some mixer manufacturers offer a few basic mixer bodies that can be mounted on the old gasoline carburetor throttle plates with adapters. This reduces the cost of the conversion and simplifies throttle linkage connections since the throttle plate is reused. Other mixer manufacturers provide an entire replacement unit complete with its own throttle plate assembly. This approach offers the time savings of not having to disassemble the gasoline carburetor to fit a mixer body to its throttle plates. Refer to Figure 15-1.



15-1 Air-fuel mixer mounted with throttle – dedicated mono-fuel application.
Inset Mixer with air cleaner hood.

NOTE: Do not in any way tamper with the correct operation of factory emission control systems.

1. Remove the air cleaner assembly. Label vacuum hoses, throttle linkage, and electrical wires to aid reassembly. If uncertain about vacuum hose function, measure the vacuum signal by connecting a vacuum gauge to each hose or port to check pressures (vacuum) before disabling gasoline system. Disconnect the fuel lines, vacuum hoses, electrical wires, and throttle linkage from the carburetor.
2. Unbolt the carburetor from the intake manifold and remove it.
3. If the propane air-fuel mixer that you're installing is the type that mounts on the carburetor throttle plate with an adapter, remove the throttle plate assembly from the carburetor and bolt the air-fuel mixer and adapter to the throttle plate using new gaskets. Follow the manufacturer's recommendations for assembly.

Key Points & Notes

15-2

15-4

15-3

15-5

15-6

4. Install the air-fuel mixer on the intake manifold using a new base gasket. Tighten the mixer bolts evenly to avoid throttle plate assembly distortion and vacuum leaks. Use RTV type gasket sealer and gaskets when assembling adapters.
5. Reconnect the vacuum lines. Proper installation of vacuum lines will ensure correct operation of factory emission control systems. Reconnect throttle linkage and throttle return spring. On some vehicles equipped with automatic transmissions, you may need to adjust the throttle kick-down linkage for proper shifting.
6. On a mono-fuel dedicated conversion, the mechanical fuel pump must be removed and the mounting hole blocked off. Use sensor-safe RTV sealant to provide a good lasting seal. If the vehicle has an electric fuel pump, the pump may be disabled by disconnecting and safely isolating the power wires.

BI-FUEL APPLICATIONS – CARBURETED ENGINES

In a bi-fuel conversion, the air-fuel mixer is mounted on top of the existing gasoline carburetor.

If hood clearance is a problem, an offset adapter can be used to reduce the installed height. Stacking the mixer on top of the carburetor has one drawback other than limiting hood clearance – air restriction. Air must pass through the throat of a second metering body; any restriction or turbulence will affect engine performance at high speeds where unrestricted air flow is essential for maximum power. This is one reason why non-throttle body port fuel injected engines are ideal candidates for conversion to propane.

1. Remove the air cleaner and trial fit the air-fuel mixer on the carburetor. Check to see that the mixer does not interfere with the operation of the choke or throttle linkage and allows for adequate hood clearance.
2. Mount the mixer on top of the carburetor, following the manufacturer’s installation instructions. The mixer usually attaches to the carburetor with an adapter. Install a new gasket on top of the carburetor, and between all adapters. Use gasket sealer that is 0_2 sensor safe whenever possible. Do not over tighten any bolts or screws that thread into the carburetor because the soft metal casting can be easily damaged.

   NOTE: Be sure the mixer does not interfere with the vehicle hood when closed. Use screw or other thread sealer if there is any chance for a bolt to vibrate loose and fall into the engine intake.
3. If the installation requires a Bowden control cable to the mixer, follow the manufacturer’s installation instructions. Check the operation of the control cable after it is installed to make sure it works properly and does not interfere with the throttle linkage.
4. The gasoline carburetor on bi-fuel installations may require that the float chamber atmospheric air vents be re-worked to assure proper bowl pressure. Improper float bowl pressure will result in poor performance when the engine is running on gasoline.

Key Points & Notes

15-7

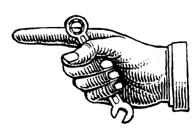
15-8

15-9

15-10

15-11

15-12



15-13

15-14

15-15

5. The installation may require that a new air cleaner assembly be installed. If so, it should be compatible with under hood conditions by completely enclosing the air filter and ducting fresh outside air into the engine. The filter canister should be rated for the air flow capacity of the engine.

   NOTE: An engine will lose 1% of available horsepower for every 10° F rise in the intake air temperature above 59° F. See Module 19.

MONO-FUEL DEDICATED – FUEL INJECTED ENGINES

When installing dedicated propane conversions on fuel injected vehicles, the propane air-fuel mixer is installed in the air intake system. The gasoline system is disabled by disconnecting the fuel pump and fuel injectors. This applies to both throttle body injection (TBI) as well as multi-port injection (MPI) systems.

1. Remove original air cleaner assembly if applicable.
2. Trial fit the adapter(s) and air-fuel mixer assembly to assure proper fit in engine compartment. Check that the assembly doesn't interfere with vehicle hood and that the throttle linkage operates smoothly. All OEM components that you move or disconnect, such as sensors and vacuum hoses, should be integrated into the propane carburetion system.
3. Disconnect and secure fuel injector and fuel pump wiring. All wire connectors should be sealed from corrosion and possible grounding. Lines should be secured to prevent interference with moving parts, such as the fan, air pump and alternator. See Module 16.
4. Drain, plug, and secure gasoline fuel lines. On TBI units, you can improve air flow by removing the gasoline fuel injector assemblies. If possible, do so.

   NOTE: On some TBI units, the removal of the injectors and manifold, as well as the control wire block, creates an opening which must be blocked off with an appropriate adapter. Follow manufacturer's recommendations.
5. Install the adapter and mixer according to manufacturer's instructions. Use sensor-safe RTV sealant between the components to prevent vacuum leaks.
6. Reinstall the OEM air cleaner assembly whenever possible. If necessary, modify the OEM air cleaner housing to insure that good air flow and a tight seal are provided for the mixer. The mixer configuration of some installations requires a new air cleaner assembly. If so, it should be compatible with underhood conditions and completely enclose the air filter element as well as incorporating a fresh air inlet. An open type air filter assembly is strongly discouraged because it can affect engine performance, increase emissions, or both. After-market replacement air filters and canisters should be rated for the air flow requirements of the engine and ducted to receive outside (not under hood) air. See Module 19.

Key Points & Notes

15-16

15-17

15-18

15-19

15-20

15-21

15-2 Air-fuel mixer adaptor.

Key Points & Notes

15-24

BI-FUEL APPLICATIONS – FUEL INJECTED ENGINES

When installing bi-fuel propane conversions on fuel injected vehicles, gasoline delivery to injectors must be interrupted by turning off the fuel pump and fuel injectors when the engine is switched to run on propane. When the switch is in the propane position, the propane fuel lock is actvated to permit the flow of propane to the system. This is accomplished by an electrical circuit controlled by a dash mounted switch that permits choice of fuels. In the gasoline operating mode, the electrical switch will turn off the propane fuel lock and activate the gasoline fuel supply system – the gasoline fuel pump and injectors. This is usually done by using either a DPDT (double pole double throw) switch, relay, or a conversion support module (with an integral relay function) that activates the fuel injectors.

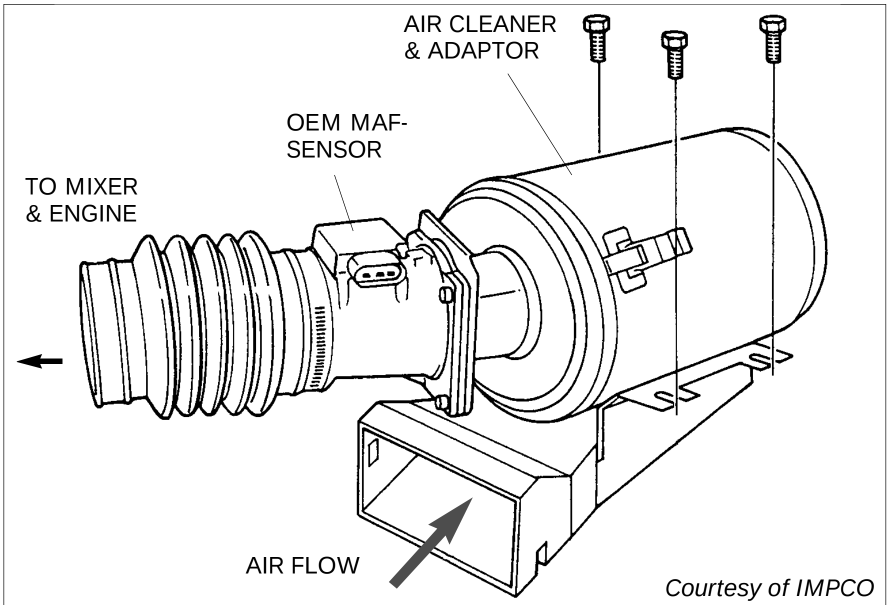
15-22

1. Remove original air cleaner assembly, if applicable.
2. Trial fit adapter and air-fuel mixer assembly to assure proper fit in the engine compartment. Refer to Figure 15-2. Check that the assembly doesn't interfere with vehicle hood and that the throttle linkage operates smoothly. All OEM components that you move or disconnect, such as sensors and vacuum hoses, should be integrated into the propane carburetion system.
3. Reinstall the OEM air cleaner assembly whenever possible. If necessary, modify the OEM air cleaner housing to ensure that good air flow and a tight seal are provided for the mixer. The mixer configuration of some installations requires a new air cleaner assembly. If so, it should be compatible with under hood conditions and completely enclose the air filter element as well as incorporating a fresh air inlet. An open type air filter assembly is strongly discouraged because it may affect engine performance and decrease power. A fresh air supply from outside the engine compartment will significantly improve performance by providing the engine with cooler, denser air – more available oxygen.

15-23

15-25

Key Points & Notes



15-3 After-market air cleaner and adaptor, adapted to MAF assembly.

It may be necessary to reposition OEM sensors or take into account how the propane component will affect OEM operation. For example, an engine with a mass airflow (MAF) sensor requires special attention; the air valve mixer must be mounted downstream of the MAF sensor. Refer to Figure 15-3.

15-27

15-26

> ***NOTE:*** A bi-fuel application may or may not require a lifting device to hold up the air valve or venturi restriction during gasoline operation. If necessary, use either an electrically or manually operated device, such as a Bowden cable.

ALL APPLICATIONS – MONO AND BI-FUEL

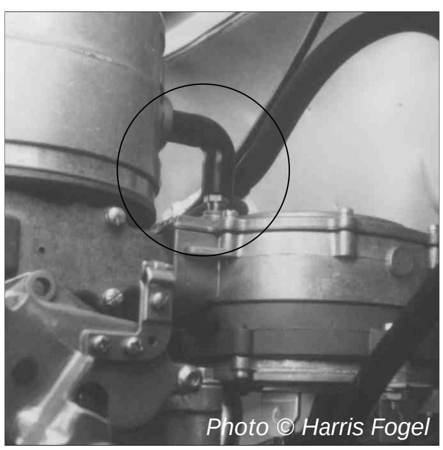
1. Install the vapor hose between the vaporizer and mixer. Use only approved vapor hose that is compatible with propane vapor. Ordinary heater hose will quickly deteriorate and collapse under vacuum.

15-28

2. Install any necessary vacuum or balance line connections, including manifold vacuum, ported vacuum, and air valve vacuum. Refer to Figure 15-4. This is imperative, because many components require precise pressure signals and will malfunction if incorrectly connected. Refer to manufacturer's instructions.

15-29

   NOTE: Determine which vacuum source is necessary for the application. Do not connect to manifold vacuum



15-4 Balance line.

15-5 Air-fuel mixer air cleaner adaptor.

where air valve vacuum or atmospheric pressure is required. Use a vacuum gauge to test the signal on a running engine.

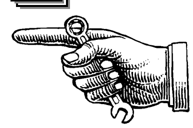
3. Pressurize and check the entire fuel system for leaks by applying leak detector solution or soapy water around all valve and fuel line connections or by using an electronic leak sniffer. Repair any leaks before you attempt to start the vehicle. Recheck each connection for leaks following any repairs to ensure system integrity.

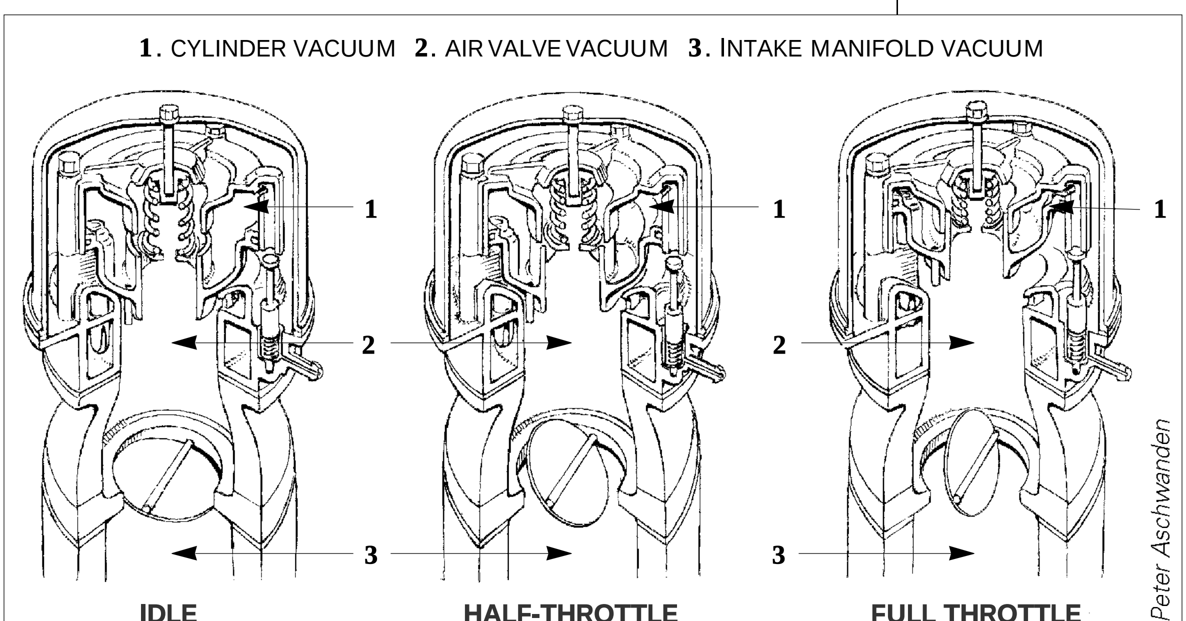
4. It may be necessary to install a balance line between the regulator and mixer to ensure that the pressure on the converter, usually atmospheric, is equal to the pressure at the mixer downstream of

Key Points & Notes

15-30

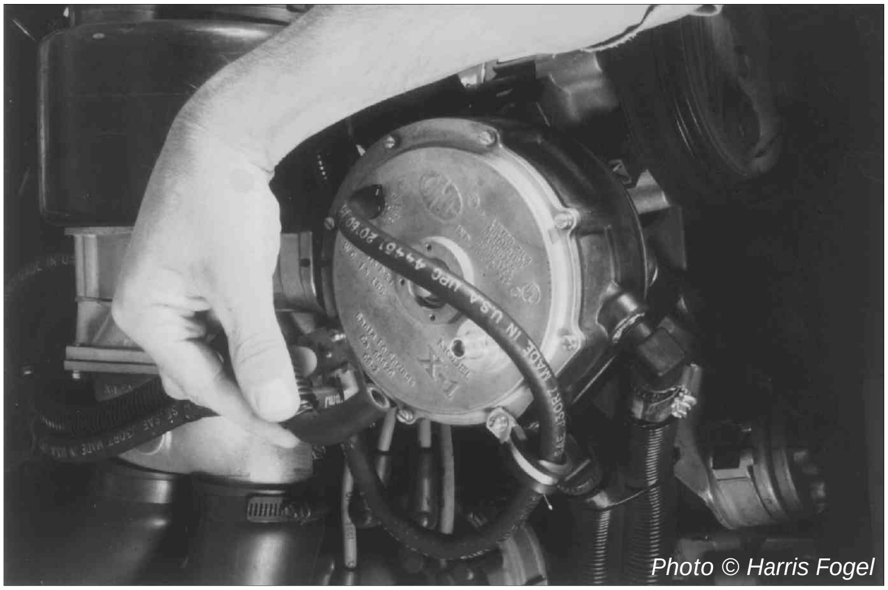
15-32





15-6 Air valve mixer cutaway.

15-31



15-7 Install vacuum and balance line connections.

the air filter. Refer to Figure 15-7. This is especially important on "air valve" type mixers as their function is controlled by diaphragm movement which requires balance within the system. Pressure differentials such as altitude change, a dirty air filter, turbo-charging, and intake duct restrictions or mass air flow sensor can affect system operation. Refer to manufacturer's recommendations.

5. **All original equipment emissions control devices must be retained, both physically and operationally, upon completion of the conversion.** The only exception to this is if the equipment certification, such as CARB or EPA, has provisions that allow control devices to be removed. An example would be evaporative fuel emissions components on a dedicated propane conversion which are non-functional after the conversion, or removal and replacement of the OEM fuel system components or air cleaner to accommodate the propane mixer. Penalties for emissions control violations are extremely severe and special care should be taken to ensure that no conversion procedures can be considered as tampering.

6. After completing the conversion, a comprehensive post conversion evaluation should be performed on the vehicle to be sure that all carburetion systems function and integrate well with the OEM systems. A recommended guide for this evaluation and explanation of procedures are covered in Modules 20 and 21.

FUEL INJECTION METERING VALVE AND DISCHARGE NOZZLE INSTALLATION

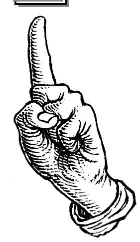
COMPUVALVEINSTALLATION

The following steps are presented as installation guidelines specific to one manufacturer's equipment.

Key Points & Notes

15-33

15-34



15-35

CAUTION: During all operations, ensure no dirt or debris is allowed to enter unit. Tightly cap or cover all open ports and openings. Do not remove factory caps until time to connect hoses.

1. Determine the proper location using the following criteria:
   - Locate unit in engine compartment.
   - Locate unit for ready access for installation and maintenance.
   - Do not locate on engine block.
   - Do not locate on radiator tank.
   - Do not locate on frontal sheet metal.
   - Do not locate in splash path.
   - Do not locate within 5” of exhaust components or manifold.
   - Do not locate unit so that it interferes with OEM mechanical operation or where mechanical operation, such as hood closing or engine movement could endanger unit.
   - Do not locate in area that interferes with routine service operations such as checking or adding fluids.
   - Do not locate within 2” of moving parts such as belts and pulleys.
   - Do not locate in area that causes hoses to be crimped or chafed.

   NOTE: Allow adequate room for hose installation. It is recommended that a minimum of 8” of extra length be added for hose fittings and hose flex.

   CAUTION: Do not orient unit with the high flow injector solenoids pointing down or at a negative angle. Debris and entrained water will collect in the top of the solenoid instead of being carried through the system, making the valve inoperable. The vertical down orientation will also expose the BAP filter to water entry.

   An installer-made bracket may be required to mount the unit; it must be strong enough to withstand severe under hood conditions.

2. The compuvalve has mounting hole arrangements on three faces. Use the arrangement that provides the most secure and rigid mounting. The holes are threaded 1/4-20 UNC-2B.

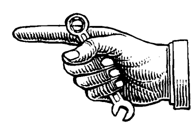
3. Mount compuvalve using stainless steel or plated steel screws with flat washers and lock washers. For stability, it is recommended that the unit is mounted from a minimum of two available faces. NEVER MOUNT UNIT IN A CANTILEVER FASHION.

   NOTE: When fastening to light-weight metal or plastic panels, use fender washers or a backing plate to properly distribute load.

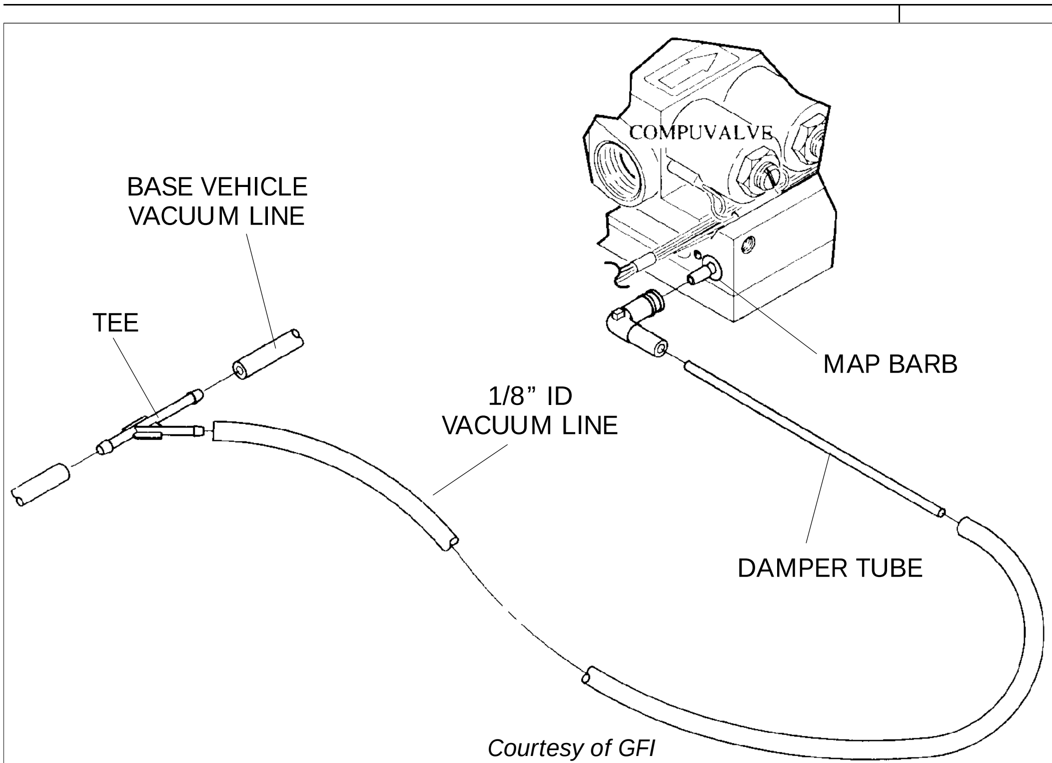
MAP TAKEOFF

The following steps are for the Manifold Absolute Pressure (MAP) sensor takeoff. This line should be installed to read the same signal as the OEM MAP sensor. Refer to manufacturers’ recommendations. Refer to Figure 15-8.

Key Points & Notes



15-37



15-8 MAP takeoff installation.

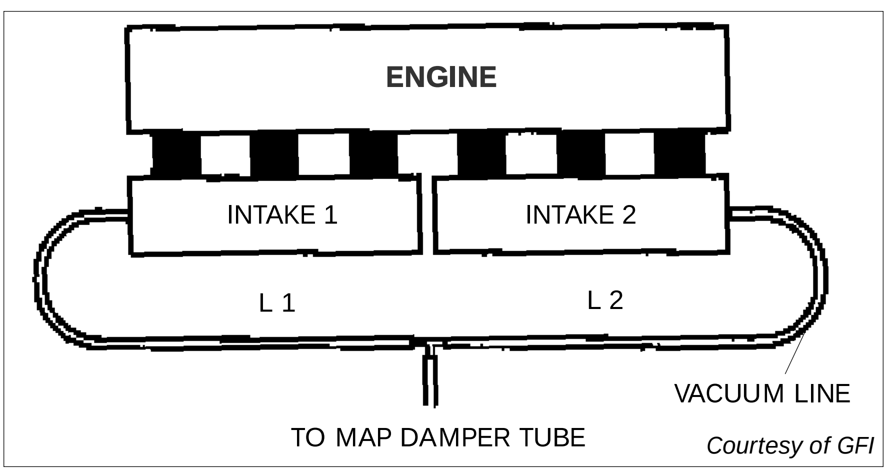
15-36

1. Cut OEM MAP line and insert plastic tee as close to OEM MAP sensor as possible. Or, when there is no OEM MAP sensor, the takeoff can be from the vacuum port from the manifold.

   CAUTION: Do not install tee close to a check valve and do not attach line to vacuum reservoir, brake booster, etc. or a controlled/ported line.

   Some engines have split manifolds that essentially creates two separate intake systems. With these manifolds, the MAP must be dual sourced. The lines from manifolds to tee must be equal in length. Refer to Figure 15-9.

15-38



15-9 MAP takeoff with split manifold.

2. Attach 1/8” hose to tee and route to compuvalve.

3. Cut the supplied damper tube (Teflon vacuum line) to the length specified in the specific vehicle supplement and insert into hose approximately 1”. Do not use lubricant to assemble hose and tube.

CAUTION: It is important that the ends of the tube be inspected after cutting and before installing. A roughly cut end may cause performance problems if the tube passage is blocked.

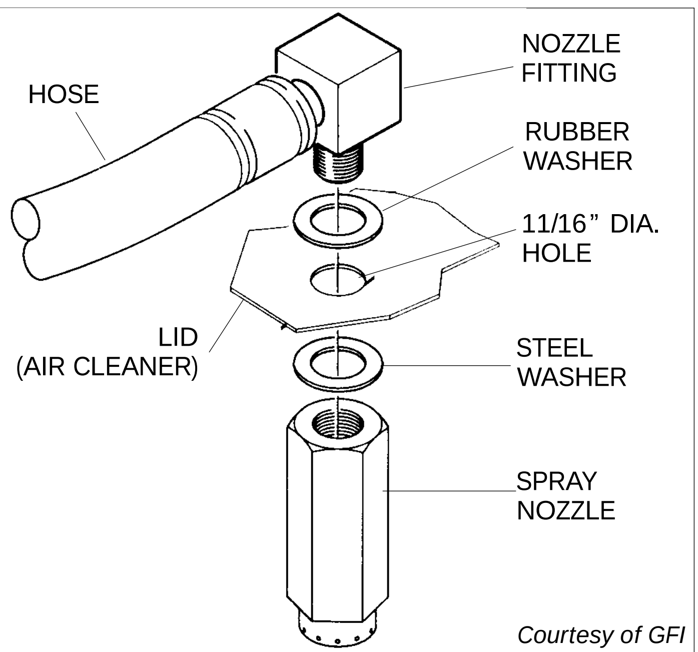
4. Insert other end of damper tube into 90^{o} rubber nipple. Do not use lubricant to assemble elbow and tube.

NOTE: When 90^{o} rubber nipple does not allow for routing, a short piece of 1/8” hose may be used. Do not allow hose to kink and do not exceed 3” in length, shorter is better (refer to note in step 5).

5. Push nipple into MAP barb on compuvalve.

NOTE: There should be no space between the damper tube and compuvalve barb. When engine is running, the monitoring screen DMAP fluctuations should be less than ± 5 in. Hg. under all steady operating conditions. If the fluctuations are greater than this, then the volume between the damper tube and the barb can be increased until the fluctuations are ± 5 in. Hg.

CAUTION: Increasing the volume trapped between damper line and compuvalve effectively slows compuvalve’s ability to respond to actual changes in MAP, such as throttle transients, and subsequently, fueling demands. This volume should be minimized to provide stable DMAP’s under steady state conditions.



15-10 Spray disk installation.

Key Points & Notes

15-39

15-40

15-41

15-43

FUEL DISCHARGE NOZZLE INSTALLATION OVERVIEW

Newer vehicles with fuel-injected engines generally require injectors to introduce fuel into the air stream of the intake manifold or directly into the throttle body. The layout for the injector(s) is primarily concerned with room for the spray bar or spray disk and where the fuel line will be routed. The spray bar is mounted before the throttle body. Refer to Figures 15-10 and 15-11. Direct injection systems will require a modified intake manifold. Because space above the engine might be tight, routing the fuel line may involve additional planning and innovative ideas. EPA rules specify that all air cleaner integrity must be maintained. Some injector systems will be vehicle specific so be sure to follow their installation instructions carefully.

FUEL DISCHARGE NOZZLE INSTALLATION PROCEDURE

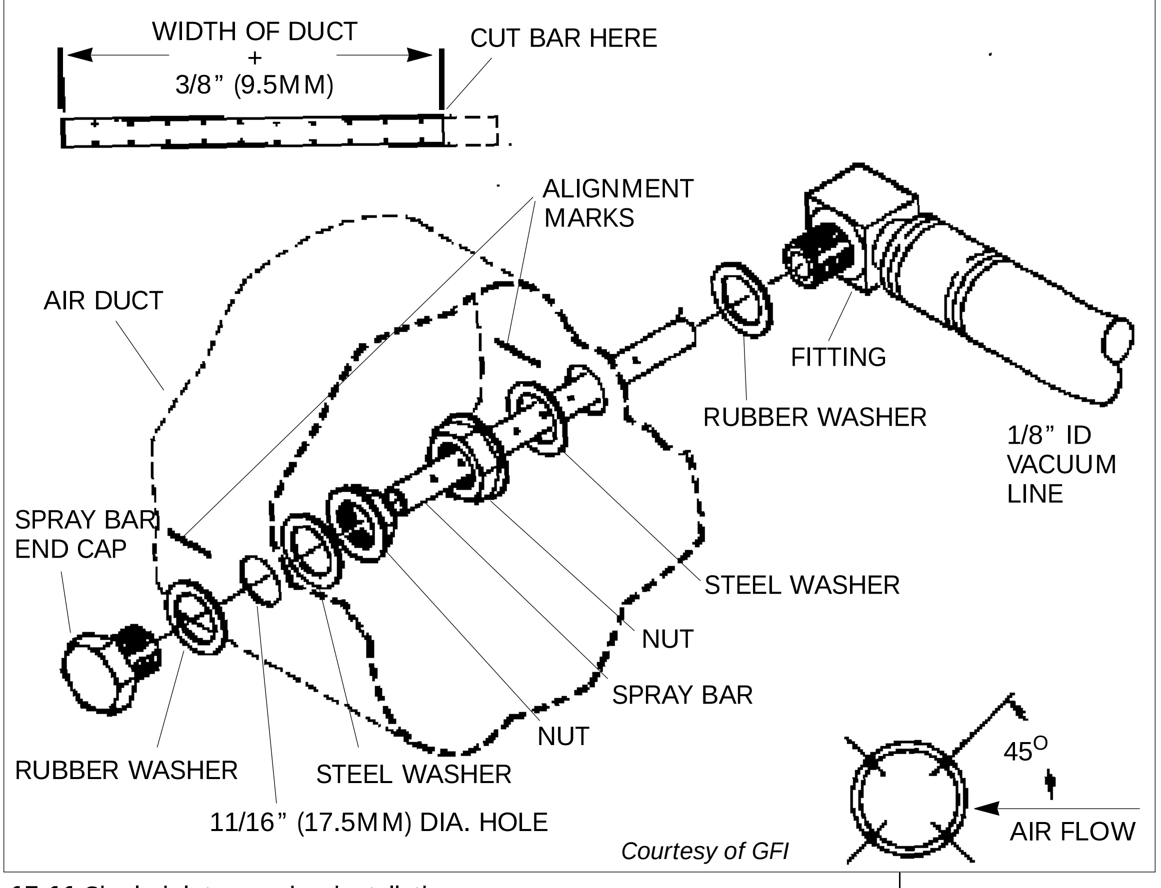
The procedure for installing the injectors involves a number of considerations, including location and alignment. Always keep the site and components clean and free of debris. Then determine the mounting bracket location and test fit the injector at the chosen site.

Key Points & Notes

15-42

15-45

15-44



Courtesy of GFI

15-11 Single inlet spray bar installation.

LOCATION CONSIDERATIONS

The spray disk is mounted in the air cleaner lid. This configuration is often associated with throttle body injection. The spray bar mounts in the air intake snorkel or duct when the air cleaner is remotely mounted, such as with port injection systems. Properties of the air-fuel distribution are dependent on proper discharge nozzle location. The location is specified in the specific vehicle supplement.

The layout for the nozzle and injectors is primarily concerned with two factors: space and routing of the fuel line. The injector layout must consider where the electrical wiring is routed and where to hook into the control circuit. Often the amount of clearance between the air cleaner cover and the spray bar or disk prohibits easy, straightforward mounts. Because of tight above-engine spaces, routing the fuel line may also be tricky.

Key Points & Notes

15-46

MODULE REVIEW ITEMS

Note to Technician: Consider all choices carefully and select the best answer to each.

1. In a dedicated propane conversion, the gasoline carburetor is removed and replaced by the propane air-fuel mixer.
A. True.
B. False.

2. One method of reducing the cost of conversion is to...
A. Use the original gasoline air-fuel mixer.
B. Reuse the throttle linkage connections.
C. Reuse the gasoline carburetor throttle plates.
D. All of the above.

3. When installing the propane air-fuel mixer it is important not to tamper with...
A. Throttle linkage connections.
B. Factory emission control systems.
C. The intake manifold.
D. The carburetor.

4. When uncertain about vacuum hose function, measure the vacuum _____ with a vacuum gauge.
A. Signal.
B. Hose.
C. Gaskets.
D. None of the above.

5. On vehicles equipped with an automatic transmission, after the throttle linkage and throttle return spring is reconnected, the following may need to be performed:
A. Reinstall the air-fuel mixer.
B. Reconnect the vacuum lines.
C. Adjust the throttle kick-down linkage.
D. None of the above.

6. On a straight conversion, the _____ must be removed and the mounting hole blocked off.
A. Carburetor.
B. Mechanical fuel pump.
C. Intake manifold.
D. All of the above.

7. In a dual fuel conversion, the air-fuel mixer is mounted atop the existing gasoline carburetor.
A. True.
B. False.

8. In a dual fuel conversion, what is the main drawback when stacking the mixer on top of the carburetor?
A. Hood clearance.
B. A new adapter is needed.
C. Air restriction.
D. A & C.

9. Non-throttle body fuel injected engines are poor candidates for conversion to propane?
A. True.
B. False.

10. All wiring connections should be...
A. Soldered.
B. Heat shrink wrapped.
C. Sealed from moisture.
D. All of the above.

11. When installing dedicated propane conversions on fuel injected vehicles, the propane air-fuel mixer is installed in the _____.
A. Fuel pump.
B. Air intake system.
C. Carburetor.
D. None of the above.

12. All OEM components removed during a conversion should not be integrated into the propane carburetion system.
A. True.
B. False.

13. An open type air filter assembly is discouraged because...
A. It is necessary to replace air filters.
B. It increases emissions.
C. It can affect engine performance.
D. B & C.

14. In all propane applications install the vapor hose between the _____ and the mixer.
A. Vaporizer.
B. Carburetor.
C. Heater hose.
D. Manifold.

15. One way to check the fuel systems for leaks is to...
A. Pressurize the system.
B. Look for bubbles.
C. Start the vehicle.
D. Apply soapy water around all valve and fuel line connections.

16. When installing the CompuValve assembly, do not locate the unit in...
A. The engine block.
B. On the radiator tank.
C. 2” of moving parts.
D. All of the above.

17. In order to allow adequate room for hose installation, it is recommended that length is extended a minimum of _____.
A. 2”.
B. 6”.
C. 8”.
D. 24”.

18. On engines that have split manifolds, the MAP must be...
A. Split.
B. Attached to the check valve.
C. Dual sourced.
D. Removed.

19. Spray bar and spray disk installation will vary depending on the individual system and vehicle type.
A. True.
B. False.

20. The spray disk is to be mounted...
A. On the compuvalve.
B. On the air cleaner.
C. In the air intake snorkel.
D. In the air cleaner lid.

MRI SCORING KEY

1. A
2. C
3. B
4. A
5. C
6. B
7. A
8. D
9. B
10. D
11. B
12. B
13. D
14. A
15. D
16. D
17. C
18. C
19. A
20. D

1 **MODULE 15:**
Air Valve Mixer &
Fuel Injection Installation

2 **MONO-FUEL APPLICATIONS -**
CARBURETED ENGINES

- Dedicated conversions-gasoline carburetor removed and replaced by propane air-fuel mixer
- Some mixer bodies can be mounted on old gasoline carburetor throttle plates with adapters
- Other models provide replacement unit with its own throttle plate assembly
- Do not tamper with operation of factory emission control systems

3 **15-1 AIR-FUEL MIXER**

4 **15-1A MIXER WITH AIR CLEANER HOOD**

5 **MONO-FUEL CARBURETED ENGINE -**
MIXER INSTALLATION

1. Remove the air cleaner assembly

- Label vacuum hoses, throttle linkage and electrical wires
- Measure vacuum signal by connecting vacuum gauge to each hose or port before disabling gasoline system
- Disconnect fuel lines, vacuum hoses, electrical wires, throttle linkage from carburetor

6 **MONO-FUEL CARBURETED ENGINE -**
MIXER INSTALLATION

2. Unbolt the carburetor from intake manifold and remove it

3. If propane air-fuel mixer mounts on carburetor throttle plate with an adapter, remove throttle plate assembly from carburetor and bolt air-fuel mixer and adapter to throttle plates using new gaskets

- Follow manufacturer's recommendations for assembly

7 **MONO-FUEL CARBURETED ENGINE -**
MIXER INSTALLATION

4. Install air-fuel mixer on intake manifold using new base gasket

- Tighten mixer bolts evenly
- Use gasket sealer when using several adapters

8 **MONO-FUEL CARBURETED ENGINE -**
MIXER INSTALLATION

5. Reconnect vacuum lines

- Proper installation of vacuum lines ensures correct emission control
- Reconnect throttle linkage and throttle return spring
- Throttle kick-down linkage may need adjustment for proper shifting

9 **MONO-FUEL CARBURETED ENGINE -**
MIXER INSTALLATION

6. On mono-fuel conversion, mechanical fuel pump must be removed and mounting hole blocked off

- Use sensor-safe RTV sealant
- If vehicle has an electric fuel pump, disable it by disconnecting and isolating power wires

10 **BI-FUEL APPLICATIONS -**
CARBURETED ENGINES

Air-fuel mixer is mounted atop existing gasoline carburetor

- Hood clearance
  - Use offset adapter to reduce height

- Stacking mixer on carburetor affects air flow
  - Air must pass through throat of second metering body
  - Any restriction or turbulence affects engine performance at high speeds

11 **BI-FUEL CARBURETED ENGINE - MIXER INSTALLATION**

1. Remove air cleaner and trial fit air-fuel mixer on carburetor

- See that mixer does not interfere with choke or throttle linkage
- Allow for adequate hood clearance

12 **BI-FUEL CARBURETED ENGINE - MIXER INSTALLATION**

2. Mount mixer on top of carburetor, following manufacturer's installation instructions

- Mixer attaches to carburetor with adapter
- Install new gasket on top of carburetor and between all adapters
- Use O_2 sensor safegasket sealer
- Do not over tighten bolts or screws that thread into carburetor

13 **BI-FUEL CARBURETED ENGINE - MIXER INSTALLATION**

- NOTE: Be sure the mixer does not interfere with vehicle hood when closed
- Use screw or other thread sealer if any chance for bolts to vibrate loose and fall into engine intake

14 **BI-FUEL CARBURETED ENGINE - MIXER INSTALLATION**

3. If installation requires Bowden control cable to mixer, follow manufacturer's installation instructions

- Check control cable installation operation so it works properly and does not interfere with throttle linkage

15 **BI-FUEL CARBURETED ENGINE - MIXER INSTALLATION**

4. Gasoline carburetor on dual fuel installations may require the float chamber atmospheric air vents be re-worked to assure proper bowl pressure

- Improper float bowl pressure results in poor performance when engine is running on gasoline

16 **BI-FUEL CARBURETED ENGINE - MIXER INSTALLATION**

5. A new air cleaner assembly may be needed

- Should be compatible with under hood conditions by enclosing air filter and ducting fresh outside air into engine
- Filter canister should be rated for air flow capacity of engine
- Above 59^{o} F, engine will lose 1% of HP for every 10^{o} F rise in intake air temperature

17 **MONO-FUEL DEDICATED - FUEL INJECTED ENGINES**

- Propane air fuel mixer installed in air intake system
- Gasoline system disabled by disconnecting fuel pump and fuel injectors
- Applies to throttle body injection and multi-port injection systems

18 **MONO-FUEL DEDICATED FUEL INJECTED ENGINE MIXER INSTALLATION**

1. Remove OEM air cleaner if necessary

2. Trial-fit adapters and mixer assembly for proper fit in engine compartment

- Assembly shouldn't interfere with hood
- Throtle linkage should operate smoothly
- All OEM components moved or disconnected should be integrated into LPG

system

19 **MONO-FUEL DEDICATED FUEL INJECTED ENGINE MIXER INSTALLATION**

3. Disconnect and secure fuel injector and fuel pump wiring
- Seal all wire connectors and lines

4. Drain, plug, secure gasoline fuel lines
- Removing gasoline fuel injector assemblies improves air flow on TBI units
- Removal of injectors, manifold, and control wire block on some TBI units creates an opening which must be blocked off

20 **MONO-FUEL DEDICATED FUEL INJECTED ENGINE MIXER INSTALLATION**

5. Install adapter and mixer
- Use sensor-safe RTV sealant to prevent vacuum leaks

21 **MONO-FUEL DEDICATED FUEL INJECTED ENGINE MIXER INSTALLATION**

6. Reinstall OEM air cleaner assembly if possible
- Modify if necessary
- Some mixers require new air cleaner assemblies
  - Don’t use open type
  - Aftermarket replacement filters and canisters should be rated for engine air flow requirements and use outside air

22 **BI-FUEL APPLICATIONS -**
FUEL INJECTED ENGINES

- Gasoline delivery to injectors interrupted by turning off fuel pump and injectors when switched to propane
- When switched for LPG, propane fuel lock opens allowing flow
- When switched for gasoline, fuel lock closes

23 **BI-FUEL FUEL INJECTED ENGINES**
MIXER INSTALLATION

1. Remove OEM air cleaner if necessary

2. Trial-fit adapters and mixer assembly for proper fit in engine compartment
- Assembly shouldn’t interfere with hood
- Throtle linkage should operate smoothly
- All OEM components moved or disconnected should be integrated into LPG system

24 **15-2 AIR-FUEL MIXER ADAPTOR**

25 **BI-FUEL FUEL INJECTED ENGINES**
MIXER INSTALLATION

6. Reinstall OEM air cleaner assembly if possible
- Modify if necessary
- Some mixers require new air cleaner assemblies
  - Don’t use open type
  - Aftermarket replacement filters and canisters should be rated for engine air flow requirements and use outside air

26 **BI-FUEL FUEL INJECTED ENGINES**
MIXER INSTALLATION

- OEM sensors may need repositioning
- Air valve mixer must be downstream of the MAF sensor
- Bi-fuel applications might need lifting device to hold up air valve or venturi restriction during gasoline operation
  - Use a device such as a Bowden cable

27 **15-3 AFTERMARKET AIR CLEANER AND ADAPTOR**

28 **ALL APPLICATIONS -**

MONO AND BI-FUEL

1. Install vapor hose between vaporizer and mixer
- Use approved vapor hose

2. Install any vacuum or balance line connections
- Components may malfunction if not connected
- Know which vacuum source is necessary
  - Don't connect to manifold vacuum where air valve vacuum or atmospheric pressure is needed

29 **15-4 BALANCE LINE**

30 **15-5 AIR CLEANER ADAPTOR**

31 **15-6 MIXER CUTAWAY**

32 **ALL APPLICATIONS - MONO AND BI-FUEL**

3. Pressurize and check fuel system for leaks
- Repair leaks before starting vehicle
- Recheck for leaks after any repair

4. Balance line between regulator and mixer may be necessary
- Important on "air valve" type mixers

33 **15-7 VACUUM & BALANCE LINE CONNECTIONS**

34 **ALL APPLICATIONS - MONO AND BI-FUEL**

5. All OEM emissions control devices must be retained after conversion
- Exceptions if CARB or EPA allow removal
- Severe penalties for unauthorized removal

6. Complete a comprehensive post conversion evaluation

35 **FUEL INJECTION METERING VALVE AND DISCHARGE NOZZLE INSTALLATION**

- Compuvalve installation
  - Determine proper location
  - Use mounting hole arrangement that offers most secure and rigid mounting
  - Mount compuvalve from minimum of two faces
  - Don't mount in cantilever fashion
  - Use fender washers or a backing plate when mounting on lightweight surfaces

36 **MAP TAKEOFF**

1. Cut OEM MAP line and insert tee as close to OEM MAP sensor as possible
- Don't install tee close to check valve
- Don't install to vacuum reservoir, brake booster, etc.

37 **15-8 MAP TAKEOFF**

38 **15-9 MAP TAKEOFF WITH SPLIT MANIFOLD**

39 **MAP TAKEOFF**

2. Attach 1/8" hose to tee and route to compuvalve

3. Cut damper tube to specified length and insert into hose 1"
- Don't use lubricant to assemble hose and tube
- Roughly cut ends may cause problems if tube passage is blocked

40 **MAP TAKEOFF**

4. Insert other end of damper tube into 90^{o} rubber nipple

- Don’t use lubricant to assemble elbow and tube
- Don’t let hose kink or exceed 3” in length

41 **MAP TAKEOFF**

5. Push nipple into MAP barb on compuvalve

- No spaces between damper tube and compuvalve tube
- DMAP fluctuations should be less than +/- 5 in. Hg. when engine is running
- Volume trapped between damper line and compuvalve should be minimized to provide stable DMAP’s under steady state conditions

42 **FUEL DISCHARGE NOZZLE INSTALLATION OVERVIEW**

- Newer vehicles with FI engines require injectors to introduce fuel into air stream of intake manifold or into throttle body
- Concern for room for spray bar or disk and where fuel line is routed
- Direct injection systems require a modified intake manifold

43 **15-10 SPRAY DISK INSTALLATION**

44 **15-11 SINGLE INLET SPRAY BAR INSTALLATION**

45 **FUEL DISCHARGE NOZZLE INSTALLATION PROCEDURE**

- Location
- Alignment
- Keep site clean
- Determine bracket location
- Test fit injector

46 **LOCATION CONSIDERATIONS**

- Spray disk mounted in air cleaner lid
- Spray bar mounts in air intake snorkel or duct when air cleaner is remotely mounted
- Factors:
  - Space
  - Routing of fuel line

MODULE 15:
Air Valve Mixer & Fuel Injection Installation

MONO-FUEL APPLICATIONS - CARBURETED ENGINES

- Dedicated conversions-gasoline carburetor removed and replaced by propane air-fuel mixer
- Some mixer bodies can be mounted on old gasoline carburetor throttle plates with adapters
- Other models provide replacement unit with its own throttle plate assembly
- Do not tamper with operation of factory emission control systems

15-1 AIR-FUEL MIXER

Photo Copyright Harris Fogel

15-1A MIXER WITH AIR CLEANER HOOD

Photo Copyright Harris Fogel

MONO-FUEL CARBURETED ENGINE - MIXER INSTALLATION

1. Remove the air cleaner assembly

- Label vacuum hoses, throttle linkage and electrical wires
- Measure vacuum signal by connecting vacuum gauge to each hose or port before disabling gasoline system
- Disconnect fuel lines, vacuum hoses, electrical wires, throttle linkage from carburetor

MONO-FUEL CARBURETED ENGINE - MIXER INSTALLATION

2. Unbolt the carburetor from intake manifold and remove it

3. If propane air-fuel mixer mounts on carburetor throttle plate with an adapter, remove throttle plate assembly from carburetor and bolt air-fuel mixer and adapter to throttle plates using new gaskets

- Follow manufacturer's recommendations for assembly

MONO-FUEL CARBURETED ENGINE - MIXER INSTALLATION

4. Install air-fuel mixer on intake manifold using new base gasket
   - Tighten mixer bolts evenly
   - Use gasket sealer when using several adapters

MONO-FUEL CARBURETED ENGINE - MIXER INSTALLATION

5. Reconnect vacuum lines

- Proper installation of vacuum lines ensures correct emission control
- Reconnect throttle linkage and throttle return spring
- Throttle kick-down linkage may need adjustment for proper shifting

MONO-FUEL CARBURETED ENGINE - MIXER INSTALLATION

6. On mono-fuel conversion, mechanical fuel pump must be removed and mounting hole blocked off

- Use sensor-safe RTV sealant
- If vehicle has an electric fuel pump, disable it by disconnecting and isolating power wires

BI-FUEL APPLICATIONS - CARBURETED ENGINES

Air-fuel mixer is mounted atop existing gasoline carburetor

- Hood clearance
  - Use offset adapter to reduce height
- Stacking mixer on carburetor affects air flow
  - Air must pass through throat of second metering body
  - Any restriction or turbulence affects engine performance at high speeds

BI-FUEL CARBURETED ENGINE - MIXER INSTALLATION

1. Remove air cleaner and trial fit air-fuel mixer on carburetor

- See that mixer does not interfere with choke or throttle linkage
- Allow for adequate hood clearance

BI-FUEL CARBURETED ENGINE - MIXER INSTALLATION

2. Mount mixer on top of carburetor, following manufacturer's installation instructions

- Mixer attaches to carburetor with adapter
- Install new gasket on top of carburetor and between all adapters
- Use O_2 sensor safegasket sealer
- Do not over tighten bolts or screws that thread into carburetor

BI-FUEL CARBURETED ENGINE - MIXER INSTALLATION

- NOTE: Be sure the mixer does not interfere with vehicle hood when closed
- Use screw or other thread sealer if any chance for bolts to vibrate loose and fall into engine intake

BI-FUEL CARBURETED ENGINE - MIXER INSTALLATION

3. If installation requires Bowden control cable to mixer, follow manufacturer's installation instructions

- Check control cable installation operation so it works properly and does not interfere with throttle linkage

BI-FUEL CARBURETED ENGINE - MIXER INSTALLATION

4. Gasoline carburetor on dual fuel installations may require the float chamber atmospheric air vents be re-worked to assure proper bowl pressure

- Improper float bowl pressure results in poor performance when engine is running on gasoline

BI-FUEL CARBURETED ENGINE - MIXER INSTALLATION

5. A new air cleaner assembly may be needed

- Should be compatible with under hood conditions by enclosing air filter and ducting fresh outside air into engine
- Filter canister should be rated for air flow capacity of engine
- Above 59^{o} F, engine will lose 1% of HP for every 10^{o} F rise in intake air temperature

MONO-FUEL DEDICATED - FUEL INJECTED ENGINES

- Propane air fuel mixer installed in air intake system
- Gasoline system disabled by disconnecting fuel pump and fuel injectors
- Applies to throttle body injection and multi-port injection systems

MONO-FUEL DEDICATED FUEL INJECTED ENGINE MIXER INSTALLATION

1. Remove OEM air cleaner if necessary

2. Trial-fit adapters and mixer assembly for proper fit in engine compartment

- Assembly shouldn't interfere with hood
- Throtle linkage should operate smoothly
- All OEM components moved or disconnected should be integrated into LPG system

MONO-FUEL DEDICATED FUEL INJECTED ENGINE MIXER INSTALLATION

3. Disconnect and secure fuel injector and fuel pump wiring
   - Seal all wire connectors and lines

4. Drain, plug, secure gasoline fuel lines
   - Removing gasoline fuel injector assemblies improves air flow on TBI units
   - Removal of injectors, manifold, and control wire block on some TBI units creates an opening which must be blocked off

MONO-FUEL DEDICATED FUEL INJECTED ENGINE MIXER INSTALLATION

5. Install adapter and mixer

- Use sensor-safe RTV sealant to prevent vacuum leaks

MONO-FUEL DEDICATED FUEL INJECTED ENGINE MIXER INSTALLATION

6. Reinstall OEM air cleaner assembly if possible

- Modify if necessary
- Some mixers require new air cleaner assemblies
  - Don't use open type
  - Aftermarket replacement filters and canisters should be rated for engine air flow requirements and use outside air

BI-FUEL APPLICATIONS - FUEL INJECTED ENGINES

- Gasoline delivery to injectors interrupted by turning off fuel pump and injectors when switched to propane
- When switched for LPG, propane fuel lock opens allowing flow
- When switched for gasoline, fuel lock closes

BI-FUEL FUEL INJECTED ENGINES
MIXER INSTALLATION

1. Remove OEM air cleaner if necessary

2. Trial-fit adapters and mixer assembly for proper fit in engine compartment

- Assembly shouldn't interfere with hood
- Throtle linkage should operate smoothly
- All OEM components moved or disconnected should be integrated into LPG system

15-2 AIR-FUEL MIXER ADAPTOR

Photo Copyright Harris Fogel

BI-FUEL FUEL INJECTED ENGINES
MIXER INSTALLATION

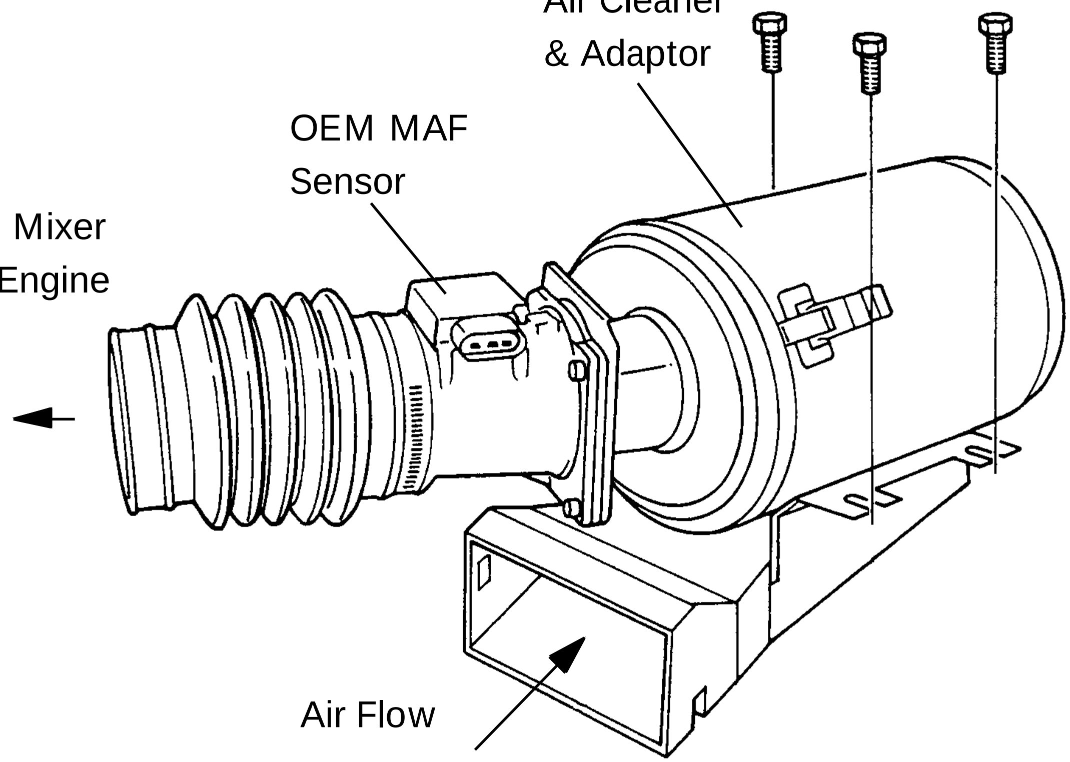
6. Reinstall OEM air cleaner assembly if possible

- Modify if necessary
- Some mixers require new air cleaner assemblies
  - Don't use open type
  - Aftermarket replacement filters and canisters should be rated for engine air flow requirements and use outside air

BI-FUEL FUEL INJECTED ENGINES MIXER INSTALLATION

- OEM sensors may need repositioning
- Air valve mixer must be downstream of the MAF sensor
- Bi-fuel applications might need lifting device to hold up air valve or venturi restriction during gasoline operation
  - Use a device such as a Bowden cable

15-3 AFTERMARKET AIR CLEANER AND ADAPTOR



Courtesy of IMPCO

ALL APPLICATIONS - MONO AND BI-FUEL

1. Install vapor hose between vaporizer and mixer

- Use approved vapor hose

2. Install any vacuum or balance line connections

- Components may malfunction if not connected
- Know which vacuum source is necessary
  - Don’t connect to manifold vacuum where air valve vacuum or atmospheric pressure is needed

15-4 BALANCE LINE

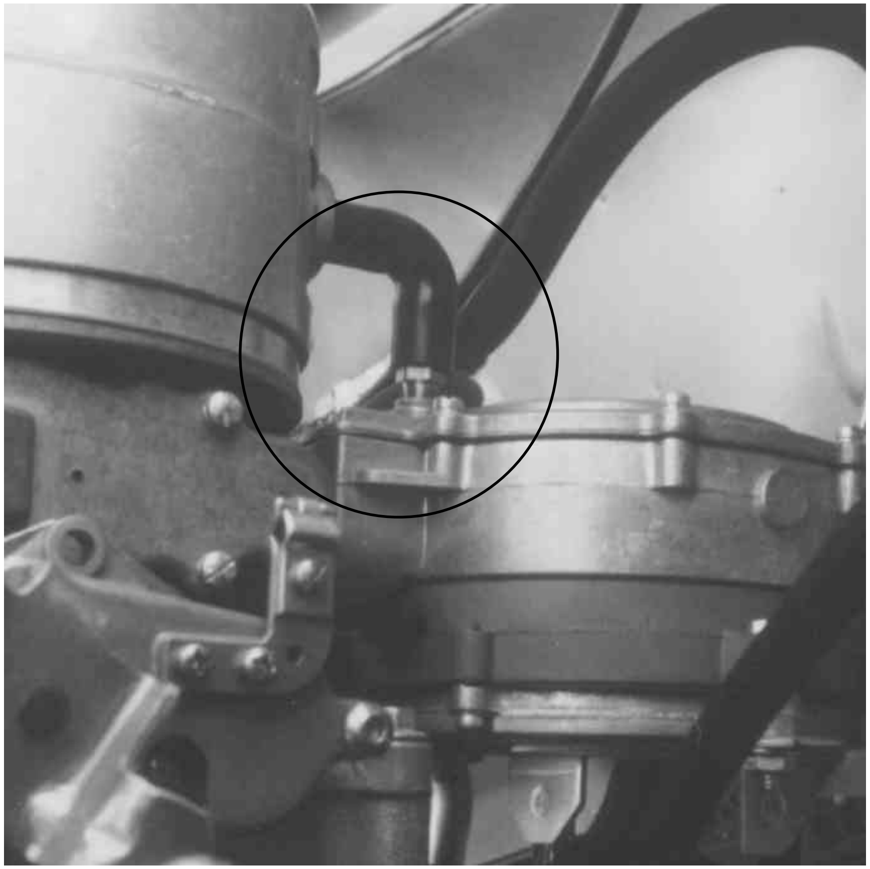


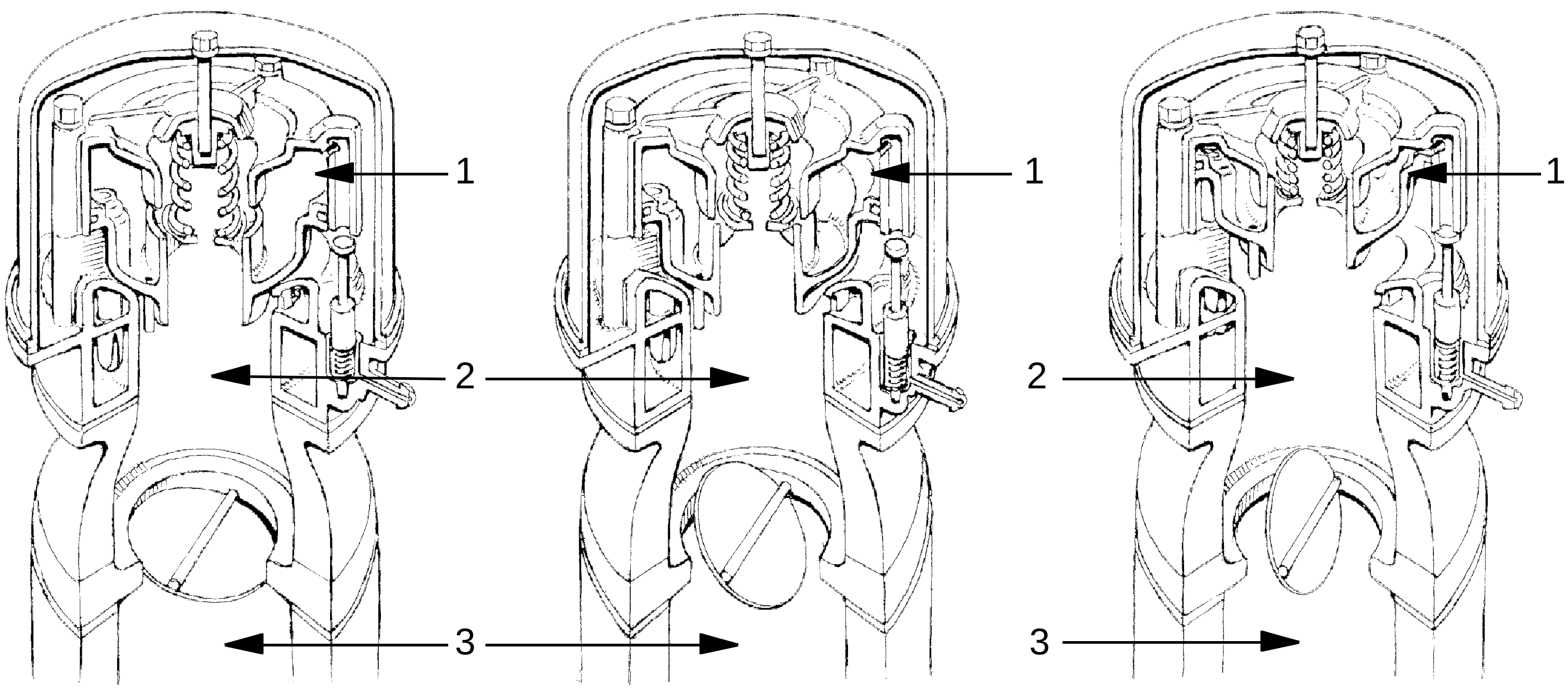
Photo Copyright Harris Fogel

15-5 AIR CLEANER ADAPTOR

Photo Copyright Harris Fogel

15-6 MIXER CUTAWAY

1. Cylinder Vacuum
2. Air Valve Vacuum
3. Intake Manifold Vacuum



IDLE **HALF THROTTLE** **FULL THROTTLE**

Peter Aschwanden

ALL APPLICATIONS - MONO AND BI-FUEL

3. Pressurize and check fuel system for leaks
- Repair leaks before starting vehicle
- Recheck for leaks after any repair

4. Balance line between regulator and mixer may be necessary
- Important on “air valve” type mixers

15-7 VACUUM & BALANCE LINE CONNECTIONS

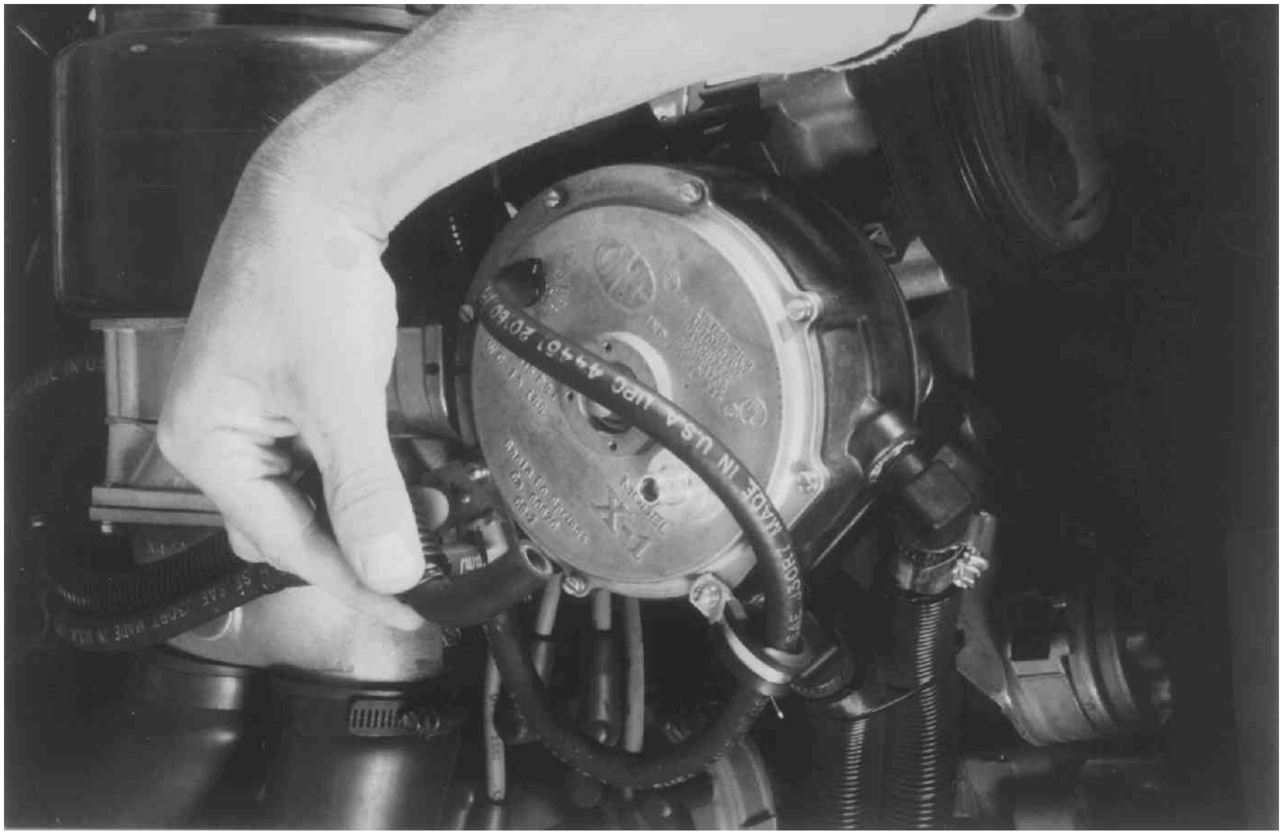


Photo Copyright Harris Fogel

ALL APPLICATIONS - MONO AND BI-FUEL

5. All OEM emissions control devices must be retained after conversion
   - Exceptions if CARB or EPA allow removal
   - Severe penalties for unauthorized removal

6. Complete a comprehensive post conversion evaluation

FUEL INJECTION METERING VALVE AND DISCHARGE NOZZLE INSTALLATION

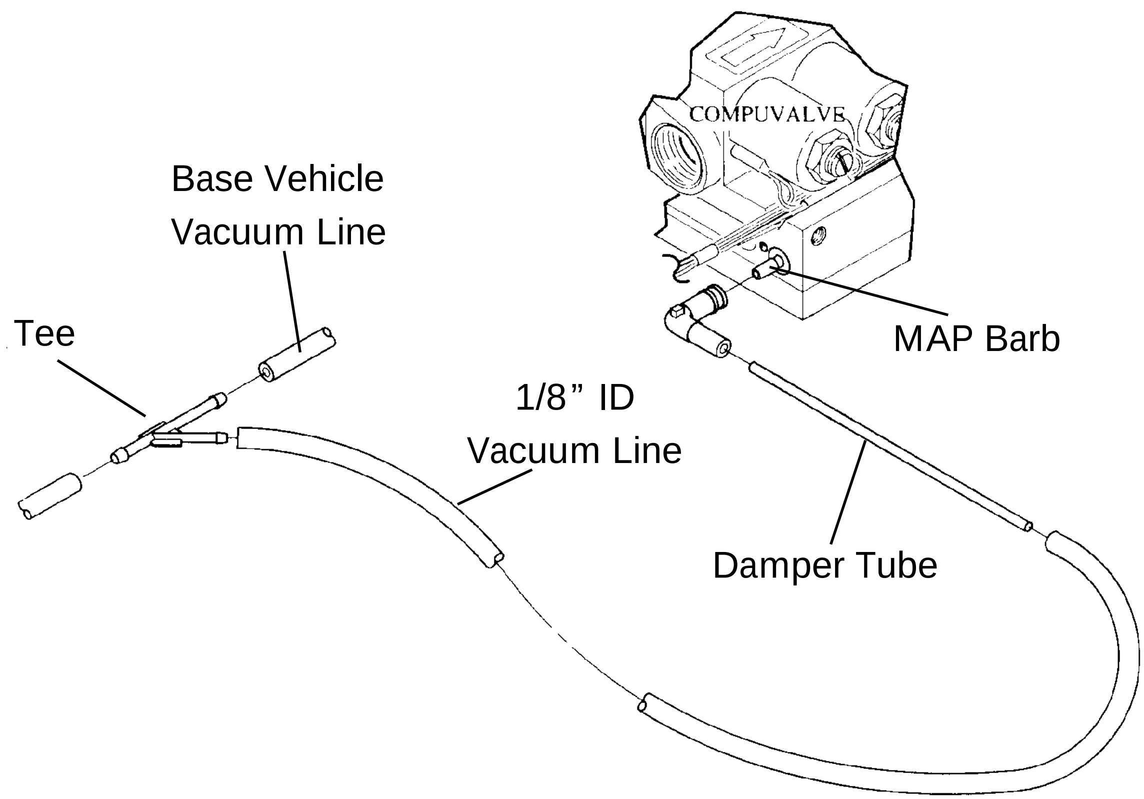
- Compupvalve installation
  - Determine proper location
  - Use mounting hole arrangement that offers most secure and rigid mounting
  - Mount compuvalve from minimum of two faces
  - Don't mount in cantilever fashion
  - Use fender washers or a backing plate when mounting on lightweight surfaces

MAP TAKEOFF

1. Cut OEM MAP line and insert tee as close to OEM MAP sensor as possible

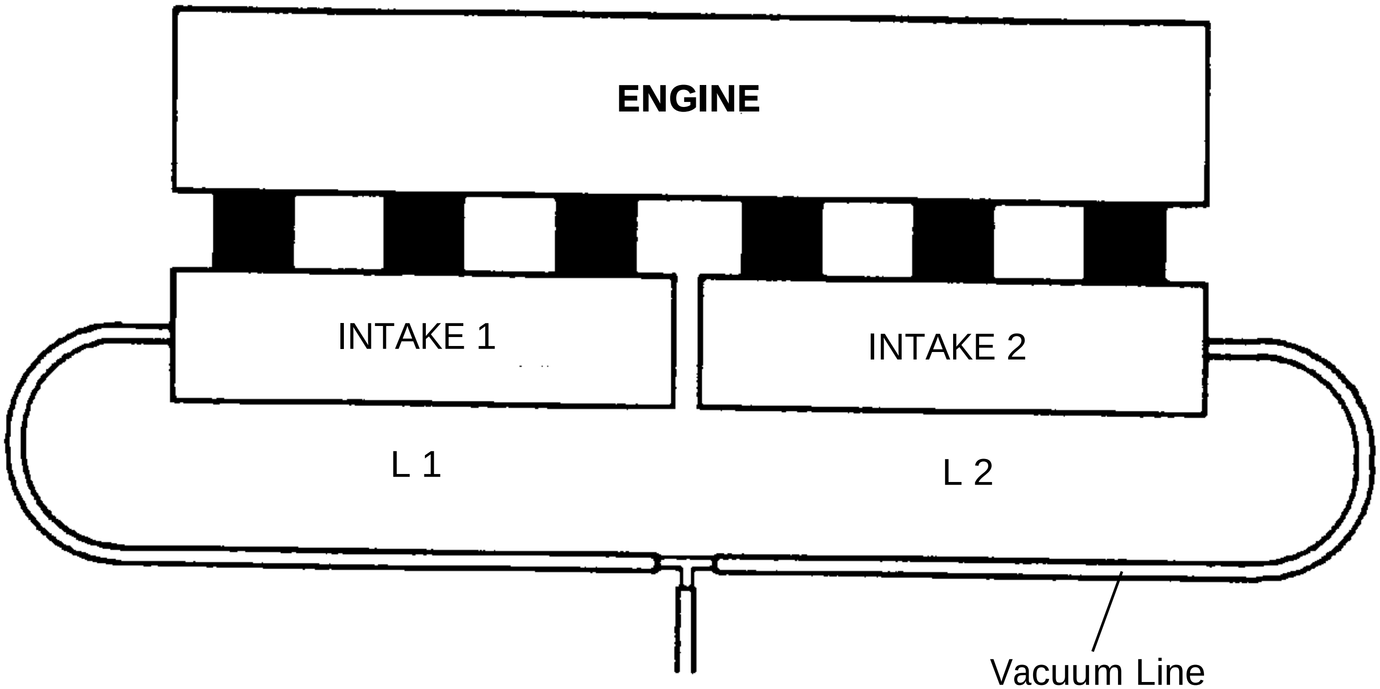
- Don’t install tee close to check valve
- Don’t install to vacuum reservoir, brake booster, etc.

15-8 MAP TAKEOFF



Courtesy of GFI

15-9 MAP TAKEOFF WITH SPLIT MANIFOLD



Courtesy of GFI

MAP TAKEOFF

2. Attach 1/8” hose to tee and route to compuvalve

3. Cut damper tube to specified length and insert into hose 1”

- Don’t use lubricant to assemble hose and tube
- Roughly cut ends may cause problems if tube passage is blocked

MAP TAKEOFF

4. Insert other end of damper tube into 90^{o} rubber nipple

- Don't use lubricant to assemble elbow and tube
- Don't let hose kink or exceed 3" in length

MAP TAKEOFF

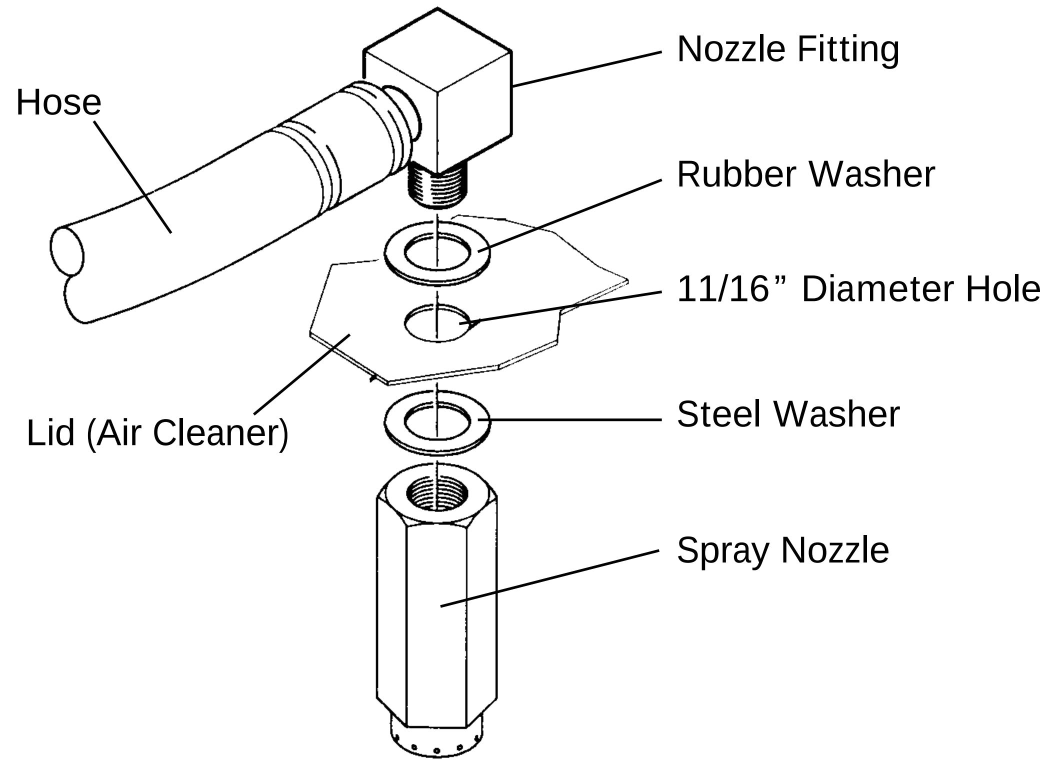
5. Push nipple into MAP barb on compuvalve

- No spaces between damper tube and compuvalve tube
- DMAP fluctuations should be less than +/- 5 in. Hg. when engine is running
- Volume trapped between damper line and compuvalve should be minimized to provide stable DMAP’s under steady state conditions

FUEL DISCHARGE NOZZLE INSTALLATION OVERVIEW

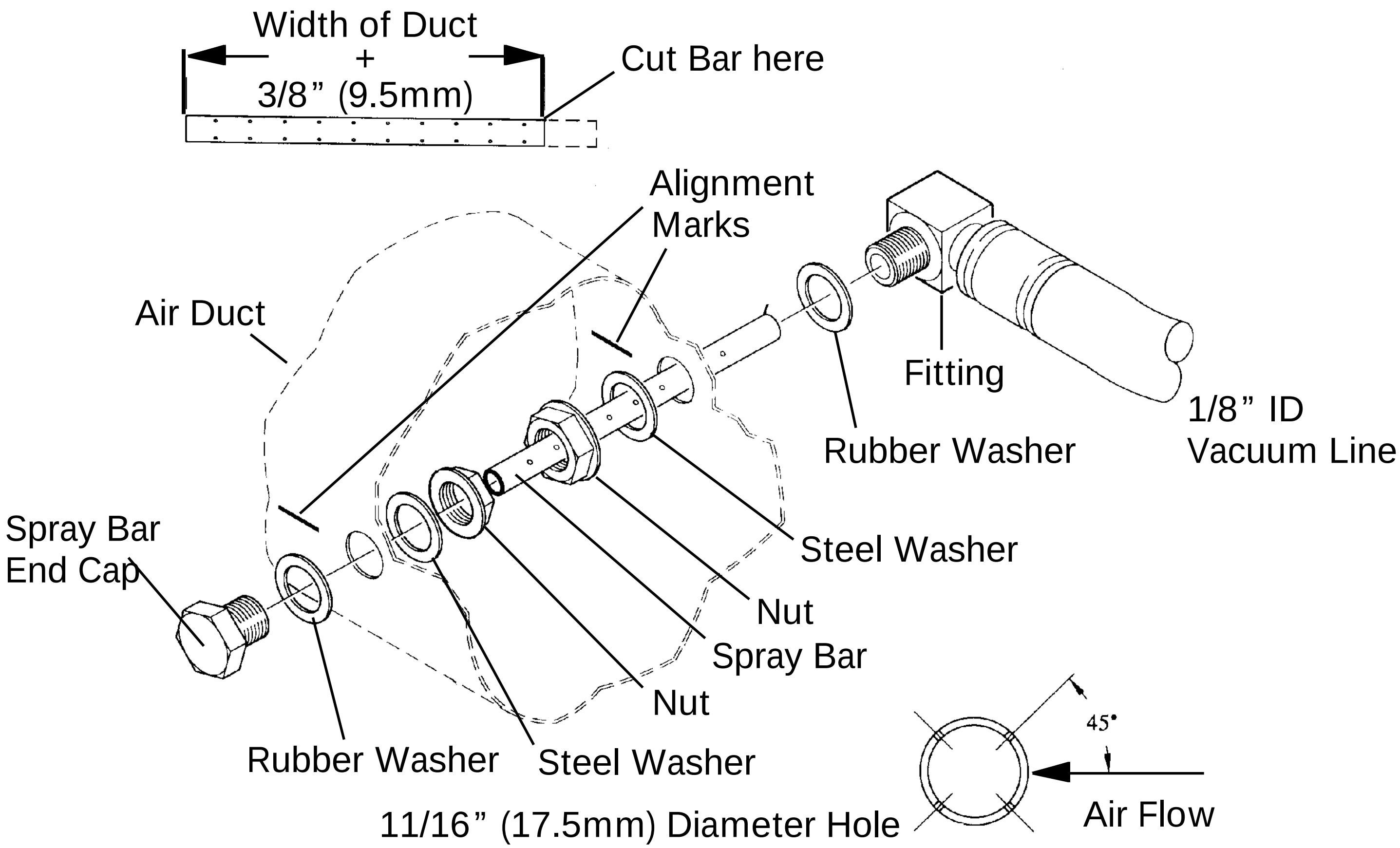
- Newer vehicles with FI engines require injectors to introduce fuel into air stream of intake manifold or into throttle body
- Concern for room for spray bar or disk and where fuel line is routed
- Direct injection systems require a modified intake manifold

15-10 SPRAY DISK INSTALLATION



Courtesy of GFI

15-11 SINGLE INLET SPRAY BAR INSTALLATION



Courtesy of GFI

FUEL DISCHARGE NOZZLE INSTALLATION PROCEDURE

- Location
- Alignment
- Keep site clean
- Determine bracket location
- Test fit injector

LOCATION CONSIDERATIONS

- Spray disk mounted in air cleaner lid
- Spray bar mounts in air intake snorkel or duct when air cleaner is remotely mounted
- Factors:
  - Space
  - Routing of fuel line

MODULE 16:
Electrical Wiring, Connections, Protection & Routing

State of Oklahoma
College of the Desert
West Virginia University

MODULE 16: ELECTRICAL WIRING, CONNECTIONS, PROTECTION & ROUTING

CONTENTS

MODULE 16: ELECTRICAL WIRING, CONNECTIONS, PROTECTION & ROUTING

OBJECTIVES

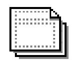
At the completion of this module, the technician will be able to:

- Determine the best and safest location to install the wiring and connections.
- Securely connect wires and components, using the proper tools and techniques.
- Test and troubleshoot the connections.

INSTRUCTOR NOTES

INSTRUCTOR MATERIALS/MEDIA NEEDED

Overhead projector or LCD panel/projection equipment
Overhead transparency masters or Microsoft PowerPoint 4.0 presentation file Mod16.ppt

Note: Slides correspond to text as indicated by icon 

VCR with TV or projection unit

STUDENT MATERIALS/MEDIA NEEDED

Module 16: Electrical Wiring, Connections, Protection & Routing

MODULE REVIEW ITEMS

The Module Review Items (MRI) are designed to allow for flexibility in their use. The exam may be utilized as a post-module review, pre/post test, part of a term examination, or it may be used by the student if the module is used as a self study text.

OVERHEAD TRANSPARENCY MASTERS

The printouts enclosed with this module are taken from the Microsoft PowerPoint 4.0 presentation file Mod16.ppt . Instructors planning to use overhead projectors should make transparencies from these printouts on a copier (or laser printer designed to safely print to acetate.

Note: Please review Module 25: Training of Trainers for more hints on instructional needs and strategies.

MODULE 16: ELECTRICAL WIRING, CONNECTIONS, PROTECTION & ROUTING

OVERVIEW COMPONENT INSTALLATION

NOTE: Before working on any part of the electrical system, disconnect the negative (–) battery cable. Reconnect only when all components and connections are secure and insulated.

Consider the following when locating electrical components:

- Mount on sturdy stable surfaces. Refer to Figure 16-1.
- Guard and shield from moisture and vibration.
- Provide room to make splices.
- Allow for neat wire routing, use separate loom and harness when possible.
- Allow for accessibility to the timing components.
- Place dashboard meters in clear view of the driver.
- Mount switches where they can be reached but not accidentally tripped or damaged.

Most new vehicles use digital electronic systems that are sensitive. Many electrical problems are caused by resistance (poor connections) or interference generated by high-frequency electro-magnetic waves. Electronic control devices and wires should be placed away from secondary ignition coil(s), wires or spark plugs, electric motors, radios, horns, and antennas.

Obtain a schematic of the vehicle before wiring and make notes on that schematic as needed. Propane conversion equipment manufacturers provide electrical component wiring diagrams. Use both the OEM and propane equipment schematics and save for future reference. If maintenance is required later, the schematic becomes the information that saves hours of wire tracing. Identify and check


Courtesy of GFI

16-1 Mounted integrated processor.

Key Points & Notes

16-2

16-3

16-4

previous "add-on" components such as radio equipment, lights, or other power take-offs. Take care not to interrupt OEM circuits that may affect other components. Refer to wiring diagrams frequently during conversion. Triple check all connections before making them permanent. Improper connections can damage equipment or make it inoperable.

WIRE ROUTING

A mating wiring harness may be furnished with the kit. Some connections are pre-made to fit OEM and propane system electrical connections. Other equipment may require considerable adaptation. Instructions for making taps and intercepts should be provided with the equipment. Before cutting and connecting OEM or propane system wiring, lay out and route the conversion system wiring in relation to the OEM and add-on components. Consider the following notations

- Avoid routing near "hot spots" where heat can damage insulation, wire, or both.
- Do not route within 6" of secondary ignition coils, wires or sparkplugs.
- Do not route wire within OEM harness or along hoses. This particularly applies to primary ignition (tachometer) wires.
- Do not route in area where wire can be damaged from sharp edges or rubbing against vehicle parts.
- Allow adequate wire length to avoid straining wire from installation or vehicle operation.
- Do not permanently place or conceal wires until system is fully operational.
- Route wire in bundles as much as possible.
- Secure wires with clips, ties or both.

SPLICING

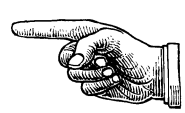
Proper splicing and soldering are required for good electrical conductivity and strength. Most taps and intercepts are connected to low current (milliamp) circuits. Others provide battery voltage and higher current. In both cases, all wire-to-wire or connector-to-connector splices and connections must be soldered and sealed. Wire connections should be spliced by Western Union or tap splice, not by twisting into a pigtail. Do not use connectors that are joined by simply crimping. If crimps are used, the connection should be soldered and insulated. Match wire size and color whenever possible.

> ***NOTE:*** Connect grounds first before connecting the power or any other connections. Connect the ground to a clean, bare metal surface or a designated return ground wire. Prepare the ground point and connector(s) by roughening the surfaces with a file or emory paper. Clean with degreaser/solvent to remove all grease, paint, and dirt to ensure good conductivity. Verify the ground with the voltmeter and ohmeter if uncertain of the connection.

Key Points & Notes

16-5

16-6



There are two common types of splices:

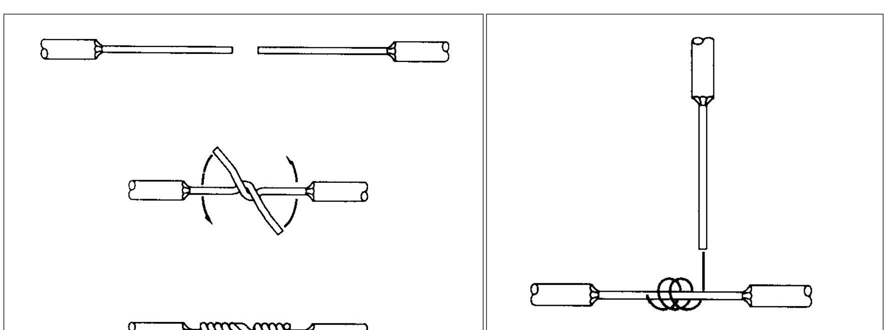
1. The Western Union splice is used to join two or more wire ends and to parallel tap or series intercept circuits. Refer to Figure 16-2.
2. The tap splice is used to connect an existing wire (parallel) to another circuit where it is difficult to cut and rejoin a wire after adding an additional wire. Refer to page 16-5.

The sequence for making wire-to-wire splices involves the following tools and steps. Refer to page 16-4.

You will need a wire cutter and stripper, soldering tool, solder, sponge, heat shrink, and heat gun.

1. Strip approximately 1” (25.4 mm) of insulation from wire without cutting strands. Cut enough heat shrink to completely cover bare wire, soldered join, and overlap insulation. Slide on heat shrink; position well away from the solder point so heat shrink isn’t affected by heat from soldering.
2. Twist wires together so solder will flow and heat shrink will slide over join.
3. Heat, clean, and tin the tip of the soldering tool. Wipe hot soldering tip on damp sponge to clean. Melt small amount of solder on tip to tin.

   NOTE: Non-electrical, gas-powered soldering tools are preferred for automotive use. Gas heated tools do not create unwanted power induction in sensitive circuits.
4. Heat wire joint on one end of twist. Place solder so solder flows through joint toward tip. Heat wire and solder completely. Do not “glob-on” unnecessary solder. Make sure the solder spreads and penetrates the connection thoroughly. Resolder any cold joins or cracked connections.
5. Keep splice stationary and allow to cool before moving or handling.
6. Slip heat shrink tubing over joint when cool. Apply heat from heat gun (or the like) evenly to shrink the tubing. DO NOT USE OPEN FLAME.
7. Once system is operating properly, enclose wires with split-loom tubing and tape where necessary.



Courtesy of GFI

16-2 Western Union splice (left) and tap splice (right).

Key Points & Notes

16-9

16-10

16-11

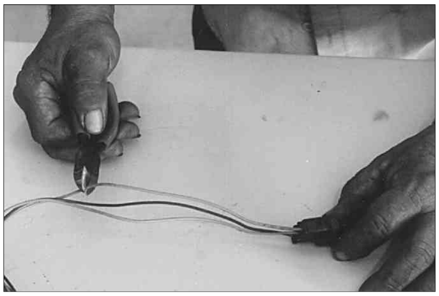
16-12

16-7

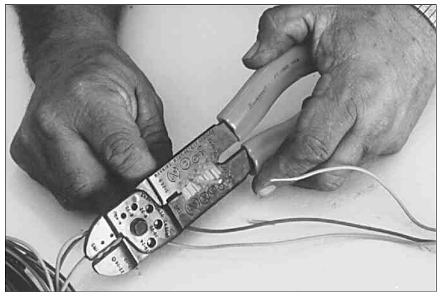
16-8

MODULE 16: ELECTRICAL WIRING, CONNECTIONS, PROTECTION & ROUTING

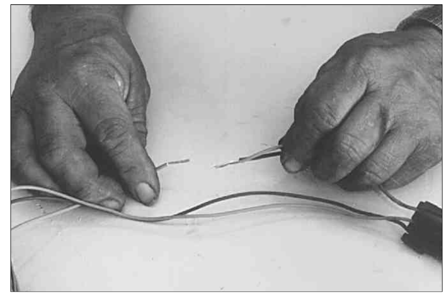
Make tap by cutting OEM wire and connecting new circuit to OEM wire:



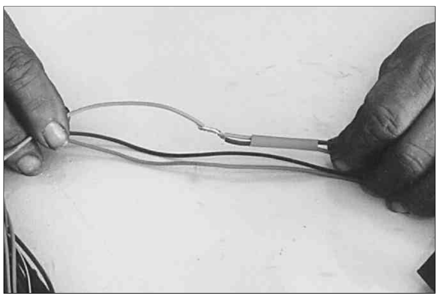
Step 1: Cut OEM wire.



Step 2: Strip insulation from OEM wire (stripped tap wire not shown).

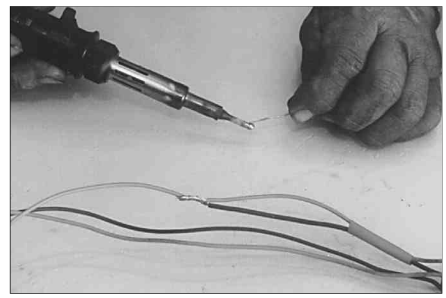


Step 3: Twist together one OEM wire and tap wire.

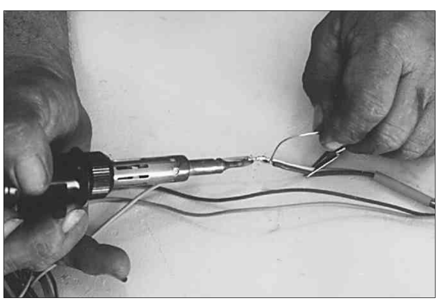


Step 4: Slip heat shrink over spliced OEM and tap wires, twist together all three wires – position heat shrink well away from solder joint.

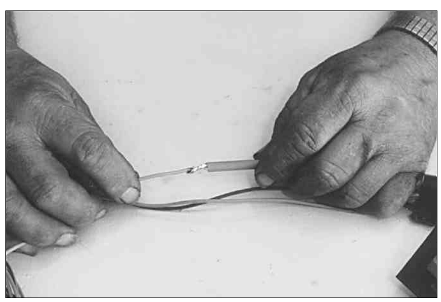
Step 5: Clean tip of soldering iron on damp sponge.



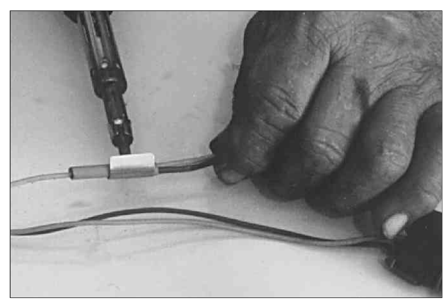
Step 6: Melt drop of solder on hot tip to "tin the tip."



Step 7: Heat wire with tip until wire conducts heat and melted solder is drawn through wire toward tip. Note: To avoid "cold joint" do not dab solder on wire.



Step 8: Slip heat shrink over soldered join.



Step 9: Apply heat to shrink tubing to insulate soldered join.

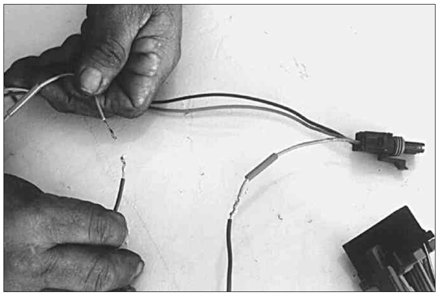
Splice: 16-13 - 16-21

Intercept: 16-22 - 16-24

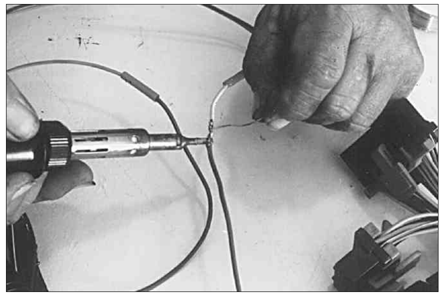
Continuity: 16-25, 16-26

Tap: 16-27 - 16-31

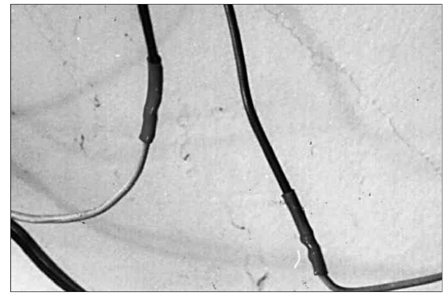
Make intercept by cutting OEM wire and connecting new circuit to OEM wires:



Step 1: After cutting, stripping, and applying heat shrink, twist wire ends together and prepare for soldering.

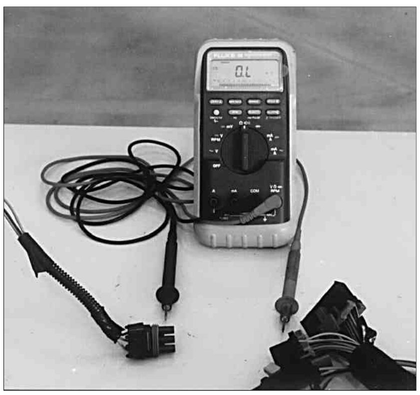


Step 2: Heat connection to melt and draw solder toward tip. Note: Do not dab solder into wire.



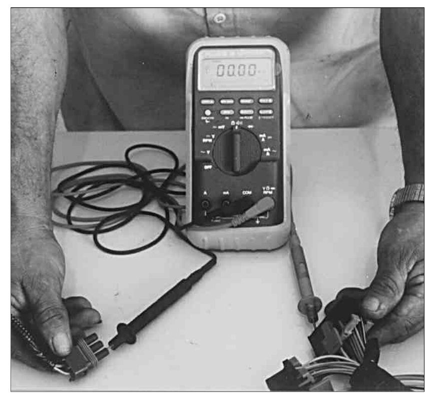
Step 3: After soldering connection and letting join cool, slip shrink over join and heat to shrink and insulate.

Check circuit for continuity:

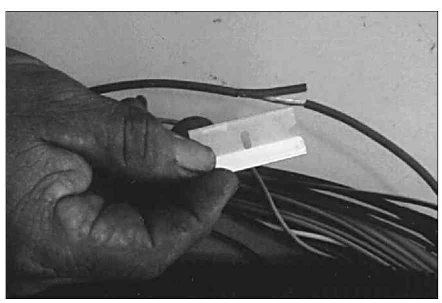


Step 1: Meter works, meter not connected. Meter reads OL Ω (Overload or infinite) resistance.

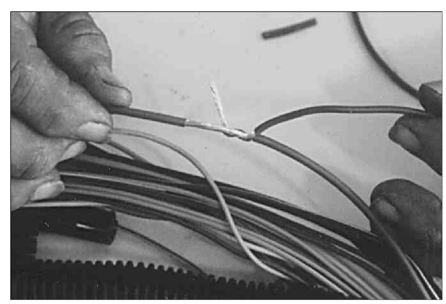
Step 2: Continuity in circuit, meter connected. Meter reads 0 Ω (no) resistance. **Note:** if meter displays OL when probes are connected to circuit, verify connections at probes and circuit.



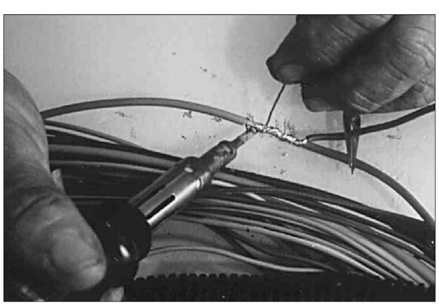
Tap without cutting OEM wire, cold shrink tape used to insulate:



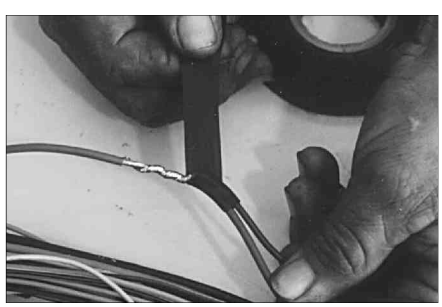
Step 1: Cut insulation.



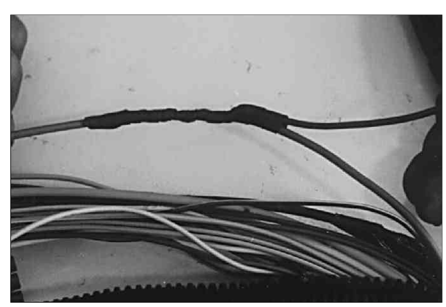
Step 2:Make tap connection – wrap tap wire unto OEM wire.



Step 3: Solder connection.



Step 4: Wrap cold shrink tape to insulate tap connection.

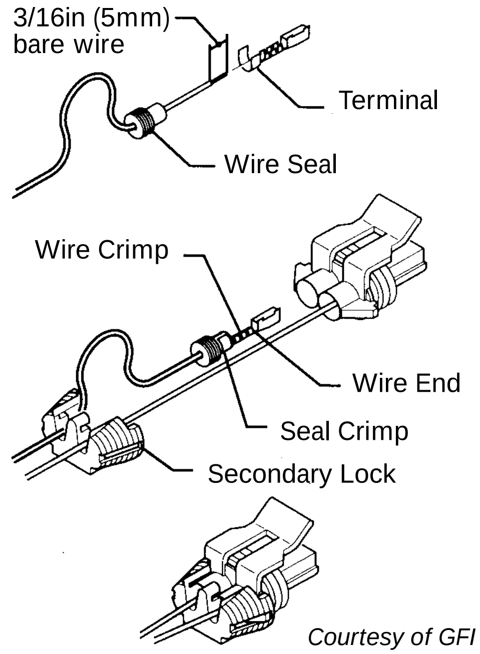


Step 5: Completed tap solder with insulation cold shrink wrap.

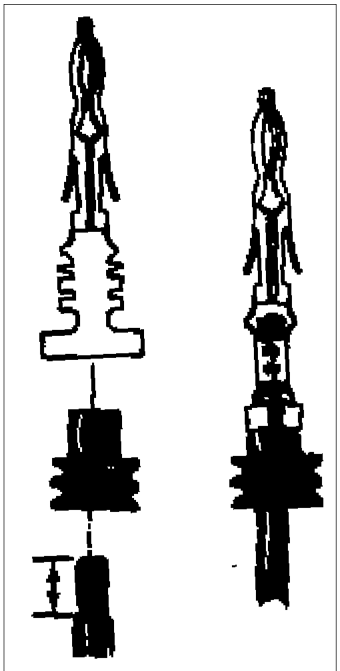
WIRE AND CONNECTOR ASSEMBLY

The following steps are specific to Weather-Pack and Metri-Pack type connectors. Refer to Figures 16-3 and 16-4.

1. Use the proper gauge wire and cut wire to length. Allow adequate length for all splices, terminals, connectors, and routing.
2. Attach connector terminal to wire end.
   a. Place wire seal over unstripped wire end.
   b. Strip 3/16” of insulation from wire.
   c. Place wire into terminal. Do not let wire fray out of crimp area and do not let wire extend beyond terminal crimp. Crimp terminal to secure wire. Do not over crimp so that terminal is deformed. Use the proper crimping tool.
   d. Solder ALL hand crimped terminals.
   e. Slide seal to terminal and crimp large wings around seal. Do not crimp ribs of seal under crimp wings.
3. Insert wire terminal into connector housing until terminals click in place. Terminals are keyed to fit in one direction; do not force terminal.
4. Fill empty socket(s) with plug(s).
5. When all wires are installed, push secondary lock over end of connector housing.
6. Splice other end of wire using techniques described previously.



16-3 Metri-Pack connector.



16-4 Weather-Pack connector.

Key Points & Notes

16-32

16-36

16-33

16-37

16-34

16-35

MODULE REVIEW ITEMS

Note to Technician: Consider all choices carefully and select the best answer to each.

1. When working on any part of the electrical system,
A. Reconnect the (+) when all connections are insulated.
B. Leave the (-) connected but remove the (+).
C. Take the battery out.
D. Disconnect the (-) before working.

2. Which is not good electrical component installation practice?
A. Guard the components from water and ice buildup.
B. Keep splices in close inaccessible quarters.
C. Place the dashboard meters within view of the driver.
D. Keep the wiring neat and orderly.

3. Which is good electrical component installation practice?
A. Mount the components on sound stable surfaces.
B. Mount switches in the most easily accessible areas.
C. Use looms and harnesses only if called for by the conversion manufacturer.
D. Mount the components only where the manufacturer's instructions say to.

4. Many electrical problems in new digital electronic systems are not caused by high-frequency electromagnetic waves.
A. True.
B. False.

5. Electronic control devices should be placed away from:
A. Plug wires and horns.
B. Only Ignition coils and antennas.
C. Only spark plugs and plug wires.
D. Electric motors but near radios.

6. Save only the OEM equipment schematics for future reference.
A. True.
B. False.

7. Don't interrupt the _____ circuits that may affect other components.
A. Power take-off.
B. GFI.
C. OEM.
D. Conversion unit.

8. _____ all connections before making them permanent.
A. Check.
B. Double check.
C. Triple check.
D. Disconnect.

9. Lay out and route the conversion system wiring in relation to OEM components before connecting LPG system wiring.
A. True.
B. False.

10. Which is not a valid consideration when wiring?
A. Leave extra wire for strain relief.
B. Route away from areas that will rub on the wires.
C. Keep wires at least 6" away from secondary ignition coils.
D. Secure wires with paper clips, ties, or both.

MRI SCORING KEY

1. D
2. B
3. A
4. B
5. A
6. B
7. C
8. C
9. A
10. D

1 **MODULE 16:**
Electrical Wiring, Connections, Protection & Routing

2 **OVERVIEW COMPONENT INSTALLATION**

- Disconnect the negative (-) battery cable before working on electrical system
- Mount components on sturdy surfaces
- Guard, shield from moisture, vibration
- Leave room for splices
- Wire neatly, use looms and harnesses
- Allow access to timing components
- Place dashboard meters in driver's view
- Mount switches within reach

3 **OVERVIEW COMPONENT INSTALLATION**

- Problems caused by resistance or interference
- Place control devices and wires away from secondary ignition coils, wires or spark plugs, electric motors, radios, horns, antennas
- Vehicle and LPG electrical schematics on hand
- Don't interrupt other OEM circuits
- Triple check all connections

4 **16-1 MOUNTED INTEGRATED PROCESSOR**

5 **WIRE ROUTING**

Considerations:

- Avoid hot spots, heat damage
- Stay 6" away from secondary ignition coils
- Don't route within OEM harnesses or hoses
- Stay away from sharp edges
- Allow extra wire length
- Wait to mount wires until system works
- Route wires in bundles
- Secure wires with clips, ties

6 **SPLICING**

- Splices and connections must be soldered and sealed
- Splicing by Western Union or tap splice
- Don't use pigtails or crimping connectors
- Connect grounds before power connections
- Connect to clean metal surfaces
- Verify connection with voltmeter

7 **16-2 WESTERN UNION SPLICE**

8 **16-2A TAP SPLICE**

9 **SPLICING**

1. Strip 1" of insulation without cutting strands
- Cut enough heat shrink to overlap insulations
- Slide on heat shrink away from soldering area

2. Twist wires together

10 **SPLICING**

3. Heat, clean, and tin solder gun tip
- Wipe hot tip on damp sponge to clean
- Melt a little solder on tip to tin

- Non-electrical gas-powered soldering guns are preferred

11 **SPLICING**

4. Heat wire joint on one end of twist
- Place solder so it flows through joint toward tip
- Solder completely, without globing it up
- Check solder penetrates thoroughly
- Resolder cold joints or cracked connections

5. Keep splice still and let it cool

12 **SPLICING**

6. Slip heat shrink tubing over joint when cool
- Apply heat to shrink tubing
- Don't use open flames

7. Enclose wires with split-loom tubing and tape after system works

13 **SPLICE STEP 1**
CUT OEM WIRE

14 **SPLICE STEP 2**
STRIP INSULATION

15 **SPLICE STEP 3**
TWIST TOGETHER OEM & TAP WIRES

16 **SPLICE STEP 4**
SLIP HEAT SHRINK OVER WIRES

17 **SPLICE STEP 5**
PREP SOLDER TIP

18 **SPLICE STEP 6**
MELT SOLDER ON TIP

19 **SPLICE STEP 7**
HEAT WIRE

20 **SPLICE STEP 8**
SLIP HEAT SHRINK OVER CONNECTION

21 **SPLICE STEP 9**
HEAT THE SHRINK TUBING

22 **INTERCEPT STEP 1**
TWIST WIRE ENDS TOGETHER

23 **INTERCEPT STEP 2**
HEAT CONNECTION

24 **INTERCEPT STEP 3**
INSTALL SHRINK WRAP

25 **CONTINUITY STEP 1**
CHECK METER

26 **CONTINUITY STEP 2**
METER CONNECTED TO CIRCUIT

27 **TAP STEP 1**
CUT INSULATION

28 **TAP STEP 2**
MAKE TAP CONNECTION

29 **TAP STEP 3**
SOLDER CONNECTION

30 **TAP STEP 4**
WRAP COLD SHRINK TAPE

31 **TAP STEP 5**

FINISHED TAP

32 **WIRE AND CONNECTOR ASSEMBLY**

1. Use proper gauge wire and cut to length
- Allow extra wire for splices, terminals, routing

33 **WIRE AND CONNECTOR ASSEMBLY**

2. Attach connector terminal to wire end
- Place wire seal over unstripped wire end
- Strip 3/16” insulation
- Place wire into terminal and crimp using crimp tool
- Solder all hand crimped terminals
- Slide seal to terminal and crimp wings around seal

34 **WIRE AND CONNECTOR ASSEMBLY**

3. Insert wire terminal into connector housing until terminals click in place
- Do not force terminal

4. Fill empty sockets with plugs

35 **WIRE AND CONNECTOR ASSEMBLY**

5. When all wires installed, push secondary lock over connecting housing end

6. Splice other end of wire following same instructions

36 **16-3 METRI-PACK CONNECTOR**

37 **16-4 WEATHER-PACK CONNECTOR**

MODULE 16:
Electrical Wiring, Connections, Protection & Routing

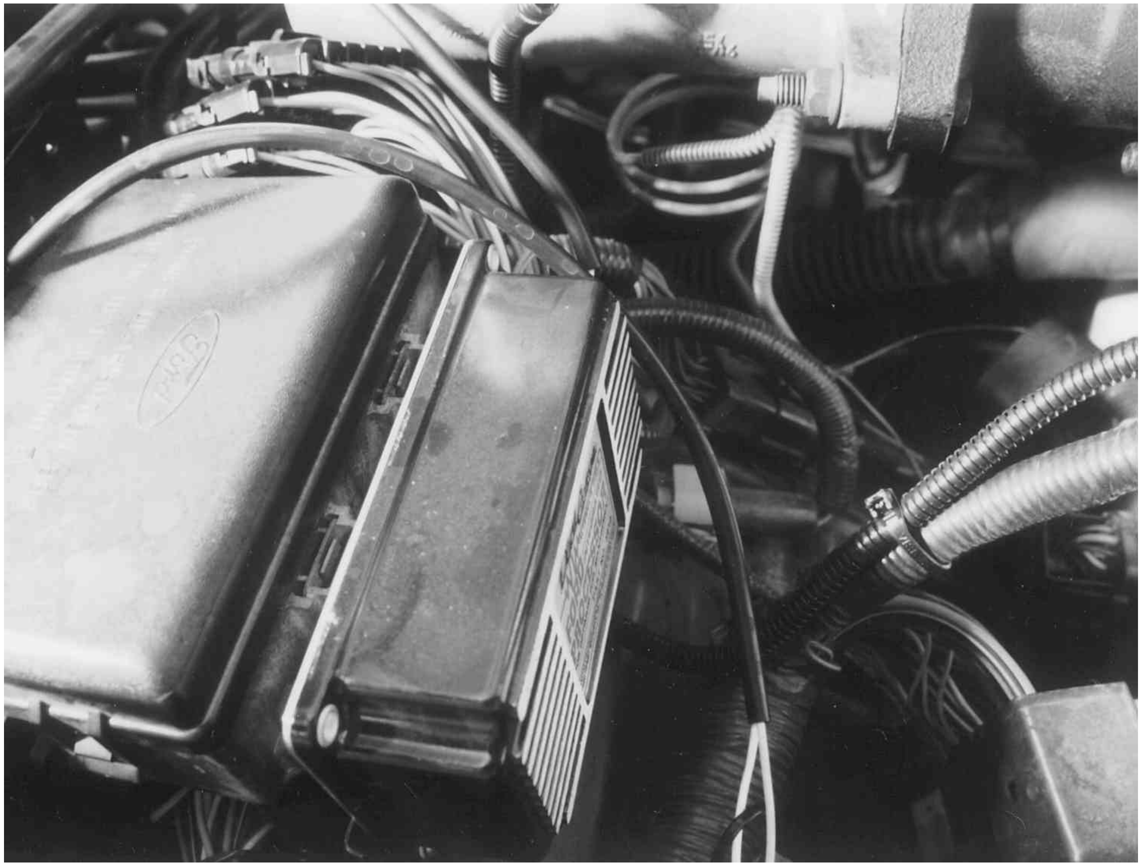
OVERVIEW COMPONENT INSTALLATION

- Disconnect the negative (-) battery cable before working on electrical system
- Mount components on sturdy surfaces
- Guard, shield from moisture, vibration
- Leave room for splices
- Wire neatly, use looms and harnesses
- Allow access to timing components
- Place dashboard meters in driver's view
- Mount switches within reach

OVERVIEW COMPONENT INSTALLATION

- Problems caused by resistance or interference
- Place control devices and wires away from secondary ignition coils, wires or spark plugs, electric motors, radios, horns, antennas
- Vehicle and LPG electrical schematics on hand
- Don’t interrupt other OEM circuits
- Triple check all connections

16-1 MOUNTED INTEGRATED PROCESSOR



Courtesy of GFI

WIRE ROUTING

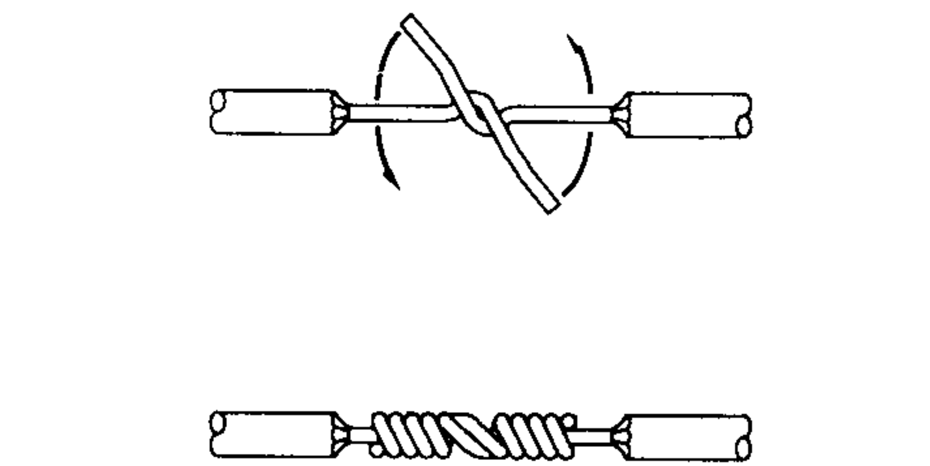
Considerations:

- Avoid hot spots, heat damage
- Stay 6” away from secondary ignition coils
- Don’t route within OEM harnesses or hoses
- Stay away from sharp edges
- Allow extra wire length
- Wait to mount wires until system works
- Route wires in bundles
- Secure wires with clips, ties

SPLICING

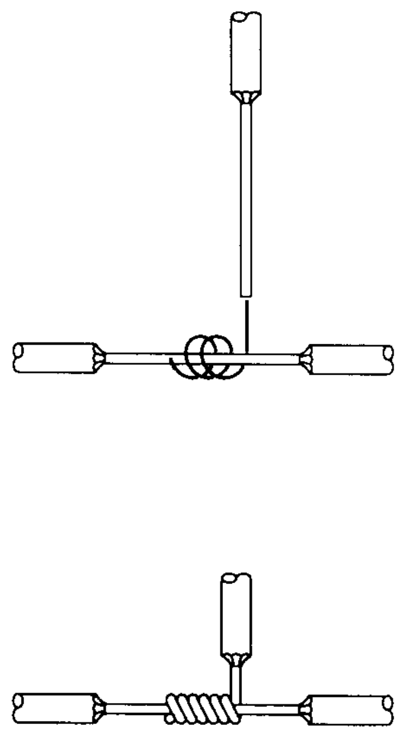
- Splices and connections must be soldered and sealed
- Splicing by Western Union or tap splice
- Don’t use pigtails or crimping connectors
- Connect grounds before power connections
- Connect to clean metal surfaces
- Verify connection with voltmeter

16-2 WESTERN UNION SPLICE



Courtesy of GFI

16-2A TAP SPLICE



Courtesy of GFI

SPLICING

1. Strip 1” of insulation without cutting strands
- Cut enough heat shrink to overlap insulations
- Slide on heat shrink away from soldering area

2. Twist wires together

SPLICING

3. Heat, clean, and tin solder gun tip

- Wipe hot tip on damp sponge to clean
- Melt a little solder on tip to tin
- Non-electrical gas-powered soldering guns are preferred

SPLICING

4. Heat wire joint on one end of twist
- Place solder so it flows through joint toward tip
- Solder completely, without globing it up
- Check solder penetrates thoroughly
- Resolder cold joints or cracked connections

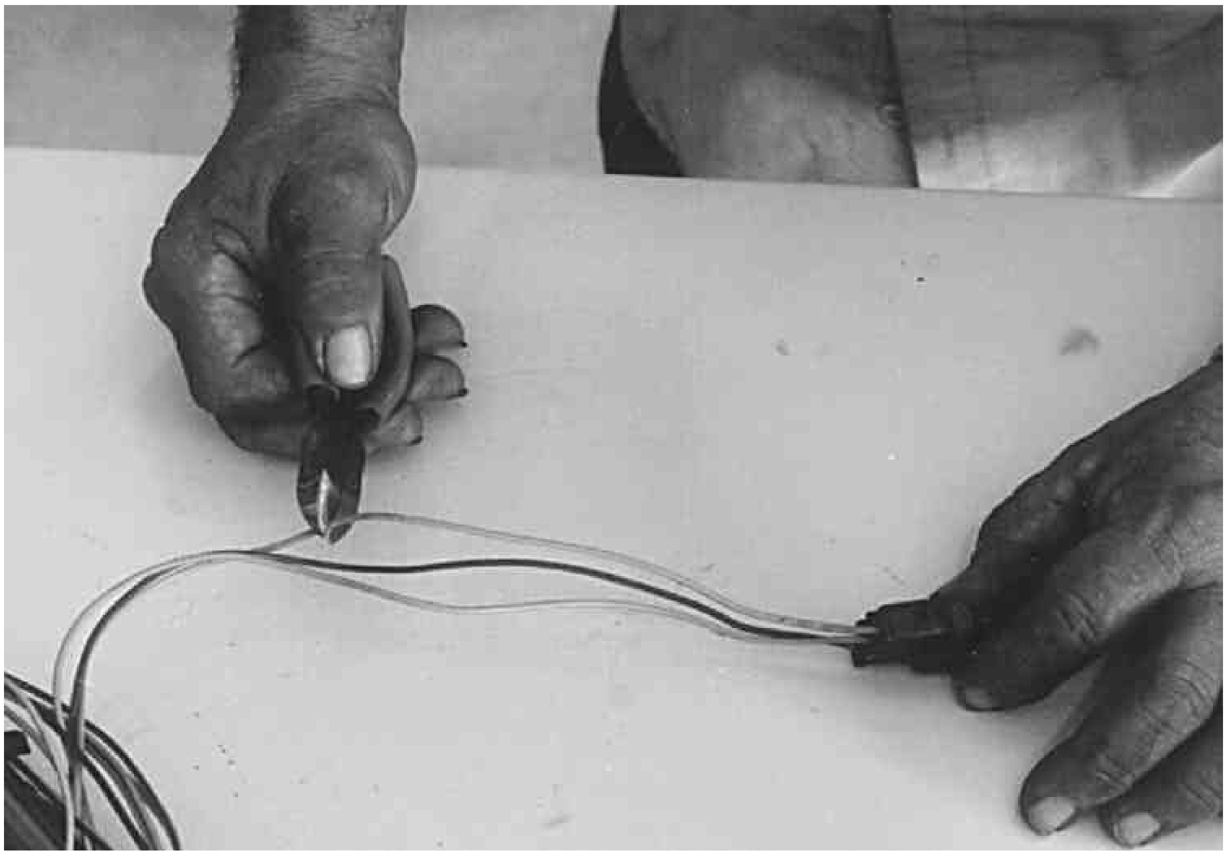
5. Keep splice still and let it cool

SPLICING

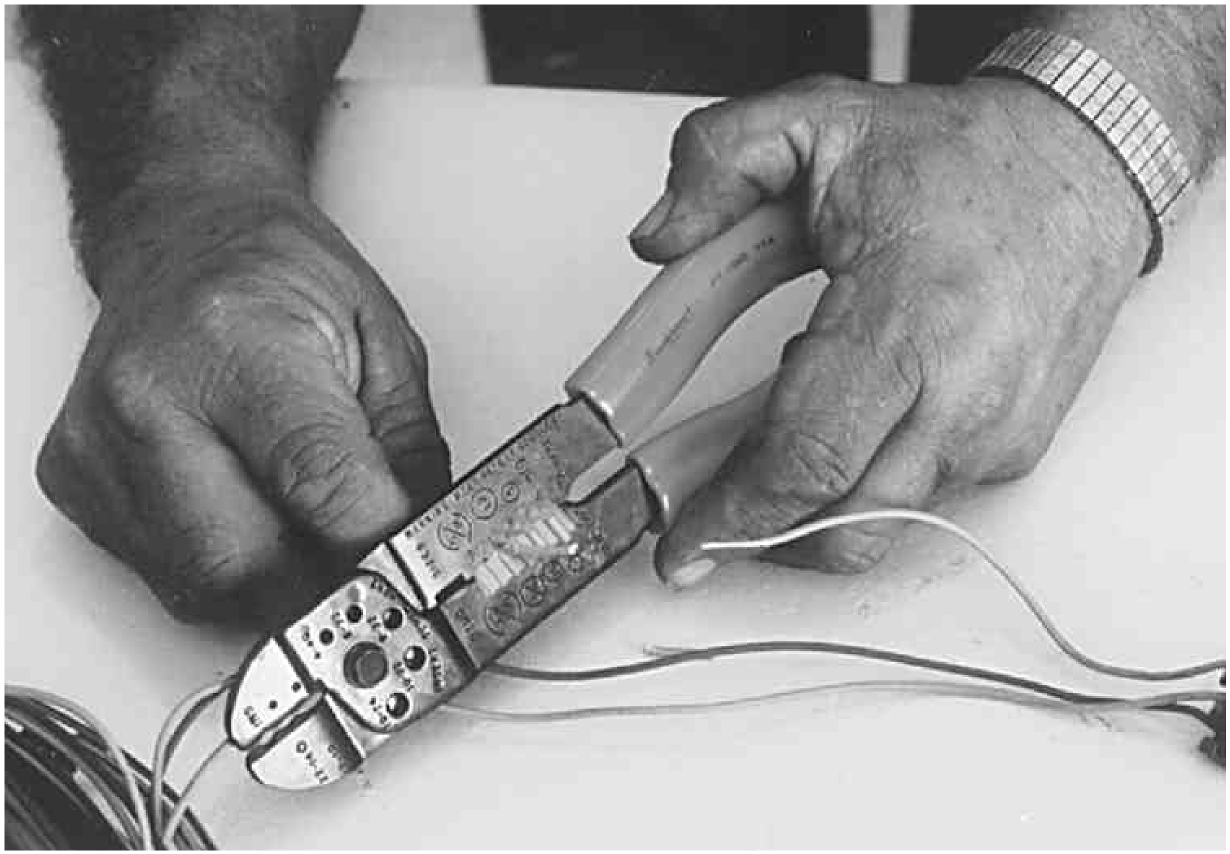
6. Slip heat shrink tubing over joint when cool
- Apply heat to shrink tubing
- Don’t use open flames

7. Enclose wires with split-loom tubing and tape after system works

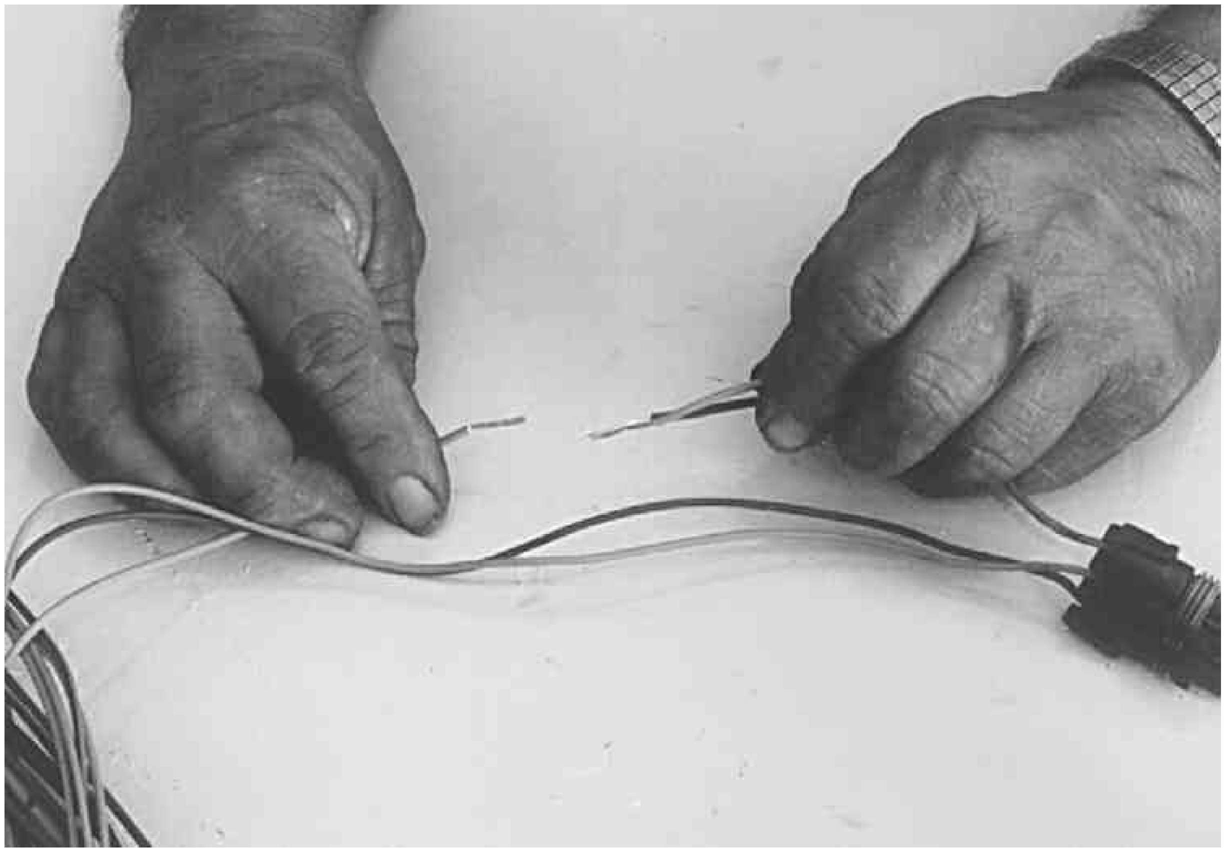
SPLICE STEP 1
CUT OEM WIRE



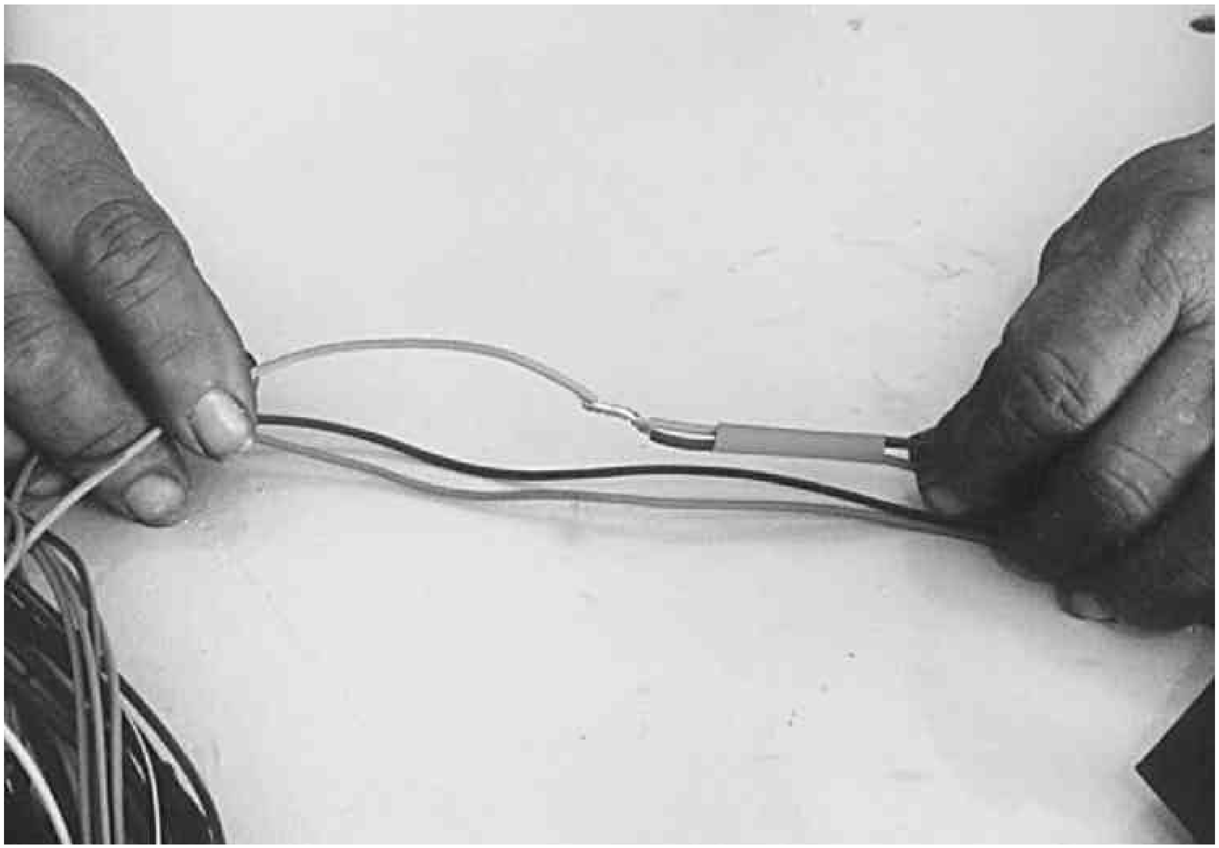
SPLICE STEP 2
STRIP INSULATION



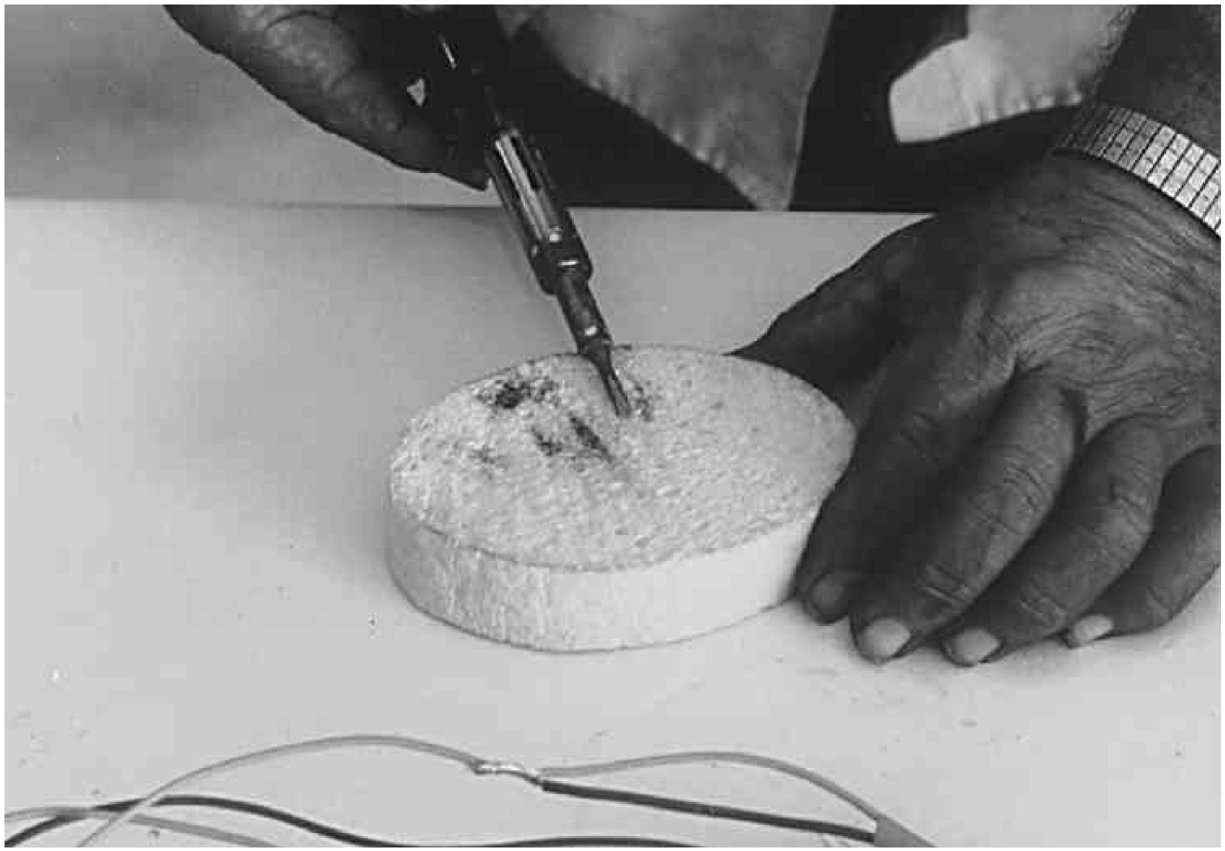
SPLICE STEP 3
TWIST TOGETHER OEM & TAP WIRES



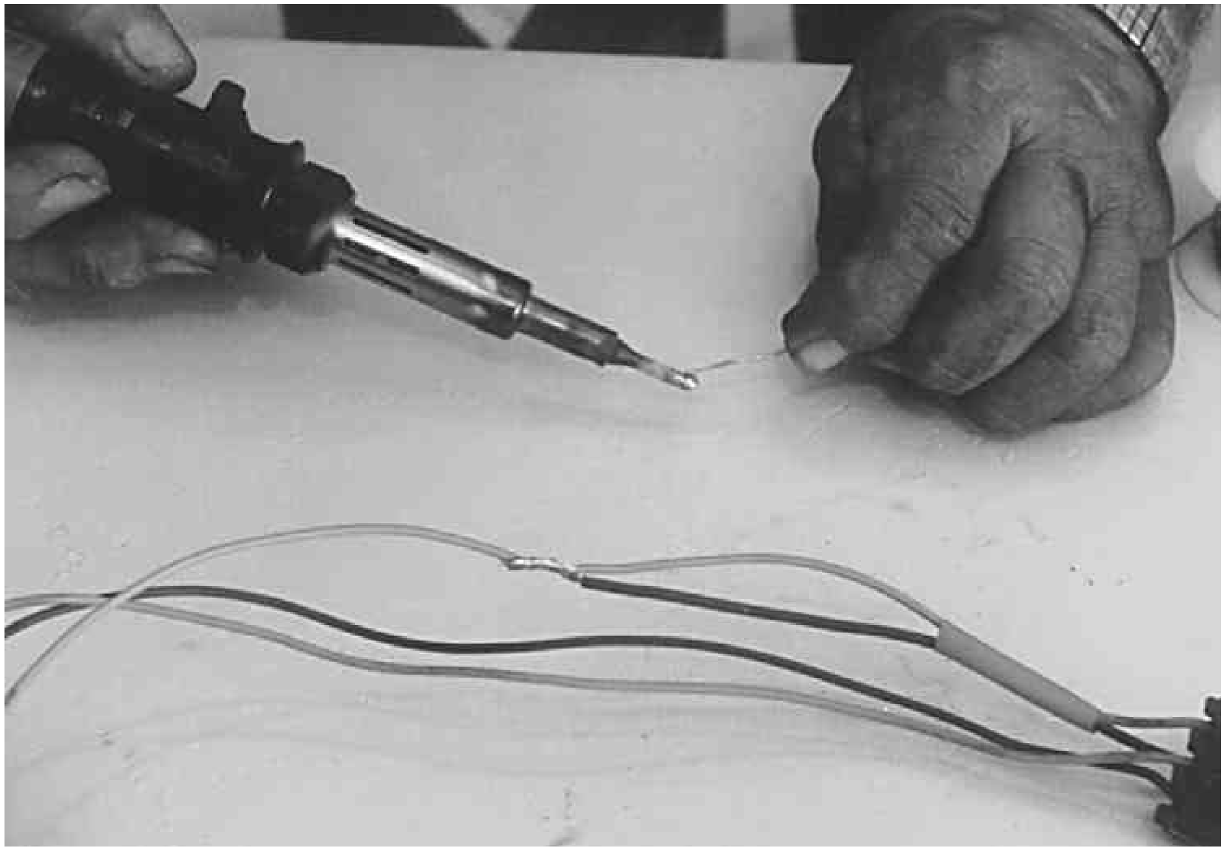
SPLICE STEP 4
SLIP HEAT SHRINK OVER WIRES



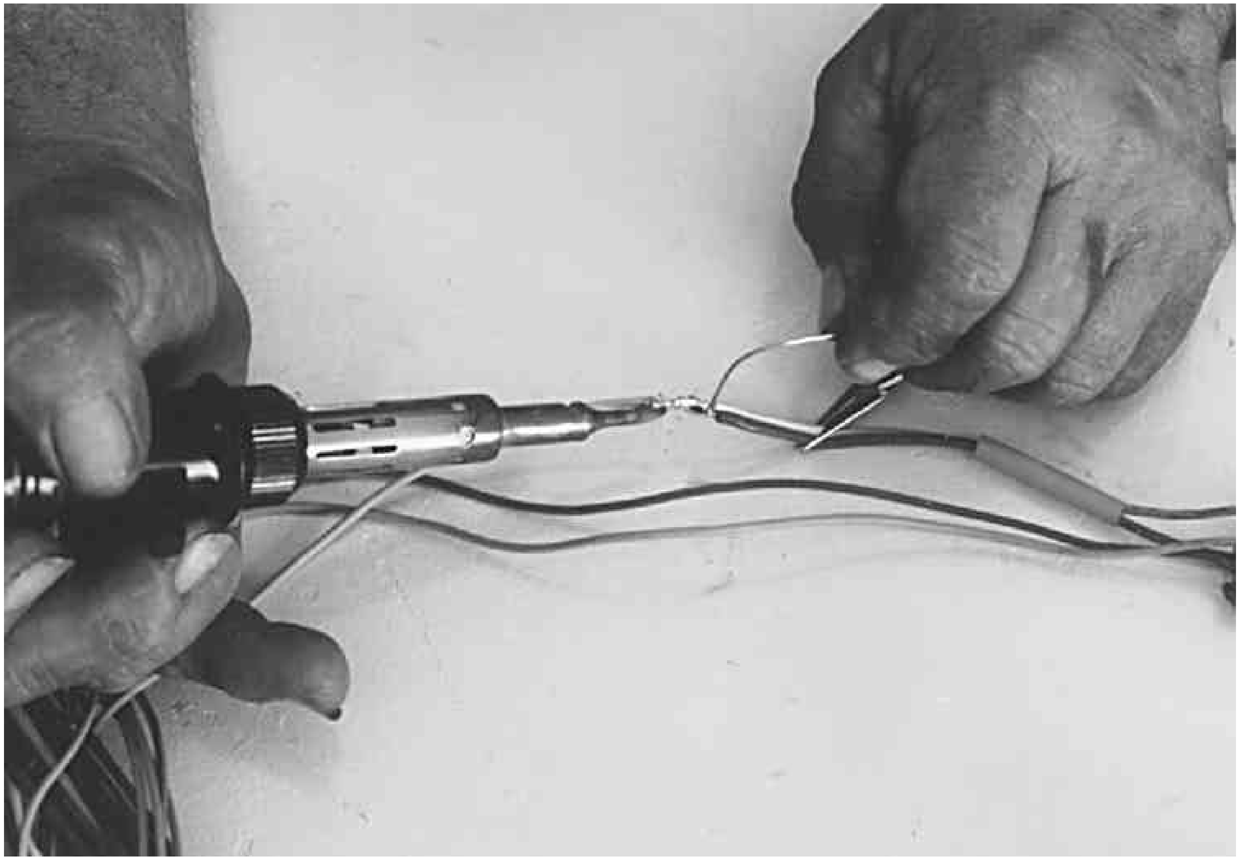
SPLICE STEP 5
PREP SOLDER TIP



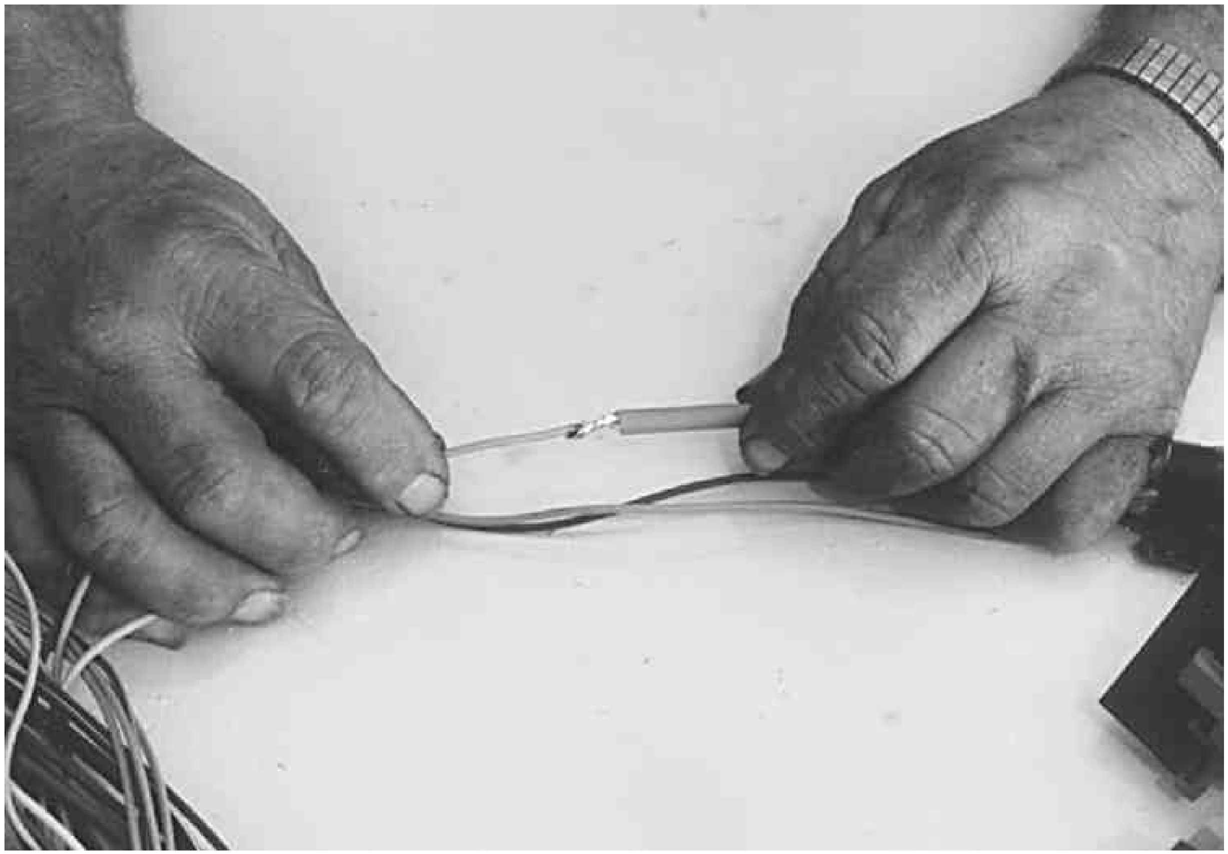
SPLICE STEP 6
MELT SOLDER ON TIP



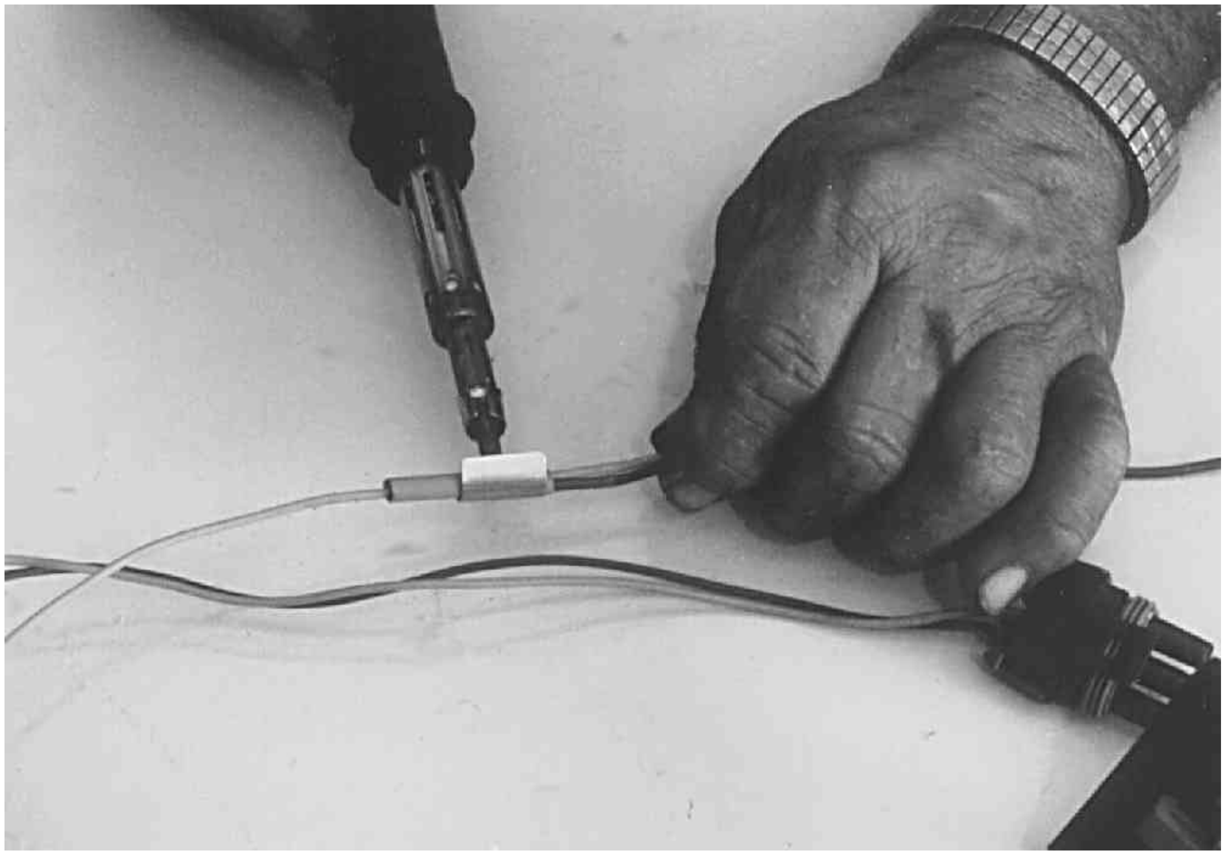
SPLICE STEP 7
HEAT WIRE



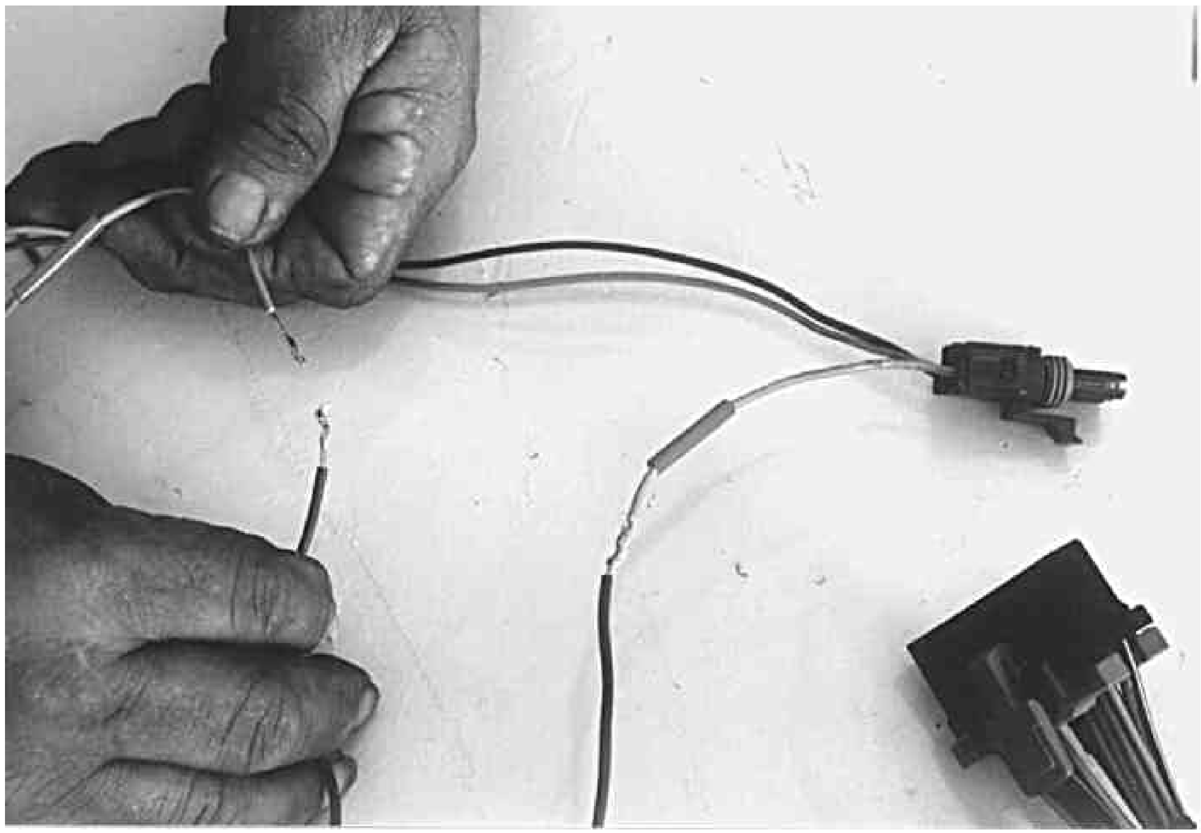
SPLICE STEP 8
SLIP HEAT SHRINK OVER CONNECTION



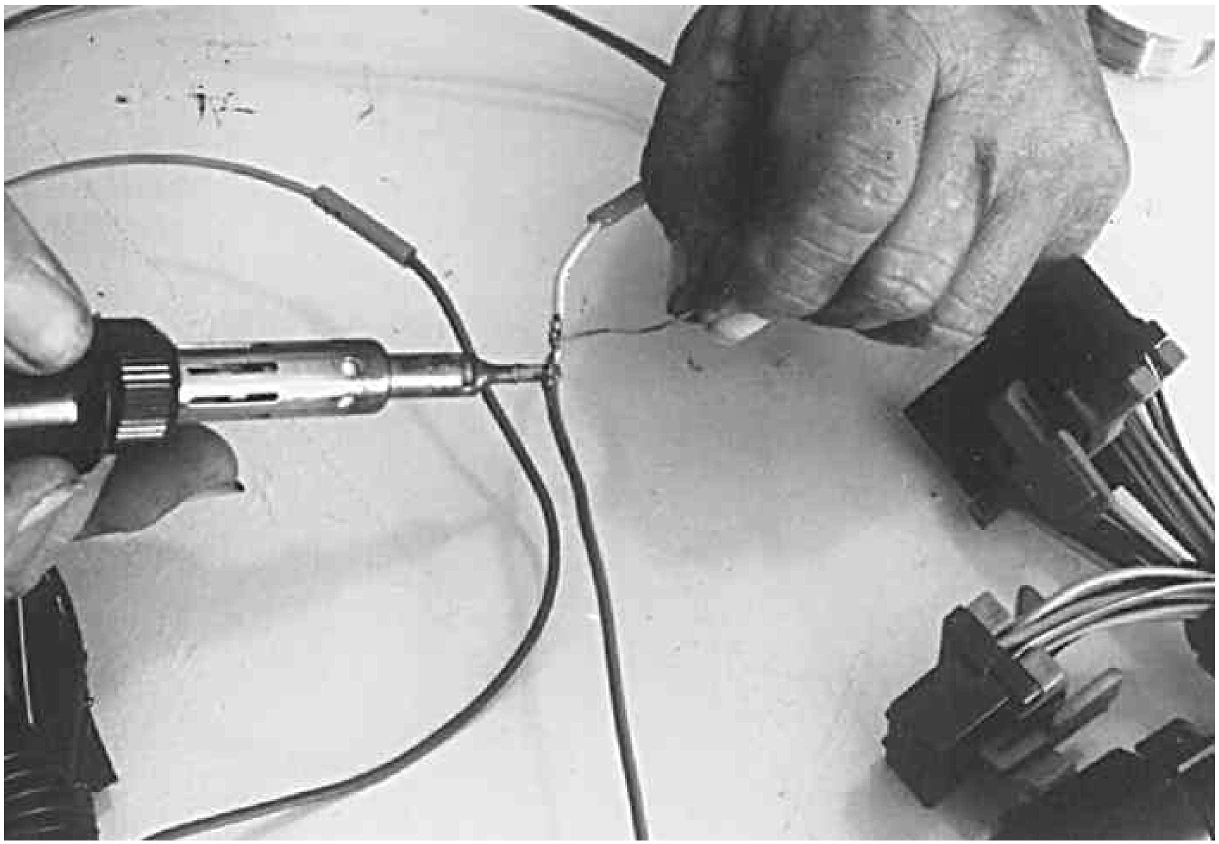
SPLICE STEP 9
HEAT THE SHRINK TUBING



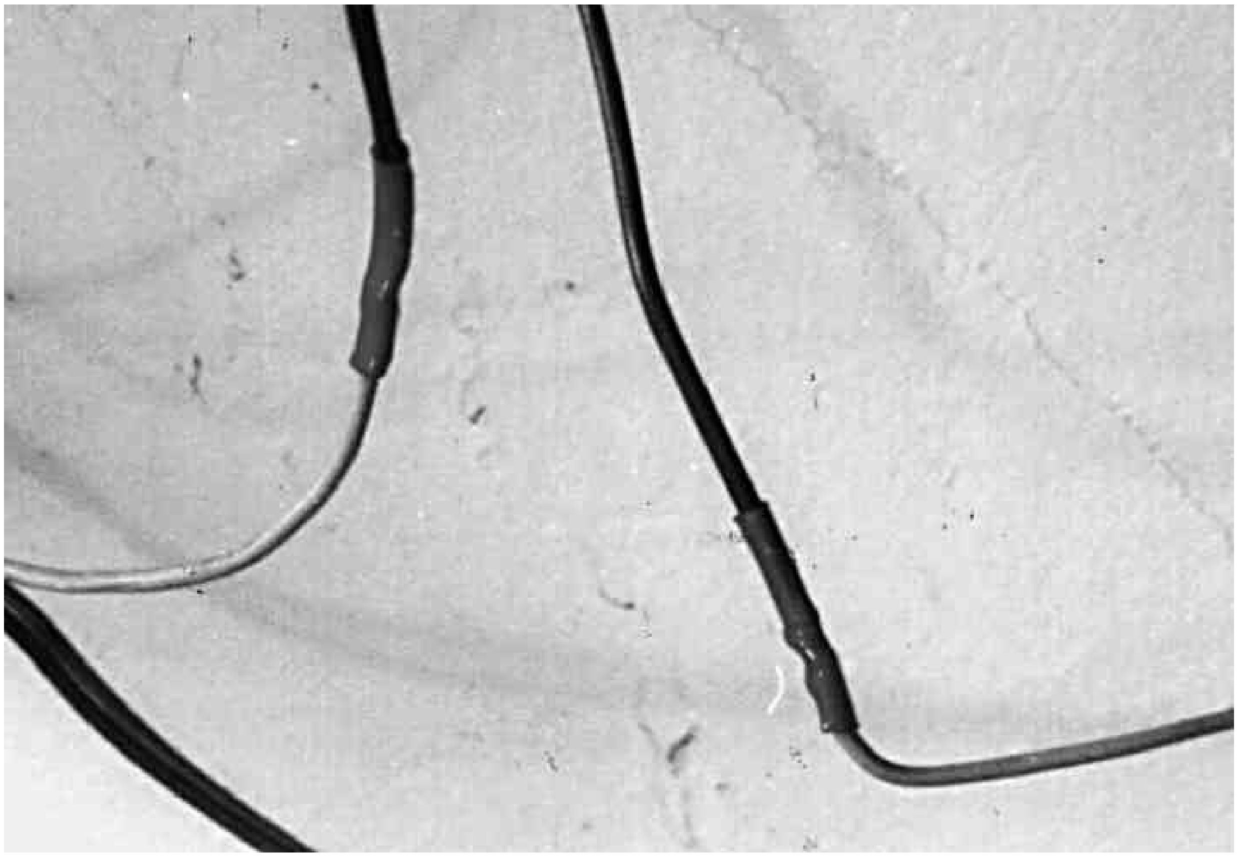
INTERCEPT STEP 1
TWIST WIRE ENDS TOGETHER



INTERCEPT STEP 2
HEAT CONNECTION

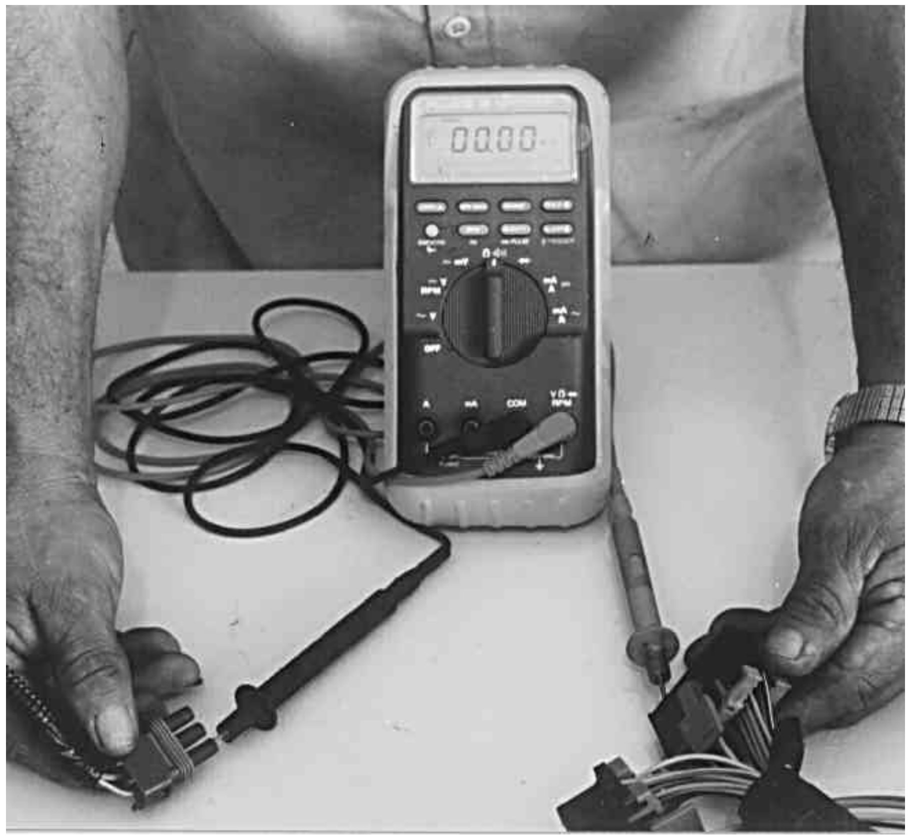


INTERCEPT STEP 3
INSTALL SHRINK WRAP

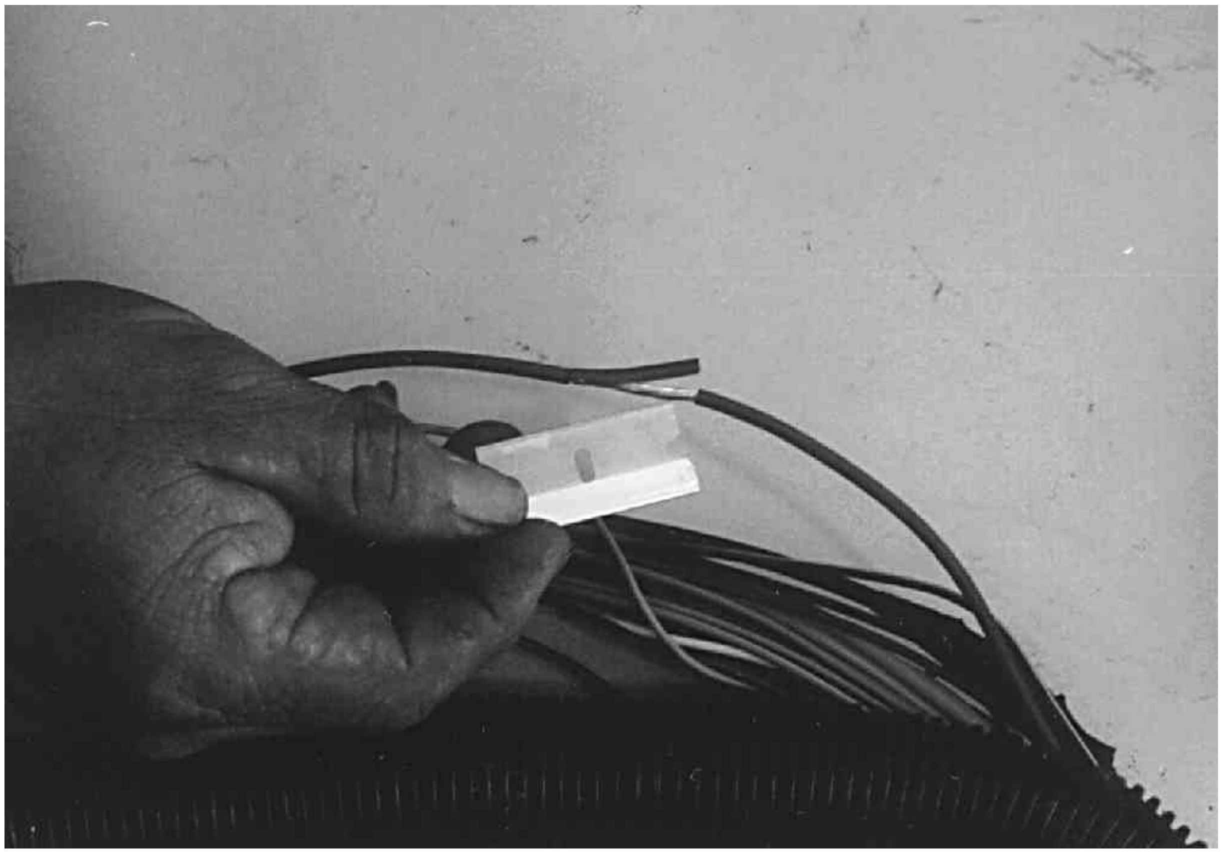


CONTINUITY STEP 1
CHECK METER

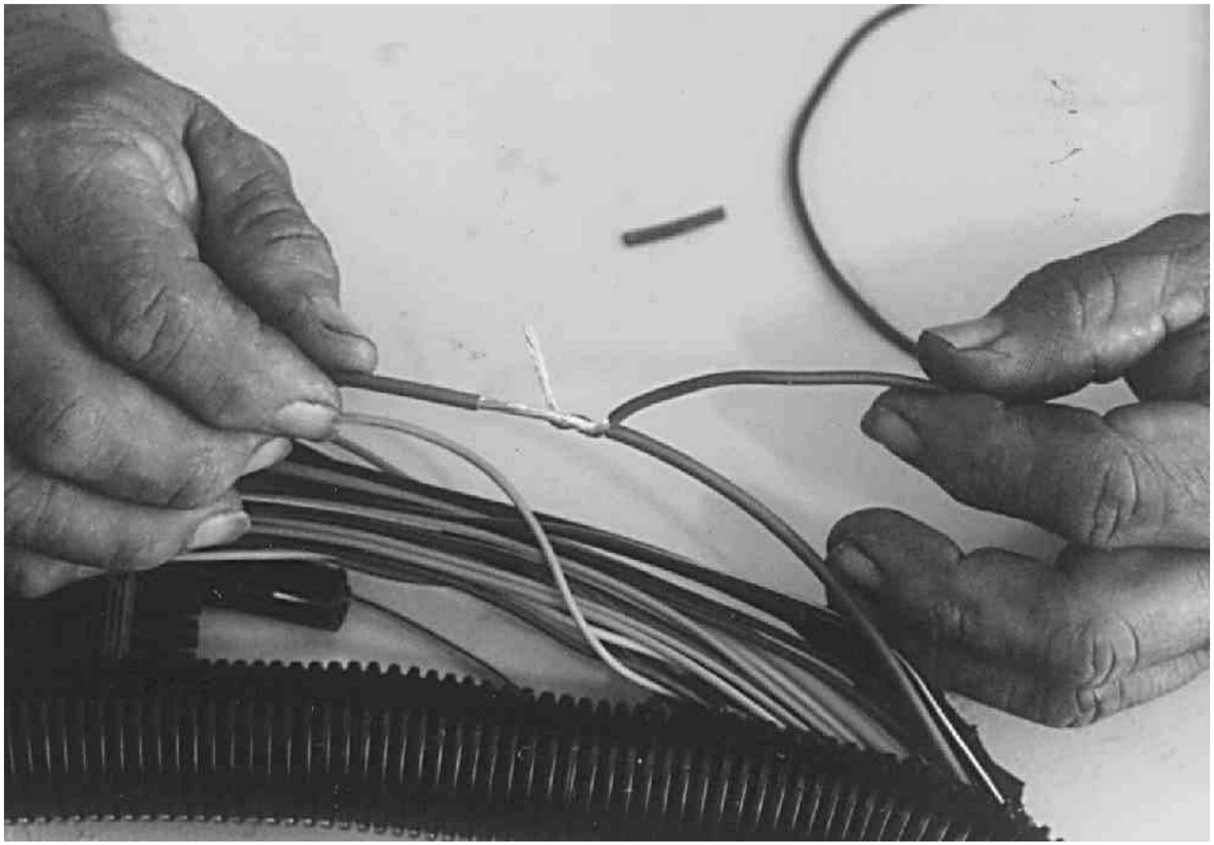
CONTINUITY STEP 2
METER CONNECTED TO CIRCUIT



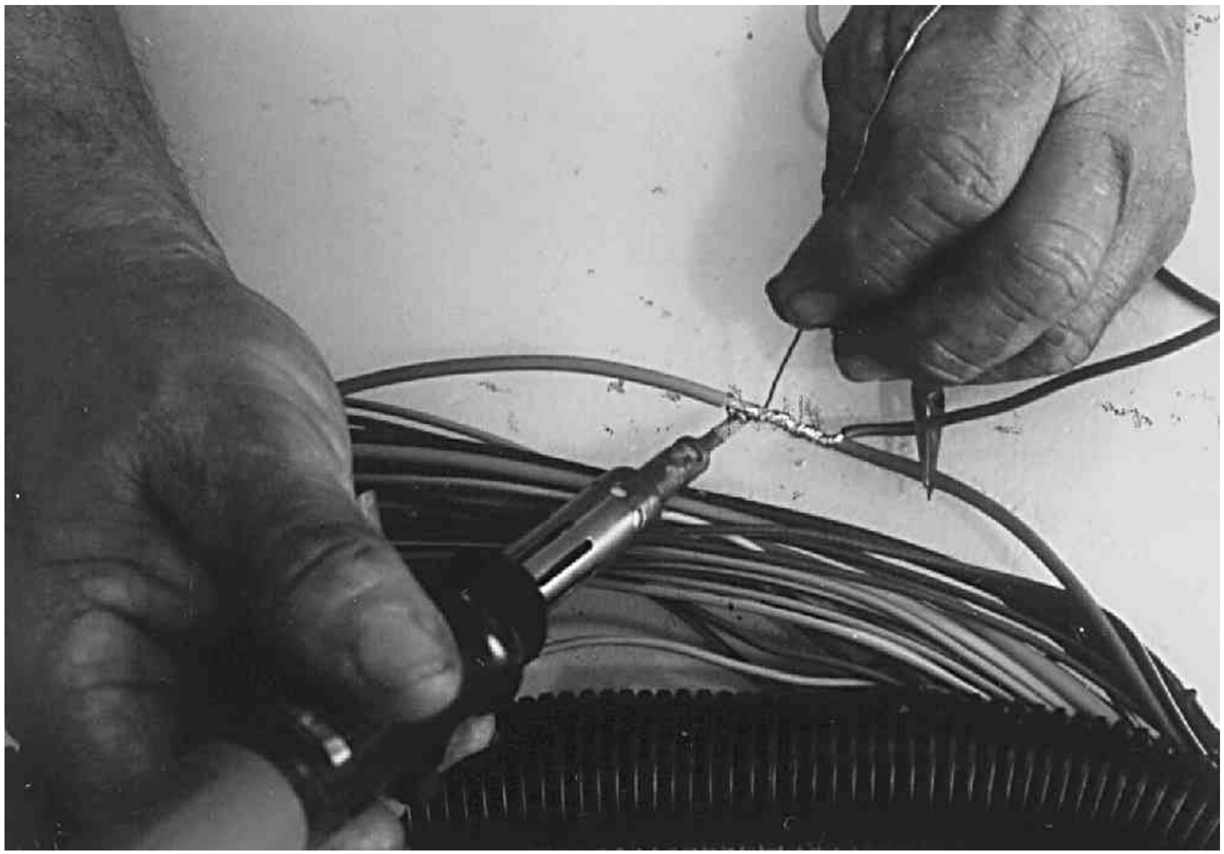
TAP STEP 1
CUT INSULATION



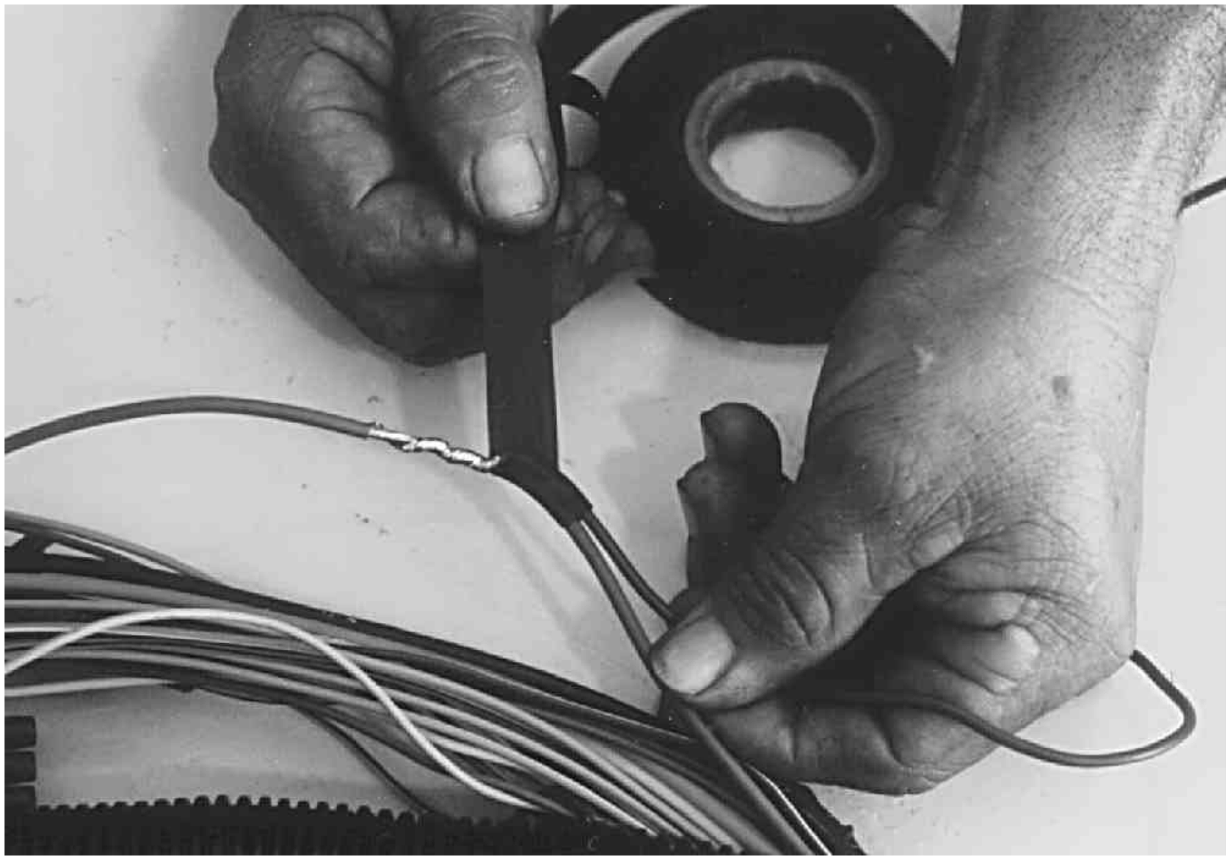
TAP STEP 2
MAKE TAP CONNECTION



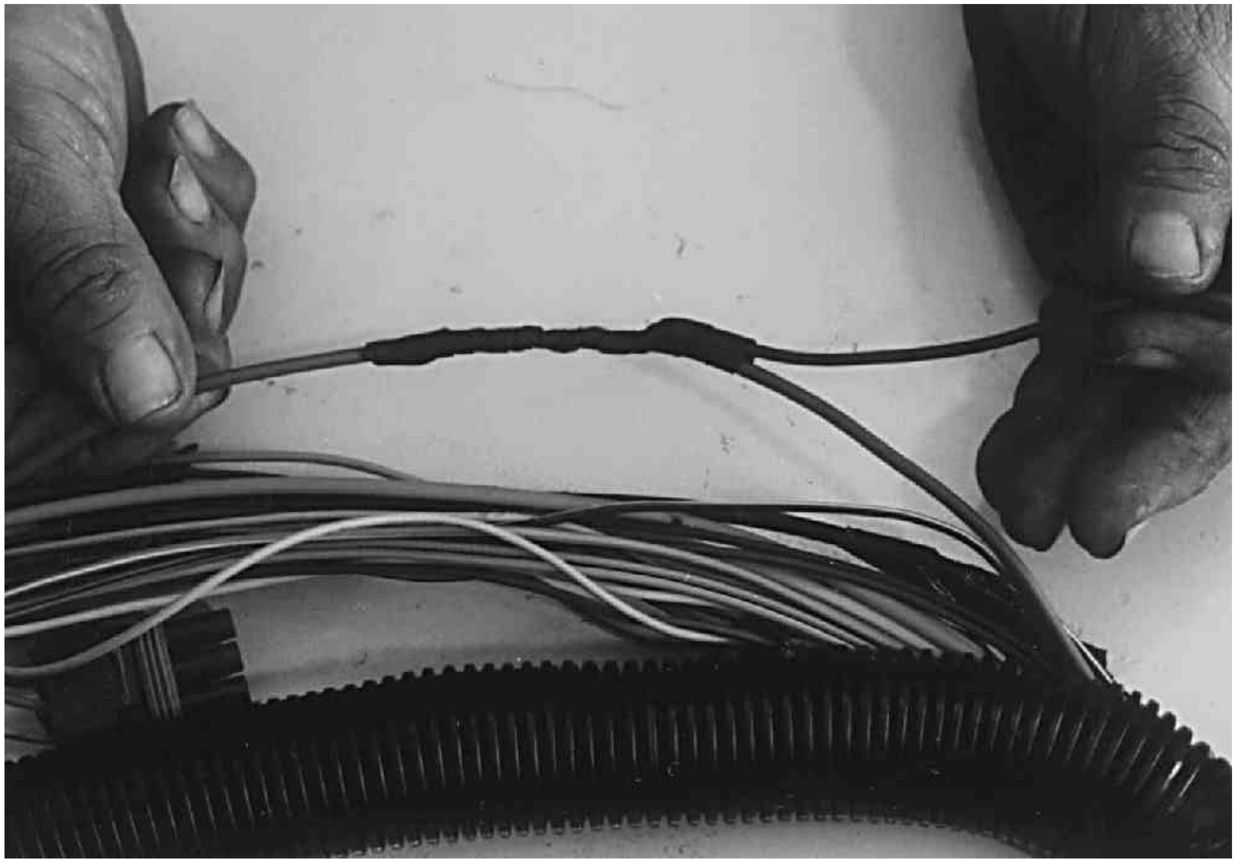
TAP STEP 3
SOLDER CONNECTION



TAP STEP 4
WRAP COLD SHRINK TAPE



TAP STEP 5
FINISHED TAP



WIRE AND CONNECTOR ASSEMBLY

1. Use proper gauge wire and cut to length

- Allow extra wire for splices, terminals, routing

WIRE AND CONNECTOR ASSEMBLY

2. Attach connector terminal to wire end

- Place wire seal over unstripped wire end
- Strip 3/16” insulation
- Place wire into terminal and crimp using crimp tool
- Solder all hand crimped terminals
- Slide seal to terminal and crimp wings around seal

WIRE AND CONNECTOR ASSEMBLY

3. Insert wire terminal into connector housing until terminals click in place

- Do not force terminal

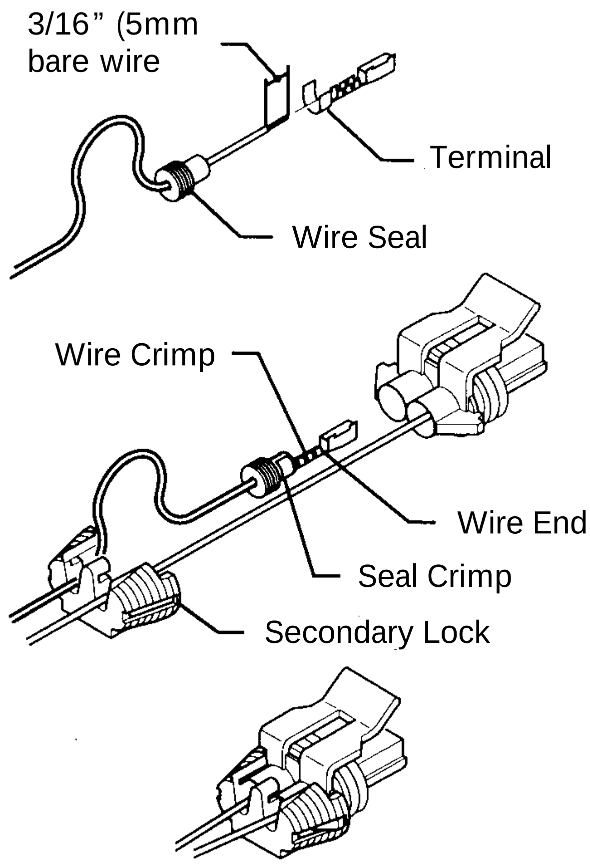
4. Fill empty sockets with plugs

WIRE AND CONNECTOR ASSEMBLY

5. When all wires installed, push secondary lock over connecting housing end

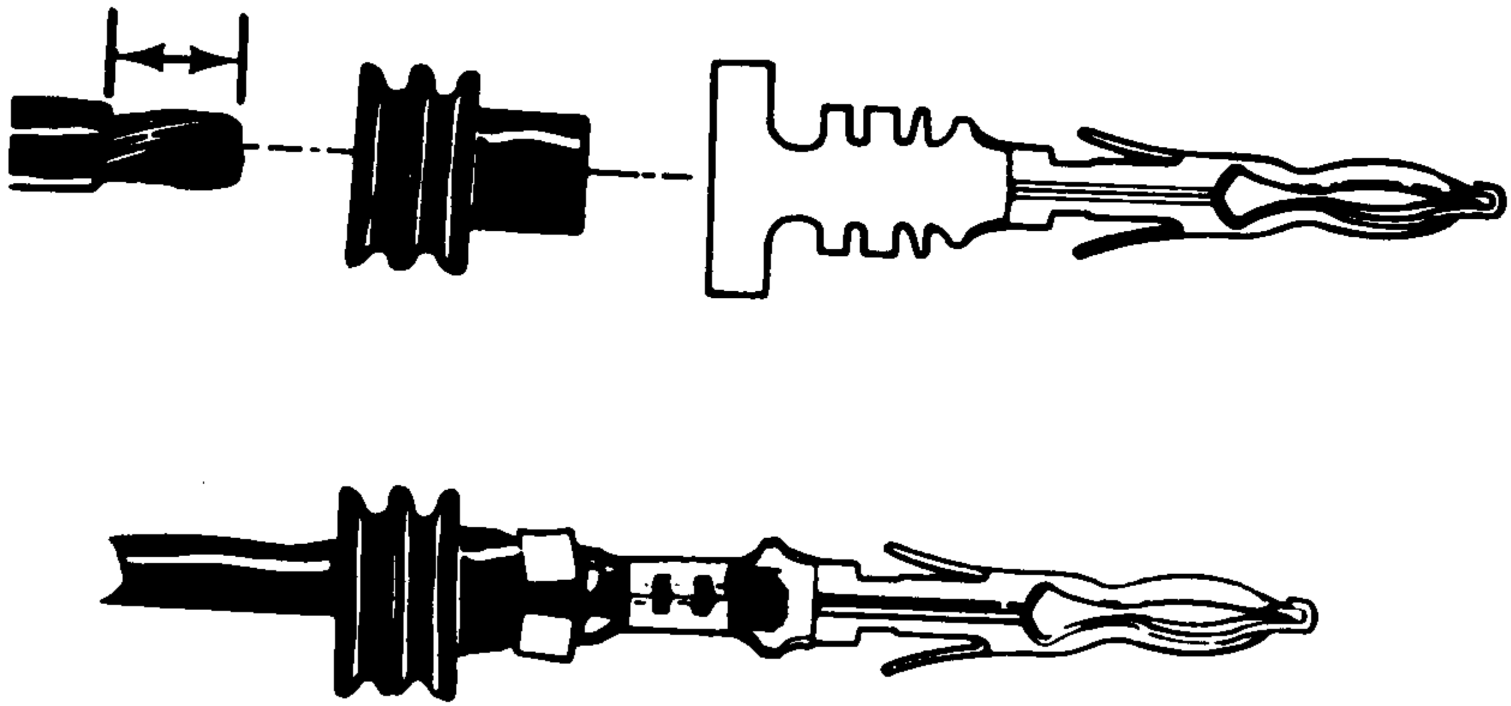
6. Splice other end of wire following same instructions

16-3 METRI-PACK CONNECTOR



Courtesy of GFI

16-4 WEATHER-PACK CONNECTOR



Courtesy of Oklahoma Dept. of Vocational & Technical Education

MODULE 17:

Fuel Switching & Level Monitoring

State of Oklahoma
College of the Desert
West Virginia University

MODULE 17: FUEL SWITCHING & LEVEL MONITORING

CONTENTS

MODULE 17: FUEL SWITCHING & LEVEL MONITORING

OBJECTIVES

At the completion of this module, the technician will be able to:

- Discuss the installation of fuel switching and sending components.
- Properly mount the fuel gauge and fuel switch.

INSTRUCTOR NOTES

INSTRUCTOR MATERIALS/MEDIA NEEDED

Overhead projector or LCD panel/projection equipment
Master overhead transparencies or Microsoft PowerPoint 4.0 presentation file Mod17.ppt

Note: Slides correspond to text as indicated by icon

STUDENT MATERIALS/MEDIA NEEDED

Module 17: Fuel Switching & Level Monitoring

MODULE REVIEW ITEMS

The Module Review Items (MRI) are designed to allow for flexibility in their use. The exam may be utilized as a post-module review, pre/post test, part of a term examination, or it may be used by the student if the module is used as a self study text.

MASTER OVERHEAD TRANSPARENCIES

The printouts enclosed with this module are taken from the Microsoft PowerPoint 4.0 presentation file Mod17.ppt . Instructors planning to use overhead projectors should make transparencies from these printouts on a copier (or laser printer designed to safely print to acetate.

Note: Please review Module 25: Training of Trainers for more hints on instructional needs and strategies.

MODULE 17: FUEL SWITCHING & LEVEL MONITORING

OVERVIEW OF FUEL SWITCHING AND LEVEL MONITORING

Key Points & Notes

17-2

This section covers the mounting and integration of fuel switching and sending components. By installing a sender on the propane tank, fuel level can be monitored by a magnetic sensor and wired to a gauge. Either a separate or the OEM dash gauge may be used. If the OEM gauge is used, the propane sender is connected to the OEM circuit. The sender must match the resistance value of the OEM gauge.

As with all automotive circuits, solder, heat shrink, and secure all wires and connectors. When mounting switches and gauges, take care when drilling into OEM panels. Route wiring securely away from high frequency radio signals. Follow manufacturers' instructions. Check all circuits for continuity and voltage with a DVOM.

FUEL GAUGE INSTALLATION PROCEDURE

PROPANE FUEL LEVEL

17-3

17-4

The installation requires mounting a two-wire sender onto the tank that magnetically couples to the float mechanism in the tank. The original non-electrical tank sensor may have to be removed and replaced with the new sender. The sender contains a potentiometer in the range of 15 to 160 ohms. Often a two-pin connector assembly is provided to allow sender to be easily diconnected. Refer to Figure 17-1.

17-1 Remote fuel level sender – magnetic type.

MATCHING GAUGE TO VEHICLE

17-5

Below are OHM ratings for senders typically found.

1989 Ford 70 – 10 Ω

1987 – 1995 Ford 10 – 160 Ω

1995 GMC 0 – 90 Ω

1988 Chrysler 70 – 10 Ω

1989 – 92 Chrysler 110 – 10 Ω

1992 – 1995 Chrysler 95 – 5 Ω

All GFI 15 – 60 Ω

All remote receivers 0 – 90 Ω

GAUGE MOUNTING

17-6

Gauges should be mounted where visible and close to fuel switch, if installed. Brackets are available to mount both the gauge and switch.

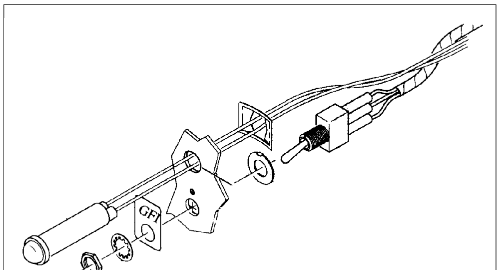
FUEL SWITCH INSTALLATION PROCEDURE

MANUAL CONTROL

Route the wiring connections to the dual-fuel control switch on the dash. Refer to Figure 17-2. Use solder type connectors and heat shrink.

Route all wires through a loom and secure with tie straps. Wiring should never be left loose or exposed. Follow manufacturer's installation instructions.

The fuel switch and indicator light are mounted inside the vehicle. Actual location varies from vehicle to vehicle and is dependent on available room (generally on the dash). Mount the switch and light close to each other and in a position for easy access for the operator. A typical installation is shown.

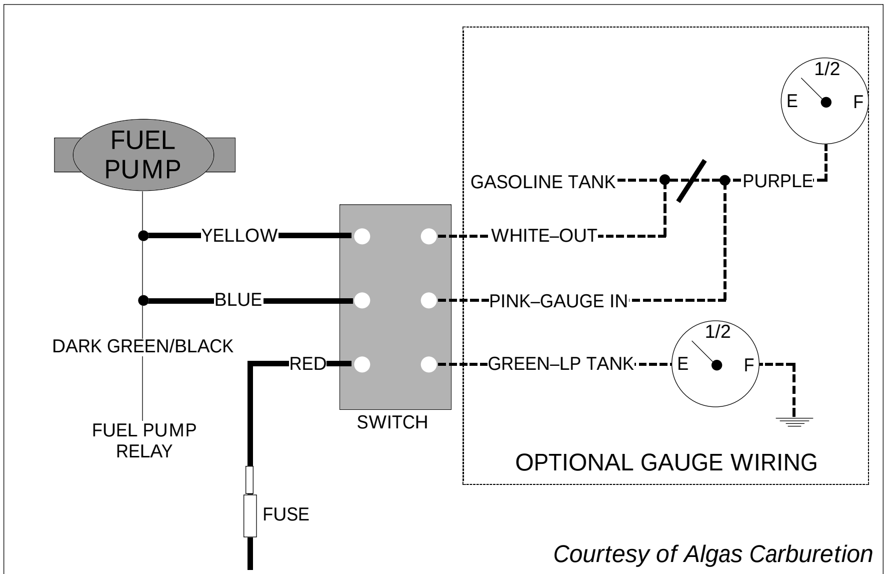


Courtesy of GFI

17-2 Dash mounted fuel switch and light.

Install the light and switch assemblies in the dash and route wires through firewall.

> **NOTE:** The pin numbers of the wires on the switch assembly should be are marked on the ends for proper connector assembly. Refer to Figure 17-3. Be sure to connect the sender wires to the correct OEM sender and gauge wires. Do not connect sender wires to 12 volt source unless instructed. Use DVOM to verify circuit voltage. All grounds must be clean and secure. Use DVOM to prove continuity.



Courtesy of Algas Carburetion

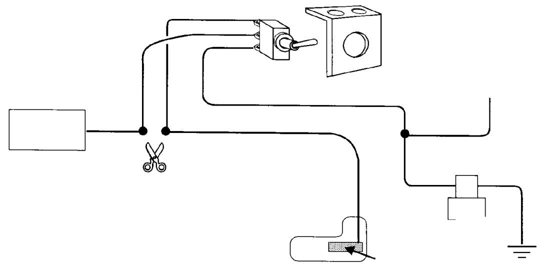
17-3 OEM and remote LPG fuel level sensor interface.

Key Points & Notes

17-7

17-8

17-9



Courtesy of Autotronic Controls

17-4 Typical manual fuel switch installation.

Key Points & Notes

17-10

AUTOMATIC SWITCHING

Some systems integrate automatic fuel switching with their processers. These systems are wired through the processor and switch to gasoline if the propane level drops. When refilled, the system automatically switches back to propane operation.

17-11

Key Points & Notes

MODULE REVIEW ITEMS

Note to Technician: Consider all choices carefully and select the best answer to each.

1. A _____ on the propane tank allows magnetic sensors to monitor the fuel level.
A. Wire.
B. OEM gauge.
C. OEM circuit.
D. Sender.

2. The sender must duplicate the resistance value of the OEM gauge.
A. True.
B. False.

3. The original non-electrical tank sensor is not to be removed if a new sender is used.
A. True.
B. False.

4. The sender potentiometer range is from:
A. 20-100 ohms.
B. 15-200 ohms.
C. 15-160 ohms.
D. 20-200 ohms.

5. The sender ohm range on all GFI units is:
A. 15-160 ohms.
B. 15-60 ohms.
C. 20-60 ohms.
D. 0-60 ohms.

6. The sender ohm range on all remote receivers is:
A. 0-60 ohms.
B. 0-90 ohms.
C. 20-100 ohms.
D. 15-160 ohms.

7. The gauge should be mounted _____ and _____ the fuel switch.
A. Visible; close to.
B. Apart from; close to.
C. Upright; away from.
D. Under the dash; next to.

8. Wiring should be left loose and exposed for servicing.
A. True.
B. False.

9. The fuel switch and indicator light are mounted...
A. On the roof.
B. Under the dash.
C. In the glove compartment.
D. Inside the vehicle.

10. Do not connect the sender wires to a 12 volt source unless instructed to do so.
A. True.
B. False.

MRI SCORING KEY

1. D
2. A
3. B
4. C
5. B
6. B
7. A
8. B
9. D
10. A

1 **MODULE 17:**
Fuel Switching & Level Monitoring

2 **OVERVIEW OF FUEL SWITCHING AND LEVEL MONITORING**

- Tank sender monitors fuel level by a magnetic sensor
- Use OEM or custom dash gauge
- OEM gauge and sender resistances must match
- Solder, heatshrink, secure all wires and connectors
- Use DVOM to check circuits

3 **FUEL GAUGE INSTALLATION PROCEDURE**
PROPANE FUEL LEVEL

- Two-wire sender
- May replace mechanical sensor with electrical
- Range: 15-160 ohms

4 **17-1 REMOTE FUEL LEVEL SENDER**

5 **MATCHING GAUGE TO VEHICLE**

- 1989 Ford: 70-10 ohms
- 1987-95 Ford: 10-160 ohms
- 1995 GMC: 0-90 ohms
- 1988 Chysler: 70-10 ohms
- 1989-92 Chrysler: 95-5 ohms
- 1992-95 Chrysler: 95-5 ohms
- All GFI: 15-60 ohms
- All remote receivers: 0-90 ohms

6 **GAUGE MOUNTING**

- Mount close to fuel switch
- Use bracket for both

7 **FUEL SWITCH INSTALLATION PROCEDURE**
MANUAL CONTROL

- Route wires to dash through looms
- Mount for easy accessibility
- Connect polarity properly
- Check ground and circuit with DVOM

8 **17-2 DASH MOUNTED FUEL SWITCH AND LIGHT**

9 **17-3 FUEL LEVEL SENSOR INTERFACE**

10 **17-4 MANUAL FUEL SWITCH INSTALLATION**

11 **AUTOMATIC SWITCHING**

- Switching controlled by processor

MODULE 17:
Fuel Switching & Level Monitoring

OVERVIEW OF FUEL SWITCHING AND LEVEL MONITORING

- Tank sender monitors fuel level by a magnetic sensor
- Use OEM or custom dash gauge
- OEM gauge and sender resistances must match
- Solder, heatshrink, secure all wires and connectors
- Use DVOM to check circuits

FUEL GAUGE INSTALLATION PROCEDURE
PROPANE FUEL LEVEL

- Two-wire sender
- May replace mechanical sensor with electrical
- Range: 15-160 ohms

17-1 REMOTE FUEL LEVEL SENDER

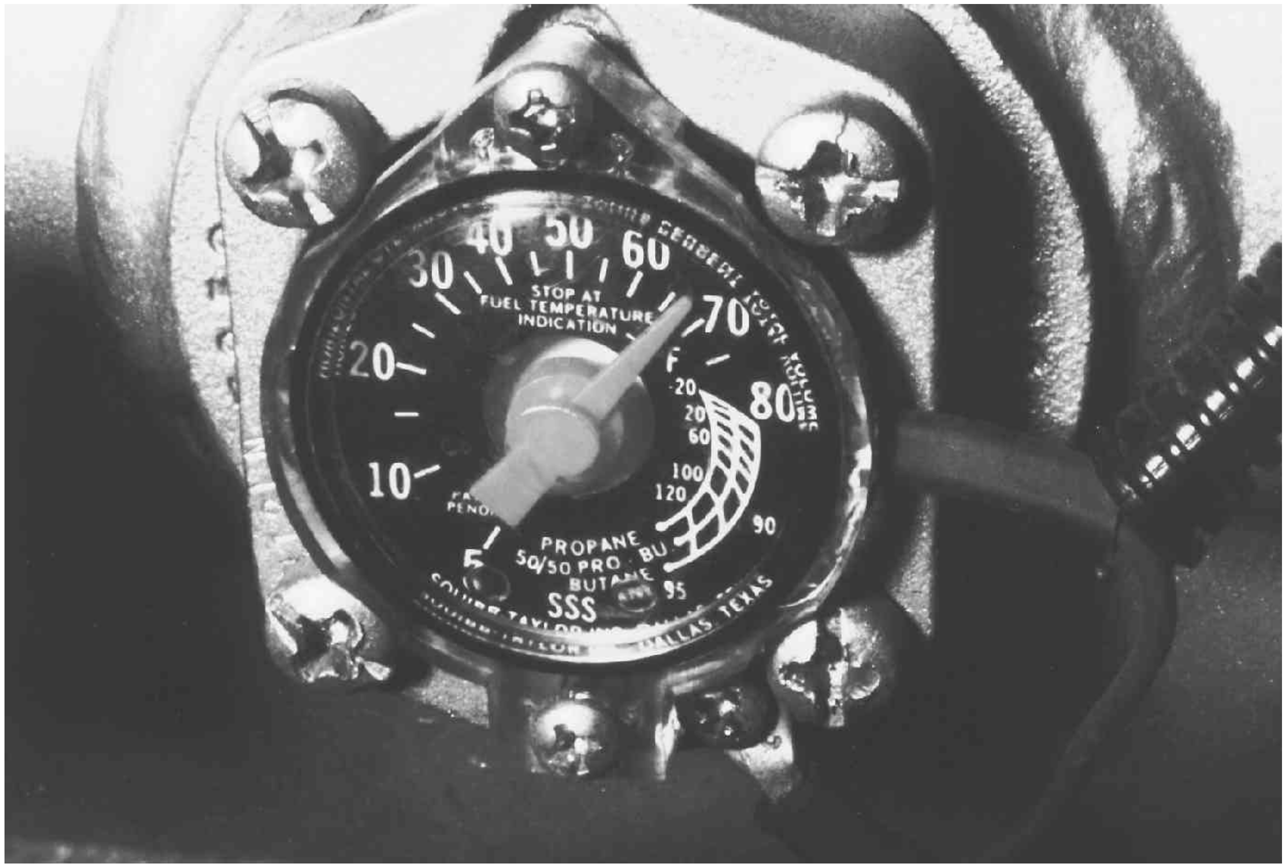


Photo Copyright Harris Fogel

MATCHING GAUGE TO VEHICLE

- 1989 Ford: 70-10 ohms
- 1987-95 Ford: 10-160 ohms
- 1995 GMC: 0-90 ohms
- 1988 Chysler: 70-10 ohms
- 1989-92 Chrysler: 95-5 ohms
- 1992-95 Chrysler: 95-5 ohms
- All GFI: 15-60 ohms
- All remote receivers: 0-90 ohms

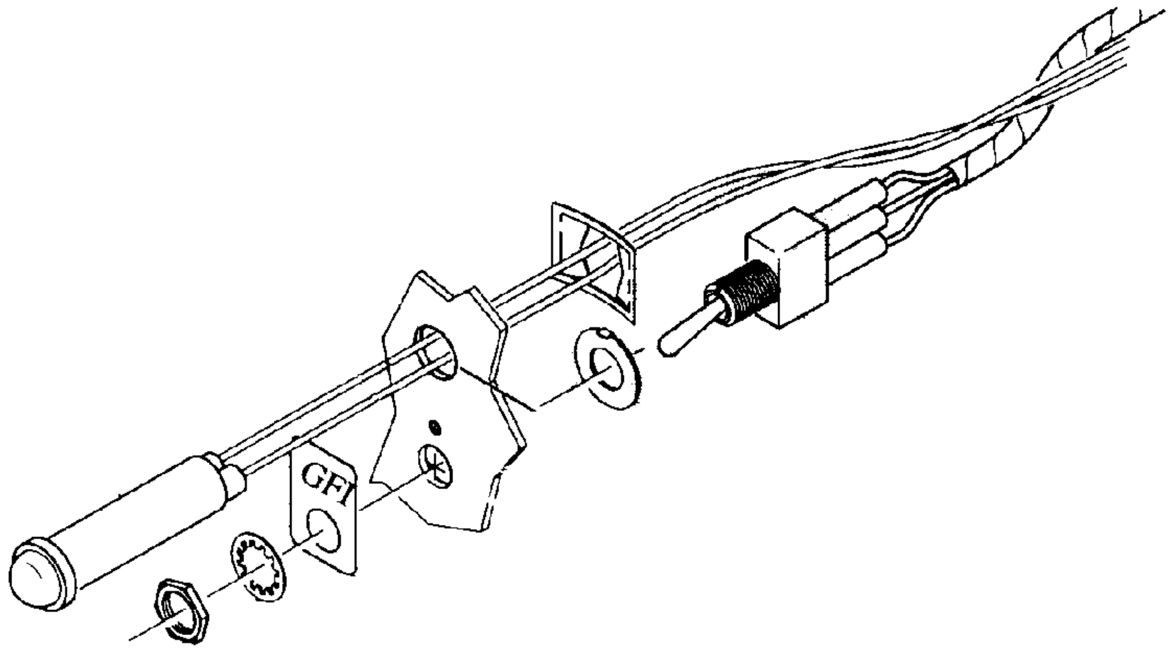
GAUGE MOUNTING

- Mount close to fuel switch
- Use bracket for both

FUEL SWITCH INSTALLATION PROCEDURE MANUAL CONTROL

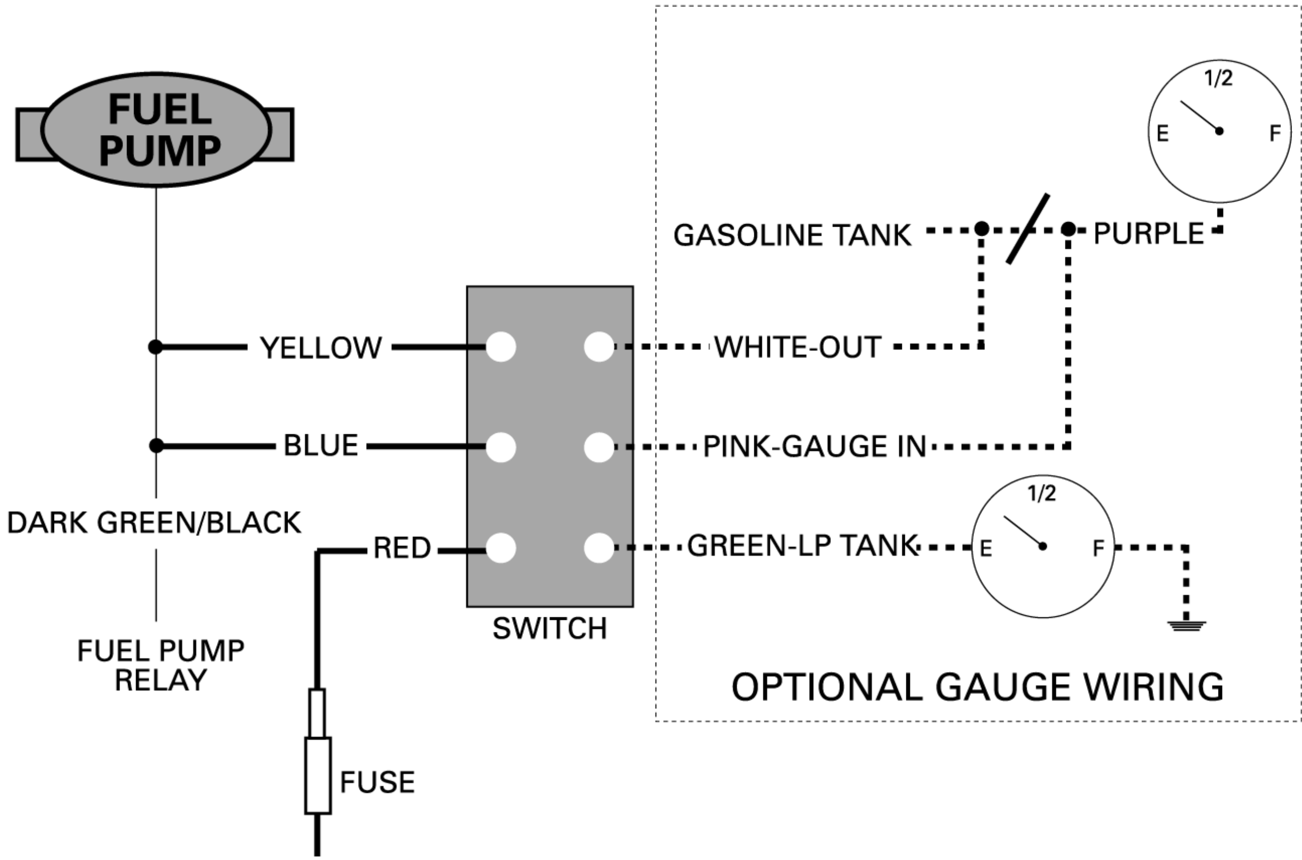
- Route wires to dash through looms
- Mount for easy accessibility
- Connect polarity properly
- Check ground and circuit with DVOM

17-2 DASH MOUNTED FUEL SWITCH AND LIGHT



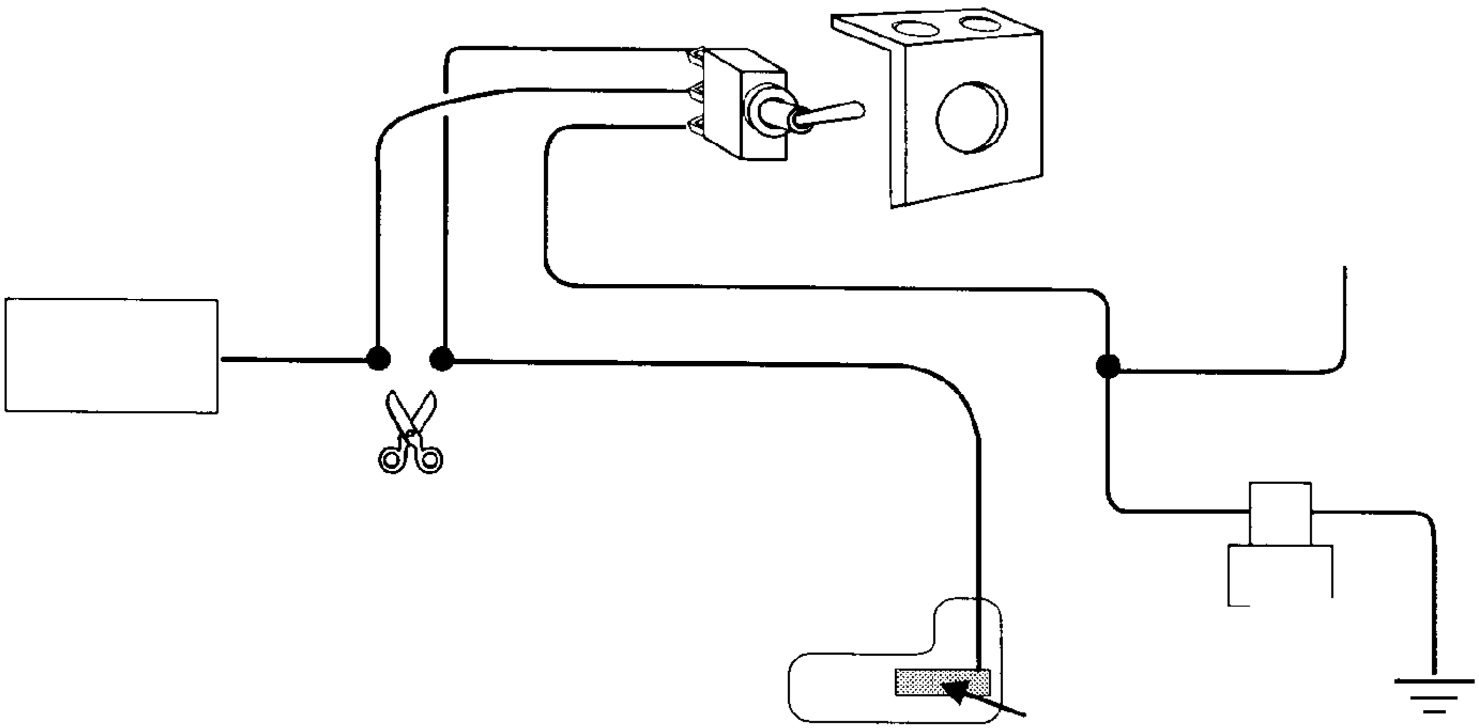
Courtesy of GFI

17-3 FUEL LEVEL SENSOR INTERFACE



Courtesy of Algas Carburetion

17-4 MANUAL FUEL SWITCH INSTALLATION



Courtesy of Autotronic Controls

AUTOMATIC SWITCHING

- Switching controlled by processor

MODULE 18:

Electronics Interface

State of Oklahoma
College of the Desert
West Virginia University

MODULE 18: ELECTRONICS INTERFACE

CONTENTS

MODULE 18: ELECTRONICS INTERFACE

OBJECTIVES

At the completion of this module, the technician will be able to:

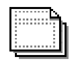
- Identify and discuss the components of closed loop systems and their interaction.
- Identify and discuss the component pinouts and wires, and their functions and properties.
- Determine the best and safest location to install each component's wiring and connections.
- Properly install all components using the proper tools and techniques.
- Test and troubleshoot the system and connections.

MODULE 18: ELECTRONICS INTERFACE

INSTRUCTOR NOTES

INSTRUCTOR MATERIALS/MEDIA NEEDED

Overhead projector or LCD panel/projection equipment
Master overhead transparencies or Microsoft PowerPoint 4.0 presentation file Mod18.ppt

Note: Slides correspond to text as indicated by icon 

STUDENT MATERIALS/MEDIA NEEDED

Module 18: Electronics Interface

MODULE REVIEW ITEMS

The Module Review Items (MRI) are designed to allow for flexibility in their use. The exam may be utilized as a post-module review, pre/post test, part of a term examination, or it may be used by the student if the module is used as a self study text.

OVERHEAD TRANSPARENCY MASTERS

The printouts enclosed with this module are taken from the Microsoft PowerPoint 4.0 presentation file Mod18.ppt . Instructors planning to use overhead projectors should make transparencies from these printouts on a copier (or laser printer designed to safely print to acetate.

Note: Please review Module 25: Training of Trainers for more hints on instructional needs and strategies.

MODULE 18: ELECTRONICS INTERFACE

OVERVIEW

Key Points & Notes

18-2

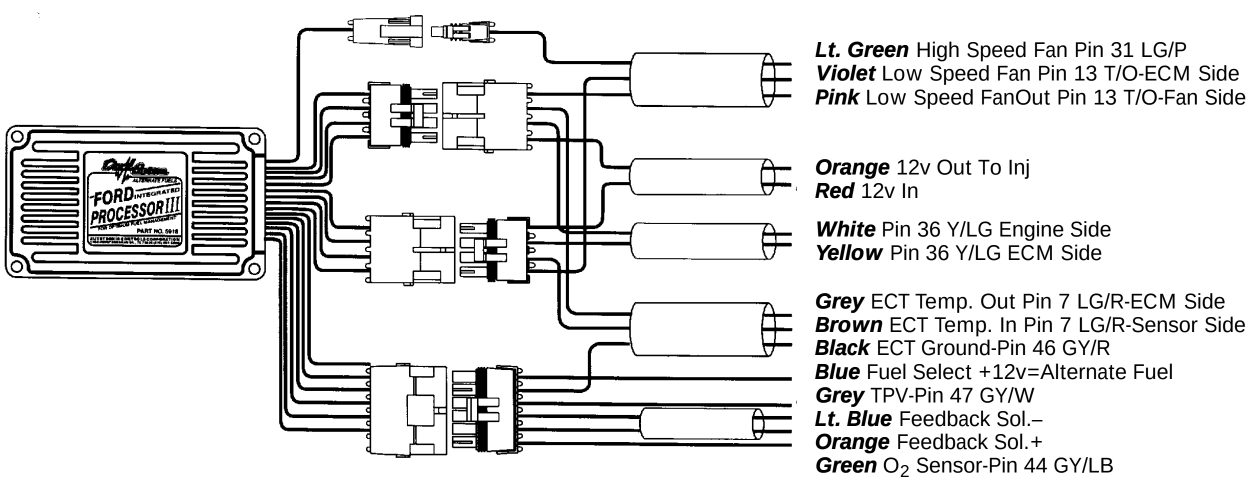
This section will cover the installation of the closed loop components. As mentioned previously, component use will vary by manufacturer and desired conversion. This section covers general installation procedures. Please have on hand any manufacturer's instructions that were included with the components.

All original equipment emissions control devices must be retained, both physically and operationally, upon completion of the conversion. The only exception to this is if the equipment certification, such as CARB or EPA, has provisions that allow control devices to be removed. An example would be evaporative fuel emissions components on a dedicated propane conversion, which are non-functional after the conversion, or removal and replacement of the OEM fuel system components or air cleaner to accommodate the propane mixer. Penalties for emissions control violations are extremely severe and special care should be taken to ensure that no conversion procedures can be considered as tampering.

COMPONENT INSTALLATION

18-3

When making preparations for mounting the control unit brackets, remember to check to make sure they will be mounted in a secure place and mount them in place after the connections are made. Leave extra wire for all connections to be made so that there is extra loose wire for routing the wire. Route and mount. Refer to Figure 18-1.



Courtesy of Autotronic Controls

18-1 Integrated processor wiring.

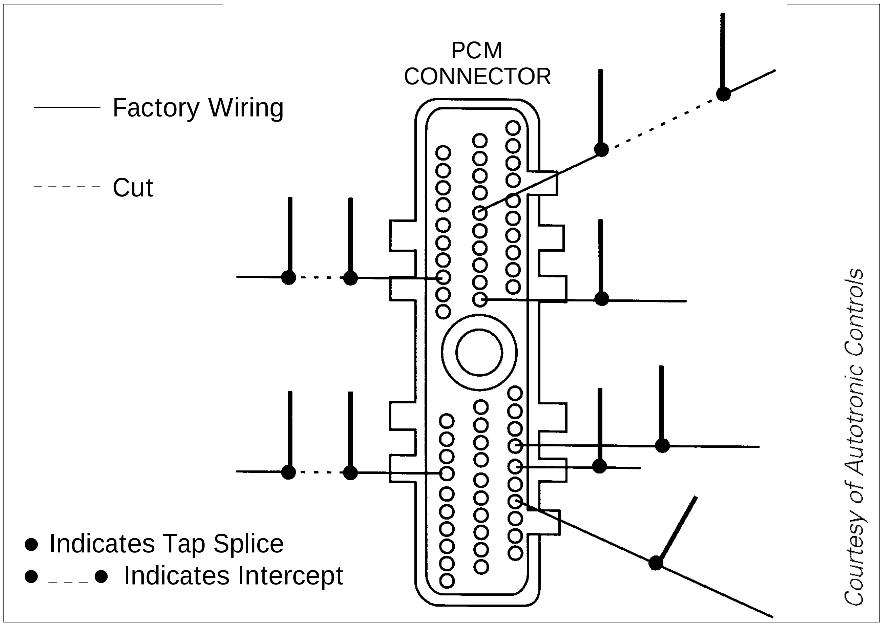
18-5

Connect grounds first before connecting the power or any other connections. Connect the ground to a clean, bare metal surface, or a designated return ground wire. Verify the ground with the DVOM if uncertain of the connection.

Make the appropriate electrical connections as designated in the schematics, allowing extra wire. Use good quality connectors,

Key Points & Notes

18-6



18-2 Taps and intercepts at OEM PCM; harness side of connector shown.

18-4

preferably Weather-Pack, or solder and shrink wrap all connections. If conversion schematics don't match or are not available for the particular vehicle you are converting, take time to design custom wiring. Note any customized layouts for future reference by other technicians.

The other electrical components, computer modification devices, relay, and timing adaptation devices, should be sealed using a silicone sealant before installation. This will help prevent moisture from entering and possibly damaging the device. Whenever possible, mount electrical components on the fire wall in a dry location away from all heat sources.

Mount and wire the relays, fuel selector switches, indicator lights, sensors, etc. Be prepared to drill in tight spots and near other wires and components. Some components may have required mounting locations and restrictions, and others might be required to be wired with the correct polarity. Be sure to double check with the meter whether the wires are + or – before connecting; the component might not work or could be damaged.

Components used in closed loop systems are going to be conversion-system specific. The specific conversion system will have the various components and correct wiring configurations and pinouts. Use the instructions provided to lay out the components, identify their mounting sites and mounting installation needs, and wiring configuration and installation needs.

GROUND LUG CONNECTOR

18-7

CONNECT GROUND LUGS BEFORE CONNECTING POWER OR ANY OTHER CONNECTIONS. Grounds should be the FIRST electrical connection made when installing a system and the last to be removed when disconnecting the system. Connect ground lug ring to a clean, bare metal surface of the engine. Roughen surface with a file or sand paper, then thoroughly clean location with acetone or equivalent degreaser or solvent; remove all grease, dirt, paint, etc.

To verify that the ground is solidly connected, measure voltage between battery negative terminal and the installed system ground lug. Voltage must be ±50 mv (.05v). An alternate means of measurement is to measure the resistance between the ground lug and battery negative (–) terminal. Resistance should be ±5 ohms.

CLOSED LOOP/FEEDBACK

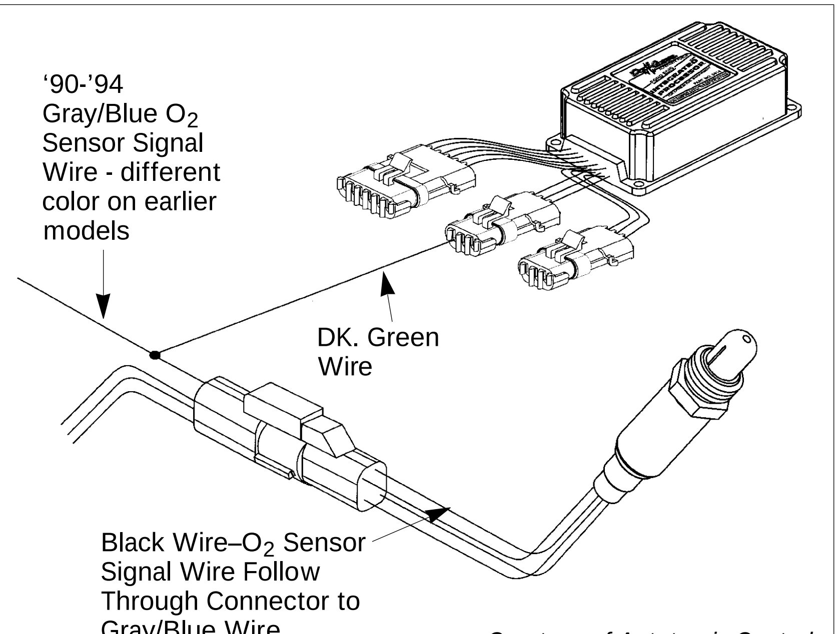
OXYGEN SENSOR

The 0_2 sensor intercept provides the system with information to control fueling requirements for emissions compliance. There are several configurations for the 0_2 sensor intercept. Some of the more common are discussed below. Refer to the system schematic for the wiring configuration for a particular application. Use the standard wire and splice procedures described previously. Do not solder on the sensor signal line. This may cause damage to the sensor unit. Make the intercept using the existing wires. Do not add extensions.

Single wire 0_2 sensors may be found on some vehicles. This sensor should be replaced if possible with a heated 3 wire sensor. This is to improve emissions by going closed loop sooner than with the OEM sensor. To install the intercept complete the following steps.

1. Unplug the vehicle computer side connector and remove existing sensor.

2. Cut off plug on replacement sensor and discard.



18-3 O_2 sensor wiring (tap shown).

Key Points & Notes

18-8

18-9

18-11

3. Install a 2-pin connector on the two white wires (heater section).
4. Install a 1-pin connector that matches the base vehicle connector for the signal wire.
5. Install sensor and fasten connectors.
6. Make intercept between new single pin connector on sensor and vehicle computer
7. Run a wire to sensor ground.

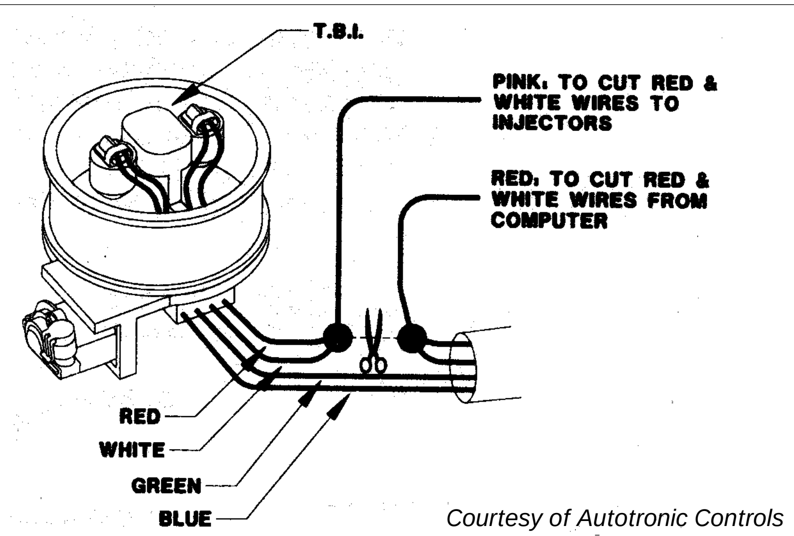
When wiring a new 0_2 sensor, it is important to provide a separate ground point for the sensor ground wire and 0_2 heater ground wire.

FUEL INJECTION INTERCEPT

When installing bi-fuel propane conversions on fuel injected vehicles, gasoline delivery to injectors must be interrupted by turning off the fuel pump and fuel injectors when the engine is switched to run on propane. When the switch is in the propane position, the propane fuel lock is activated to permit the flow of propane to the system. This is accomplished by an electrical circuit controlled by a dash mounted switch that permits choice of fuels. In the gasoline operating mode, the electrical switch will turn off the propane fuel lock and activate the gasoline fuel supply systems, the gasoline fuel pump, and injectors. This is usually done by using either a DPDT relay or a conversion support module (with an integral relay function) that activates the fuel injectors.

Install wiring to control operation of fuel injectors and fuel pump when gasoline operation is selected. Follow installation instructions provided by the equipment maker. An injector simulator or other supplemental module may be necessary.

A mating harness may be furnished to wire the necessary taps and intercepts required for the installation such as injector or MAP intercepts. The connectors, terminals, and wire to make proper mating connectors for the main wire harness are supplied.



Courtesy of Autotronic Controls

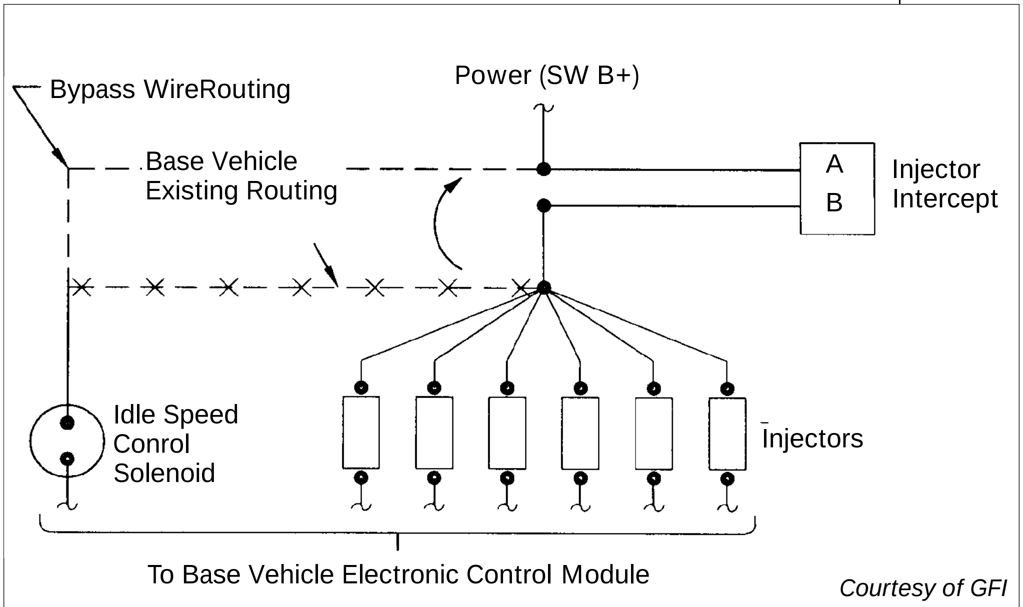
18-4 Injector intercept – Throttle Body Injection.

Key Points & Notes

18-10

18-12

18-13



18-5 Fuel injector intercept and by-pass (port Injection).

Key Points & Notes

18-15

THROTTLE BODY injectors generally have a common power line and separate computer control grounds. The intercept should be done on the power side of the injectors, this requires only one relay to be used. Intercepting the ground side would require the use of two relays. Refer to Figure 18-4.

18-14

PORT FUEL INJECTORS are commonly intercepted on the power side of the gasoline injectors. If the injectors are bank fired they can be intercepted on the ground side. This would require the use of two relays. Refer to Figure 18-5.

SEQUENTIAL FUEL INJECTORS have a common power line and separate grounds for each injector. The intercept should be made on the power line; otherwise it would require a separate relay for each injector on the ground side. **Note:** Some systems provide an auxiliary harness that interfaces directly with gasoline fuel injectors and connectors.

OTHER SENSORS AND ENGINE SIGNALS

The following information is a generic description of the taps, intercepts and connections commonly made. Specific locations for specific vehicles should be provided with manufacturers' instructions, depending on make and model of vehicle.

18-16

> **NOTE:** Do not connect harness connectors or battery power until all vehicle connections are made.

TDC and Tach/RPM Reference

These are two essential connections and are make and model specific. Some propane fuel control processors use one or both of these.

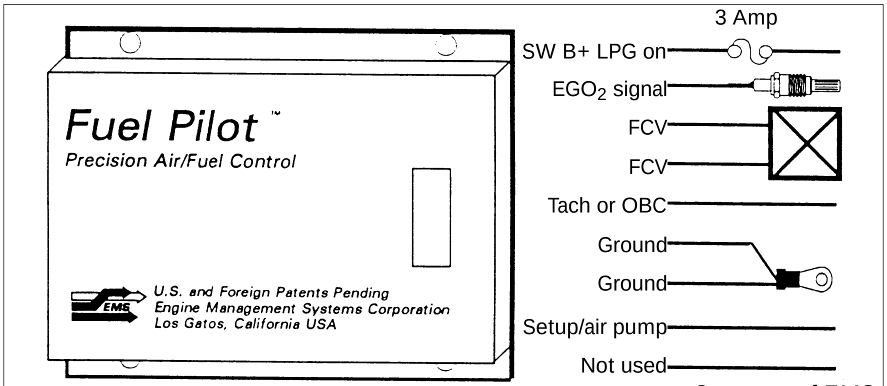
TDC is typically an intercept that is used to monitor and modify OEM timing to optimize power output while running on propane.

There are several possible configurations for the TDC intercept. Refer to manufacturer's instructions.

The tach or reference signal is used to determine engine speed. This information is critical for the propane fuel processor to calculate correct air-fuel ratio. Refer to manufacturer's instructions.

Map Sensor (MAP)

Unless the propane fuel processor has its own MAP sensor, it may be necessary to intercept the OEM MAP sensor to get a load signal. Load and RPM are important signals for the propane processor. A harness connector is often provided to interface the processor with the OEM sensor.

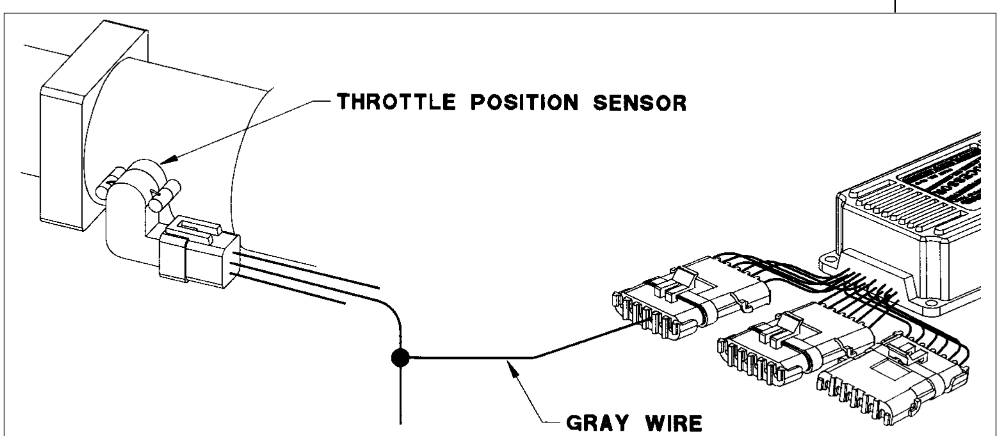


Courtesy of EMS

18-6 LPG fuel processor, non-integrated.

Throttle Position Sensor (TPS)

This connection may be a single tap, double tap, or intercepts. One wire may be tied to the vehicle's reference ground (sensor return), close to the OEM TPS. The other wire connects to the signal wire from the TPS sensor. Or the signal wire may be intercepted by the processor. Figure 18-7 shows a single tap connection. This connection is not required for all applications. Refer to manufacturer's instructions.



Courtesy of Autotronic Controls

18-7 TPS intercept.

Key Points & Notes

18-17

18-18

18-19

18-20

Key Points & Notes

Knock

Depending on the vehicle make and model, it may be necessary to tap the OEM knock sensor circuit. This allows the propane fuel control processor to monitor PCM diagnostic signals; otherwise, the PCM sets a fault code for Knock or ECT when running on propane. There are several configurations for the knock sensor. Refer to manufacturer's instructions for details.

18-21

Canister Purge Solenoid (CPS)

This circuit is connected only when required to meet emissions standards. Because of OEM strategy differences, use of the canister purge is not standardized so only certain vehicles require this circuit. This is an INTERCEPT that is done using an auxiliary relay harness.

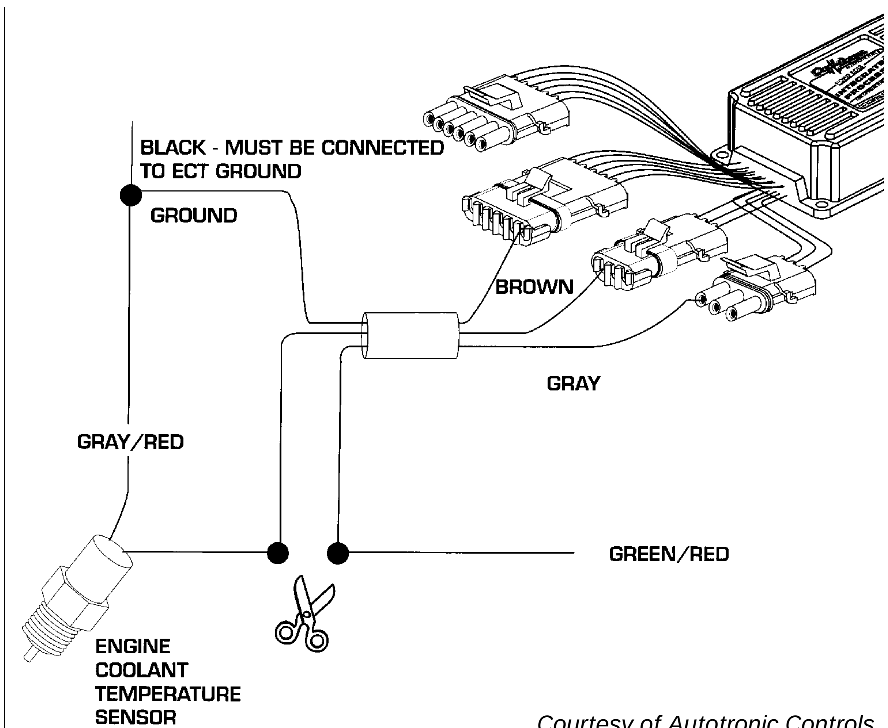
18-23

Coolant Temperature Sensor (CTS)

The LPG Processor monitors and intercepts the coolant temperature to keep the PCM from performing gasoline computer diagnostics. If the PCM doesn't see the feedback expected because the engine is running on propane, a fault code is logged (MIL). This connection involves tapping and intercepting.

18-24

18-22



18-8 ECT sensor tap and intercept.

Thermactor Air Bipass (TAB)

The TAB diverts pumped air into the exhaust manifold which is needed for exhaust and catalyst efficiency. The LPG processor monitors this signal. When air is diverted, the oxygen sensor

18-25

senses excess oxygen. The gasoline PCM will ignore the lean O_2 sensor signal. By monitoring the signal, the propane processor knows when the air is being diverted and ignores the O_2 signal and goes into open loop when the TAB is on.

Starter

This tap is not used in all systems to recognize the engine crank. Using a test light, identify a suitable line that has power when the ignition switch is turned to the start position. Install a tap line using the standard wire and splice procedures. In some applications, it may be more convenient to crimp and solder an eyelet to the end of the connector pigtail and fasten directly to the starter solenoid engage terminal.

Intake Air Temperature (IAT) Sensor

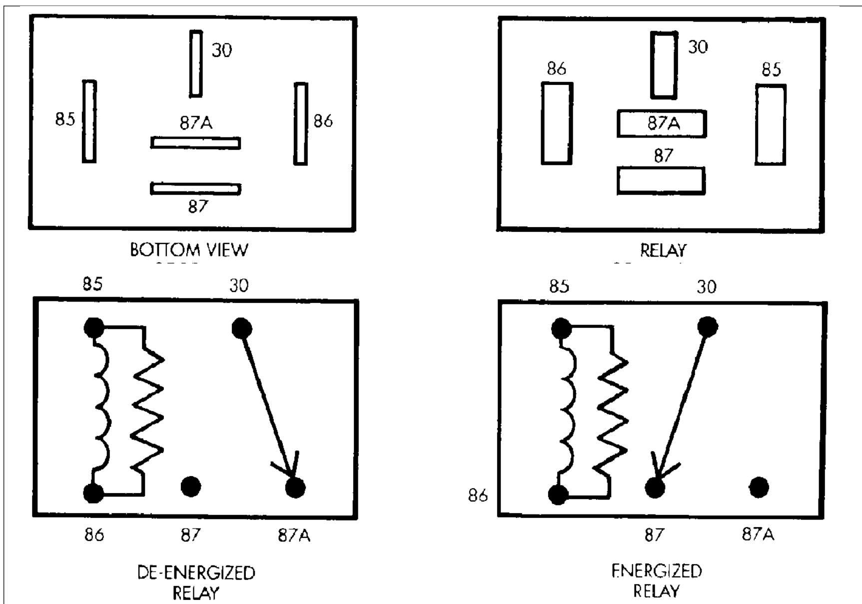
This sensor is added to the engine and connects with its own harness to the propane fuel metering valve/controller. Intake Air Temperature (IAT) sensor is used to determine air density. This add-on sensor is not used in all systems.

Manifold Skin Temperature (MST) Sensor

This non-OEM sensor is part of the propane conversion. It is a thermister; as the temperature at the sensor increases, the resistance decreases. MST is used to calculate air-fuel density by measuring engine intake manifold temperature.

Tach

The TACH provides the engine RPM. The signal equals one pulse per spark event. The TACH TAP is detailed with the TCD intercept in the specific vehicle supplement for a particular application.



Courtesy of Chrysler Corporation

18-9 Example of relay function.

Key Points & Notes

18-26

18-27

18-28

18-29

18-31

Fuse And Relay Module

A fuse and relay module may be provided for the propane fuel system processor. The propane processor must be protected by an inline fuse with the correct ampere rating.

It also may be necessary to incorporate a relay or relays into the circuit. Relays are typically used to turn on or turn off component(s) such as the gasoline fuel injectors and the fuel pump, the fuel lock-off solenoid, or computer support modules.

PROCESSOR POWER

This connector supplies voltage from the vehicle, through the fuse and relay module, to the GFI system. It draws from two sources: B+ (battery) and SW B+ (power supply controlled by the ignition switch). A mating connector may be provided with the processor harness.

SWITCHED BATTERY POWER (SW B+)

This tap provides initial power to energize the processor or relay that supplies power to the processor. The switched B+ tap must be taken from a source that is hot in all ignition switch positions except for OFF and ACC positions. THE CIRCUIT MUST PROVIDE 10 VOLTS IN THE START POSITION. In bi-fuel conversions, switched B+ may be controlled by a fuel selector switch and relay; this power may also be used to tell the propane fuel processor which fuel is selected.

CAUTION: Other OEM actuators may be powered by the same SW B+ source. Cutting that power may interrupt actuator operation.

BATTERY POWER (B+)

The B+ tap is required to provide a constant power source to backup the adaptive memory after the ignition has been turned off. When the key is off, the processor will shut off after the backup procedure is completed. Using a test light, locate an easily accessible battery voltage line that consists of a wire heavy enough to withstand added load (12 to 16 AWG). A source might be found at the fuse or relay panel or the ignition relay for the OEM computer. This connection must be done on the unswitched side of the relay.

INJECTOR SIMULATORS

Some aftermarket applications may require an additional "fix". These modules are generally used to prevent check-engine codes and to send compatible signal aliases to the base vehicle computer.

FUEL CONTROL VALVE

The fuel control valve, also known as the dithering valve, is an actuator that controls the propane regulator and adjusts air-fuel ratio. The dithering valve is a pulse width modulated, duty cycle solenoid. It receives signals from the LPG processor and moves the secondary diaphram in the regulator by applying air valve vacuum or atmospheric pressure to the top of the diaphram, changing fuel delivery to an air valve mixer. Oxygen sensor and RPM are the

Key Points & Notes

18-30

18-32

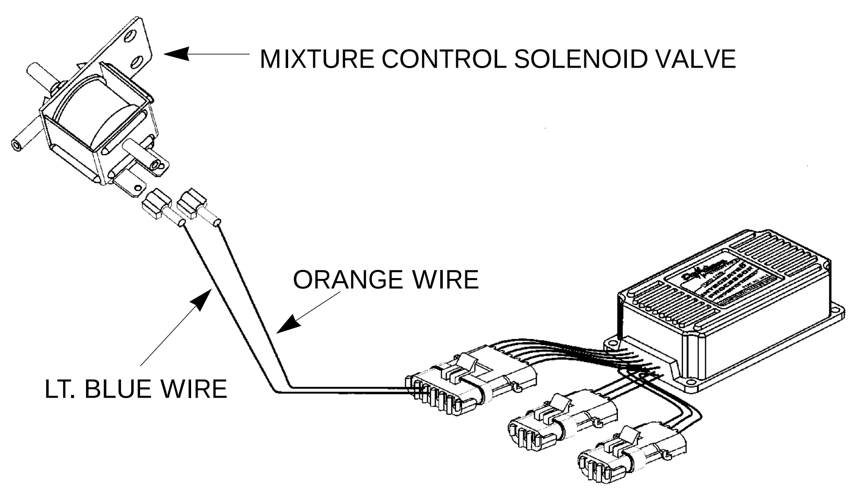
18-33

18-34

18-35

18-36

principle sensor inputs that provide information to the processor that in turn controls the fuel control valve. Refer to Figure 18-10.



18-10 Fuel control solenoid wiring.

POST-INSTALLATION

The closed loop system should be checked for proper operation before installing or adjusting the mixer or fuel injection system for optimum engine performance. Attach a test computer, if the system has such capability, and run a diagnostics test to observe the system operation.

Check all connections before leaving to work on other sites. Specifically, see that the connectors are tight, both at the wire and at the connection to the component. See that all connections are firm, all screws are snug, and the area has no paint or debris that may be insulating the connection in any way. Use the continuity and voltage tester to see that the circuit conforms to the schematic paths and voltages. Lastly, if possible, see if the component works by applying voltage or proper operation and monitoring the results, and adjust if necessary.

Key Points & Notes

18-37

18-38

MODULE REVIEW ITEMS

Note to Technician: Consider all choices carefully and select the best answer to each.

1. OEM emissions control devices can be exchanged upon completion of the conversion.
A. True.
B. False.

2. Connect the ground wires first before attaching other connections.
A. True.
B. False.

3. Connect grounds to:
A. Designated return ground wires.
B. Painted or primered surface.
C. Clean metal.
D. A or C.

4. If the conversion schematics don't match the particular application,
A. Make it fit.
B. Design custom wiring.
C. Return the unit for the one that fits.
D. Adapt it as closely as possible as it is installed.

5. Computer modification and timing adaptation devices should be _____ before installation.
A. Mounted.
B. Located in restricted areas.
C. Sealed with silicone.
D. Located near electromagnetic radiation sources.

6. If the polarity is not checked before connecting, the device might not work but it won't be damaged.
A. True.
B. False.

7. To verify the ground is solidly connected, the resistance between the ground lug and the battery negative (-) terminal should be:
A. +/- 3 ohms.
B. +/- 5 ohms.
C. +/- 10 ohms.
D. +/- 50 ohms.

8. Which is a proper consideration of oxygen sensor installation?
A. Do not solder on the sensor line.
B. Add line extensions if necessary.
C. Use the most convenient wire and splice techniques to save time.
D. Most sensor wiring configurations are standard.

9. For bi-fuel conversions on fuel injected vehicles, the gasoline delivery to the injectors must be interrupted by _____ when switched to LPG.
A. Turning off the fuel pump.
B. Turning off the fuel injectors and turning on the fuel pump.
C. Turning off the fuel injectors.
D. Turning off the fuel pump and fuel injectors.

10. Throttle body injectors:
A. Have a common power line.
B. Intercept on the ground side.
C. A and D.
D. Have separate computer control grounds.

11. Do not connect harness connectors until all vehicle connections are made.
A. True.
B. False.

12. Which of the following is correct?
A. TDC monitors OEM timing.
B. TDC modifies OEM timing.
C. RPM is critical to calculate the correct air-fuel ratio.
D. All of the above.

13. Tapping the OEM knock sensor unit allows the LPG fuel control unit to monitor ECT signals.
A. True.
B. False.

14. The canister purge solenoid is connected when required to meet emissions standards.
A. True.
B. False.

15. The LPG processor monitors and intercepts coolant temperature...
A. To know when air is being diverted.
B. To log a fault code (MIL).
C. To keep the PCM from performing gasoline computer diagnostics.
D. To set a fault code for ECT.

16. To check the closed loop system for proper operation,
A. Attach a test computer.
B. Run a diagnostics test.
C. Both A and B.
D. Both A and B before adjusting the mixer.

MRI SCORING KEY

1. B
2. A
3. D
4. B
5. C
6. B
7. B
8. A
9. D
10. C
11. A
12. D
13. B
14. A
15. C
16. D

1 **MODULE 18:**
Electronics Interface

2 **OVERVIEW**

- General installation procedures
- OEM control devices must be retained
  – Exceptions for CARB or EPA regulations
- Severe penalties for violations and tampering

3 **COMPONENT INSTALLATION**

- Mount in secure place
- Leave extra wire
- Connect grounds before connecting power
- Connect to designated ground wire or bare metal surface
- Verify ground with DVOM

4 **COMPONENT INSTALLATION**

- Use quality connectors
  – Weather-Pack
- Note customized layouts
- Seal other electrical components
- Mount & wire relays, fuel selector switches, indicator lights, sensors
- Double-check polarity
- Closed-loop systems are conversion-system specific

5 **18-1 INTEGRATED PROCESSOR WIRING**

6 **18-2 TAPS AND INTERCEPTS AT OEM PCM**

7 **GROUND LUG CONNECTOR**

- Connect ground lugs before connecting power or other connections
- Clean ground contacts
- Verify ground
  – Must be +/- 50 mv (.05v)
  – Resistance +/- 5 ohms

8 **CLOSED LOOP/FEEDBACK**
OXYGEN SENSOR

- Gives info to control fueling requirements for emissions
- Single wire sensors should be replaced with heated 3 wire sensors to go closed loop sooner

9 **OXYGEN SENSOR**
INSTALLATION

1. Unplug vehicle computer side connector & remove existing sensor
2. Cut off plug on replacement sensor
3. Install 2-pin connector on two white wires (heater section)
4. Install 1-pin connector matching base vehicle connector for signal wire

10 **OXYGEN SENSOR**
INSTALLATION

5. Install sensor and fasten connectors
6. Make intercept between new single pin connector on sensor and vehicle computer
7. Run a wire to sensor ground

- Provide separate ground point for sensor ground wire and O_2 heater ground wire

11 **18-3 O_2 SENSOR WIRING**

12 **FUEL INJECTION INTERCEPT**

- Gasoline delivery to injectors interrupted by turning off fuel pump and fuel injectors when switched to propane
  - Switched by DPDT relay or conversion support module
- Install wiring to control fuel injectors and fuel pump
- Injector simulator or other module may be needed
- Mating harness to wire taps and intercepts

13 **18-4 INJECTOR INTERCEPT**

14 **FUEL INJECTION INTERCEPT**

- Throttle Body Injectors
- Port Fuel Injectors
- Sequential Fuel Injectors

15 **18-5 FUEL INJECTOR INTERCEPT AND BY-PASS**

16 **OTHER SENSORS AND ENGINE SIGNALS**
TDC AND TACH/RPM REFERENCE

- TDC- monitors and modifies OEM timing
  - Optimize power output while on LPG
- Tach- determines engine speed
  - Info for correct air-fuel ratio

17 **MAP SENSOR (MAP)**

- If LPG system is without MAP sensor, intercept OEM sensor for load signal
  - Load & RPM used by LPG system

18 **18-6 LPG FUEL PROCESSOR**

19 **THROTTLE POSITION SENSOR (TPS)**

- Single tap, double tap, or intercepts
  - One wire to vehicle reference ground
  - Other to TPS sensor signal ground
    - Or single wire intercepted by processor

20 **18-7 TPS INTERCEPT**

21 **KNOCK**

- May have to tap OEM knock sensor circuit
  - Allows LPG system to monitor PCM diagnostic signals
  - Else PCM sets fault code for knock or ECT when on LPG

22 **18-8 ECT SENSOR TAP AND INTERCEPT**

23 **CANISTER PURGE SOLENOID (CPS)**

- Connected when necessary to meet emissions standards
- OEM strategy differences

24 **COOLANT TEMPERATURE SENSOR (CTS)**

- LPG system monitors and intercepts coolant temperature
  - Keeps PCM from performing gasoline computer diagnostics
  - PCM not seeing feedback logs MIL

25 **THERMACTOR AIR BIPASS (TAB)**

- Diverts air into exhaust manifold for exhaust and catalyst
- LPG system monitors TAB Gasoline PCM ignores lean O_2 signal
- LPG goes into open loop when TAB on

26 **STARTER**

- Tap not used in all systems to recognize engine crank

27 **INTAKE AIR TEMPERATURE (IAT) SENSOR)**

- Determines air density

28 **MANIFOLD SKIN TEMPERATURE (MST) SENSOR**

- Thermister
  - Increases in temperature decreases its resistance
- Used to calculate air-fuel density by measuring engine intake manifold temperature

29 **TACH**

- Provides engine RPM
  - Equals one pulse per spark event

30 **FUSE AND RELAY MODULE**

- Processor protected by inline fuse with correct amp rating
- Relays may be needed to control components or computer support modules

31 **18-9 RELAY FUNCTION**

32 **PROCESSOR POWER**

- Supplies voltage from vehicle to LPG system
  - B+ and SW B+ sources

33 **SWITCHED BATTERY POWER (SW B+)**

- Tap taken from source hot in all ignition positions except Off and ACC
- Circuit must provide 10V in Start position
- Cutting SW B+ circuit may cut other OEM actuators

34 **BATTERY POWER (B+)**

- Required to backup adaptive memory
- Processor backs up and powers down after key off
- Tap on unswitched side of relay

35 **INJECTOR SIMULATORS**

- May require additional fix
- Used to prevent check-engine codes and send signal aliases

36 **FUEL CONTROL VALVE**

- Dithering Valve
- Controls LPG regulator and adjusts air-fuel ratio
- Receives input from O_2 and RPM sensors

37 **18-10 FUEL CONTROL SOLENOID WIRING**

38 **POST-INSTALLATION**

- Check for proper operation before installing or adjusting mixer or FI system
- Run diagnostics program
- Revisit connections, check continuity, operate components and adjust if necessary

MODULE 18:
Electronics Interface

OVERVIEW

- General installation procedures
- OEM control devices must be retained
  - Exceptions for CARB or EPA regulations
- Severe penalties for violations and tampering

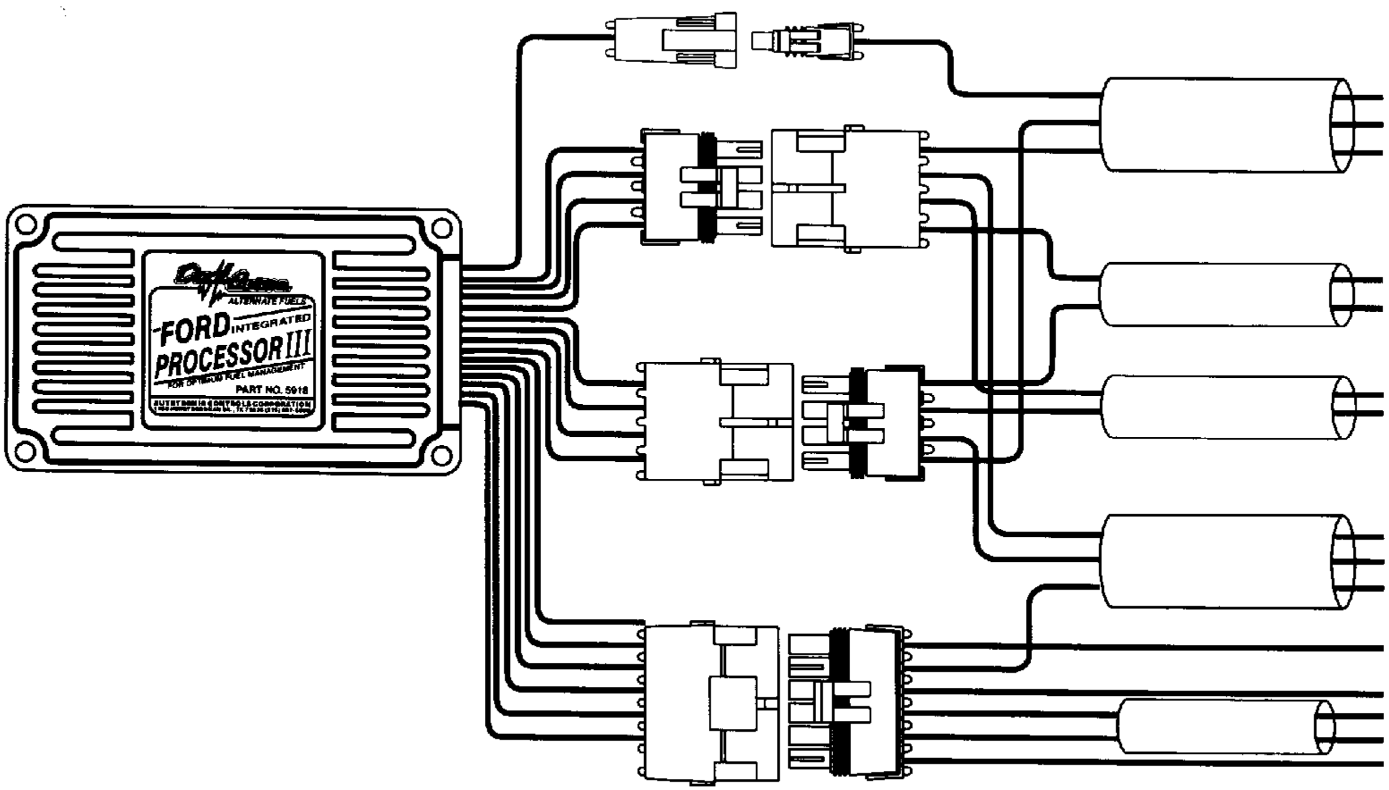
COMPONENT INSTALLATION

- Mount in secure place
- Leave extra wire
- Connect grounds before connecting power
- Connect to designated ground wire or bare metal surface
- Verify ground with DVOM

COMPONENT INSTALLATION

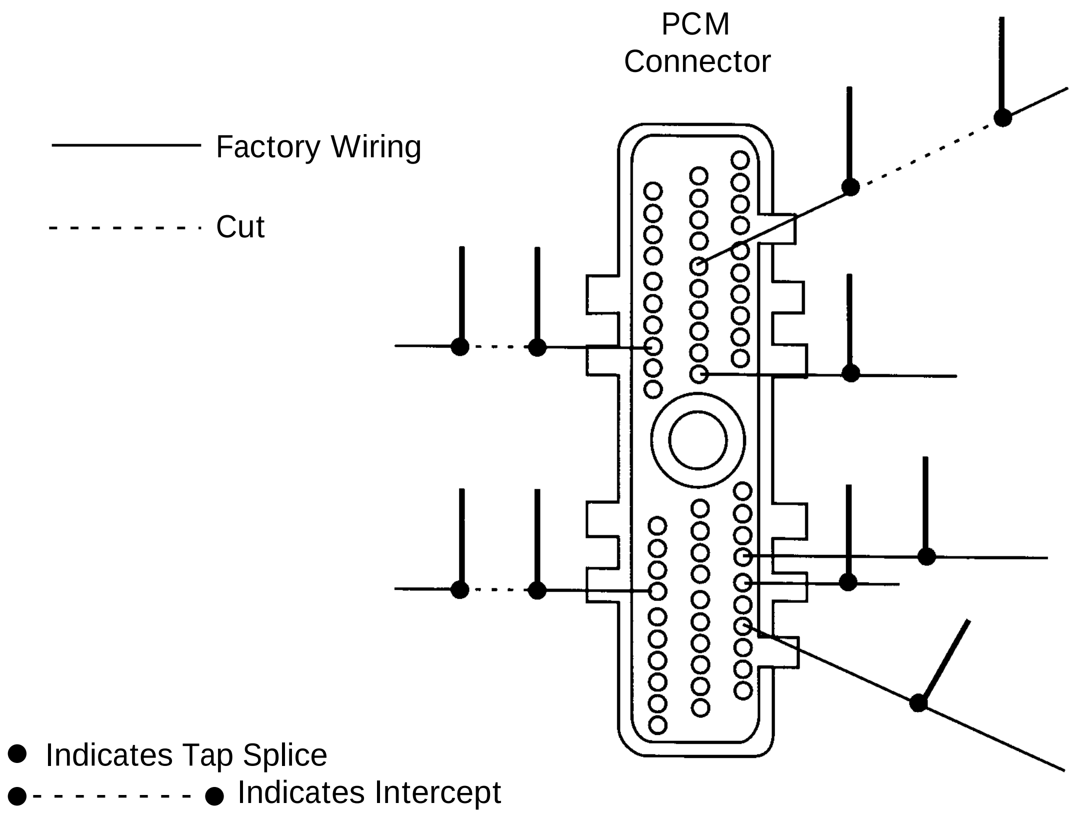
- Use quality connectors
  - Weather-Pack
- Note customized layouts
- Seal other electrical components
- Mount & wire relays, fuel selector switches, indicator lights, sensors
- Double-check polarity
- Closed-loop systems are conversion-system specific

18-1 INTEGRATED PROCESSOR WIRING



Courtesy of Autotronic Controls

18-2 TAPS AND INTERCEPTS AT OEM PCM



Courtesy of Autotronic Controls

GROUND LUG CONNECTOR

- Connect ground lugs before connecting power or other connections
- Clean ground contacts
- Verify ground
  - Must be +/- 50 mv (.05v)
  - Resistance +/- 5 ohms

CLOSED LOOP/FEEDBACK OXYGEN SENSOR

- Gives info to control fueling requirements for emissions
- Single wire sensors should be replaced with heated 3 wire sensors to go closed loop sooner

OXYGEN SENSOR INSTALLATION

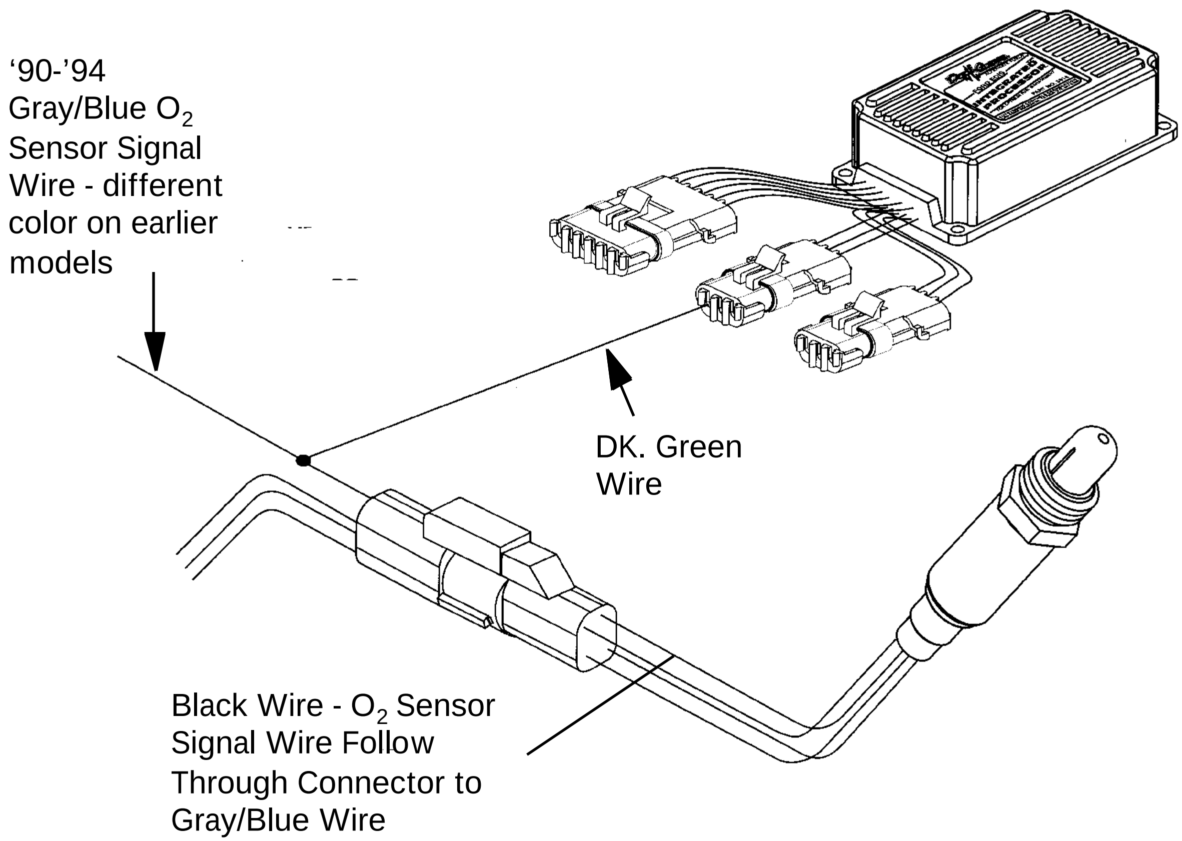
1. Unplug vehicle computer side connector & remove existing sensor
2. Cut off plug on replacement sensor
3. Install 2-pin connector on two white wires (heater section)
4. Install 1-pin connector matching base vehicle connector for signal wire

OXYGEN SENSOR INSTALLATION

5. Install sensor and fasten connectors
6. Make intercept between new single pin connector on sensor and vehicle computer
7. Run a wire to sensor ground

- Provide separate ground point for sensor ground wire and O_2 heater ground wire

18-3 O_2 SENSOR WIRING

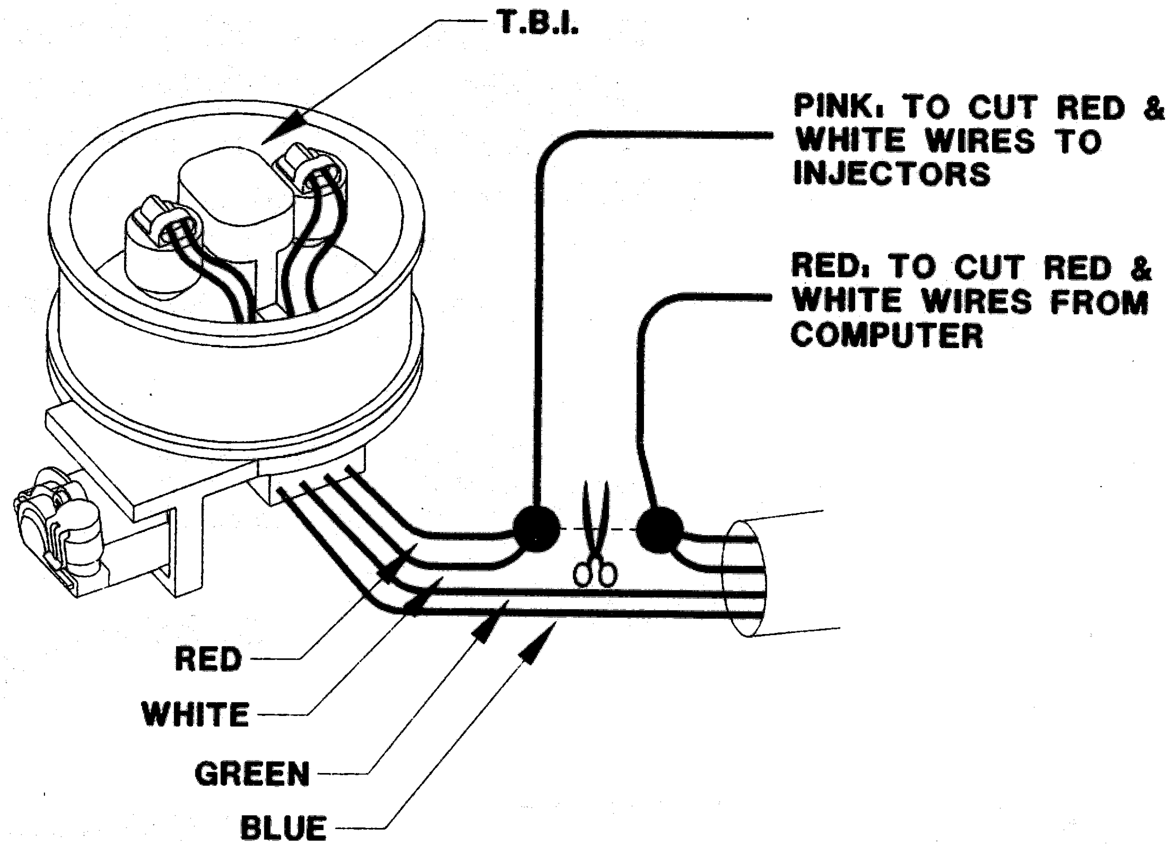


Courtesy of Autotronic Controls

FUEL INJECTION INTERCEPT

- Gasoline delivery to injectors interrupted by turning off fuel pump and fuel injectors when switched to propane
  - Switched by DPDT relay or conversion support module
- Install wiring to control fuel injectors and fuel pump
- Injector simulator or other module may be needed
- Mating harness to wire taps and intercepts

18-4 INJECTOR INTERCEPT

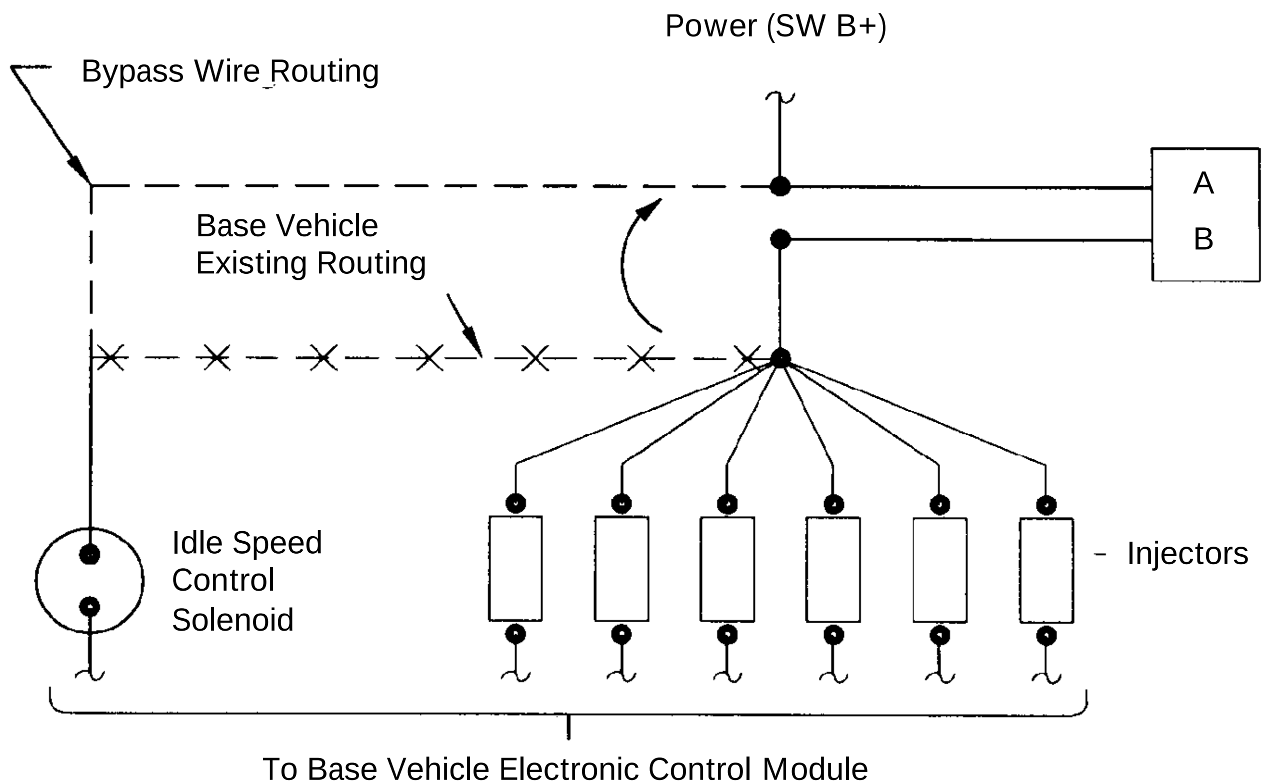


Courtesy of Autotronic Controls

FUEL INJECTION INTERCEPT

- Throttle Body Injectors
- Port Fuel Injectors
- Sequential Fuel Injectors

18-5 FUEL INJECTOR INTERCEPT AND BY-PASS



Courtesy of GFI

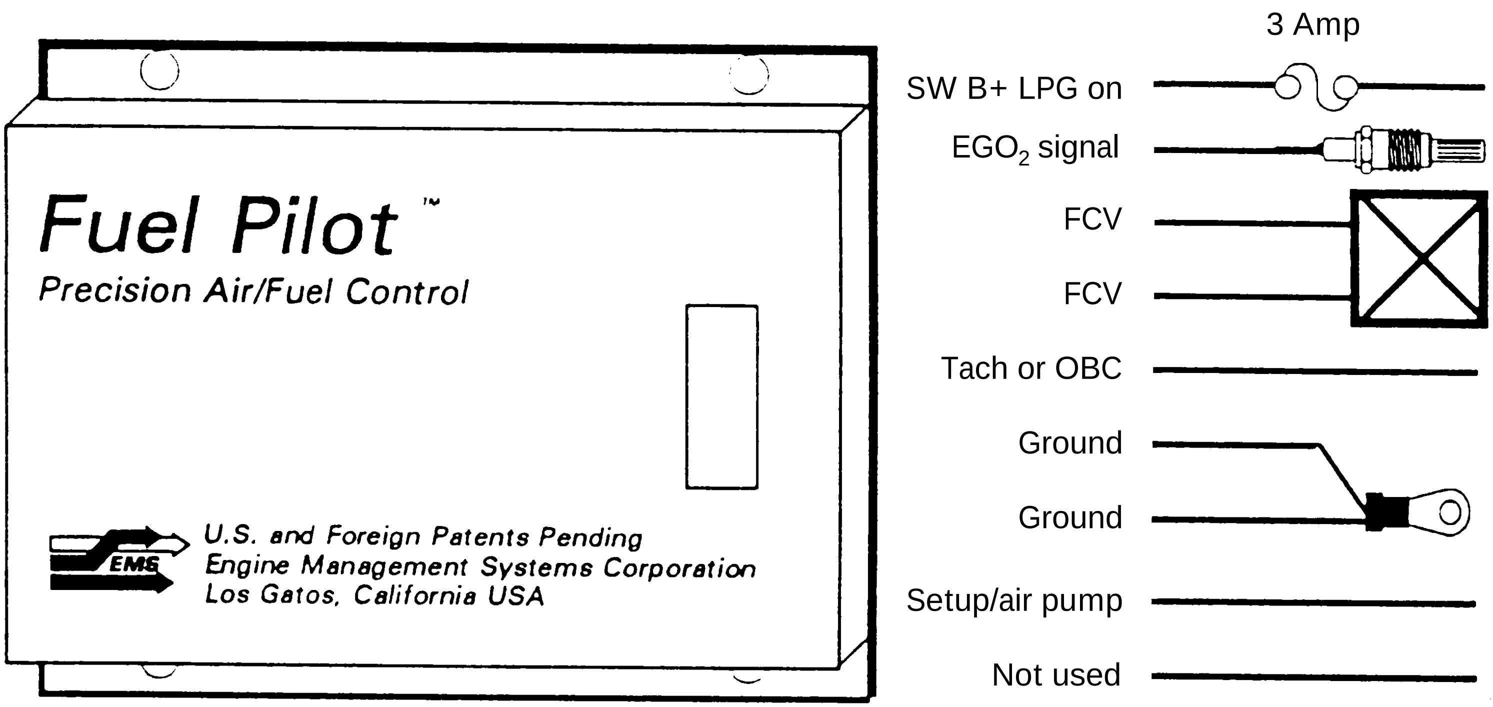
OTHER SENSORS AND ENGINE SIGNALS
TDC AND TACH/RPM REFERENCE

- TDC- monitors and modifies OEM timing
  - Optimize power output while on LPG
- Tach- determines engine speed
  - Info for correct air-fuel ratio

MAP SENSOR (MAP)

- If LPG system is without MAP sensor, intercept OEM sensor for load signal
  - Load & RPM used by LPG system

18-6 LPG FUEL PROCESSOR

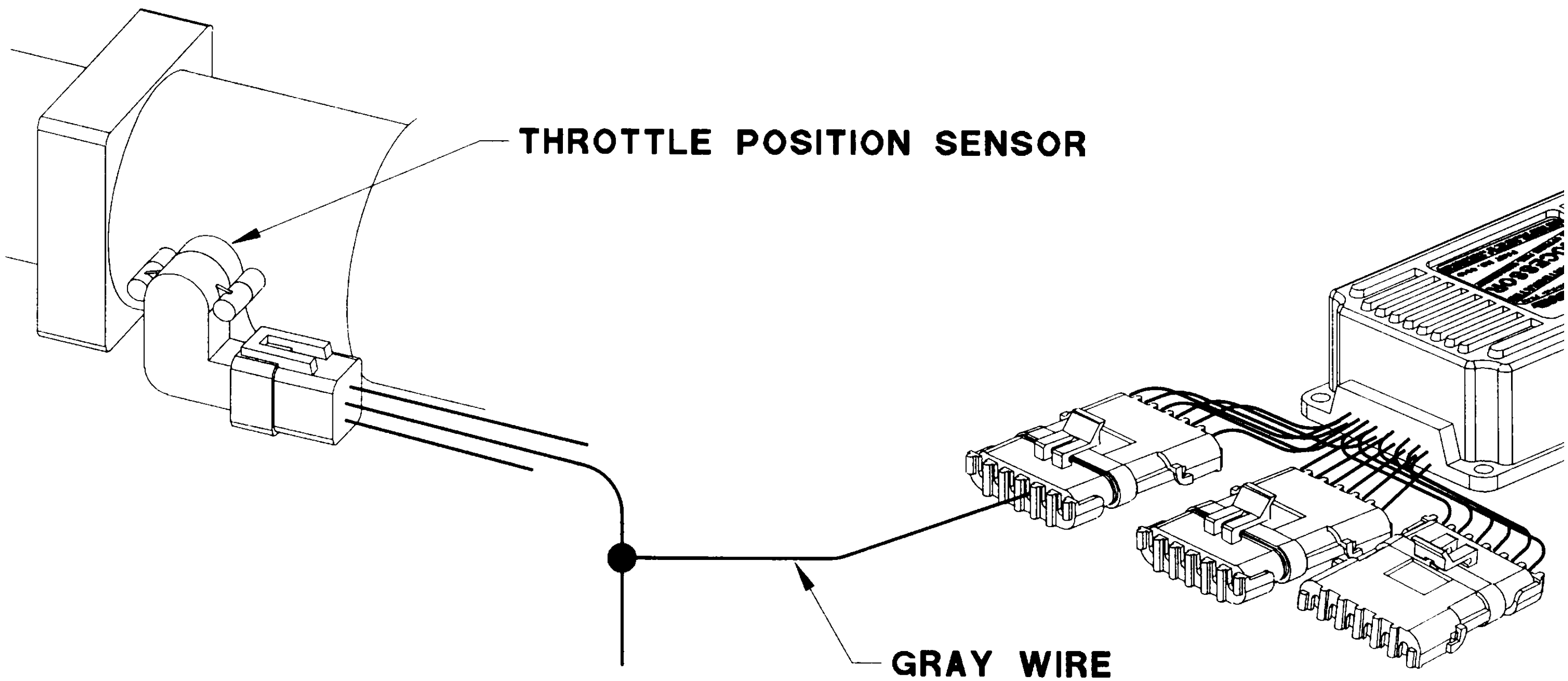


Courtesy of EMS

THROTTLE POSITION SENSOR (TPS)

- Single tap, double tap, or intercepts
  - One wire to vehicle reference ground
  - Other to TPS sensor signal ground
    - Or single wire intercepted by processor

18-7 TPS INTERCEPT

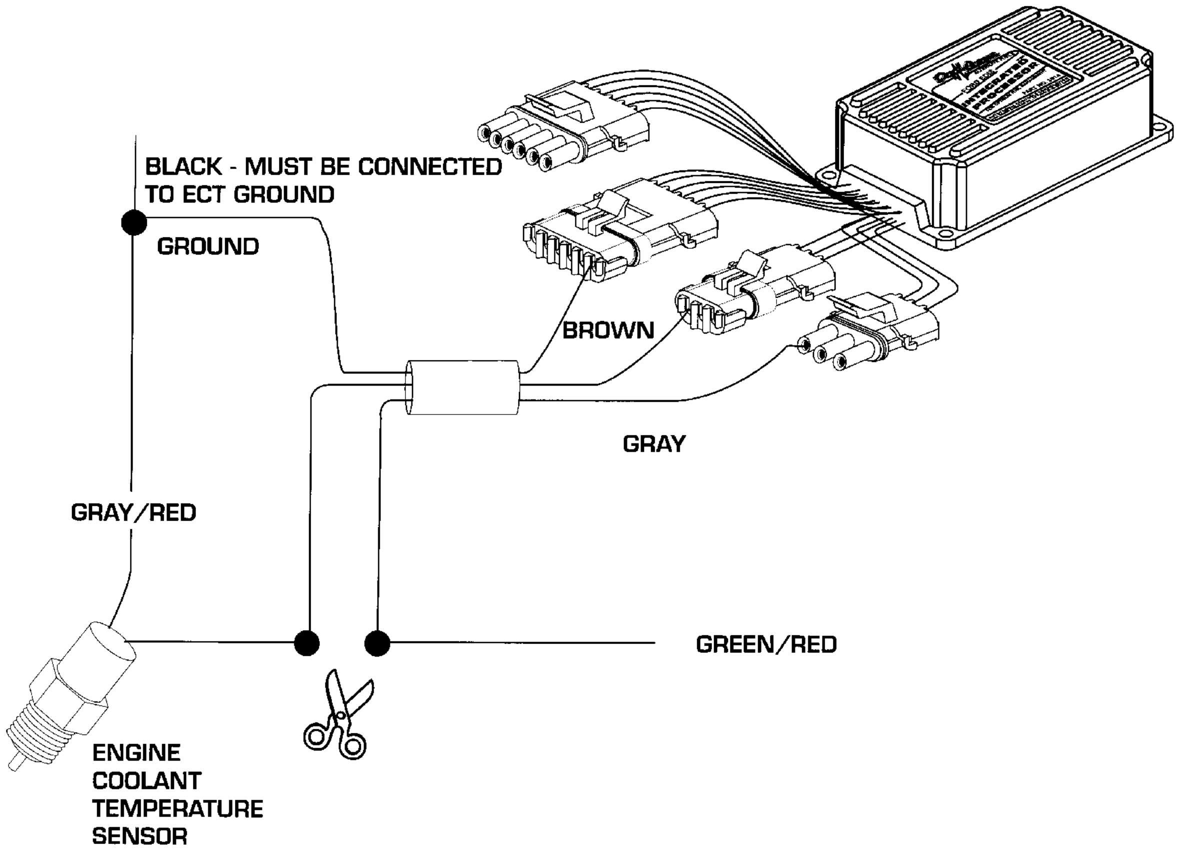


Courtesy of Autotronic controls

KNOCK

- May have to tap OEM knock sensor circuit
  - Allows LPG system to monitor PCM diagnostic signals
  - Else PCM sets fault code for knock or ECT when on LPG

18-8 ECT SENSOR TAP AND INTERCEPT



Courtesy of Autotronic Controls

CANISTER PURGE SOLENOID (CPS)

- Connected when necessary to meet emissions standards
- OEM strategy differences

COOLANT TEMPERATURE SENSOR (CTS)

- LPG system monitors and intercepts coolant temperature
  - Keeps PCM from performing gasoline computer diagnostics
  - PCM not seeing feedback logs MIL

THERMACTOR AIR BIPASS (TAB)

- Diverts air into exhaust manifold for exhaust and catalyst
- LPG system monitors TAB Gasoline PCM ignores lean O_2 signal
- LPG goes into open loop when TAB on

STARTER

- Tap not used in all systems to recognize engine crank

INTAKE AIR TEMPERATURE (IAT) SENSOR)

- Determines air density

MANIFOLD SKIN TEMPERATURE (MST) SENSOR

- Thermister
  - Increases in temperature decreases its resistance
- Used to calculate air-fuel density by measuring engine intake manifold temperature

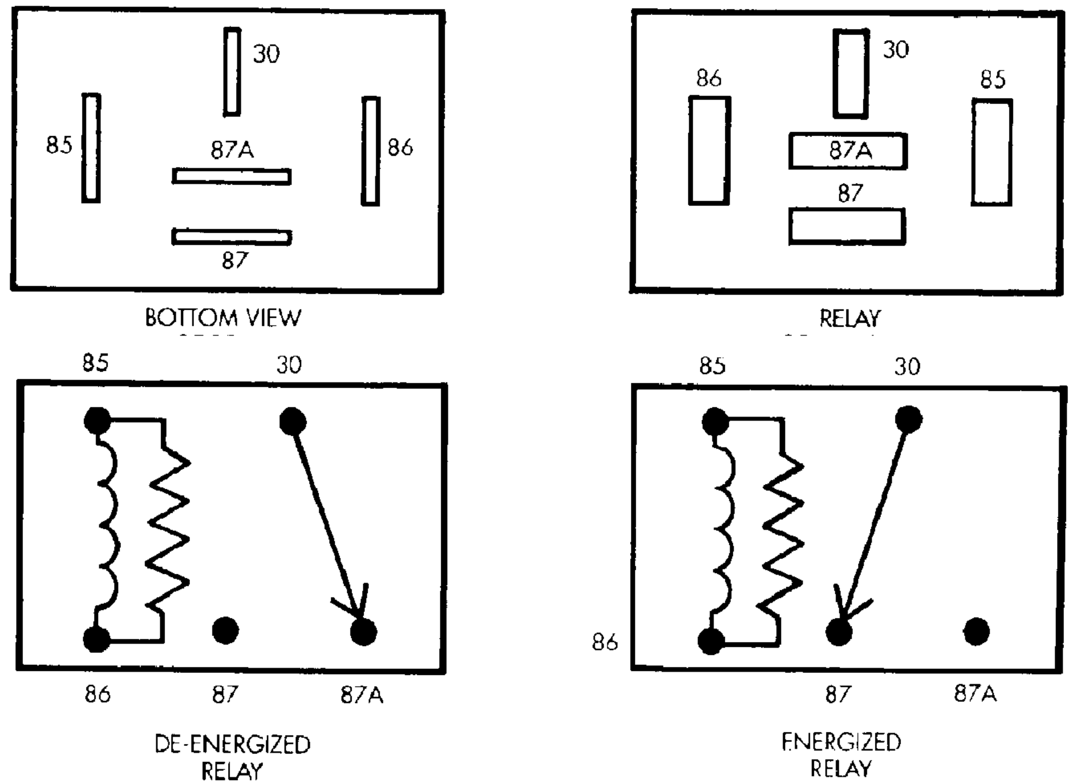
TACH

- Provides engine RPM
  - Equals one pulse per spark event

FUSE AND RELAY MODULE

- Processor protected by inline fuse with correct amp rating
- Relays may be needed to control components or computer support modules

18-9 RELAY FUNCTION



Courtesy of Chrysler Corporation

PROCESSOR POWER

- Supplies voltage from vehicle to LPG system
  - B+ and SW B+ sources

SWITCHED BATTERY POWER (SW B+)

- Tap taken from source hot in all ignition positions except Off and ACC
- Circuit must provide 10V in Start position
- Cutting SW B+ circuit may cut other OEM actuators

BATTERY POWER (B+)

- Required to backup adaptive memory
- Processor backs up and powers down after key off
- Tap on unswitched side of relay

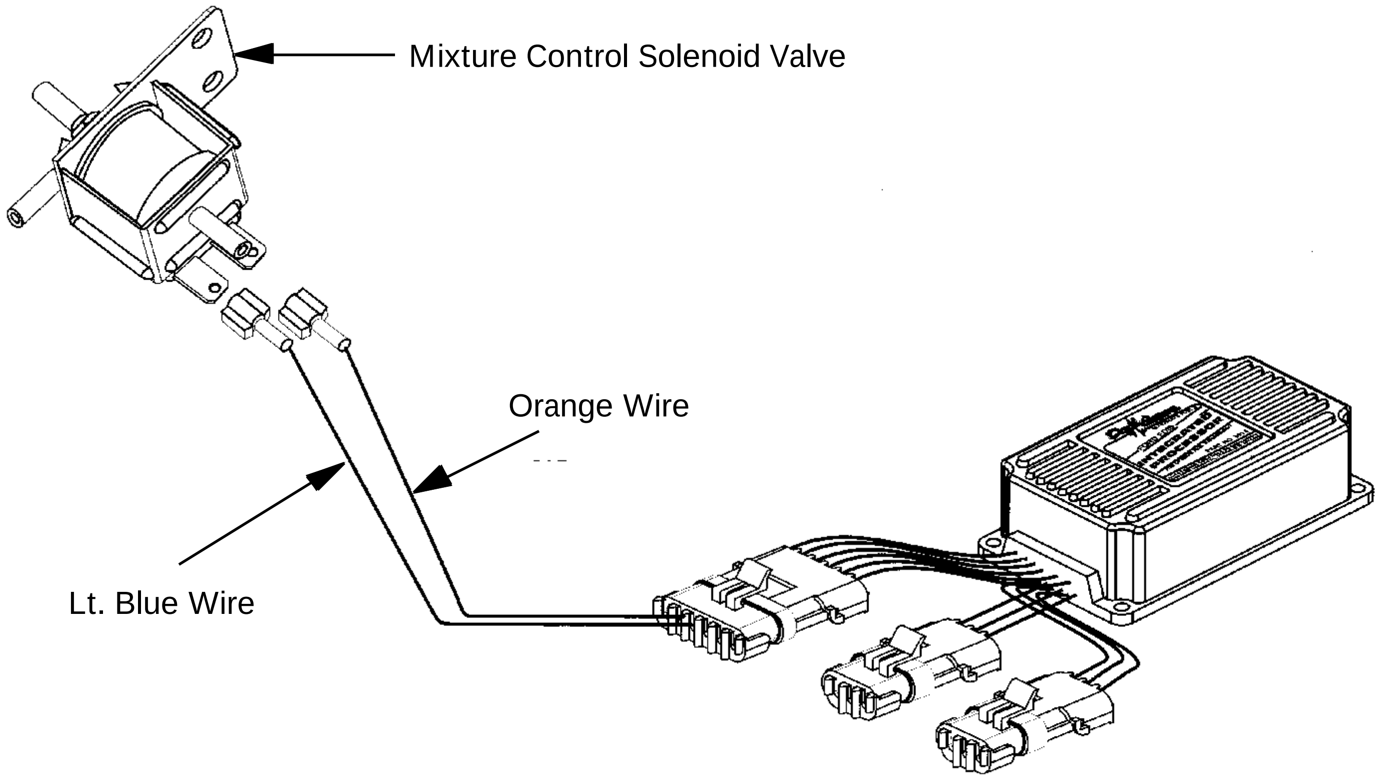
INJECTOR SIMULATORS

- May require additional fix
- Used to prevent check-engine codes and send signal aliases

FUEL CONTROL VALVE

- Dithering Valve
- Controls LPG regulator and adjusts air-fuel ratio
- Receives input from O_2 and RPM sensors

18-10 FUEL CONTROL SOLENOID WIRING



Courtesy of Autotronic Controls

POST-INSTALLATION

- Check for proper operation before installing or adjusting mixer or FI system
- Run diagnostics program
- Revisit connections, check continuity, operate components and adjust if necessary

MODULE 19:

Air Induction Installation

State of Oklahoma
College of the Desert
West Virginia University

MODULE 19: AIR INDUCTION INSTALLATION

CONTENTS

MODULE 19: AIR INDUCTION INSTALLATION

OBJECTIVES

At the completion of this module, the technician will be able to:

- Discuss characteristics and considerations of the air induction system.
- Discuss the functions and considerations of the air filter.
- Compare and contrast frontal air vs. under hood air
- Discuss effects of intake air temperature on engine power.
- Determine the proper size air cleaner for a particular engine.

INSTRUCTOR NOTES

INSTRUCTOR MATERIALS/MEDIA NEEDED

Overhead projector or LCD panel/projection equipment
Master overhead transparencies or Microsoft PowerPoint 4.0 presentation file Mod19.ppt

Note: Slides correspond to text as indicated by icon

STUDENT MATERIALS/MEDIA NEEDED

Module 19: Air Induction Installation

MODULE REVIEW ITEMS

The Module Review Items (MRI) are designed to allow for flexibility in their use. The exam may be utilized as a post-module review, pre/post test, part of a term examination, or it may be used by the student if the module is used as a self study text.

MASTER OVERHEAD TRANSPARENCIES

The printouts enclosed with this module are taken from the Microsoft PowerPoint 4.0 presentation file Mod19.ppt . Instructors planning to use overhead projectors should make transparencies from these printouts on a copier (or laser printer designed to safely print to acetate.

Note: Please review Module 25: Training of Trainers for more hints on instructional needs and strategies.

MODULE 19: AIR INDUCTION INSTALLATION

Key Points & Notes

BREATHING EASY

19-2

Take a deep breath of air. That ís what an engine constantly does, consuming a lot more than a person. In one hour, a 200 HP engine consumes about 18,500 cu. ft. of air while a human being consumes only 12.7 cu. ft. It's no wonder internal combustion engines are often referred to as air pumps. In both cases, clean air is essential.

WHAT IT DOES & HOW

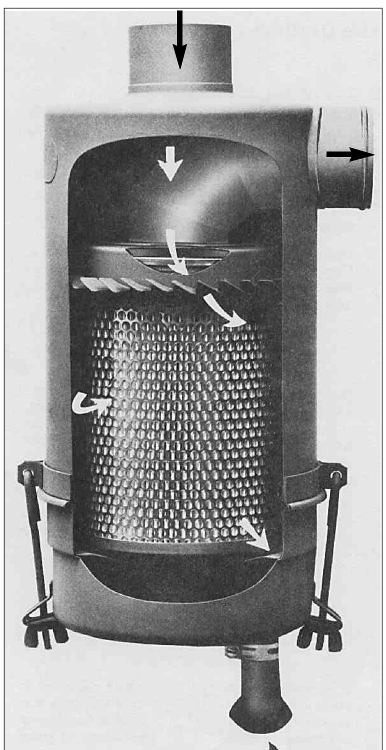
19-3

The air induction system captures outside air, separates out moisture, filters out dirt and other impurities, then delivers clean air to the engine. This process restricts the airflow slightly, creating a pressure drop. Careful design, however, minimizes this pressure loss so the engine can still breathe efficiently. The design can be quite involved and is not readily duplicated by a shade-tree mechanic.

Water separation is a function of the air cleaner that is not typically considered. Too much moisture will overburden the filter element and ruin it. So water needs to be stripped from the air before it gets into the filter. A standard recommendation is that 80 percent of the airborne water be removed prior to reaching the filter element.

This is done by taking advantage of a simple principle: water is heavier than air so it is less nimble. Air can change its direction of flow faster than the water it carries. If, for example, air makes a sudden 90^{o} turn, much of the water won't make that turn and will instead keep on going forward.

19-4


Courtesy of Vortox

19-1 Vortox air cleaner.

Engineers take advantage of this by installing two small exit holes at the corner of that right-angle turn to catch the water droplets as they collide into the wall. As they coalesce into larger droplets, they run down the wall and outside the system, dropping back into the ambient air.

In many systems, it is not quite that simple. Air intakes installed under the hood cannot be bent 90^{o}. Furthermore, right-angle turns aren't desirable because the restriction they create increases fuel consumption. So, airflow within the intake snout must be designed to make droplets zigzag away from the main path.

Fashioning the correct alterations in air flow requires analyzing the flow paths of the air. For example, a large dimple may be manufactured into the snout for no apparent

Key Points & Notes

reason; it is there because analysis showed that, combined with other features like plenums, it will alter air flow to remove the correct amount of water.

THE FILTER FUNCTION

19-5

Air must now pass through the filter where it will leave behind any of the moisture it may still carry along with virtually all the dirt, pollen, and whatever else may be airborne. The filter, consisting of the cylindrical canister and the element, is designed to handle reasonable amounts of impurities without strain – without too much of a drop in pressure.

A filter that is designed for normal road use may get plugged if put into dusty or off-road service. Thus, a filter for an off-road vehicle might have more capacity than one for a highway vehicle.

The “dry” filter element on a vehicle will usually be made of special paper. This “media” is chemically treated to grab misty water, and its tiny holes are designed to block passage of minute dirt and dust particles and most everything else that is airborne.

Filter media is pleated, serving two functions: giving extra strength to the paper, increasing the media’s surface area, and adding capacity in excess of what its external dimensions might otherwise be.

As dirt particles are caught on the media’s surface, they initially increase its efficiency. This phenomenon occurs because the thin coating of particles further increases the media’s surface area. But as dirt continues to build, restriction begins to increase. Eventually the filter element reaches its holding capacity, the engine’s breathing becomes labored, and it’s time for a new element.

Changing the element too soon will lower restriction and improve engine performance and fuel economy, but the extra cost of the premature element change might cancel out the money saved in fuel. On the other hand, waiting too long may waste fuel and increase emissions. It will certainly decrease performance. Inspecting the filter is not necessarily an accurate way to judge the condition of the filter. The only way to judge filter condition accurately is with a restriction gauge. The gauge face can be mounted on the instrument panel or, if the fleet manager believes it’s not the driver’s concern, on the air cleaner plumbing under the hood. Either way, it’s wise to specify one into the system.

CUTTING AIR RESTRICTION

19-6

Overall size still has a great bearing on the filter’s capacity. In other words, the larger the element, the more dirt it can grab and hold. And it will last longer. A larger filter also provides a given volume of air more avenues of passage so the restriction on intake air is less.

Cutting air restriction should be one of your major concerns in checking out the vehicle manufacturer’s air intake system. The manufacturer establishes how much restriction, measured in inches of water, an engine will tolerate before performance is affected. The less restriction the better; if the system offers less than approximately ten inches of water restriction (10 in. W.C.) with a clean element, the air induction system should work efficiently.

Key Points & Notes

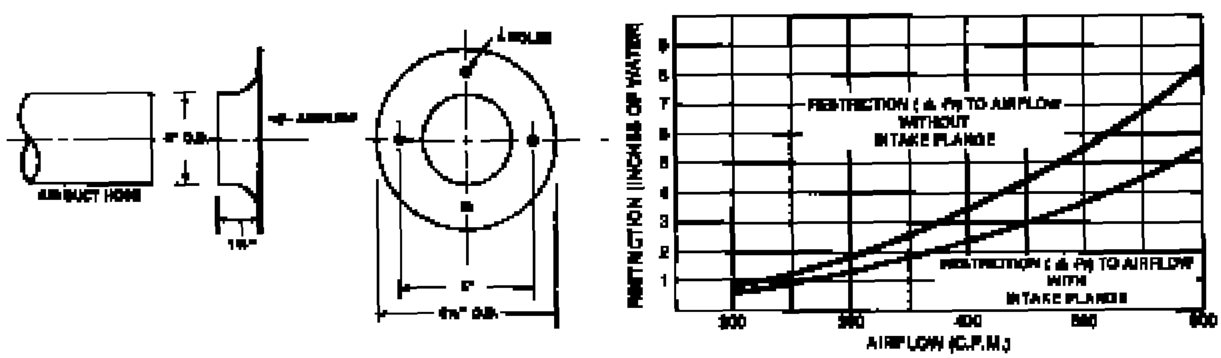
FRONTAL AIR VS. UNDER HOOD AIR

19-7

Cool the air to your engine! With engine exhaust manifold temperatures frequently running over 1000° F and glowing red hot, under hood air temperatures can easily reach 200° F and higher. To counter this, cooler air is brought in from outside the engine compartment and delivered to the engine intake.

Using cooler intake air is nothing new. It's a proven method used every day on millions of gasoline and diesel vehicles that take intake air from out front or high above the cab. Cooler air increases engine horsepower and fuel economy and also lessens the possibility of detonation of the fuel.

NOTE: In the illustration below, the air inlet shroud has a curved



Courtesy of Vortox

19-2 Vortox streamlined air entrance flange and airflow chart.

19-8, 19-9

entry. This design reduces air flow restriction significantly as seen in the chart.

EFFECTS OF INTAKE AIR TEMPERATURE ON POWER PRODUCED BY AN ENGINE

19-10

For the same reason that an engine produces less power at a high altitude, it also produces less power breathing heated air because the air weighs less.

a. The weight of air decreases one percent for each 10° F rise in temperature above 59° F. A decrease in air weight of six percent at 119° F will result in the engine producing six percent less horsepower than it would breathing 59° F air.

b. Conversely, an engine breathing 119° F under hood air and producing 100 horsepower will gain 6.37 horsepower by obtaining 59° F air from an outside source.

TO DETERMINE THE PROPER SIZE AIR CLEANER FOR A NATURALLY ASPIRATED ENGINE

19-11

Determine the volumetric displacement of the engine by using one of the following formulas where bore and stroke are expressed in inches and the maximum governed speed or the maximum speed anticipated is expressed in R.P.M.

AIR FLOW FORMULA:

a. For Four Cycle Engines:

(Stroke x Bore x .785 x No. of cylinders) x R.P.M./3456 = Ideal C.F.M.

b. For Two Cycle Engines:

(Stroke x Bore x .785 x No. of cylinders) x R.P.M./1728 = Ideal C.F.M.

ACTUAL AIR FLOW FACTORS [IDEAL AIR FLOWS x (FACTORS LISTED BELOW)]

Naturally Aspirated Engines

Diesel = .90

Gasoline = .75

Supercharged = 1.4

Turbocharged = 1.4

EXAMPLE: (Four Cycle Engine)

300 cu. in x 2800 R.P.M./3456 = 243 C.F.M. (Ideal)

Turbocharged 243 x 1.4 = 340 C.F.M. (Actual)

To convert Liters to Cubic Inches:

Liters divided by 16.39 = Cu. In. Displacement

Key Points & Notes

19-12

MODULE REVIEW ITEMS

Note to Technician: Consider all choices carefully and select the best answer to each.

1. In one hour, a 200 HP engine consumes about _____ cubic feet of air.
A. 18,500.
B. 21,000.
C. 12.7.
D. 4500.

2. The air induction system does not perform which function?
A. Captures outside air and separates out moisture.
B. Filters out dirt and other impurities.
C. Conditions the air.
D. Delivers clean air to the engine.

3. Air induction creates a pressure increase.
A. True.
B. False.

4. It is recommended that _____ of airborne water be removed from the air prior to reaching the filter element.
A. 5%.
B. 50%.
C. 55%.
D. 80%.

5. Water is _____ than air so it is _____.
A. Heavier; more nimble.
B. Heavier; less nimble.
C. Lighter; more nimble.
D. Lighter; less nimble.

6. A large dimple in the snout...
A. Is there for decoration only.
B. Increases fuel consumption.
C. Alters air flow to remove water.
D. Is actually part of the plenum.

7. Pleated filter media does not...
A. Have extra strength than flattened out paper.
B. Have less surface area than flattened out paper.
C. Trap minute dirt and dust.
D. Grab misty-type airborne water.

8. The only way to judge filter condition accurately is with a restriction gauge.
A. True.
B. False.

9. The _____ the element, the _____ dirt it will trap and the _____ it will last.
A. Smaller; more; shorter.
B. Smaller; less; longer.
C. Larger; less; longer.
D. Larger; more; longer.

10. The weight of air decreases _____ % for each _____ degree F rise in temperature above _____ degrees F.
A. 1; 1; 59.
B. 1; 10; 59.
C. 10; 1; 59.
D. 1; 59; 10.

MRI SCORING KEY

1. A
2. C
3. B
4. D
5. B
6. C
7. B
8. A
9. D
10. B

1 **MODULE 19:**
Air Induction Installation

2 **BREATHING EASY**

- IC engine = air pump
- 200 HP engine uses about 18500 CF air

3 **WHAT IT DOES & HOW**

- Captures air, moisture, impurities; delivers clean air to engine
- Creates pressure drop
- 80% airborne water needs removed
- Water catches at turn corner or obstruction and drips away

4 **19-1 VORTOX AIR CLEANER**

5 **THE FILTER FUNCTION**

- Removes airborne contaminants without much pressure drop
- "Dry" filter elements
- Operation
- Replacement cost vs. improved performance
- Restriction gauge monitors filter condition

6 **CUTTING AIR RESTRICTION**

- Larger filters are better
- Cut air restriction for improved performance

7 **FRONTAL AIR VS. UNDER HOOD AIR**

- Cooler air increases HP, fuel economy, decreases detonation
- Note air inlet shroud design

8 **19-2A VORTOX STREAMLINED AIR ENTRANCE FLANGE**

9 **19-2B VORTOX AIRFLOW CHART**

10 **EFFECTS OF INTAKE AIR TEMPERATURE ON POWER PRODUCED BY AN ENGINE**

- Air weight decreases 1% for each 10% rise in temp above 59^{o}

11 **TO DETERMINE THE PROPER SIZE AIR CLEANER FOR A NATURALLY ASPIRATED ENGINE**

- 4-cycle formula:
  - (Stroke x Bore x .785 x # cylinders) x RPM / 3456 = ideal CFM
- 2-cycle formula:
  - (Stroke x Bore x .785 x # cylinders) x RPM / 1728 = ideal CFM

12 **ACTUAL AIR FLOW FACTORS**

- Naturally Aspirated Engines
  - Diesel = .90
  - Gasoline = .75
  - Supercharged = 1.4
  - Turbocharged = 1.4
- Convert Liters To Cubic Inches
  - L / 16.39 = CI Displacement

MODULE 19:
Air Induction Installation

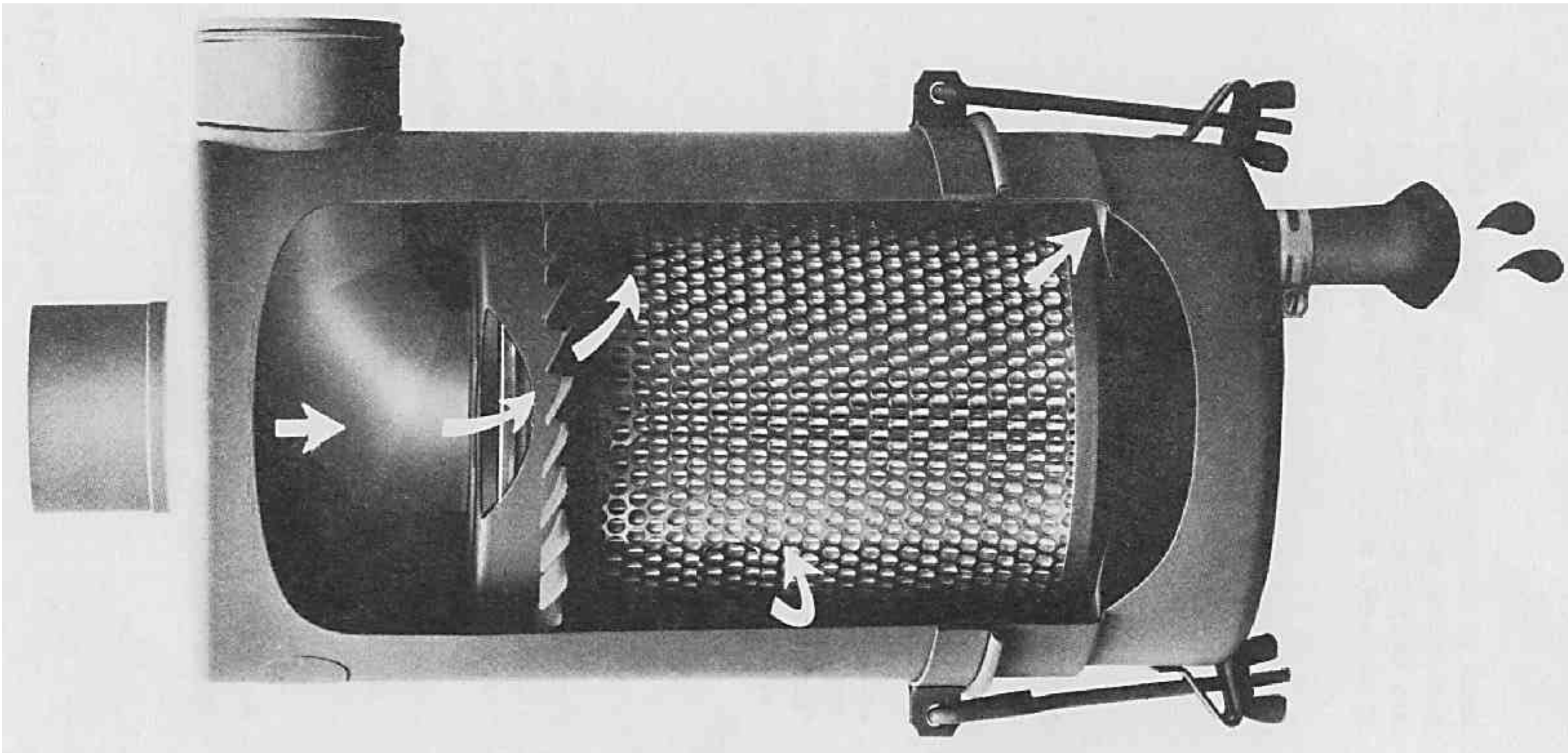
BREATHING EASY

- IC engine = air pump
- 200 HP engine uses about 18500 CF air

WHAT IT DOES & HOW

- Captures air, moisture, impurities; delivers clean air to engine
- Creates pressure drop
- 80% airborne water needs removed
- Water catches at turn corner or obstruction and drips away

19-1 VORTOX AIR CLEANER



Courtesy of Vortox

THE FILTER FUNCTION

- Removes airborne contaminants without much pressure drop
- "Dry" filter elements
- Operation
- Replacement cost vs. improved performance
- Restriction gauge monitors filter condition

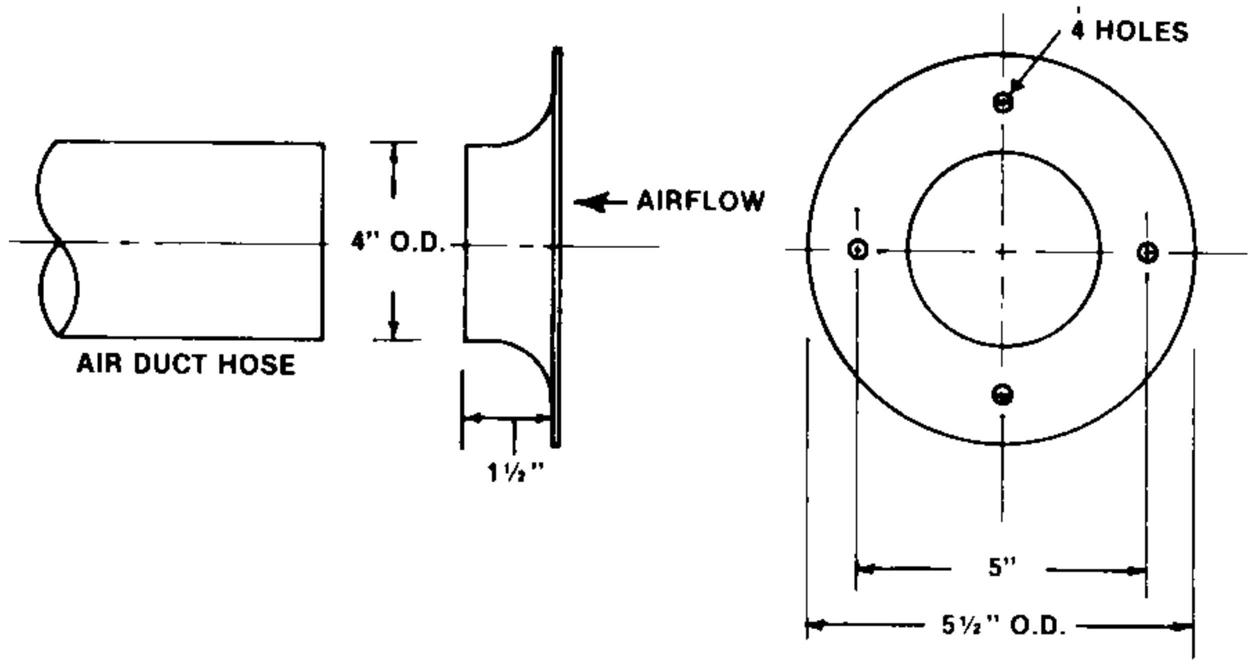
CUTTING AIR RESTRICTION

- Larger filters are better
- Cut air restriction for improved performance

FRONTAL AIR VS. UNDER HOOD AIR

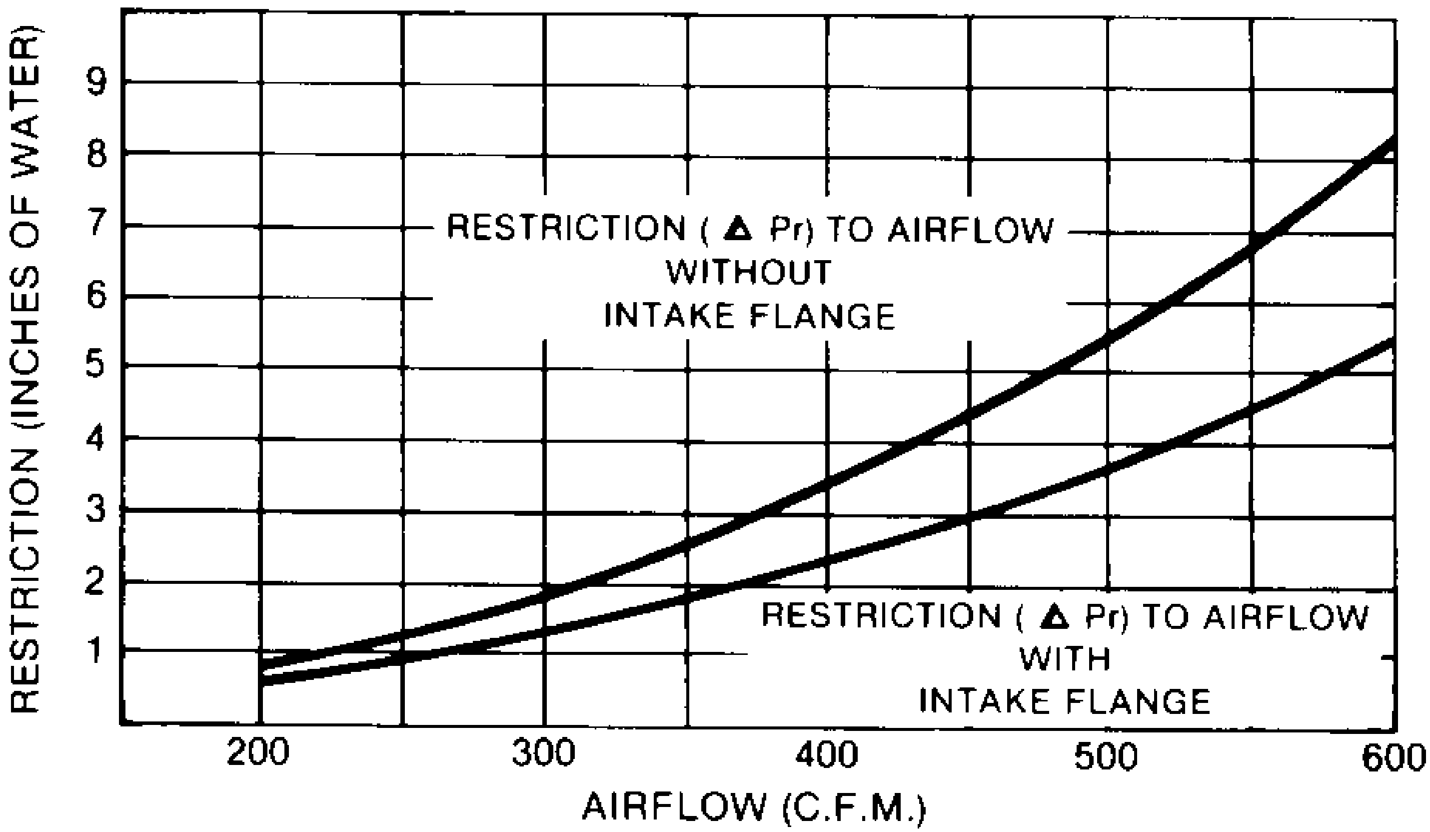
- Cooler air increases HP, fuel economy, decreases detonation
- Note air inlet shroud design

19-2A VORTOX STREAMLINED AIR ENTRANCE FLANGE



Courtesy of Vortox

19-2B VORTOX AIRFLOW CHART



Courtesy of Vortox

EFFECTS OF INTAKE AIR TEMPERATURE ON POWER PRODUCED BY AN ENGINE

- Air weight decreases 1% for each 10% rise in temp above 59^{o}

TO DETERMINE THE PROPER SIZE AIR CLEANER FOR A NATURALLY ASPIRATED ENGINE

- 4-cycle formula:
  - (Stroke x Bore x .785 x # cylinders) x RPM / 3456 = ideal CFM

- 2-cycle formula:
  - (Stroke x Bore x .785 x # cylinders) x RPM / 1728 = ideal CFM

ACTUAL AIR FLOW FACTORS

- Naturally Aspirated Engines
  - Diesel = .90
  - Gasoline = .75
  - Supercharged = 1.4
  - Turbocharged = 1.4
- Convert Liters To Cubic Inches
  - L / 16.39 = CI Displacement

MODULE 20:

Tank Purging & Leak Checking

State of Oklahoma
College of the Desert
West Virginia University

MODULE 20: TANK PURGING & LEAK CHECKING

CONTENTS

Liquefied Petroleum Gas

MODULE 20: TANK PURGING & LEAK CHECKING

OBJECTIVES

At the completion of this module, the technician will be able to:

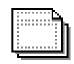
- Discuss and properly purge the fuel tanks of air and moisture.
- Discuss and properly leak test all fittings and connections.

MODULE 20: TANK PURGING & LEAK CHECKING

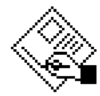
INSTRUCTOR NOTES

INSTRUCTOR MATERIALS/MEDIA NEEDED

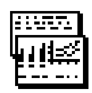
Overhead projector or LCD panel/projection equipment
Overhead transparency masters or Microsoft PowerPoint 4.0 presentation file Mod20.ppt

Note: Slides correspond to text as indicated by icon 

Laboratory Activities:
Activity 20-1: Tank Purging
Activity 20-2: Leak Testing

Note: Lab activities correspond to text as indicated by icon 

Handouts:
NPGA #133-89(a) Purging LP-Gas Containers

Note: Handouts correspond to text as indicated by icon 

STUDENT MATERIALS/MEDIA NEEDED

Module 20: Tank Purging & Leak Checking

MODULE REVIEW ITEMS

The Module Review Items (MRI) are designed to allow for flexibility in their use. The exam may be utilized as a post-module review, pre/post test, part of a term examination, or it may be used by the student if the module is used as a self study text.

OVERHEAD TRANSPARENCY MASTERS

The printouts enclosed with this module are taken from the Microsoft PowerPoint 4.0 presentation file Mod20.ppt . Instructors planning to use overhead projectors should make transparencies from these printouts on a copier (or laser printer designed to safely print to acetate.

Note: Please review Module 25: Training of Trainers for more hints on instructional needs and strategies.

MODULE 20: TANK PURGING & LEAK CHECKING

FILL SYSTEM WITH FUEL AND CHECK FOR LEAKS

OVERVIEW

When the LPG system is fully installed, it must be partly filled with gas – two or three gallons – then checked thoroughly for leaks before completely filling the tank or operating the engine on propane. Refueling and leak checking should be done in a well-ventilated area, preferably outdoors. All fittings and connections must be fully tightened before gas is introduced into the system. Locate all shut-off and lock-off valves before refueling. It is important to know how to open and close the flow of gas through the system before refueling.

Once there is a little fuel in the system, open the fuel supply valve(s) to pressurize the system. Immediately start checking for leaks with either non-ammonia leak soap squirted on all fittings and connections or with an electronic leak detector. **Caution:** Repair the cause of the leak before operating the vehicle.

TANK PURGING AND MOISTURE REMOVAL

New or completely empty tanks must be purged of air and other contaminants before being filled with liquid propane and put into service. Water vapor in the gas tank may cause regulator freeze-up and affect the ability of the odorant to meet safe standards. (Water can cause oxidation on the inside of the tank and cause “odorant fade.”) Air in the tank will cause abnormally high pressures and possible relief valve opening. Air also creates unstable, inaccurate air-fuel mixtures and poor running. If a used container has been sitting empty exposed to the atmosphere it should be purged as if it were a new container.

Purging a tank with vapor propane rather than liquid is done to keep liquid entering the tank from flashing into vapor, chilling the tank, and condensing the moisture inside the tank. This is extremely important when storage tanks are large; motor fuel tanks are considered small.

After thoroughly purging air, the tank will contain fuel both as liquid and vapor. The purging process vents gas to the atmosphere and creates a serious fire hazard. Therefore, it is essential that safety precautions be taken. Refer to local fire and gas regulations.

Below are general steps as published in National Propane Gas Association, Bulletin/Pamphlet # 133, *Purging LP-Gas Containers*

1. Purging of containers should be performed in an approved area. See NFPA 58, 4-3.2 (1995).
2. Determine if the container pressure is zero. Should the container contain only air pressure, the air may be vented directly to the atmosphere through the service valve.
3. If free water is present in the container, it should be drained.
4. Pressurize the container to approximately 15 psig with LP-gas vapor. Never purge with liquid LP-gas; to do so will cause the moisture vapor to chill and remain in the container.

Key Points & Notes

20-2

20-3

NPGA #133-89(a) Purging LP-Gas Containers

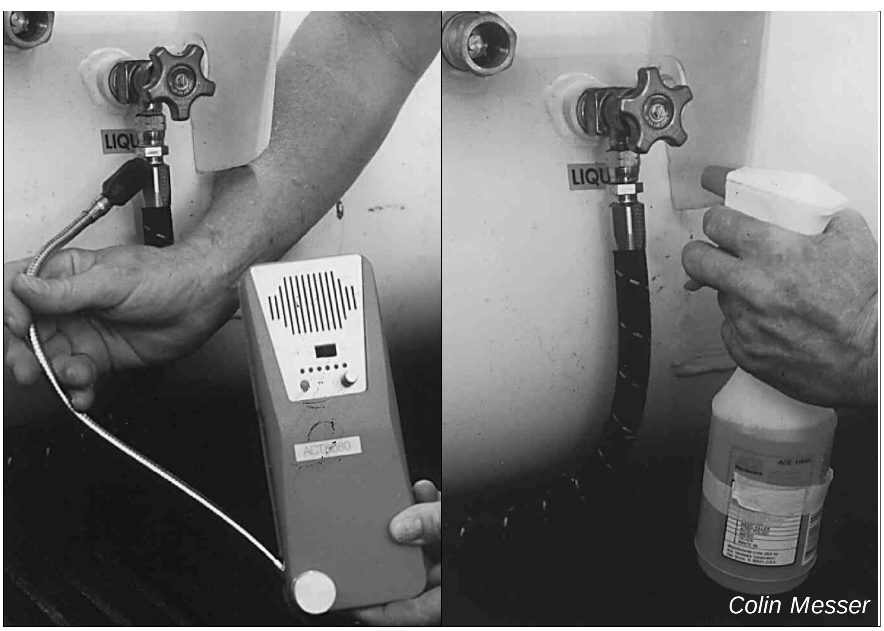
20-4

5. Fully open the container service valve and vent to a safe atmosphere.
6. Repeat Steps 4 and 5 for a total of five purgings.
7. The usual purge pressurization method requires the venting of about 15–18 gallons of LP-gas per 1000 gallons of container capacity.
8. Add the suggested amount of methanol and close valve. Methanol must be used in an approved and safe manner. Refer to methanol Material Safety Data Sheet for proper handling and warnings. **Note:** Unless the interior of the tank has been exposed to extreme moisture, it probably isn't necessary to perform the methanol routine. The suggested amount of methanol is 1 pint for every 100 gallons tank capacity.
9. Repressurize the container with odorized LP-gas vapor to 15 psig.
10. The container is now ready to be filled with LP-gas.
11. Once filled, all fittings and tank openings should be checked for leaks using an approved leak detector solution.
12. The container is now ready to be placed in service.

LEAK TESTING

Leak testing should be done in a well-ventilated area that meets all local health, safety and environmental regulations and standards. Leak checks must be made before the vehicle is completely refilled and released into service.

Squirt non-ammonia leak detection soap solution over all fittings and connections. Look closely for bubbles that indicate a leak. If using an electronic leak detector, move the sensor tip over all



Colin Messer

20-1 Leak testing with electronic detector, left, and with soap solution.

Key Points & Notes

20-5

Activity 20-1: Tank Purging

20-6

20-8

20-9

fittings and connections listening for a change in tone frequency of the detector, which indicates a leak.

> ***NOTE:*** Look for frosting around fittings. This indicates a liquid leak. Listen for high pressure hissing or smell (sniff) for the distinctive scent of odorant.

WARNING: If a leak is found, shut-off all tank valves then de-pressurize and purge the system of all LPG before attempting to tighten (or loosen) a fitting.

If the engine doesn't yet run on LPG, the line pressure must be vented to bring system down to atmospheric pressure. Do this very carefully outdoors away from all sources of combustion. Slowly and carefully crack a fitting to vent all pressure from the system. Typically the liquid line is vented, which means frosting at the connection. Wear gloves and eye protection then proceed with extreme caution. Ensure that all gas has been ventilated from the area before continuing!

If the engine does run on propane, shut off all tank valves and run the vehicle until all the propane in the system is used up and the engine stalls or automatically switches to gasoline.

Key Points & Notes

20-7

Activity 20-2: Leak Testing

Key Points & Notes

MODULE REVIEW ITEMS

Note to Technician: Consider all choices carefully and select the best answer to each.

1. Which order is the correct procedure for checking for leaks?
A. Fill tank with 3 gallons LP, install system, check for leaks, completely fill tank.
B. Install system, fill tank with 3 gallons LP, check for leaks, completely fill tank.
C. Fill tank with 3 gallons LP, check for leaks, install system.
D. Check for leaks, fill tank with 3 gallons LP, completely fill tank.

2. New or completely empty tanks must be purged of air before being filled with LPG.
A. True.
B. False.

3. Water in the tank can cause oxidation and can also cause _____.
A. Odorant fade.
B. Oxicution.
C. Distillation.
D. Pressurization.

4. Purging the tank with vapor propane is done to:
A. Condense the moisture inside the tank.
B. Keep liquid entering the tank from flashing into vapor.
C. Warm the tank.
D. A and B.

5. The purging process vents gas to the atmosphere, which does not create a fire hazard.
A. True.
B. False.

6. Frosting around the fittings does not necessarily indicate a leak.
A. True.
B. False.

7. If a leak is found, depressurize the system before working on a fitting.
A. True.
B. False.

MRI SCORING KEY

1. B
2. A
3. A
4. D
5. B
6. B
7. A

ACTIVITY 20-1: TANK PURGING

OBJECTIVE

To purge fuel tanks of air and moisture.

MATERIALS NEEDED

Module 20: Tank Purging and Leak Checking

NPGA #133-89(a) Purging LP-Gas Containers

LP fuel tank

LP filling station

Methanol

Leak detector solution

Shop air

METHOD

Using the procedures from either Module 20 pages 1-2 or NPGA #133, purge the fuel tank of air and moisture. Attempt the alternate purge method using shop air if applicable.

Fill the tank and leak test it.

QUESTIONS

Why must air and water be removed from the tank?

How do you know when a tank must be purged?

Why is methanol used in the purging process?

COMMENTS

ACTIVITY 20-2: LEAK CHECKING

OBJECTIVE

To leak test all fittings and connections.

MATERIALS NEEDED

Leak test solution or electronic leak detector

Filled tank or converted vehicle

METHOD

Squirt the liquid solution over all fittings and connections. Watch for bubbles that indicate a leak.

For an electronic detector, make sure it operates properly and move it over all fittings and connections. A leak will cause a change of tone frequency.

QUESTIONS

Where should leak testing of a vehicle be performed?

What other indications are there for escaping LPG?

COMMENTS

To observe an actual leak, create one with low pressure LP. For example, on a fuel tank that is low pressurized spray the solution on a valve and SLOWLY AND CAREFULLY loosen it, watching for bubbles. Apply more solution as necessary to observe the leak. Tighten the valve and note when the leak stops. Wear gloves and eye protection when working with the valve.

If a leak is found, shut off all tank valves and de-pressurize and purge the system of all LPG before tightening (or loosening) a fitting.

If a leak was found, what was the reason for it? Note this in a log if applicable.

1 **MODULE 20:**
Tank Purging & Leak Checking

2 **FILL SYSTEM WITH FUEL AND CHECK FOR LEAKS- OVERVIEW**

- Fill tank with 2-3 gallons to test system
- Refuel and leak-check outdoors
- Tighten all fittings
- Locate and initially close all shut-off and lock-off valves
- Open valves and leak check fittings and connections
- Repair as needed

3 **TANK PURGING AND MOISTURE REMOVAL**

- Purge all tanks to be used
- Purge with vapor propane
- Use NPGA #133 purging procedures

4 **PURGING LP-GAS CONTAINERS**

1. Perform in an approved area
2. Determine if tank pressure is zero
3. Drain any free water in tank
4. Pressurize with LPG vapor to 15 psig
5. Fully open tank service valve and vent to a safe atmosphere
6. Repeat steps 4-5 for five purgings

5 **PURGING LP-GAS CONTAINERS**

7. Purge pressurization vents 15-18 gal. LPG per 1000 gal. tank capy.
8. Add methanol and close valve
   1 pint/100 gal. tank capy.
9. Repressurize tank with odorized LPG to 15 psig
10. Tank ready for LPG
11. After filling, check fittings and openings for leaks
12. Place tank in service

6 **LEAK TESTING**

- Use non-ammonia leak detection soap solution or electronic leak detector
- Look for frosting around fittings
- Listen for hissing
- Smell for LPG odorant
- Shut off valves if leak is found

7 **LEAK TESTING**

Line pressure dumping procedure:

- Crack a fitting slowly
- Wear gloves and eye protection
- Vent area
- Or run vehicle until all LPG used and engine stalls

8 **20-1A ELECTRONIC LEAK DETECTOR**

9 **20-1B LEAK TESTING WITH SOAP SOLUTION**

MODULE 20:
Tank Purging & Leak Checking

FILL SYSTEM WITH FUEL AND CHECK FOR LEAKS- OVERVIEW

- Fill tank with 2-3 gallons to test system
- Refuel and leak-check outdoors
- Tighten all fittings
- Locate and initially close all shut-off and lock-off valves
- Open valves and leak check fittings and connections
- Repair as needed

TANK PURGING AND MOISTURE REMOVAL

- Purge all tanks to be used
- Purge with vapor propane
- Use NPGA #133 purging procedures

PURGING LP-GAS CONTAINERS

1. Perform in an approved area
2. Determine if tank pressure is zero
3. Drain any free water in tank
4. Pressurize with LPG vapor to 15 psig
5. Fully open tank service valve and vent to a safe atmosphere
6. Repeat steps 4-5 for five purgings

PURGING LP-GAS CONTAINERS

7. Purge pressurization vents 15-18 gal. LPG per 1000 gal. tank capy.
8. Add methanol and close valve

   1 pint/100 gal. tank capy.
9. Repressurize tank with odorized LPG to 15 psig
10. Tank ready for LPG
11. After filling, check fittings and openings for leaks
12. Place tank in service

LEAK TESTING

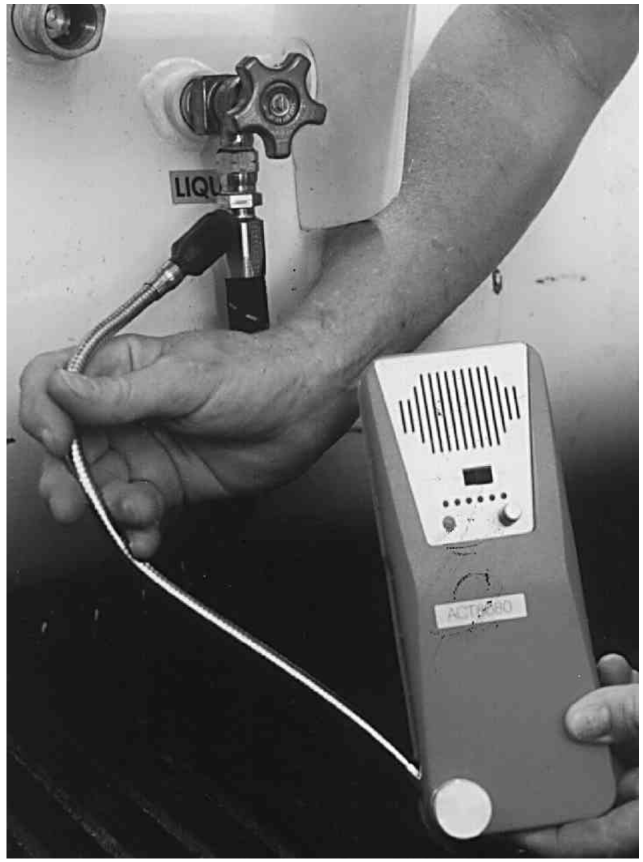
- Use non-ammonia leak detection soap solution or electronic leak detector
- Look for frosting around fittings
- Listen for hissing
- Smell for LPG odorant
- Shut off valves if leak is found

LEAK TESTING

Line pressure dumping procedure:

- Crack a fitting slowly
- Wear gloves and eye protection
- Vent area
- Or run vehicle until all LPG used and engine stalls

20-1A ELECTRONIC LEAK DETECTOR



Colin Messer

20-1B LEAK TESTING WITH SOAP SOLUTION

Colin Messer

MODULE 21:

Post-Conversion - Vehicle Performance

State of Oklahoma
College of the Desert
West Virginia University

MODULE 21: POST-CONVERSION – VEHICLE PERFORMANCE

CONTENTS

MODULE 21: POST-CONVERSION – VEHICLE PERFORMANCE

OBJECTIVES

At the completion of this module, the technician will be able to:

- Describe the preliminary procedures for post conversion vehicle performance.
- Describe the procedures and optimize idle, timing, power mixture, and idle mixture adjustments.
- Describe and demonstrate basic dynamometer and IR exhaust analyzer testing.
- Discuss and optimize closed loop LPG systems.
- Test drive the converted vehicle and evaluate its performance.
- Properly label the vehicle.

INSTRUCTOR NOTES

INSTRUCTOR MATERIALS/MEDIA NEEDED

Overhead projector or LCD panel/projection equipment
Overhead transparency masters or Microsoft PowerPoint 4.0 presentation file Mod21.ppt

Note: Slides correspond to text as indicated by icon

Handouts:
Note: Handouts correspond to text as indicated by icon

STUDENT MATERIALS/MEDIA NEEDED

Module 21: Post-Conversion - Vehicle Performance

MODULE REVIEW ITEMS

The Module Review Items (MRI) are designed to allow for flexibility in their use. The exam may be utilized as a post-module review, pre/post test, part of a term examination, or it may be used by the student if the module is used as a self study text.

OVERHEAD TRANSPARENCY MASTERS

The printouts enclosed with this module are taken from the Microsoft PowerPoint 4.0 presentation file Mod21.ppt . Instructors planning to use overhead projectors should make transparencies from these printouts on a copier (or laser printer designed to safely print to acetate.

Note: Please review Module 25: Training of Trainers for more hints on instructional needs and strategies.

MODULE 21: POST-CONVERSION – VEHICLE PERFORMANCE

Key Points & Notes

Pre-conversion procedures and safety checks are found in Module 10, Table 10-A. These procedures are appropriate for pre-conversion setup, post-conversion procedures, and subsequent preventive maintenance. The engine and its related systems must be evaluated immediately after the conversion and thereafter during preventative maintenance.

PRELIMINARY PROCEDURES

21-2

The overall purpose is to tune the engine for best fuel economy and engine performance, and lowest exhaust emissions. Reliability is also extremely important. Typical propane engine operations to monitor, and in some cases adjust, are as follows:

1. Idle speed
2. Ignition timing
3. Power mixture
4. Idle air/fuel mixture
5. Feedback controls

Table 21-A is a convenient form to record post-conversion information. Refer to Table 21-A and complete while working through this module.

IDLE SPEED ADJUSTMENTS

21-3

Engine idle speed affects both timing and air-fuel mixture. The procedures for idle speed adjustments vary, based on the year of the engine and the model of vehicle. For example, an older medium-duty engine may have an adjustable idle screw, where a newer fuel-injected engine may have little or no adjustment and require special tools and equipment to change the idle speed. Many LPG systems are only adjustable by changing computer calibrations. In fact, it may be illegal to change idle speed depending on the system and vehicle. Therefore, the procedures listed here are basic and general.

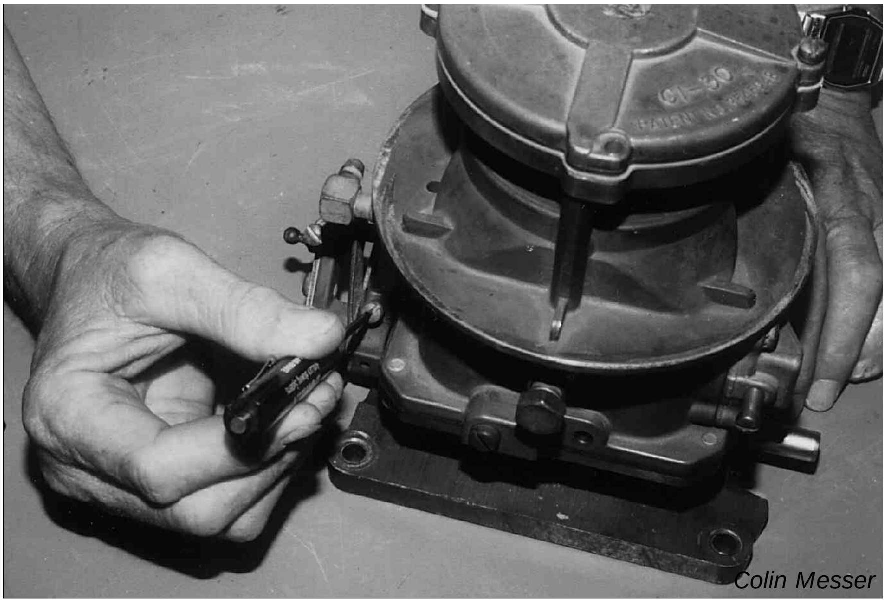
> ***NOTE:*** Adjustments to any system must be made specifically as instructed by the manufacturer; this information is affixed under-hood on the emissions decal or outlined in a service manual for the vehicle.

21-4

For non-feedback, conventional carbureted engines, the idle speed may be adjusted as follows:

1. Run the engine in park/neutral, at stable RPM, at operating temperature.
2. Connect a tachometer to the ignition or locate the dash mounted tach for an engine RPM reference.
3. Set the idle speed to the manufacturer's specifications by adjusting the idle speed control screw, which is located on the propane mixer throttle body for mono-fuel applications or on the OEM throttle body for bi-fuel applications.
4. These adjustments should be made for curb idle. Operation of fast-idle, transmission passing gear levers, choke pull-offs, and other applicable settings should be checked also.

21-5



21-1 Idle speed adjustment.

Key Points & Notes

21-7

21-6

21-8

21-9

5. Verify idle speed control with and without the air conditioner or other power take off (PTO) operated devices and other engine loads.

For feedback (computer-controlled) engines, the idle speed may be adjusted as follows:

1. Most feedback carbureted or fuel-injected engines have no accessible means for adjustment; therefore, attempting to do so may constitute tampering.

2. On all fuel-injected vehicles, the idle speed is controlled as an output function of the computer (PCM). This process is controlled by a stepper motor device. Some of these idle speed controls (ISC) or idle air controls (IAC) have an adjustable range. However, this generally requires specific OEM procedures. **Caution:** Adjustment may be considered tampering. Refer to OEM service information.

IGNITION TIMING

NOTE: Timing cannot be adjusted on non-distributor engines.

Although propane is about 105 octane, and may perform better with the timing more advanced than the gasoline setting, modifications to timing may constitute tampering. Therefore, all settings should be based on OEM specifications found on the underhood decal or in appropriate service manuals.

The procedures for vehicles with points type ignition systems are as follows:

1. The ignition components (points, advance module, mechanical advance, pickup, cap, rotor, and wiring) should be inspected for proper operation and repaired or replaced as needed.

2. Initial timing should be set with the engine at a stable idle speed, and if applicable, with the vacuum advance disconnected and

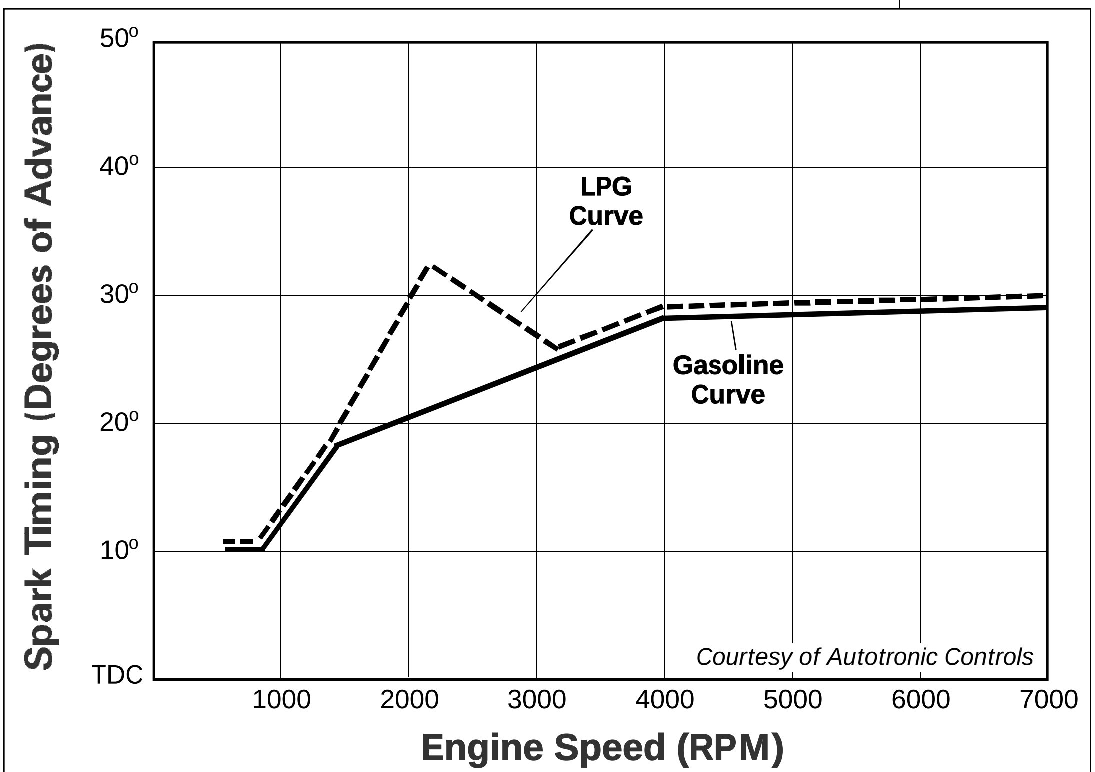
sealed. Refer to the underhood decal for wiring schematic and timing adjustment instructions.

3. Using a timing light, preferably with a variable advance, adjust the initial timing as recommended by the manufacturer. Set the distributor in position and recheck the timing. All final settings should be set to OEM specs, + or – 3^o.

NOTE: Initial timing may be advanced $1/2^o$ to 1^o per 1000 feet of altitude to compensate for a slower burn rate caused by less dense air. Refer to propane equipment manufacturer's literature for recommendations concerning timing modication.

4. Run the engine speed to about 3000 RPM to verify the mechanical (centrifugal) advance mechanism. If no or insufficient advance is indicated, the distributor should be inspected and repaired. A variety of springs, limiter plates and weights are available if this is required. Repeat to verify results.

5. Reconnect the vacuum advance source and again run the engine to about 3000 RPM to verify total advance with vacuum (if applicable). If no or incorrect vacuum advance is indicated, replace the vacuum module. Repeat the test to verify results. Reconnect the hose or wire to generate correct (normal) timing function.



21-2 Ignition timing curve, LPG and Gasoline.

Caution: Electronic timing devices may improve propane performance and mileage but increase emissions. Remember, the installer is responsible for the legal installation of such devices. Consult

Key Points & Notes

21-10

21-11

21-12

applicable rules and regulations or ask the manufacturer. The procedures for adjusting timing on an engine with computer controlled ignition are as follows:

1. Run the engine in park/neutral at stable RPM and operating temperature.
2. Connect a tachometer or refer to the dash mounted tach to read engine speed.
3. Set the idle speed to the manufacturer's specifications. On most systems it is necessary to remove the SPOUT or BYPASS connector to observe and change the initial setting. Timing must be set within + or – 2^{o} as all computer control is based on a known initial setting.

   NOTE: Disconnect the SPOUT or BYPASS connector with ignition in the off position.
4. No other adjustments are possible.

   NOTE: Changing the timing may affect idle speed; therefore, it must be rechecked after all adjustments have been made to the fuel system.

POWER (WOT/LOAD) MIXTURE ADJUSTMENTS

This adjustment is the full load or power setting and requires a chassis dynamometer and an infra-red exhaust analyzer. All other methods are for use in field or emergency environments only.

Refer to the dynamometer manufacturer's instructions for use. These basic guidelines may be applied:

1. Be sure that the dynamometer area is safe and properly marked as a hazardous area. Use OSHA safety marking.

Key Points & Notes

21-13

21-14

21-15

21-20

21-19

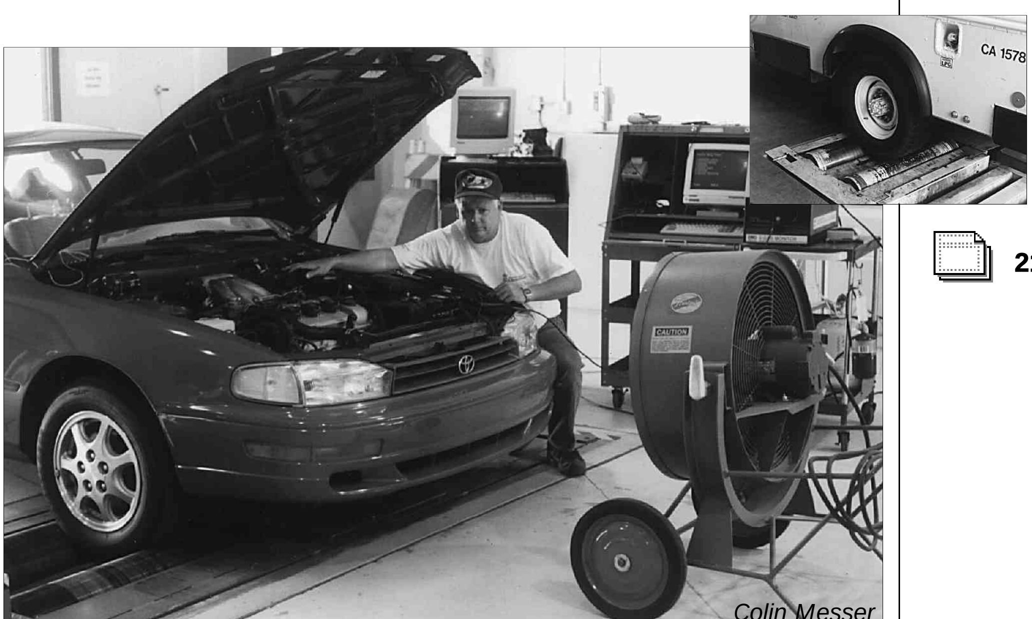


Photo © Harris Fogel

Figure 21-3, FWD vehicle positioned on dynamometer rollers, external cooling fan and test equipment in place. **Inset** RWD vehicle on rollers.

2. For rear wheel drive vehicles, the front wheels should be chocked to prevent movement. Front wheel drive vehicles should have the rear wheels chocked.

   NOTE: Do not turn the steering wheel or apply brakes when the vehicle is running on the dynamometer.

3. The vehicle should be secured to the ground so good contact and friction between the wheels and dyno-rollers is maintained. Keep the steering wheel turned straight ahead.

4. Power adjustments are generally made with the engine at wide open throttle, full dyno load at or about 50 mph or 3000 RPM.

5. Take precautions to ensure that the engine does not overheat during loaded runs. Place a fan in front of the radiator or compartment heater during load periods (tests).

6. Fuel mixtures should be set as lean as possible, to maintain the power and performance requirements and must be in compliance with federal, state, and local regulations. A target range of 0.00 to 1.0% CO, with the lowest possible HC ppm, relative to performance and power output, is recommended. Generally, the system can be leaned out to the point where power starts to drop, as indicated on a dynamometer. **Note:** Oxides of nitrogen (NO_x) emissions are affected by slight changes in air-fuel mixture. Too lean a mixture increases NO_x dramatically.

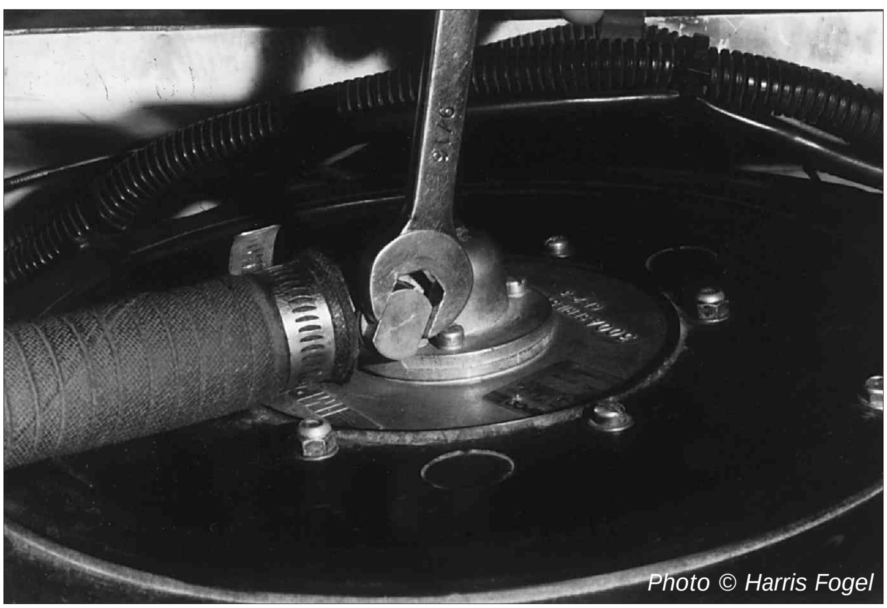


Photo © Harris Fogel

Figure 21-4 Power valve adjustment, air-valve mixer shown.

IDLE AIR-FUEL MIXTURES

The idle mixture is usually made by turning the idle mixture adjustment screw. This procedure requires an infra-red exhaust gas analyzer. All other methods are for use in field or emergency environments only. The procedures for this adjustment are as follows:

Key Points & Notes

21-16

21-21

21-17

1. The engine must be running at a stabilized idle speed, at full operating temperature, in park or neutral.
2. Be sure the exhaust gas analyzer is warm and calibrated within federal, state, and local regulations. (Re-zero and span each gas display before each use.)

21-5 Idle air-fuel mixture adjustment.

3. All mixture adjustments must be made in compliance with equipment manufacturer's instructions and all federal, state, and local regulations. Apply the following basic guidelines:
   a. Set idle mixture to between 0.00 to 0.75% CO and the lowest possible HC. High CO_2 (above 10%) is a good additional indicator.
   b. High HC with low CO may indicate poor ignition, poor fuel distribution, or a vacuum leak. Disproportionate gas readings must be diagnosed and repaired prior to delivery of vehicles.
   c. Once the idle fuel mixture is set, re-check hot curb idle speed.

CLOSED LOOP PROPANE SYSTEMS

This procedure applies to vehicles with propane, closed loop feedback systems. Precise adjustment of the feedback control is essential in order to achieve full integration with the OEM electronic engine controls. All techniques for this procedure must be followed as specified by the equipment manufacturer. Only carburetion components with California Air Resources Board (CARB) or Environmental Protection Agency (EPA) certification can be installed on OEM feedback engines. Furthermore, the propane system must be installed according to the certification orders.

WARNING! Substituting certified components with non-certified components is considered tampering. Consult the manufacturer for further information.

Key Points & Notes

21-18

21-23

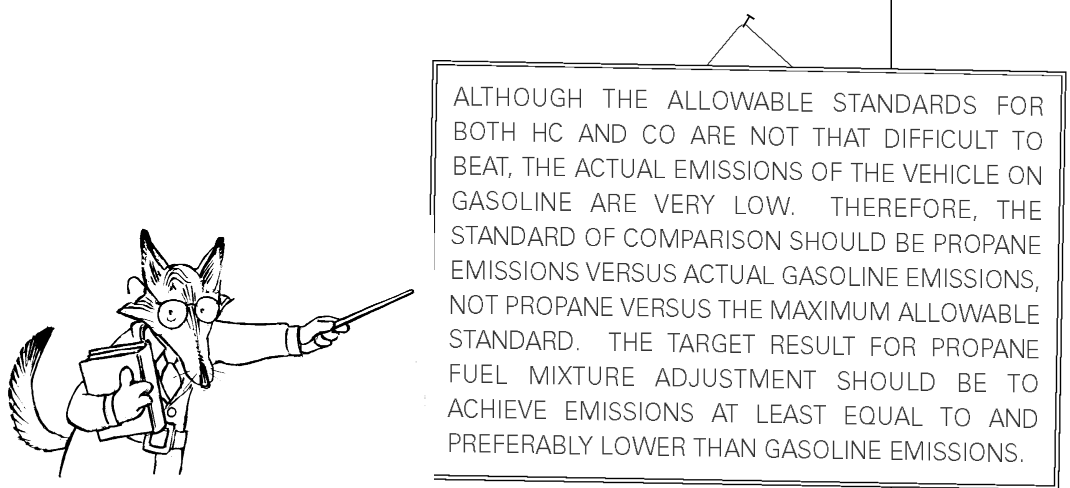
21-22

21-24

MODULE 21: POST-CONVERSION – VEHICLE PERFORMANCE

There are several fuel control processing assemblies on the market. As emissions technology and regulations evolve, components and their strategies change. Most of these components, however, are quite similar in their strategy of control and fuel management; likewise, they share similar wiring and installation procedures.

All electronic feedback fuel controls must be set-up according to the manufacturer's instructions, utilizing special tools when necessary. Many manufacturers have developed equipment specifically to monitor the performance of their devices.



The following guidelines may be applied in conjunction with OEM directives:

1. The engine should be at operating temperature and stable idle to ensure that the O_2 sensor is functioning and the system is in closed loop.
2. The PCM should be queried (scanned) for trouble codes prior to adjustments. All codes must be corrected and cleared before proceeding.
3. Fuel mixtures should be set so the emissions are at or below actual gasoline emissions. This should be indicated on most system analyzers as a steady dwell or pulse width to the fuel control valve (FCV). The percentage of duty cycle as specified by the manufacturer usually averages around 50 percent. Cross-check the operation of the FCV with the O_2 sensor signal, which should average between 0.460 to 0.540 volts. The voltage can be checked by connecting a digital volt meter to the O_2 sensor signal wire. The reading should be crossing the stoichiometric point (0.480 to 0.520) continuously.

   NOTE: When probing any circuit on a computer-controlled system, always use a digital volt/ohm meter with a minimum of 10 megohms impedance. NEVER use an analog meter, as this may damage the PCM.

The recommended settings from the manufacturer should be close enough to get the engine started, but it will probably need some

Key Points & Notes

21-25

21-26

21-27

21-28

21-6 Checking oxygen sensor output with digital volt meter, left; and checking fuel control valve duty cycle percentage with digital volt meter, right.

tuning. After the engine is running, make the initial timing and adjustment settings. Switch between fuels to verify that both systems are operational if it is a bi-fuel system.

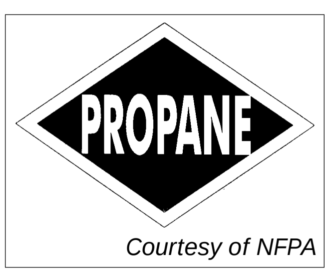
TEST DRIVE THE VEHICLE

Review the pre-conversion test drive information. Once the vehicle has been tuned as close to ideal as possible in the shop, it should be ready for a road test. On gasoline, the vehicle should perform as well as it did prior to the conversion. It should run as well as on gasoline or with slightly less power on propane. Drive the vehicle on both fuels to determine if the vehicle operates safely and performs well. With the help of an assistant, monitor oxygen sensor and fuel control valve operation while driving. **Note:** If adjustments are made on the road, the emissions should be tested before releasing the vehicle to the customer.

It is important to ensure that the vehicle operates well throughout its full driving range, such as cold start, hot start, acceleration, deceleration, idle, under full and part load on both fuels.

APPLY NECESSARY BODY AND UNDERHOOD LABELING

In most states, both body and underhood labeling are required. The minimum marking required is a weather-resistant diamond-shaped label (4.75” long by 3.25” high) located on the exterior vertical or near vertical surface on the lower right rear of the vehicle (on the trunk lid of the vehicle if so equipped but not on the bumper) inboard from any other markings. Refer to Figure 21-7.



21-7 Example of vehicle identification marking.

Key Points & Notes

21-29

21-30

21-31

21-32

21-33

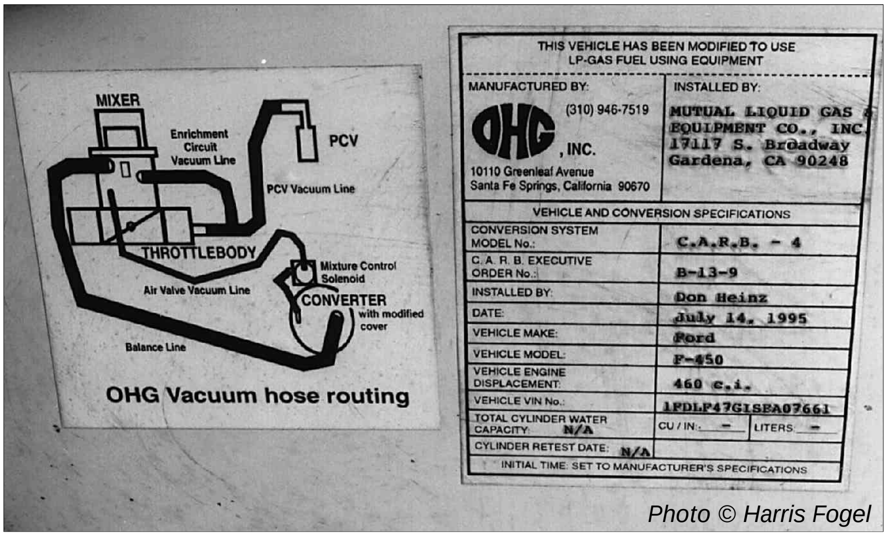


Photo © Harris Fogel

21-8 Example of underhood emissions compliance decal.

It may also be necessary and a good idea to document the conversion underhood. This may be required for the conversion to be within emissions compliance. Refer to Figure 21-8.

Key Points & Notes

21-34

MODULE 21: POST-CONVERSION – VEHICLE PERFORMANCE

POST-CONVERSION PROCEDURES

TANK/CYLNDR	SIZE	SERIAL #	MFR	DATE	COND	D-PLATE	VALVES	LP GAL

EQUIP	FUEL LINES	LP SHUTOFF	CONVERTER	MIXER	GAS SHUTOFF	ELECTRONICS
MAKE						
MODEL						

DECALS/LPG DIAMOND		HOSES ROUTE & SECURE		WATER HOSES
FUEL TANK (S)		HYDROSTATIC RELIEF		VACUUM HOSES
REMOTE FILL		BACK FLOW CHECK VALVES		VAPOR HOSES
REMOTE RELIEF		LPG FUEL LOCK/SAFETY		ELECTRICAL CONNECTIONS
VAPOR SEAL		GASOLINE FUEL LOCK		DUAL FUEL WIRING
VALVE OPERATIONS		FUEL PUMP OFF/COVER		AUXILIARY ELECTRONICS
FUEL LINES & FITTINGS		PROPANE CONVERTER		FEEDBACK ELECTRONICS
DRIVER INFO PACKAGE		CLOSED AIR CLEANER		

IGNITION TIMING	DEG	**FUEL MIXTURES**	MPH	HC	CO	O2	CO2	BHP
BASE TIMING IDLE		IDLE MIXTURES						
3000 NO VAC		CRUISE MIXTURES						
3000 W/VAC		WOT/LOAD MIXTURES						

CUSTOMER SIGN	DATE	TECHNICIAN SIGN	DATE

Table 21-A Post Conversion Procedures checklist.

MODULE REVIEW ITEMS

Note to Technician: Consider all choices carefully and select the best answer to each.

1. Which of the following is an operation to monitor or adjust?
A. Idle air/fuel mixture.
B. Power mixture.
C. Feedback controls.
D. All of the above.

2. Engine idle speed affects both _____ and _____.
A. Power; air-fuel mixture.
B. Power; feedback control.
C. Timing; air-fuel mixture.
D. Power, timing.

3. To adjust the idle on a non-feedback, carbureted engine, which is an appropriate setup?
A. Run the vehicle at operating temperature.
B. Run the engine in first or second gear.
C. Run the engine at variable RPMs.
D. Run the engine at high RPMs.

4. After the adjustment is made for curb idle, which should also be checked?
A. Choke pull-offs.
B. Fast-idle.
C. Choke gear idle.
D. A and B.

5. Adjustment of idle on fuel-injected vehicles is not considered tampering?
A. True.
B. False.

6. Timing cannot be adjusted on vehicles lacking distributors.
A. True.
B. False.

7. Initial timing may be advanced _____ to _____ per _____ of altitude to compensate for a slower burn rate caused by dense air.
A. .5 degree; 1 degree, 1000 feet.
B. 1 degree; 2 degrees; 500 feet.
C. .5 degree; 1 degree; 2000 feet.
D. .5 degree; 2 degrees; 2000 feet.

8. Electronic timing devices may improve propane _____ and _____, but increase _____.
A. Emissions; mileage; performance.
B. Mileage; performance; emissions.
C. Emissions; performance; mileage.
D. Quality; performance; mileage.

9. On most systems it is necessary to remove the _____ connector to observe or change the initial idle speed setting.
A. RPM.
B. TAD.
C. BYPASS.
D. ACK.

10. If testing a rear wheel drive vehicle on a dyno,
A. Set the parking brake.
B. Place the engine in PARK.
C. Chock the front wheels.
D. Chock the rear wheels.

11. The target range of emissions while doing a dyno test is:
A. 0-1% CO; lowest HCs; lowest NO_X.
B. 0% CO, no HCs; no NO_X.
C. 1-2% CO; 8.3% HCs; no NO_X.
D. No CO; 8.3% HCs; 12.2% NO_X.

12. The PCM should be scanned for _____ prior to adjustments.
A. Latent codes.
B. Spikes.
C. Dwell.
D. Trouble codes.

13. Cross-check the operation of the FCV with the oxygen sensor signal, which should average between _____ and _____.
A. .232v; .392v.
B. .46v; .54v.
C. .624v; .81v.
D. .23v; .54v.

14. If available, use an analog meter to test the PCM.
A. True.
B. False.

15. Place the black diamond PROPANE sticker...
A. On the rear right of the vehicle.
B. On the rear left of the vehicle.
C. On the left bottom of the windshield.
D. On the right bottom of the winshield.

MRI SCORING KEY

1. D
2. C
3. A
4. D
5. B
6. A
7. A
8. B
9. C
10. C
11. A
12. D
13. B
14. B
15. A

1 **MODULE 21:**
Post-Conversion -
Vehicle Performance

2 **PRELIMINARY PROCEDURES**

- Tune engine for best fuel economy, performance, lowest emissions
  - Idle speed
  - Ignition timing
  - Power mixture
  - Idle air/fuel mixture
  - Feedback controls

3 **IDLE SPEED ADJUSTMENTS**

- Affects both timing and air-fuel mixture
- Some LPG systems only adjustable by changing computer calibrations
- Note- Be sure adjustments are legal before proceeding

4 **IDLE SPEED ADJUSTMENTS**

Non-feedback conventional carbureted engine adjustments:

1. Run engine in park/neutral at stable RPM at operating temperature
2. Connect tach to ignition or read from dash tach
3. Set idle speed to mfg's specs by adjusting idle speed control screw

5 **IDLE SPEED ADJUSTMENTS**

4. Adjustments made for curb idle

   Check fast-idle, transmission passing gear levers, choke pull-offs, and other settings
5. Verify idle speed control with & without A/C or other power take off devices and loads

6 **IDLE SPEED ADJUSTMENTS**

Feedback computer-controlled engine adjustments:

1. Most feedback and fuel-injected engines are not adjustable, so don't tamper
2. All fuel injected vehicles control idle speed by PCM, stepper motor device with adjustable range
   - Requires OEM procedures- don't tamper with, check OEM service info

7 **21-1 IDLE SPEED ADJUSTMENT**

8 **IGNITION TIMING**

- Note- Timing can't be adjusted on non-distributor engines
- LPG performs better with advanced timing
- Modifications may be considered tampering
- Settings should be based on OEM specs

9 **IGNITION TIMING**

Points-type ignition system procedures:

1. Ignition system checked for operation
2. Initial timing set with engine at stable idle and with vacuum advance disconnected and sealed
3. Use timing light with variable advance to adjust timing to mfg specs
   - Set distributor in position and recheck timing
   - Settings within OEM specs +/- 3^{o}

10 **IGNITION TIMING**

- Note- Initial timing advance $.5^{o}$ to 1^{o} per 1000' altitude for slower burn rates

4. Run engine speed to 3000 RPM to verify mechanical advance mechanism
   - If no advance indicated, distributor should be inspected and repaired

– Use springs, limiter plates, weights
– Repeat to verify results

11 **IGNITION TIMING**

5. Reconnect vacuum advance source and run engine to 3000 RPM to verify total advance with vacuum
   – If wrong advance indicated, replace vacuum module
   – Repeat to verify results
   – Reconnect hose or wire to generate normal timing function
- Note- Electronic timing devices may improve LPG performance and mileage but increase emissions

12 **21-2 IGNITION TIMING CURVE**

13 **IGNITION TIMING**

Computer-controlled ignition timing adjustment procedure:

1. Run engine in park/neutral at stable RPM and operating temperature
2. Connect tach or read from dash tach
3. Set idle speed to mfg's specs
   – Remove SPOUT or BYPASS connector to observe and change initial setting
   – Timing set within +/- 2^o

14 **IGNITION TIMING**

- Note- Disconnect SPOUT or BYPASS connector with ignition in OFF position

4. No other adjustments are possible

- Note- Changing timing may affect idle speed- recheck it after adjustments are made to fuel system

15 **POWER (WOT/LOAD) MIXTURE ADJUSTMENTS**

1. Secure dyno area
2. Chock front wheels on rear wheel drive vehicles; chock rear wheels on front wheel drives

- Note- Don't turn steering wheel or set brakes on unsecured vehicle when dyno is running

3. Secure vehicle with straps or chains

16 **POWER (WOT/LOAD) MIXTURE ADJUSTMENTS**

4. Power adjustments made with engine at wide open throttle, full dyno load, or 50 MPH or 3000 RPM
5. Operate fan in front of radiator during tests
6. Fuel mixtures set lean- range 0.0 to 1.0% CO & lowest HC ppm
   – Lean out until power drops

- Note- Too lean mixtures increases NO_x significantly

17 **IDLE AIR-FUEL MIXTURES**

- Idle mixture adjustment screw
- Use IR exhaust gas analyzer

18 **IDLE AIR-FUEL MIXTURES**

1. Run engine at stable idle
2. Warm up and calibrate gas analyzer
3. Mixture adjustments conform to LPG system mfg & govt regulations
   – Set idle mixture to 0.0-0.75% CO, lowest HC
   – High CO_2 above 10% good indicator
   – High HC with low CO = poor ignition, fuel distribution, or vacuum leak
   – Set idle fuel mixture, check hot curb idle speed

19 **21-3A FWD CAR ON DYNO**

20 **21-3B RWD TRUCK ON ROLLERS**

21 **21-4 POWER VALVE ADJUSTMENT**

22 **21-5A IDLE AIR-FUEL MIXTURE ADJUSTMENT**

23 **21-5B IDLE AIR-FUEL MIXTURE ADJUSTMENT**

24 **CLOSED LOOP PROPANE SYSTEMS**

- Precise adjustment to achieve integration with OEM engine controls
- Follow system mfg's instructions
- CARB or EPA carburetion components allowed on OEM feedback engines
- Don't use non-certified components

25 **CLOSED LOOP PROPANE SYSTEMS**

Although allowable standards for both HC & CO are not difficult to beat, actual emissions of the vehicle on gasoline are very low. Therefore, the standard of comparison should be LPG emissions vs. actual gasoline emissions, not LPG vs. maximum allowable standard. The target result for LPG fuel mixture adjustment should be to achieve emissions at least equal to and preferably lower than gasoline emissions.

26 **CLOSED LOOP PROPANE SYSTEMS**

1. Engine at operating temperature and stable idle
   - Ensure O_2 sensor functioning
   - System in closed loop
2. PCM queried for trouble codes prior to adjustments
   - Correct and clear codes before continuing

27 **CLOSED LOOP PROPANE SYSTEMS**

3. Fuel mixtures set so emissions are at or below actual gasoline emissions
   - Indicated on system analyzers as steady dwell or pulse width to fuel control valve
   - % duty cycle around 50%
   - Cross-check FCV operation with O_2 sensor signal
     - Average between .460 to .540v
   - Reading crossing stoich point (.480 to .520v) continuously

28 **CLOSED LOOP PROPANE SYSTEMS**

- Note- Use only digital VOM with minimum 10 megaohm impedance
- After engine runs, make initial timing and adjustment settings
- Switch between fuels to verify both systems operate

29 **21-6A CHECKING O_2 SENSOR**

30 **21-6B CHECKING FUEL CONTROL VALVE**

31 **TEST DRIVE THE VEHICLE**

- Review pre-conversion test drive information
- Vehicle should operate well on both gasoline and LPG
- Monitor O_2 sensor and fuel control valve operation while driving
- Vehicle should operate well in cold start, hot start, acceleration, deceleration, idle, full- part-load; on both fuels

32 **APPLY NECESSARY BODY AND UNDERHOOD LABELING**

- Body & underhood labeling required
- Black PROPANE diamond
- Mounted on right rear
- Document conversion under the hood

33 **21-7 PROPANE BLACK DIAMOND**

34 **21-8 UNDERHOOD EMISSIONS COMPLIANCE DECAL**

MODULE 21:
Post-Conversion - Vehicle Performance

PRELIMINARY PROCEDURES

- Tune engine for best fuel economy, performance, lowest emissions
  - Idle speed
  - Ignition timing
  - Power mixture
  - Idle air/fuel mixture
  - Feedback controls

IDLE SPEED ADJUSTMENTS

- Affects both timing and air-fuel mixture
- Some LPG systems only adjustable by changing computer calibrations
- Note- Be sure adjustments are legal before proceeding

IDLE SPEED ADJUSTMENTS

Non-feedback conventional carbureted engine adjustments:

1. Run engine in park/neutral at stable RPM at operating temperature
2. Connect tach to ignition or read from dash tach
3. Set idle speed to mfg's specs by adjusting idle speed control screw

IDLE SPEED ADJUSTMENTS

4. Adjustments made for curb idle

    Check fast-idle, transmission passing gear levers, choke pull-offs, and other settings

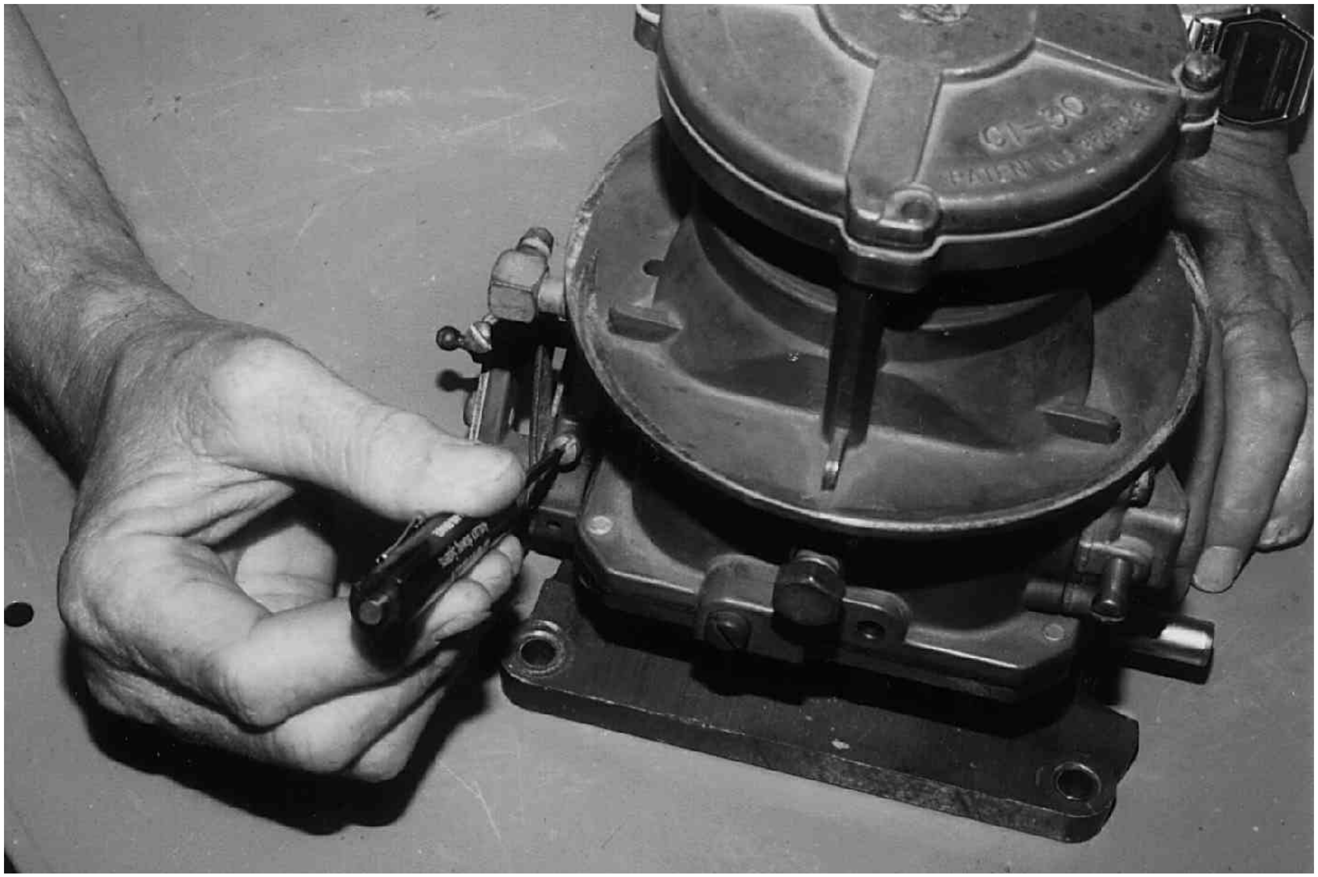
5. Verify idle speed control with & without A/C or other power take off devices and loads

IDLE SPEED ADJUSTMENTS

Feedback computer-controlled engine adjustments:

1. Most feedback and fuel-injected engines are not adjustable, so don't tamper
2. All fuel injected vehicles control idle speed by PCM, stepper motor device with adjustable range
   – Requires OEM procedures- don't tamper with, check OEM service info

21-1 IDLE SPEED ADJUSTMENT



Colin Messer

IGNITION TIMING

- Note- Timing can't be adjusted on non-distributor engines
- LPG performs better with advanced timing
- Modifications may be considered tampering
- Settings should be based on OEM specs

IGNITION TIMING

Points-type ignition system procedures:

1. Ignition system checked for operation
2. Initial timing set with engine at stable idle and with vacuum advance disconnected and sealed
3. Use timing light with variable advance to adjust timing to mfg specs
   - Set distributor in position and recheck timing
   - Settings within OEM specs +/- 3^o

IGNITION TIMING

- Note- Initial timing advance .5^{o} to 1^{o} per 1000' altitude for slower burn rates

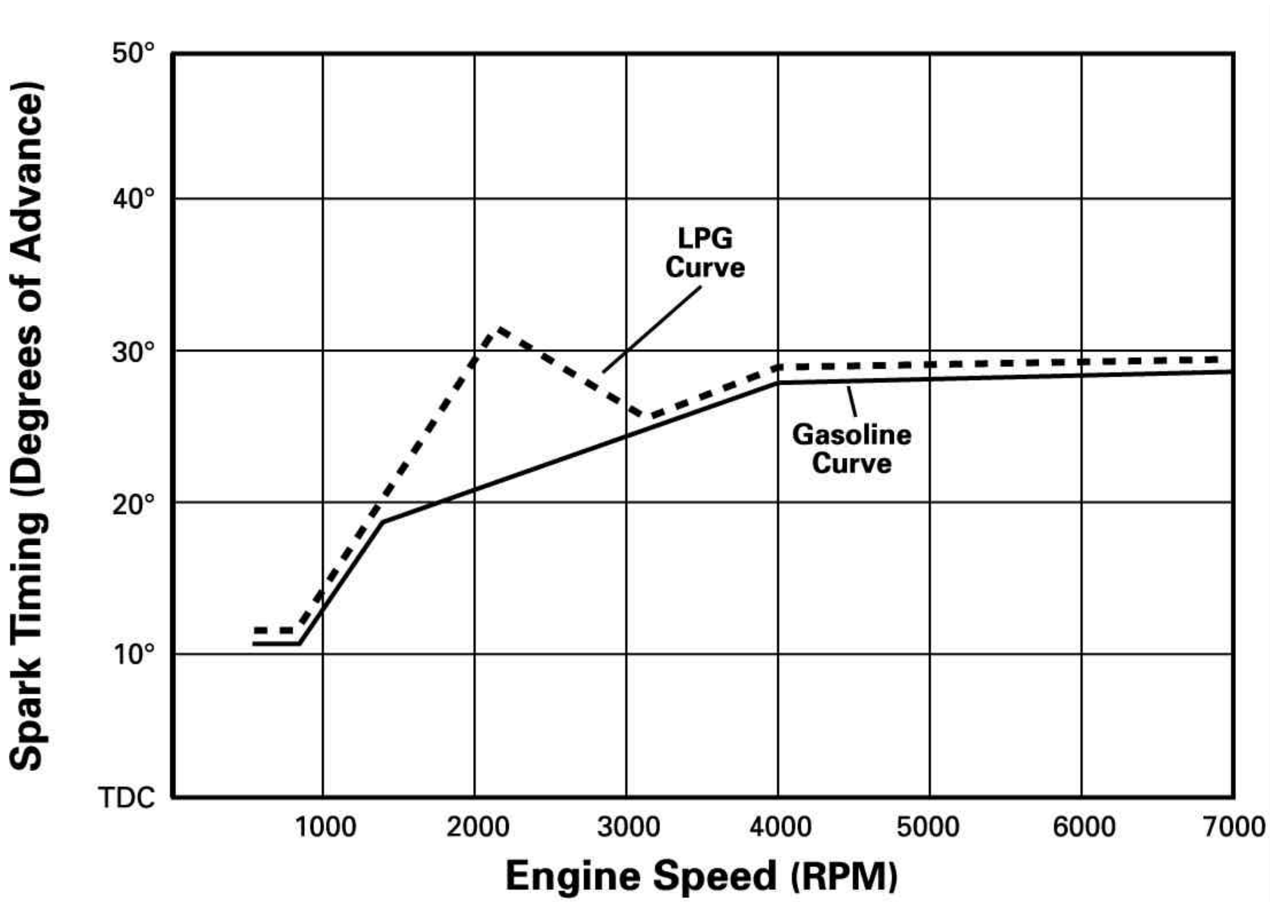
4. Run engine speed to 3000 RPM to verify mechanical advance mechanism
   – If no advance indicated, distributor should be inspected and repaired
   – Use springs, limiter plates, weights
   – Repeat to verify results

IGNITION TIMING

5. Reconnect vacuum advance source and run engine to 3000 RPM to verify total advance with vacuum
   - If wrong advance indicated, replace vacuum module
   - Repeat to verify results
   - Reconnect hose or wire to generate normal timing function

- Note- Electronic timing devices may improve LPG performance and mileage but increase emissions

21-2 IGNITION TIMING CURVE



Courtesy Autotronic Controls

IGNITION TIMING

Computer-controlled ignition timing adjustment procedure:

1. Run engine in park/neutral at stable RPM and operating temperature
2. Connect tach or read from dash tach
3. Set idle speed to mfg's specs
   - Remove SPOUT or BYPASS connector to observe and change initial setting
   - Timing set within +/- 2^o

IGNITION TIMING

- Note- Disconnect SPOUT or BYPASS connector with ignition in OFF position

4. No other adjustments are possible

- Note- Changing timing may affect idle speed- recheck it after adjustments are made to fuel system

POWER (WOT/LOAD) MIXTURE ADJUSTMENTS

1. Secure dyno area
2. Chock front wheels on rear wheel drive vehicles; chock rear wheels on front wheel drives

- Note- Don’t turn steering wheel or set brakes on unsecured vehicle when dyno is running

3. Secure vehicle with straps or chains

POWER (WOT/LOAD) MIXTURE ADJUSTMENTS

4. Power adjustments made with engine at wide open throttle, full dyno load, or 50 MPH or 3000 RPM
5. Operate fan in front of radiator during tests
6. Fuel mixtures set lean- range 0.0 to 1.0% CO & lowest HC ppm
   – Lean out until power drops

- Note- Too lean mixtures increases NO_x significantly

IDLE AIR-FUEL MIXTURES

- Idle mixture adjustment screw
- Use IR exhaust gas analyzer

IDLE AIR-FUEL MIXTURES

1. Run engine at stable idle
2. Warm up and calibrate gas analyzer
3. Mixture adjustments conform to LPG system mfg & govt regulations
   - Set idle mixture to 0.0-0.75% CO, lowest HC
   - High CO_2 above 10% good indicator
   - High HC with low CO = poor ignition, fuel distribution, or vacuum leak
   - Set idle fuel mixture, check hot curb idle speed

21-3A FWD CAR ON DYNO

Colin Messer

21-3B RWD TRUCK ON ROLLERS

Photo Copyright Harris Fogel

21-4 POWER VALVE ADJUSTMENT

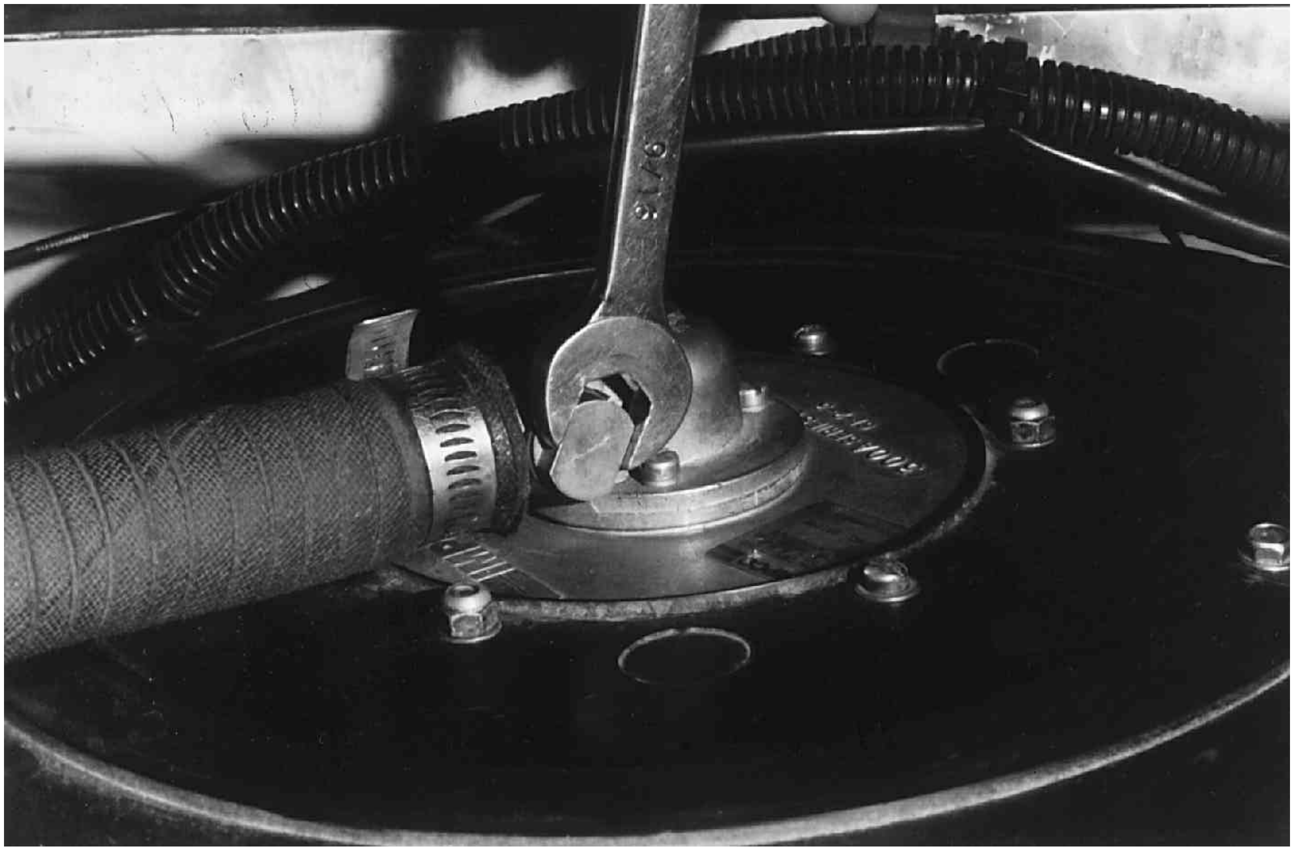


Photo Copyright Harris Fogel

21-5A IDLE AIR-FUEL MIXTURE ADJUSTMENT

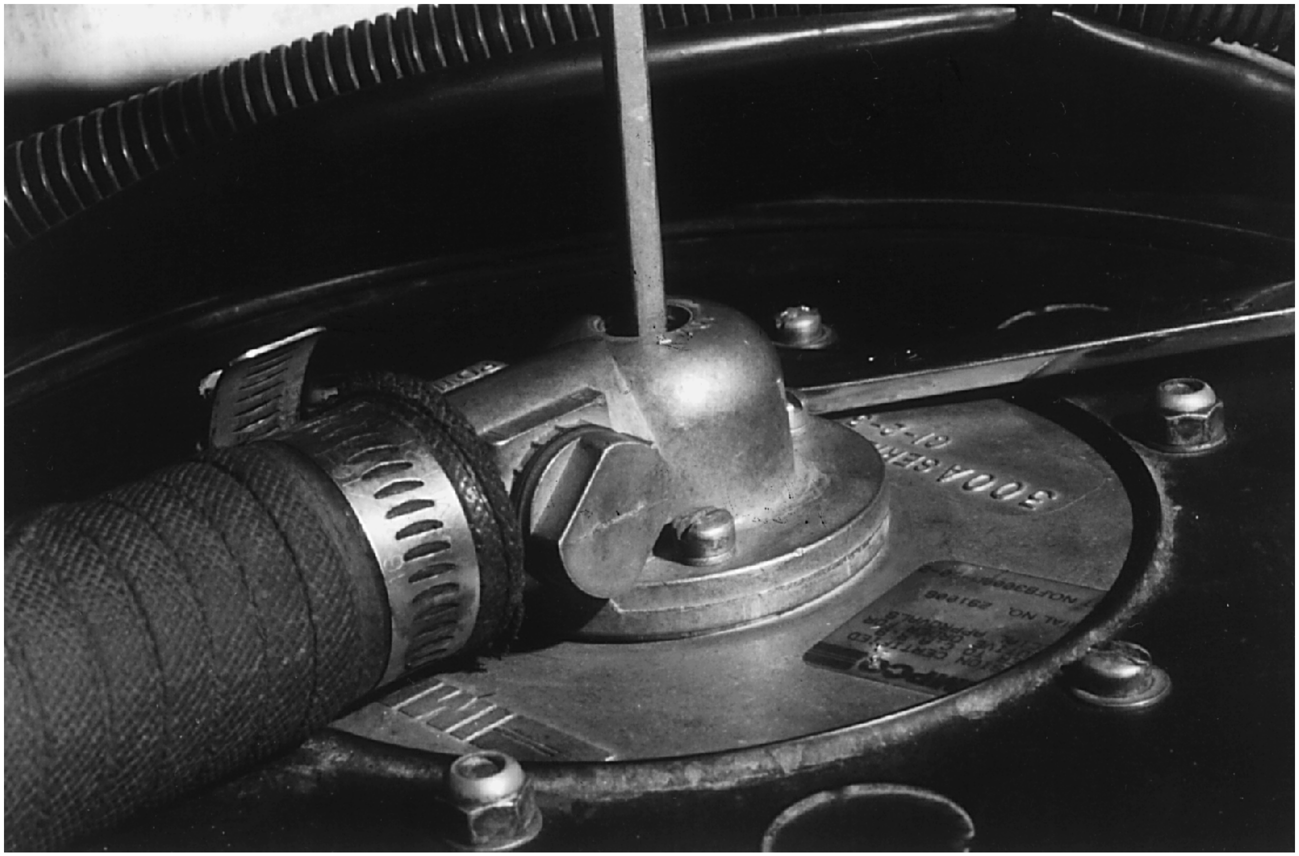


Photo Copyright Harris Fogel

21-5B IDLE AIR-FUEL MIXTURE ADJUSTMENT

Photo Copyright Harris Fogel

CLOSED LOOP PROPANE SYSTEMS

- Precise adjustment to achieve integration with OEM engine controls
- Follow system mfg's instructions
- CARB or EPA carburetion components allowed on OEM feedback engines
- Don't use non-certified components

CLOSED LOOP PROPANE SYSTEMS

Although allowable standards for both HC & CO are not difficult to beat, actual emissions of the vehicle on gasoline are very low. Therefore, the standard of comparison should be LPG emissions vs. actual gasoline emissions, not LPG vs. maximum allowable standard. The target result for LPG fuel mixture adjustment should be to achieve emissions at least equal to and preferably lower than gasoline emissions.

CLOSED LOOP PROPANE SYSTEMS

1. Engine at operating temperature and stable idle
   – Ensure O_2 sensor functioning
   – System in closed loop
2. PCM queried for trouble codes prior to adjustments
   – Correct and clear codes before continuing

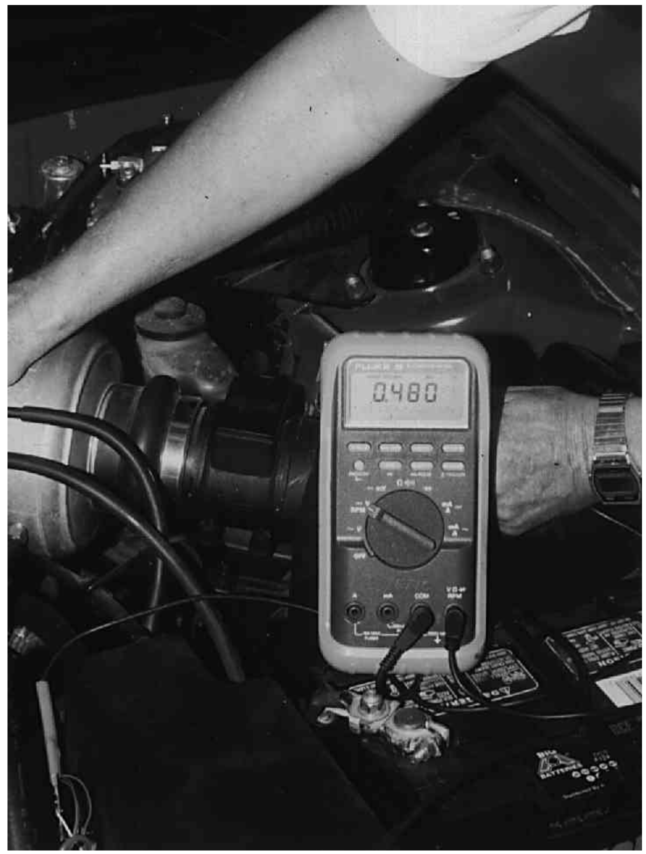
CLOSED LOOP PROPANE SYSTEMS

3. Fuel mixtures set so emissions are at or below actual gasoline emissions
   - Indicated on system analyzers as steady dwell or pulse width to fuel control valve
   - % duty cycle around 50%
   - Cross-check FCV operation with O_2 sensor signal
     - Average between .460 to .540v
   - Reading crossing stoich point (.480 to .520v) continuously

CLOSED LOOP PROPANE SYSTEMS

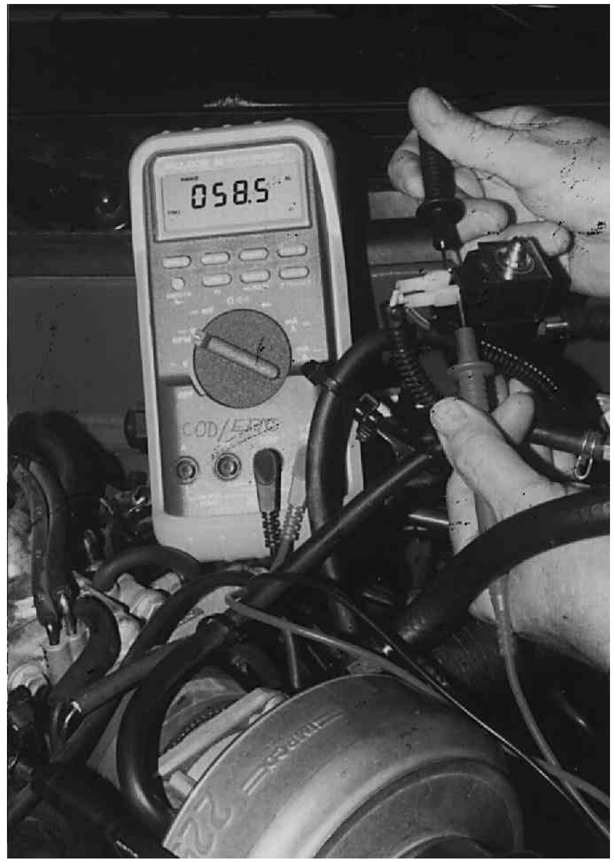
- Note- Use only digital VOM with minimum 10 megaohm impedance
- After engine runs, make initial timing and adjustment settings
- Switch between fuels to verify both systems operate

21-6A CHECKING O_2 SENSOR



Colin Messer

21-6B CHECKING FUEL CONTROL VALVE



Colin Messer

TEST DRIVE THE VEHICLE

- Review pre-conversion test drive information
- Vehicle should operate well on both gasoline and LPG
- Monitor O_2 sensor and fuel control valve operation while driving
- Vehicle should operate well in cold start, hot start, acceleration, deceleration, idle, full- part-load; on both fuels

APPLY NECESSARY BODY AND UNDERHOOD LABELING

- Body & underhood labeling required
- Black PROPANE diamond
- Mounted on right rear
- Document conversion under the hood

21-7 PROPANE BLACK DIAMOND

Courtest of NPGA

21-8 UNDERHOOD EMISSIONS COMPLIANCE DECAL

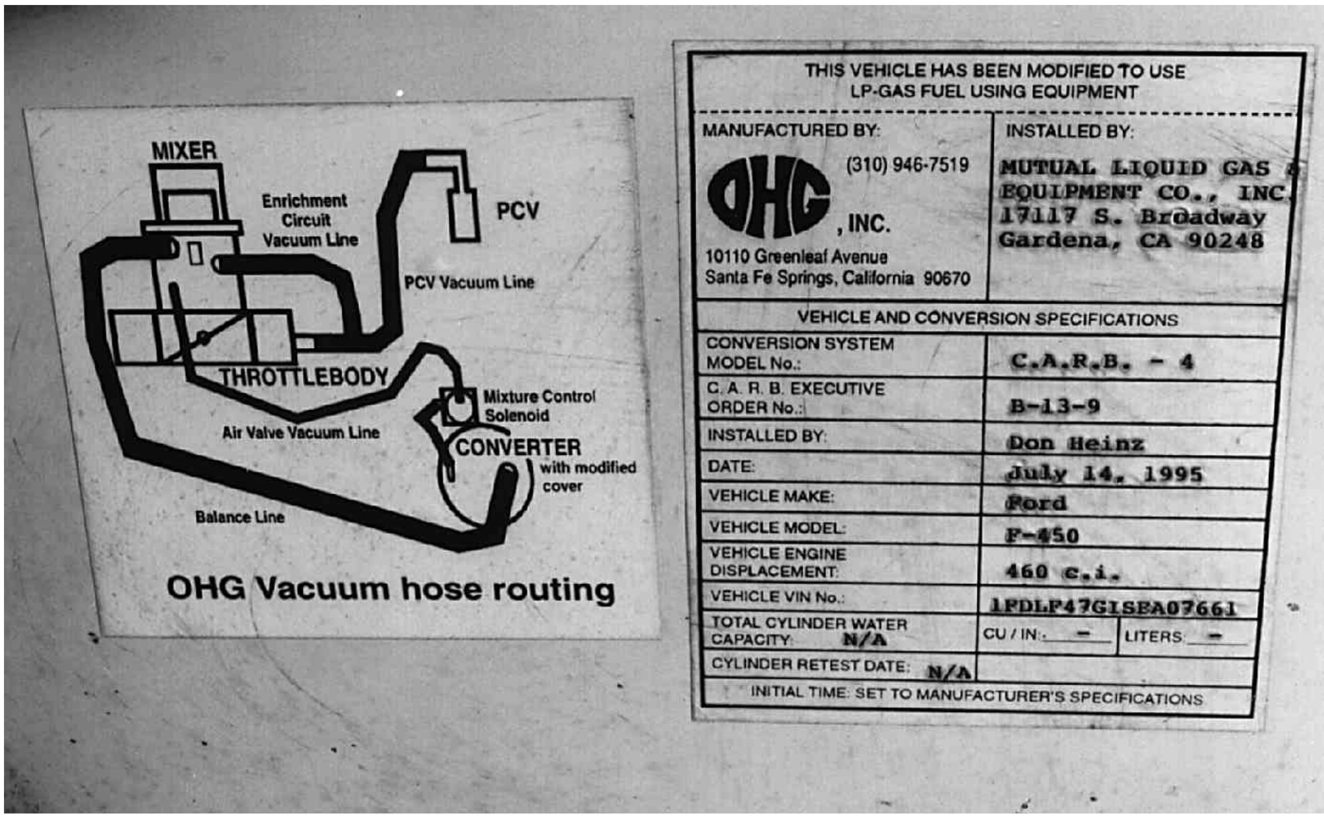


Photo Copyright Harris Fogel

MODULE 22:
Driver Orientation

State of Oklahoma
College of the Desert
West Virginia University

MODULE 22: DRIVER ORIENTATION

CONTENTS

MODULE 22: DRIVER ORIENTATION

OBJECTIVES

At the completion of this module, the technician will be able to:

- Identify the need for and content of a driver orientation session.
- Explain the steps and procedures for fueling a LPG vehicle.
- Discuss and practice safety procedures for operating an LPG vehicle.
- Discuss (and perform as necessary) initial maintenance procedures.
- Discuss (and perform as necessary) short and long term vehicle storage.

INSTRUCTOR NOTES

INSTRUCTOR MATERIALS/MEDIA NEEDED

Overhead projector or LCD panel/projection equipment
Overhead transparency masters or Microsoft PowerPoint 4.0 presentation file Mod22.ppt

Note: Slides correspond to text as indicated by icon

VCR with TV or projection unit
Videotape Segment: NPGA #0989 "Dispensing LP-Gas Safely", 21:00 minutes

Note: Videotape segments correspond to text as indicated by icon

Laboratory Activities:
22-1: Refueling with LPG

Note: Lab activities correspond to text as indicated by icon

Handouts:
Suburban Propane: Operator's Manual for Propane-Powered Vehicles

Note: Handouts correspond to text as indicated by icon

STUDENT MATERIALS/MEDIA NEEDED

Module 22: Driver Orientation

MODULE REVIEW ITEMS

The Module Review Items (MRI) are designed to allow for flexibility in their use. The exam may be utilized as a post-module review, pre/post test, part of a term examination, or it may be used by the student if the module is used as a self study text.

OVERHEAD TRANSPARENCY MASTERS

The printouts enclosed with this module are taken from the Microsoft PowerPoint 4.0 presentation file Mod22.ppt . Instructors planning to use overhead projectors should make transparencies from these printouts on a copier (or laser printer designed to safely print to acetate.

Note: Please review Module 25: Training of Trainers for more hints on instructional needs and strategies.

MODULE 22: DRIVER ORIENTATION

ORIENTATION SESSION

Before any drivers operate an LPG vehicle, it is highly recommended that an orientation session be held with them to discuss LPG theory, safety, operation, and maintenance. Some organizations may require driver certification for LPG vehicle operation.

Fleet managers may decide what topics should be presented to the drivers. Some managers may want them to be able to perform basic diagnostics, while others would prefer that the drivers leave the conversion equipment alone. Check with the fleet manager to determine what the drivers will be taught.

GENERAL PROCEDURE FOR FUELING AN LPG VEHICLE

NOTE: New or refurbished containers must be purged of air using propane vapor prior to filling. See NPGA Bulletin/Pamphlet #133, *Purging LP-Gas Containers* or Module 20 for guidelines regarding purging.

Motor fuel tanks are commonly filled by volume because they are bolted in place and cannot be easily removed and weighed. Industrial or stationary engine installations often have removable tanks, much like portable barbecue or residential LPG tanks. Such tanks are weighed empty, then full; the weight difference is the amount of fuel loaded. The following are procedures for Volume Filling and Weight Filling – both procedures share the same safety guidelines:

FILLING CONTAINERS BY VOLUME

Most ASME tanks and some DOT cylinders are filled by volume. Careful attention to safety is critical to the filling procedure. Attention is required to assure that containers are not overfilled.

1. Refuel in a well-ventilated area, never indoors.
2. Stop the engine, and set parking brake.
3. Chock wheels.
4. Remove or extinguish all sources of ignition. This includes pilot lights in motor homes and smoking materials.
5. Unload all passengers from the vehicle.
6. Inspect the container to see that it is in good condition and approved for LPG service. Do not fill the tank if defects are found. Fill only containers with the proper DOT or ASME nameplates or markings.

   NOTE: If leak testing the system, calculate one tenth of the water capacity (W.C. on the nameplate). Dispense only that number of gallons into the tank, stop filling, then leak check the system. Once the system is leakfree, fill tank to capacity.

7. Ensure that tank(s) is equipped with a pressure relief valve(s). The discharge vent(s) should be capped or otherwise protected from water or dirt.

Key Points & Notes

22-2

Suburban Propane: Operator's Manual for Propane-Powered Vehicles

22-3

NPGA #0989: Dispensing LP-Gas Safely

22-4

Key Points & Notes

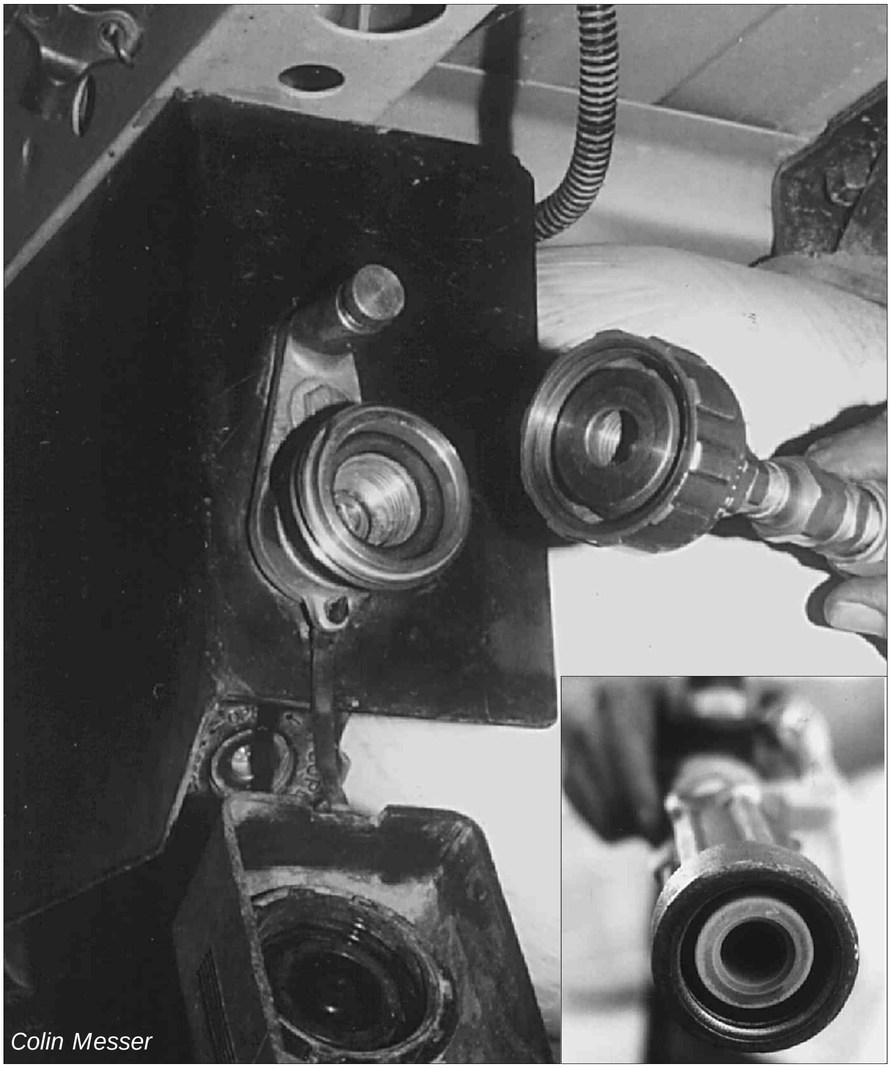
22-1 Remote refueling assembly with dust cap.

22-8

8. Inspect all container valves for leakage at the time of filling. A leaking container must not be filled.
9. Remove the protective cap from the tank filler valve, and connect filling hose coupling to the tank filler valve.

22-5

10. Determine that the tank is not already full by a) observing the discharge from the fixed liquid level gauge; or b) calculating the weight of the container.
11. Be sure you have a full understanding of the propane dispenser equipment and operation before beginning. Refer to posted instructions. Don't forget to "zero" the meter.
12. Open the main liquid valve at storage tank.
13. Turn on the transfer pump.
14. If closed, open the valve on the container to be filled.



22-2 Dust cap removed revealing adaptor; shown with hose end and fill valve. **Inset** Hose end coupling that connects to container fill valve.

15. Slowly open the hose end valve to start the flow of liquid. (Two full turns are typical.) **Note:** If leak checking the system, fill tank to one tenth its water capacity and stop filling.
16. Check for leaks.
17. Open the fixed liquid level (outage) gauge approximately one quarter turn until gas starts to vent. **Note:** Auto Stop type stop-fill devices must be fully opened.
18. Fill the tank until liquid (a visible white foggy cloud) vents from fixed liquid level gauge then close the hose end valve immediately. Close the fixed liquid level/outage gauge.
19. Shut-off the transfer pump.

Caution: Do not overfill the container. Adequate vapor space must be left in the container to allow for expansion of the liquid. If the container is over-filled, bleed off the excess LP-gas in safe location.

Key Points & Notes

22-9

22-10

22-6

22-3 Liquid level gauge venting vaporizing liquid; 80% of capacity, tank full.

20. If necessary, close the valve on the container being filled.
21. Partially loosen the hose end coupling at the container filler valve and bleed-off trapped liquid. When depressurized, disconnect the hose end coupling.
22. Replace the protective plastic cap on tank filler valve.
23. Check that the fixed liquid gauge is closed tightly.
24. Close the main liquid valve at storage tank, store the hose and end assembly, then set dispenser as necessary.

FILLING DOT CYLINDERS BY WEIGHT

1. Be sure you have a full understanding of the propane dispenser equipment and operation. Follow operating instructions.
2. Always wear protective gloves and eye protection.
3. Remove the plastic cap on the container filler valve.
4. Connect the hose end coupling to container filler valve.
5. Open the main liquid valve at storage tank.
6. Slowly open the hose end valve.
7. Check for leaks.
8. Set the scale to the pre-determined weight of tank and contents plus hose and connector.
9. Turn on the transfer pump.
10. If necessary, open the valve on the container.
11. Fill container until the legal weight is reached. Immediately close hose end valve. Shut off transfer pump.

Key Points & Notes

22-11

22-7

22-12

22-13

NOTE: Do not overfill containers. Adequate vapor space must be left in containers to allow for expansion of the liquid. If a cylinder is overfilled, bleed off excess LP-gas in safe location.

12. Close the valve on the container being filled, if so equipped.
13. Partially loosen the hose end coupling at the container filler valve and bleed off trapped liquid. When depressurized, disconnect the hose end coupling.
14. When filling by weight, check the weight of filled container after hose connector has been removed to ensure the container is not overfilled.
15. Replace the protective cap on the container filler valve.
16. Check that the fixed liquid gauge is closed tight.
17. Close the main liquid valve at storage tank.
18. Store the hose properly.

Key Points & Notes

22-14

Activity 22-1: Refueling with LPG

22-15

SAFETY CONSIDERATIONS FOR OPERATING A LPG VEHICLE

Review the general do's and don'ts of an LPG system. Explain to the driver not only why something should or should not be done, but also the consequences of such an action. Compare those actions to gasoline systems and make sure the drivers know the differences between the systems. Also make sure the drivers are aware of what type of car they are in at the time (LPG, gasoline, both, etc.), and that they know how and when to switch between fuels. For safe operation of the vehicle, the following precautions should be observed.

A fixed liquid level gauge bleeder valve (spit valve) is installed adjacent to the fuel filler valve behind the fuel filler door. When opened during filling, it indicates when the maximum allowable (80%) fuel level in the tank has been reached by emitting a steady stream of liquid propane. Do not attempt to force open or tamper with the fuel filler valve for any reason, because a sudden release of propane may occur, possibly causing injury.

If a fuel leak occurs, immediately switch off the engine, electrical equipment, and other ignition sources. Bring minor leaks under control as quickly as possible. If a major leak cannot be quickly controlled, call the Fire Department and the Police. Evacuate the immediate area. After a minor leak, ventilate the area to clear all traces of the fuel. Remember that LPG, which is heavier than air and settles at ground level, needs low level ventilation. Beware of any low-lying spaces such as pits and drains where pockets of LPG could linger. Large quantities of LPG vapors deplete oxygen and can cause intoxication and asphyxiation. Keep LPG away from exposed skin, and have a doctor treat any freeze burns.

If a fuel fire occurs, do not use a fire extinguisher. If possible, stop the fire by cutting off the flow of fuel. Any secondary fire can then be put out with the extinguisher. If you cannot control the fire in this way, call the Fire Department and the Police and evacuate the area.

GENERAL PREVENTIVE MAINTENANCE PROCEDURES

FIRST 2000 MILES

1. Follow the manufacturer's recommendations for vehicle maintenance and warranty compliance.
2. With the engine at normal operating temperature remove the converter drain plugs and allow the residue to drain from the converter.

   Caution: Do not attempt to clean the converter with compressed air. This will damage the converter diaphragms.
3. Check the LPG filter for foreign material and service as required. If the filter is clean at this first service check or if the fuel system is new, the filter should require servicing only at normal engine maintenance intervals.
4. Recheck the LPG fuel system for leaks and proper adjustments. Correct as required.

PROCEDURE FOR SHORT- AND LONG-TERM VEHICLE STORAGE (NFPA 58 [1995], 8-6)

Vehicles with LPG engines are permitted to be stored and serviced inside garages. The fuel system must be leak free, and the container must not filled beyond the maximum limits for the LPG tank as specified (NFPA 58 [1995], 4-4). Storage and servicing of the vehicle requires the container shutoff valve to be closed when the engine is being repaired, except for when the engine is operated. The vehicle should also be parked away from sources of heat, open flames, and similar sources of ignition. The vehicle should also be parked away from inadequately ventilated pits.

Key Points & Notes

22-16

22-17

MODULE REVIEW ITEMS

Note to Technician: Consider all choices carefully and select the best answer to each.

1. New or refurbished containers must be purged of air using 90 psi or greater shop air prior to filling.
A. True.
B. False.

2. Vehicles running on propane are usually filled by _____ because they are stationary.
A. Hand.
B. A certified attendant.
C. Weight.
D. Volume.

3. A good place to refuel is:
A. In a closed, confined area.
B. Indoors if weather is bad.
C. Outdoors.
D. All of the above.

4. If leak checking the system, fill the tank to _____ of its capacity and stop filling.
A. 1/5.
B. 1/10.
C. 8/10.
D. Half.

5. To determine if the tank is already full,
A. Figure the container weight.
B. Watch for the discharge from the fixed liquid level gauge.
C. Read the remote fuel level gauge.
D. A or B.

6. If a cylinder being filled by weight is overfilled,
A. Alert the user to keep the container in a cool sheltered place.
B. Bleed off the excess LPG somewhere safe.
C. Discharge the LPG and reload the container.
D. It probably isn't because the hose connector contributes to the overall weight.

7. Inform the driver to operate the fuel filler valve only when necessary.
A. True.
B. False.

8. If a fuel leak occurs,
A. Switch off electrical equipment.
B. Control minor leaks.
C. Ventilate the area.
D. All of the above.

9. For maintenance during the first 2000 miles, do not:
A. Remove the converter drain plugs.
B. Clean the converter with shop air.
C. Drain residue from the converter.
D. Recheck the system for leaks.

10. For long term storage,
A. Keep the shutoff valve open.
B. Fill the container to 80% or greater.
C. Park close to a heat source.
D. Don’t park near unvented inspection pits.

MRI SCORING KEY

1. B
2. D
3. C
4. B
5. D
6. C
7. B
8. D
9. B
10. D

ACTIVITY 22-1: REFUELING WITH LPG

OBJECTIVE

To properly fuel a container by volume or weight with LPG.

MATERIALS NEEDED

NPGA #0989, Dispensing LP-Gas Safely videotape (21:00 minutes)

Module 22

NPGA #0055, Refueling LP-Gas Powered Vehicles Safely, or

Suburban Propane, Operator's Manual for Propane-Powered Vehicles, or

Suburban Propane, Propane Container Filling Instructions and Safety Data, or

Suburban Propane, Safe Practices - Propane Filling Stations

Vehicle or LP-gas tank

Filling station

METHOD

This exercise gives the technician (or driver) practice in filling a propane tank.

Watch the NPGA video as indicated. Read the written procedures in Module 22 or the NPGA or Suburban Propane instructions.

Watch as the instructor demonstrates how to refuel the tank or vehicle.

Practice refueling the tank on your own.

QUESTIONS

Can you refuel the vehicle properly without the instructions?

If the driver was on the road and needed LPG, where could they find instructions on how to refuel?

COMMENTS

It may take a few times for a technician or driver to memorize and perform the correct filling procedure. During this time the use of a checklist is recommended until the process is memorized.

1 **MODULE 22:**
Driver Orientation

2 **ORIENTATION SESSION**

- Discuss theory, safety, operation, maintenance

3 **GENERAL PROCEDURE FOR FUELING AN LPG VEHICLE**

- Be sure tank has been purged
- Tanks typically filled by volume

4 **FILLING CONTAINERS BY VOLUME**

1. Refill in ventilated area
2. Stop engine, set parking brake
3. Chock wheels
4. Remove ignition sources
5. Remove passengers from vehicle
6. Inspect tank
7. Check tank has pressure relief valve
8. Inspect tank valves for leakage

5 **FILLING CONTAINERS BY VOLUME**

9. Remove cap from tank filler valve, connect hose coupling to filler valve
10. Determine tank is not already full
11. Know how to operate dispenser; zero the meter
12. Open main liquid valve at storage tank
13. Turn on transfer pump
14. Open valve on tank
15. Slowly open hose end valve two turns to start filling

6 **FILLING CONTAINERS BY VOLUME**

16. Check for leaks
17. Open fixed liquid level gauge 1/4 turn until gas vents
18. Fill tank until white foggy cloud vents and close hose end valve
19. Close fixed liquid level/outage gauge
20. Shut off transfer pump
    - Don't overfill tank
21. Close valve on tank

7 **FILLING CONTAINERS BY VOLUME**

22. Loosen hose end coupling to bleed off trapped liquid, then remove coupling
23. Replace cap on tank filler valve
24. Check fixed liquid gauge is closed tightly
25. Close main liquid valve at storage tank, store hose, set dispenser

8 **22-1 REMOTE FUELING ASSEMBLY**

9 **22-2A ADAPTOR WITH HOSE END, FILL VALVE**

10 **22-2B HOSE END COUPLING**

11 **22-3 LIQUID LEVEL GAUGE VENTING VAPORIZING LIQUID**

12 **FILLING DOT CYLINDERS BY WEIGHT**

1. Know how dispenser works
2. Wear gloves and eye protection
3. Remove cap on tank filler valve
4. Connect hose end coupling to container filler valve
5. Open main liquid valve at storage tank

6. Slowly open hose end valve
7. Check for leaks

13 **FILLING DOT CYLINDERS BY WEIGHT**

8. Set scale to desired weight of tanks and contents plus hose and connector
9. Turn on transfer pump
10. Open valve on tank
11. Fill tank until legal weight is reached, close hose end, shut off transfer pump
    - Don't overfill tank
12. Close valve on tank

14 **FILLING DOT CYLINDERS BY WEIGHT**

13. Loosen hose end coupling at tank filler valve, bleed off trapped liquid, disconnect hose end coupling
14. Check weight of tank after hose connector is removed
15. Replace cap on tank filler valve
16. Check fixed liquid gauge is closed tight
17. Close main liquid valve at storage tank
18. Store hose

15 **SAFETY CONSIDERATIONS FOR OPERATING A LPG VEHICLE**

- Review LPG fuel system
- Don't tamper with the fuel filler valve
- Shut off engine and eliminate ignition sources if leak occurs
- Call police and fire department if leak is major
- Evacuate area
- Vent area after minor leak
- Watch low-lying areas which can accumulate LPG
- Don't use fire extinguisher if fire occurs

16 **GENERAL PREVENTIVE MAINTENANCE PROCEDURES-FIRST 2000 MILES**

1. Follow OEM maintenance and warranty schedule
2. Remove converter drain plugs to drain residue
    - Don't use compressed air
3. Check LPG filter for debris and replace as necessary
4. Recheck LPG system for leaks and adjustments

17 **PROCEDURE FOR SHORT- AND LONG-TERM VEHICLE STORAGE (NPGA 58[1995], 8-6)**

- Can be stored and serviced in garages
- Leak free, tank not overfilled
- Tank shutoff valve closed when stored or serviced
- Parked away from ignition sources
- Parked away from unventilated pits

MODULE 22:
Driver Orientation

ORIENTATION SESSION

- Discuss theory, safety, operation, maintenance

GENERAL PROCEDURE FOR FUELING AN LPG VEHICLE

- Be sure tank has been purged
- Tanks typically filled by volume

FILLING CONTAINERS BY VOLUME

1. Refill in ventilated area
2. Stop engine, set parking brake
3. Chock wheels
4. Remove ignition sources
5. Remove passengers from vehicle
6. Inspect tank
7. Check tank has pressure relief valve
8. Inspect tank valves for leakage

FILLING CONTAINERS BY VOLUME

9. Remove cap from tank filler valve, connect hose coupling to filler valve
10. Determine tank is not already full
11. Know how to operate dispenser; zero the meter
12. Open main liquid valve at storage tank
13. Turn on transfer pump
14. Open valve on tank
15. Slowly open hose end valve two turns to start filling

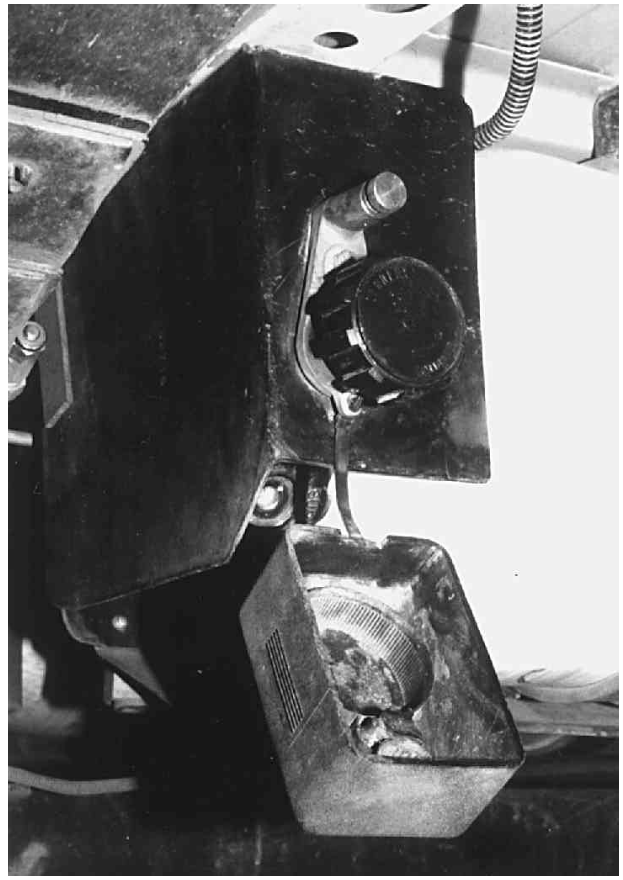
FILLING CONTAINERS BY VOLUME

16. Check for leaks
17. Open fixed liquid level gauge 1/4 turn until gas vents
18. Fill tank until white foggy cloud vents and close hose end valve
19. Close fixed liquid level/outage gauge
20. Shut off transfer pump
    – Don't overfill tank
21. Close valve on tank

FILLING CONTAINERS BY VOLUME

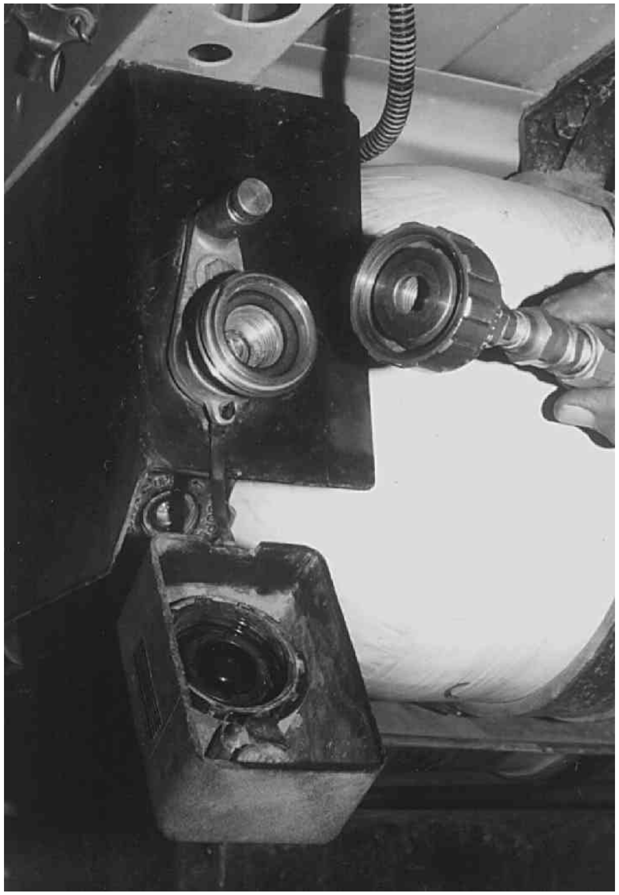
22. Loosen hose end coupling to bleed off trapped liquid, then remove coupling
23. Replace cap on tank filler valve
24. Check fixed liquid gauge is closed tightly
25. Close main liquid valve at storage tank, store hose, set dispenser

22-1 REMOTE FUELING ASSEMBLY



Colin Messer

22-2A ADAPTOR WITH HOSE END, FILL VALVE



Colin Messer

22-2B HOSE END COUPLING

Colin Messer

22-3 LIQUID LEVEL GAUGE VENTING VAPORIZING LIQUID

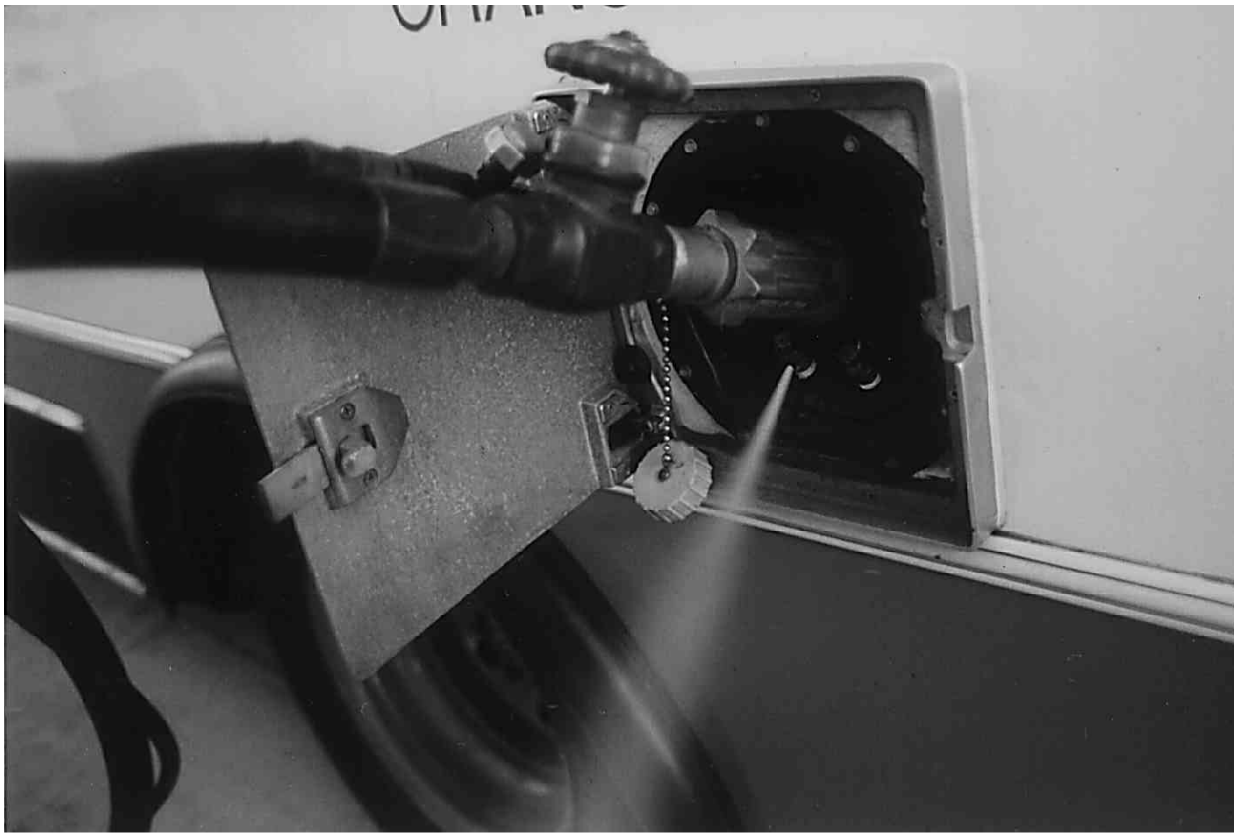


Photo Copyright Harris Fogel

FILLING DOT CYLINDERS BY WEIGHT

1. Know how dispenser works
2. Wear gloves and eye protection
3. Remove cap on tank filler valve
4. Connect hose end coupling to container filler valve
5. Open main liquid valve at storage tank
6. Slowly open hose end valve
7. Check for leaks

FILLING DOT CYLINDERS BY WEIGHT

8. Set scale to desired weight of tanks and contents plus hose and connector
9. Turn on transfer pump
10. Open valve on tank
11. Fill tank until legal weight is reached, close hose end, shut off transfer pump
    - Don't overfill tank
12. Close valve on tank

FILLING DOT CYLINDERS BY WEIGHT

13. Loosen hose end coupling at tank filler valve, bleed off trapped liquid, disconnect hose end coupling
14. Check weight of tank after hose connector is removed
15. Replace cap on tank filler valve
16. Check fixed liquid gauge is closed tight
17. Close main liquid valve at storage tank
18. Store hose

SAFETY CONSIDERATIONS FOR OPERATING A LPG VEHICLE

- Review LPG fuel system
- Don’t tamper with the fuel filler valve
- Shut off engine and eliminate ignition sources if leak occurs
- Call police and fire department if leak is major
- Evacuate area
- Vent area after minor leak
- Watch low-lying areas which can accumulate LPG
- Don’t use fire extinguisher if fire occurs

GENERAL PREVENTIVE MAINTENANCE PROCEDURES-FIRST 2000 MILES

1. Follow OEM maintenance and warranty schedule
2. Remove converter drain plugs to drain residue
   – Don't use compressed air
3. Check LPG filter for debris and replace as necessary
4. Recheck LPG system for leaks and adjustments

PROCEDURE FOR SHORT- AND LONG-TERM VEHICLE STORAGE (NPGA 58[1995], 8-6)

- Can be stored and serviced in garages
- Leak free, tank not overfilled
- Tank shutoff valve closed when stored or serviced
- Parked away from ignition sources
- Parked away from unventilated pits

MODULE 23:
Facility Safety

State of Oklahoma
College of the Desert
West Virginia University

MODULE 23: FACILITY SAFETY

CONTENTS

MODULE 23: FACILITY SAFETY

OBJECTIVES

At the completion of this module, the technician will be able to:

- Recognize the need for facility and personal safety.
- Identify aspects of building safety.
- Identify basic proctices for LPG fire control.
- Discuss the concept of explosion venting.
- Monitor and react to build-ups of smoke, HC gases and CO emissions in the shop.
- Discuss electrical and other standards and regulations.

MODULE 23: FACILITY SAFETY

INSTRUCTOR NOTES

INSTRUCTOR MATERIALS/MEDIA NEEDED

Overhead projector or LCD panel/projection equipment
Overhead transparency masters or Microsoft PowerPoint 4.0 presentation file Mod23.ppt

Note: Slides correspond to text as indicated by icon

STUDENT MATERIALS/MEDIA NEEDED

Module 23: Facility Safety

MODULE REVIEW ITEMS

The Module Review Items (MRI) are designed to allow for flexibility in their use. The exam may be utilized as a post-module review, pre/post test, part of a term examination, or it may be used by the student if the module is used as a self study text.

OVERHEAD TRANSPARENCY MASTERS

The printouts enclosed with this module are taken from the Microsoft PowerPoint 4.0 presentation file Mod23.ppt . Instructors planning to use overhead projectors should make transparencies from these printouts on a copier (or laser printer designed to safely print to acetate.

Note: Please review Module 25: Training of Trainers for more hints on instructional needs and strategies.

MODULE 23: FACILITY SAFETY

Key Points & Notes

THE NEED FOR A SAFE SHOP

23-2

The following recommendations are concerned with quality control practices and methods, identification of applicable mandatory and voluntary standards, and personnel safety within the shop. It is most important in the alternative fuels field that safety and strict operational practices, including those in the conversion and repair facility, are maintained. Oftentimes when an accident does occur the event brings more public scrutiny and questioning of alternative fuel safety than other regular fuel accidents have to contend with.

BUILDINGS AND STRUCTURES

23-3

The National Fire Protection Association (NFPA) has set forth standards for fire prevention and safety. NFPA 58, which covers liquefied petroleum gas fuel systems for vehices, contains standards for working with vehicles and handling the fuel indoors. The following recommendations contain references to these standards along with additional recommended criteria for establishing a safe working environment for LPG conversions, maintenance and repair.

BUILDING SAFETY PLAN

23-4

Every building differs in size, layout and venting capacity. Therefore, it is necessary for every technician to be familiar with a particular building's specific safety plan that includes appropriate emergency numbers, evacuation procedures and routes. These numbers should include the following:

- 911
- Fire Department
- Rescue Squad
- Buiding Supervisor (optional)

An evacuation route, with alternate emergency paths should be known and practiced so all workers can be evacuated quickly. These evacuation plans and routes and emergency numbers should be posted in public areas and where work is being performed. New employees should also be given training within the first week of their employment.

Large signs specifying that safety glasses or other safety equipment are required for entry into certain rooms should be posted. Limited access areas should be posted with appropriate warning signs. Location signs for eyewash stations, first aid kits, fire equipment and other safety related materials, including exits, must be posted clearly.

FIRE CONTROL

23-5

NPGA #211 LP-Gas Fire Control and Haz Mat Training Guide provides fire control tactics. Although meant primarily for fire and emergency response personnel, technicians can also benefit from a few of the basics of the guide. In any case of fire, it is best to notify the fire department for their response and professional handling.

Liquid propane leaks are visible and develop frost or ice at its point of escape. Large leaks may produce large ice balls. If there is no fire, close any valve that will stop the flow. Wear gloves and eye protection to avoid freeze burns caused by liquid propane (vapor propane will not produce freeze burns though). Beware of large concentrations of LPG which may exclude oxygen.

If a SMALL fire occurs, use the following precautions:

- Wear protective clothing and gloves while slowly approaching the fire to close the valves.
- Approach the fire from upwind if possible.
- Stop leaks if possible by shutting off a valve or completely crimping the hose or tubing.
- Eliminate all sources of ignition.
- If unable to shut off the gas supply, control the vapor dispersal with a water fog from a hose. Direct the gas towards a safe location.

If the fire is large, evacuate the area and let the fire personnel contain it. Get at least 3000' away from the site as in the worst case scenario a container may rupture and portions of it may travel a significant distance. Keep away from the path of the vapor's white cloud, and eliminate sources of its ignition too.

A safety plan should cover the following questions:

- How many personnel and pieces of equipment will it take to provide adequate control should the facility be involved in a fire or leak?
- Where is the nearest fire hydrant or water supply?
- Can an approach be made from several directions at the same time to insure greater coverage?
- Who should the dispatcher call at night or when the facility is shut down? Who is to be notified in case of emergency?
- Back-up personnel: Is dependable mutual assistance available to ensure adequate coverage?
- Are police and other emergency personnel prepared for emergency evacuation of the affected area to a safe distance from the accident site?
- Who will be responsible for rerouting traffic until the situation is under control?
- Will there be nearby buildings exposed which will require fire protection from radiated heat?
- Who can be notified to provide transports and pumping equipment to pump off or evacuate overturned units?
- Is heavy equipment available to lift overturned transports onto a lowboy or put it back onto its wheels?
- What city, state, and federal agencies must be notified?

Key Points & Notes

23-6

23-7

23-8

23-9

Key Points & Notes

EXPLOSION VENTING

23-10

An explosion is the bursting or rupture of a container due to the development of internal pressure from a deflagration. A deflagration is the development of a combustion zone at a speed less than the speed of sound. This differs from a detonation, which is the development of a combustion zone at a speed greater than the speed of sound, thus the resulting difference in sound.

The gases and pressures resulting from a deflagration are "vented" by proper building design so that structural and mechanical damage is minimized. NFPA 58 7-2.1.1 covers how buildings should be constructed to deal with explosion venting for LPG, and NFPA 68 Guide for the Venting of Deflagrations gives detailed information on the subject.

VENTILATION

23-11

The facility must be either mechanically or naturally ventilated. Technicians should be familiar with the vent operation and use it to keep the air moving.

VEHICLE SYSTEM TESTING

23-12

When a gasoline or LPG vehicle is leak-tested or run within the facility, adequate ventilation must be provided. Turn the exhaust fans on and make sure the air is being drawn out before the test or run begins.

SMOKE DETECTION

23-13

The facility should be equipped with smoke detectors. Check their operation monthly and if battery operated change the batteries every six months.

HC DETECTION

23-14

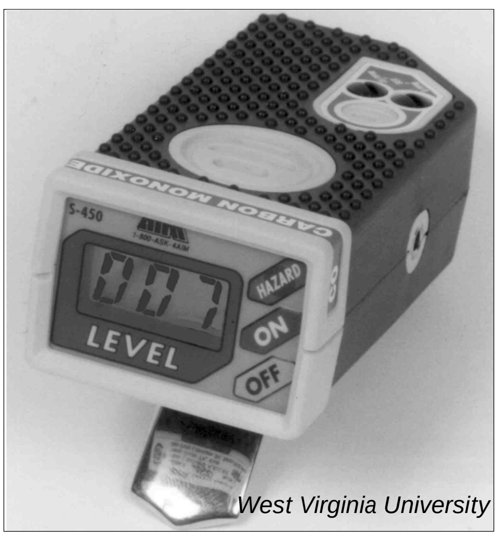
The facility should have an HC (hydrocarbon) detector installed to detect LPG before it reaches dangerous levels. Because LPG vapor is heavier than air, the detector should be mounted as close to ground level as possible. The detector is hooked up to the electrical system and should conform with National Electrical Code (NFPA 70) installation methods. Technicians should test the detector often. See Figures 23-# - 23-#. If the detector is activated, immediately ventilate the facility or evacuate the premises. If possible, determine the source of escaping LPG and contain it.

CO DETECTION

23-17

Remember that carbon monoxide is a colorless, odorless, tasteless gas that is a cumulative poison. CO poisoning occurs when a person's blood has absorbed enough carbon monoxide to impair the process of oxygen absorption by hemoglobin (the oxygen carrying component) in the blood. CO has an attraction for hemoglobin that is 200-300 times more powerful than that of oxygen. CO takes twice as long to leave the body as it does to accumulate in it. Mild health symptoms at about 50 ppm include shortness of breath, headache, dizziness, nausea, and fatigue. Severe symptoms at prolonged levels of 100-200 ppm include severe headache, mental confusion, physical impairment, collapse upon exertion, unconsciousness, and finally death.

23-1 HC Detector.



23-2 CO Detector.

Technicians should use a CO detector where engines are run. Be familiar with its calibration, operation, and if portable keep the batteries fresh. If CO is detected above 50 ppm, ventilate the area. Shut down the engine and leave the site for awhile until the air clears. Return and test the air with the detector. If the readings are above 100 ppm, evacuate the area immediately and make sure all personnel are accounted for. Spend no more than 15 minutes in an area with this concentration. If concentrations are above 200 ppm, only personnel (usually firepersons) with Self Contained Breating Apparatus (SCBA) should enter the site. These emergency services personnel need to be called if they are not already on the scene.

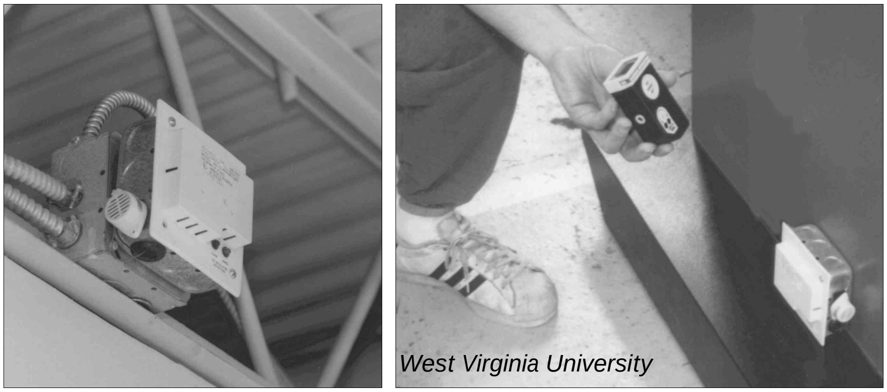
Key Points & Notes

23-18, 23-19

23-15

23-21

23-20



23-3 HC NG detector ceiling mounted; CO and LPG HC detector.

ELECTRICAL AND OTHER SYSTEMS

The electrical system in the facility should be installed and upgraded in accordance with NFPA 70 National Electrical Code. Make sure nothing is placed in front of breaker boxes or other control panels or accessories so that they may be accessed with ease during an emergency. Keep an eye out for power cords with tears or failing plug blades, broken outlets, sparking switches, breakers that trip too often, and other such abnormalities. Repair as needed or alert an electrician. The object is to prevent shocks to personnel and also to eliminate sparks as a possible source of ignition.

Make sure that emergency operation/warning signs are placed at critical shut-offs, disconnects, and safety equipment. These are important for often in emergencies workers may temporarily forget the placement or operation of such equipment. If signs, backup lighting, or control panels are lighted, make sure the bulbs are functional and replace if necessary.

The facility may also include pressurized air, natural gas, or other feeds. Be alert for loose or failing equipment and repair or report the condition as necessary. In general, try to keep the shop as clean and tidy as possible to facilitate access and egress. All personnel should know where the general location of tools, safety equipment, and other items are in case of emergency.

ADDITIONAL STANDARDS

Other NFPA standards may be pertinent to the use and operation of a conversion and repair facility, such as NFPA 88B Standard for Repair Garages. Occasional employee or team meetings may help to refresh the proper procedures or provide new information. As always, when in doubt, consult these references or ask your supervisor.

Again, safety cannot be stressed enough. Periodic training and review of procedures and equipment is necessary to keep the facility and personnel as safe as possible.

Key Points & Notes

23-16

23-22

23-23

23-24

Key Points & Notes

MODULE 23: FACILITY SAFETY

MODULE REVIEW ITEMS

Note to Technician: Consider all choices carefully and select the best answer to each.

1. It is extremely important that safety and quality control practices are maintained in the alternative fuels field.
A. True.
B. False.

2. Because every building _____ in size, venting, and layout, it is _____ for every technician to be familiar with that building's safety plan.
A. Is the same; not necessary.
B. Is the same; necessary.
C. Differs; not necessary.
D. Differs; necessary.

3. LP-gas leaks should be approached from what direction?
A. Down wind.
B. Upwind.
C. Cross wind.
D. Any direction to get to fire.

4. What should be considered first in putting out an LP-gas fire?
A. The height of the flame.
B. How many people you will need to do the job.
C. Stopping the flow of gas.
D. Putting out the flame.

5. If an LP-gas fire is large,
A. Call the Fire Department to handle it.
B. Increase the flow of water to control it.
C. Get more personnel to help and evacuate bystanders.
D. None of the above.

6. What three things would distinguish a liquid leak from a vapor leak where fire is not involved?
A. The color of gas, the odor, and/or sound.
B. It would look like water, taste like water, feel like water.
C. Frosting of piping, icing, white fog.
D. It would stand in puddles, vaporize slowly, look like snow.

7. Can fire on an LP-gas tank relief valve jump down into the tank resulting in an internal combustion?
A. Yes, if the pressure is low in the container.
B. Only if the relief valve is open at the time.
C. Only if the relief valve freezes open.
D. No, because the tank's volume is 100% LP-gas, no oxygen.

8. What effect will LP-gas liquid have when exposed to a person's body?
A. Severe frostbite.
B. Cause internal bleeding.
C. Cause shortage of wind.
D. Cause sores to appear.

9. It is OK to set up shop and work in an older building that does not wholly conform to NFPA 58 7-2.1.1 on explosion venting.
A. True.
B. False.

10. If a portable CO detector registers 25 ppm,
A. Evacuate the building.
B. Call the Fire Department.
C. Vent the area.
D. Don't worry because the minimum ppm to be concerned with is 50.

MRI SCORING KEY

1. A
2. D
3. B
4. C
5. A
6. C
7. D
8. A
9. B
10. C

1 **MODULE 23:**
Facility Safety

2 **THE NEED FOR A SAFE SHOP**

- Quality control
- Mandatory and voluntary standards
- Personnel safety
- Maintain safety and safe practices to avoid public scrutiny and questioning of alternative fuel use and safety

3 **BUILDINGS AND STRUCTURES**

- NFPA 58 standards
- Safe facility and working environment

4 **BUILDING SAFETY PLAN**

- Be familiar with building's characteristics and safety plan
- Phone numbers:
  - 911
  - Fire Department
  - Rescue Squad
  - Building Supervisor
- Evacuation route
- Signage for exits, safety equipment, services

5 **FIRE CONTROL**

- NPGA 211 LP-Gas Fire Control and Haz Mat Training Guide
- LP leaks are visible, cause frost or ice at leak point
- Large leaks cause ice balls
- Close valve to stop flow and leak
- Wear gloves, eye protection
- Watch for large propane gas concentrations to avoid asphyxiation

6 **FIRE CONTROL**
SMALL FIRES

- Wear protective clothing and gloves
- Slowly approach fire to close valves
- Approach from upwind
- Shut off valves or crimp hose or tubing
- Eliminate ignition sources
- Water fog LP vapor with a water hose, direct to safe location

7 **FIRE CONTROL**
LARGE FIRES

- Evacuate area
- Let Fire Department contain it
- Evacuate to 3000' away to avoid bursting and flying tanks
- Stay away from LP vapor cloud
- Eliminate ignition sources

8 **FIRE CONTROL**
SAFETY PLAN

- Personnel and equipment for control
- Fire hydrant locations
- Approach(es) to accident site
- Dispatcher notification during off hours
- Personnel to be notified in case of emergency
- Back-up personnel

9 **FIRE CONTROL**
SAFETY PLAN

- Police and emergency personnel operation preparation
- Traffic rerouting
- Fire protection for nearby buildings
- Transport and pumping for overturned vehicles
- Heavy equipment availability
- City, state, federal agency notification

10 **EXPLOSION VENTING**

- Explosion- burst of container due to internal pressure deflagration
- Deflagration- combustion zone speed less than sound
- Detonation- combustion zone speed greater than sound
- Deflagration gases and pressures vented by proper building design to minimize damage

11 **VENTILATION**

- Mechanical or natural ventilation
- Know and utilize vent system

12 **VEHICLE SYSTEM TESTING**

- Provide ventilation during leak-tests or engine operation
- Turn fans on, check for actual ventilation

13 **SMOKE DETECTION**

- Detects smoke from fires
- Check operation monthly
- Change batteries every six months

14 **HC DETECTION**

- Detects LPG before leaks reach dangerous levels
- Mount close to floor
- Test often
- Ventilate or evacuate area if alarm sounds

15 **23-1 HC DETECTOR**

16 **23-3A HC NG DETECTOR**

17 **CO DETECTION**

- CO is colorless, odorless, tasteless, cumulative poison
- CO takes the place of oxygen in the lungs

18 **CO DETECTION**
50 PPM

- Shortness of breath
- Headache
- Dizziness
- Nausea
- Fatigue

19 **CO DETECTION**
100-200 PPM

- Severe headache
- Mental confusion
- Physical impairment
- Collapse upon exertion
- Unconsciousness
- Possible death

20 **CO DETECTION**

- Use CO detector when operating engines
- Keep detector calibrated and maintained
- Evacuate and ventilate area if ppm over 50
- Evacuate and account for personnel if ppm over 100
- Evacuate and call Fire Department if ppm over 200

21 **23-2 CO DETECTOR**

22 **23-3B CO AND LPG HC DETECTOR**

23 **ELECTRICAL AND OTHER SYSTEMS**

- NFPA 70 National Electrical Code
- Watch for obstructions in front of boxes and equipment
- Watch for faulty cords, boxes, equipment
- Note emergency and instructional signs
- Watch for other systems repair needs
- Keep shop clean, organized

24 **ADDITIONAL STANDARDS**

- NFPA 88 Standard for Repair Garages
- Safety First!

MODULE 23:
Facility Safety

THE NEED FOR A SAFE SHOP

- Quality control
- Mandatory and voluntary standards
- Personnel safety
- Maintain safety and safe practices to avoid public scrutiny and questioning of alternative fuel use and safety

BUILDINGS AND STRUCTURES

- NFPA 58 standards
- Safe facility and working environment

BUILDING SAFETY PLAN

- Be familiar with building's characteristics and safety plan
- Phone numbers:
  - 911
  - Fire Department
  - Rescue Squad
  - Building Supervisor
- Evacuation route
- Signage for exits, safety equipment, services

FIRE CONTROL

- NPGA 211 LP-Gas Fire Control and Haz Mat Training Guide
- LP leaks are visible, cause frost or ice at leak point
- Large leaks cause ice balls
- Close valve to stop flow and leak
- Wear gloves, eye protection
- Watch for large propane gas concentrations to avoid asphyxiation

FIRE CONTROL
SMALL FIRES

- Wear protective clothing and gloves
- Slowly approach fire to close valves
- Approach from upwind
- Shut off valves or crimp hose or tubing
- Eliminate ignition sources
- Water fog LP vapor with a water hose, direct to safe location

FIRE CONTROL
LARGE FIRES

- Evacuate area
- Let Fire Department contain it
- Evacuate to 3000’ away to avoid bursting and flying tanks
- Stay away from LP vapor cloud
- Eliminate ignition sources

FIRE CONTROL SAFETY PLAN

- Personnel and equipment for control
- Fire hydrant locations
- Approach(es) to accident site
- Dispatcher notification during off hours
- Personnel to be notified in case of emergency
- Back-up personnel

FIRE CONTROL SAFETY PLAN

- Police and emergency personnel operation preparation
- Traffic rerouting
- Fire protection for nearby buildings
- Transport and pumping for overturned vehicles
- Heavy equipment availability
- City, state, federal agency notification

EXPLOSION VENTING

- Explosion- burst of container due to internal pressure deflagration
- Deflagration- combustion zone speed less than sound
- Detonation- combustion zone speed greater than sound
- Deflagration gases and pressures vented by proper building design to minimize damage

VENTILATION

- Mechanical or natural ventilation
- Know and utilize vent system

VEHICLE SYSTEM TESTING

- Provide ventilation during leak-tests or engine operation
- Turn fans on, check for actual ventilation

SMOKE DETECTION

- Detects smoke from fires
- Check operation monthly
- Change batteries every six months

HC DETECTION

- Detects LPG before leaks reach dangerous levels
- Mount close to floor
- Test often
- Ventilate or evacuate area if alarm sounds

23-1 HC DETECTOR

West Virginia University

23-3A HC NG DETECTOR

West Virginia University

CO DETECTION

- CO is colorless, odorless, tasteless, cumulative poison
- CO takes the place of oxygen in the lungs

CO DETECTION
50 PPM

- Shortness of breath
- Headache
- Dizziness
- Nausea
- Fatigue

CO DETECTION
100-200 PPM

- Severe headache
- Mental confusion
- Physical impairment
- Collapse upon exertion
- Unconsciousness
- Possible death

CO DETECTION

- Use CO detector when operating engines
- Keep detector calibrated and maintained
- Evacuate and ventilate area if ppm over 50
- Evacuate and account for personnel if ppm over 100
- Evacuate and call Fire Department if ppm over 200

23-2 CO DETECTOR

West Virginia University

23-3B CO AND LPG HC DETECTOR

West Virginia University

ELECTRICAL AND OTHER SYSTEMS

- NFPA 70 National Electrical Code
- Watch for obstructions in front of boxes and equipment
- Watch for faulty cords, boxes, equipment
- Note emergency and instructional signs
- Watch for other systems repair needs
- Keep shop clean, organized

ADDITIONAL STANDARDS

- NFPA 88 Standard for Repair Garages
- Safety First!

MODULE 24:
Fueling Stations

State of Oklahoma
College of the Desert
West Virginia University

MODULE 24: FUELING STATIONS

CONTENTS

MODULE 24: FUELING STATIONS

OBJECTIVES

At the completion of this module, the technician will be able to:

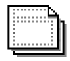
- Discuss the different types of fueling stations and location considerations.
- Identify special equipment necessary for fill stations.
- Discuss safety regulations for a fueling station.
- Discuss LPG pricing issues for the propane industry.

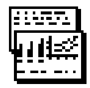
MODULE 24: FUELING STATIONS

INSTRUCTOR NOTES

INSTRUCTOR MATERIALS/MEDIA NEEDED

Overhead projector or LCD panel/projection equipment
Overhead transparency masters or Microsoft PowerPoint 4.0 presentation file Mod24.ppt

Note: Slides correspond to text as indicated by icon 

Handouts:
National Directory of Propane Refilling Stations
Note: Handouts correspond to text as indicated by icon 

STUDENT MATERIALS/MEDIA NEEDED

Module 24: Fueling Stations

MODULE REVIEW ITEMS

The Module Review Items (MRI) are designed to allow for flexibility in their use. The exam may be utilized as a post-module review, pre/post test, part of a term examination, or it may be used by the student if the module is used as a self study text.

OVERHEAD TRANSPARENCY MASTERS

The printouts enclosed with this module are taken from the Microsoft PowerPoint 4.0 presentation file Mod24.ppt . Instructors planning to use overhead projectors should make transparencies from these printouts on a copier (or laser printer designed to safely print to acetate.

Note: Please review Module 25: Training of Trainers for more hints on instructional needs and strategies.

MODULE 24: FUELING STATIONS

LPG FUELING STATION LOCATION

Current practice at public and private service stations is to store propane aboveground in barrier-protected areas. Tanks are therefore not a source of underground leaks, which are a major environmental and safety hazard at gasoline and diesel stations. A recent assessment of public service stations has concluded that the potential for fire damage and fire-related injury is higher with propane than with gasoline. Special procedures and dispensing equipment developed in the Netherlands to handle high volume and self-service vehicle refueling at public stations have been effective in reducing the service station incident rate to the gasoline level.

There are over 10,000 public propane refueling stations already in service. Many fleet users maintain their own bulk storage facilities and filling stations on site. Also, numerous truck stops and recreational vehicle facilities across the U.S. offer propane refueling. The Nation Propane Gas Association has published the National Directory of Propane Refueling Stations, “Your Guide to a National Network of Propane Refilling Stations”, 1996-1997.

FUELING STATION EQUIPMENT

The complete dispenser system consists of a fuel supply tank, power-operated pump, pump bypass valve, strainer, vapor separator, metering assembly, control valves, piping, LP-gas hose, hose valve, hose coupling and all the required electrical fixtures, wiring and housing. These components can all be arranged in one package or arranged for operation remote from the fueling area.

Dispensers are made by a variety of manufacturers and the design of each varies. In addition to the components noted above, other important safety features may include a remote emergency shutdown switch, internal valves in the fuel supply tank, excess flow valves (designed to close automatically in case of line break)

24-1 Typical fueling and dispensing dock.

Key Points & Notes

24-2

National Directory of Propane Refilling Stations 1996-1997

24-3, 24-4

24-5

24-7

and a breakaway coupling in the LP-gas hose.

To assure safe operation of the dispenser, be sure to study the operating instructions very carefully. It is also important to be aware of the location and function of each component and safety features. Technicians should know what inspections and preventive maintenance procedures are required.

A propane fueling facility costs around $30,000. Today's newer propane nozzles have a pistol-grip configuration, much like those used in gasoline fueling. To fuel a vehicle propane tank, the operator inserts the end of the nozzle into a port of the underside of the tank, securing the connection by spinning a brass fitting on the spout. The nozzle automatically shuts off flow of propane to the tanks when the tank is 80% full.

24-2 Meter/dispenser next to 30,000 gallon storage tank.

FUELING STATION SAFETY PROCEDURES

The propane industry has been working the NFPA and other standards-making organizations since 1930 to ensure the safety of all equipment and facilities. In accordance with NFPA 58, vehicle fuel dispensing stations should not be located within a building but shall be permitted to be under weather shelter or canopy, provided this area is adequately ventilated and is not enclosed for more than 50 percent of its perimeter. Vehicle fuel dispensers should not be located on the same island as a gasoline dispenser.

A manual shutoff valve and an excess-flow check valve of suitable capacity must be located in the liquid line between the pump and the dispenser inlet. A quick-acting shutoff valve must be installed at the discharge end of the transfer hose. This hose (called "wet-hose") must be protected against excessive hydrostatic pressure. A clearly identified and accessible switch(es) or circuit breaker(s) must be provided at a location remote from the vehicle fuel dispenser to shutoff power in the event of an emergency.

Key Points & Notes

24-6

24-8

24-9

Key Points & Notes

In the interest of safety, each person engaged in installing, repairing, filling or otherwise servicing an LP-Gas engine fuel system must be properly trained in the necessary procedures. (NFPA 58 8-1.4)

THE PRICE OF LP GASES IN THE U.S.

24-10

LP gases are by-products of oil and gas processing. Prices in the U.S. are coupled to those in the international market and determined by the balance that exists between supply and demand and the ease and costs of LPG substitution by the competing commodities.

The wholesale price of propane in the U.S. has historically closely tracked the wholesale price of gasoline and diesel fuel and the refiners' acquisition costs of crude oil. In the period 1980-1987 the wholesale price of a gallon of propane averaged 48% of the price of a gallon of gasoline and 53% of the lower wholesale price of diesel fuel. In 1987, the price of propane was low relative to the historic price of gasoline and diesel fuel. However in the winter of 1996-1997 the price of LPG dramatically increased, causing numerous operators and fleet managers to consider switching to natural gas or back to fossil fuels.

The differential between the price of propane and that of gasoline is expected to widen if the cost of gasoline increases. The differential relative to diesel fuel will increase as a consequence of the added investments required and higher crude oil used in the low sulfur, 10% aromatics specification fuel needed to operate diesel engines in the future (consistent with changes in the EPA particulate control regulations).

Whereas the price of propane maintained a steady relationship with crude oil in the period of 1980-1987, the wholesale price of propane relative to natural gas steadily declined. The decline occurred relative to gas costs at the production level (including propane delivery and on-site storage charges). The comparison of propane with CNG is even more favorable since the cost of electric power for compression must be added for CNG, together with substantial charges for compressor maintenance, compressor and dispenser equipment financing. Costs of propane at the retail level are higher illustrating the cost and margins associated with small-scale, retail cylinder filling and cylinder distribution of propane.

Pricing information of propane and other fuels is available on the Internet. One such site is located at: http://www.propanegas.com/markets/ .

REGIONAL COSTS OF PROPANE

24-11

Mont Belvieu, Texas is the hub of U.S. and international trade in the LPG and the reference point for pricing and wholesale contract and spot price levels. Mont Belvieu draws product from local gas plants, refineries, underground storage and oceanborne imports and acts as a center from which distribution is made by pipeline, rail or road tanker, ocean-going vessel, or barge.

The price of propane at Mont Belvieu and other sites in North America in linked to that at producing plants and refineries to reflect transportation costs to and from Mont Belvieu. Thus the product delivered by rail to the Chicago market from the large fractionator at Sarnia in Ontario, Canada will, in theory, compete with product shipped from Mont Belvieu by pipeline. In this way, transportation costs create pricing zones in North America where product is drawn for local production, storage, pipelines or rail and road deliveries to give the lowest delivered cost.

THE PUMP PRICE OF PROPANE

Fleet vehicle locations receive scheduled bulk road tanker shipments of propane directly from fuel distributors into company-owned proprietary propane storage form which it is dispensed to vehicles. Shipments to large fleets are frequently of 10,000 gallons delivered into 18-30,000 gallon storage tanks. Distributor margins of 5 cents/gallon are frequently achieved but will be lower in highly competitive situations. The cost of the propane storage and dispensing facility will vary according to fleet size and required sophistication but compares favorably with the cost of new gasoline and diesel fuel storage facilities which are required to be underground double-walled storage containers or cathodically protected steel tanks installed, monitored and maintained to avoid underground gasoline or diesel fuel leaks and/or spills.

Somewhat higher delivery costs are incurred in servicing small fleets wishing to receive shipments of propane delivered by “bobtail” truck into 500-1,000 gallon storage tanks. Most small fleet operators refuel at distributors’ terminals but a number refuel at public service stations which are currently geared to support a small vehicle propane fuel market and to fill barbecue and recreational vehicle cylinders. The retail sites require frequent small volume deliveries. Over 85% of the propane storage tanks currently installed at service stations have a capacity of 1,000 gallons or less and the diseconomies of scale are reflected in the high cost of delivery to the sites and the margins required between the wholesale and retail prices of propane. The storage tank and dispenser for propane are frequently leased to the service station operation by the propane distributor.

An aggressive vehicle propane marketing program would generate the sales required to reduce the distribution and refueling costs to the gasoline level.

Key Points & Notes

24-12

MODULE REVIEW ITEMS

Note to Technician: Consider all choices carefully and select the best answer to each.

1. Aboveground tanks are a major source of environmental problems.
A. True.
B. False.

2. The typical components of a LPG fuel station include which of the following?
A. Control valves.
B. Fuel supply tank.
C. Gas meter.
D. All of the above.

3. In accordance to NFPA 58,
A. All fueling stations must be located within a building.
B. All fueling dispensers must be located on the same island as a gasoline dispenser.
C. All fueling stations must be equipped with a manual shut-off valve.
D. All fueling stations must be nearly or totally enclosed.

4. Supply, demand, international markets, and fuel substitution determine the _____ of _____.
A. Cost; LPG to foreign customers.
B. Price; LPG to US customers.
C. Rationing; LPG to all customers.
D. History; LPG pricing.

5. Propane prices are:
A. Historically stable.
B. Typically declining.
C. Cheaper than CNG everywhere.
D. Recently unstable.

6. The hub of US and international LPG trade is:
A. Chicago, IL.
B. Sarnia, ON.
C. Mont Belvieu, TX.
D. Tulsa, OK.

7. The wholesale price of LPG may differ from region to region because of:
A. Usage.
B. Population density.
C. Delivery costs.
D. Legislation.

MRI SCORING KEY

1. B
2. D
3. C
4. B
5. D
6. C
7. C

1 **MODULE 24:**
Fueling Stations

2 **LPG FUELING STATION LOCATION**

- Aboveground storage
- Higher potential for fire damage and fire-related injury
  - Special safety procedures needed
- 10000+ public refueling stations in US

3 **FUELING STATION EQUIPMENT**

- Fuel supply tank
- Power-operated pump
- Pump bypass valve
- Strainer
- Vapor separator
- Metering assembly
- Control valves

4 **FUELING STATION EQUIPMENT**

- Piping
- LP-gas hose
- Hose valve
- Hose coupling
- Required electrical fixtures
- Wiring
- Housing

5 **FUELING STATION EQUIPMENT**

- Remote emergency shutdown switch
- Internal valves in fuel supply tank
- Excess flow valves
- Breakaway coupling in LP-gas hose

6 **FUELING STATION EQUIPMENT**

- Know inspections, operation, maintenance
- Facility costs about $30,000
- Automatic shutoffs at 80%

7 **24-1 FUELING AND DISPENSING DOCK**

8 **24-2 METER/DISPENSER**

9 **FUELING STATION SAFETY PROCEDURES**

- Station outside under ventilated shelters
- Manual shutoff valve and excess-flow check valve between pump and dispenser inlet
- Quick-acting shutoff valve at discharge end of hose
- Remote switch or breaker for emergency

10 **THE PRICE OF LP GASES IN THE US**

- International market
- Supply & demand
- Substitution of fuels
- Historic wholesale LPG price
  - Vs. gasoline
  - Vs. diesel
  - Vs. natural gas
- Pricing information sources

11 **REGIONAL COSTS OF PROPANE**

- Mont Belvieu, TX hub
- Pricing zones

12 **THE PUMP PRICE OF PROPANE**

- Large fleets receive bulk LPG shipments in 10,000 gallon lots
- LPG cost vs. fleet size, storage requirements
- Delivery costs

MODULE 24:
Fueling Stations

LPG FUELING STATION LOCATION

- Aboveground storage
- Higher potential for fire damage and fire-related injury
  - Special safety procedures needed
- 10000+ public refueling stations in US

FUELING STATION EQUIPMENT

- Fuel supply tank
- Power-operated pump
- Pump bypass valve
- Strainer
- Vapor separator
- Metering assembly
- Control valves

FUELING STATION EQUIPMENT

- Piping
- LP-gas hose
- Hose valve
- Hose coupling
- Required electrical fixtures
- Wiring
- Housing

FUELING STATION EQUIPMENT

- Remote emergency shutdown switch
- Internal valves in fuel supply tank
- Excess flow valves
- Breakaway coupling in LP-gas hose

FUELING STATION EQUIPMENT

- Know inspections, operation, maintenance
- Facility costs about $30,000
- Automatic shutoffs at 80%

24-1 FUELING AND DISPENSING DOCK

Photo Copyright Harris Fogel

24-2 METER/DISPENSER

Photo Copyright Harris Fogel

FUELING STATION SAFETY PROCEDURES

- Station outside under ventilated shelters
- Manual shutoff valve and excess-flow check valve between pump and dispenser inlet
- Quick-acting shutoff valve at discharge end of hose
- Remote switch or breaker for emergency

THE PRICE OF LP GASES IN THE US

- International market
- Supply & demand
- Substitution of fuels
- Historic wholesale LPG price
  - Vs. gasoline
  - Vs. diesel
  - Vs. natural gas
- Pricing information sources

REGIONAL COSTS OF PROPANE

- Mont Belvieu, TX hub
- Pricing zones

THE PUMP PRICE OF PROPANE

- Large fleets receive bulk LPG shipments in 10,000 gallon lots
- LPG cost vs. fleet size, storage requirements
- Delivery costs

MODULE 25:
Training the Trainer

State of Oklahoma
College of the Desert
West Virginia University

MODULE 25: TRAINING THE TRAINER

CONTENTS

MODULE 25: TRAINING THE TRAINER

OBJECTIVES

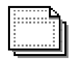
At the completion of this module, the technician will be able to:

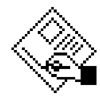
- Acquire knowledge of the minimum competencies required to perform skill-based training.
- Recognize how adult learning principles affect training.
- Identify training options available to help technicians learn specific training skills.
- Develop an understanding of the six most commonly used technical training methods.
  - Discuss how each method can be used.
  - Identify the advantages and disadvantages of each method.
- Recognize how training aids can increase learning effectiveness.
- Determine the proper sequence of steps required for planning On-The-Job Training.
- Identify the four skills that research has shown affects the effectiveness of coaching skills.

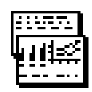
INSTRUCTOR NOTES

INSTRUCTOR MATERIALS/MEDIA NEEDED

Overhead projector or LCD panel/projection equipment
Master overhead transparencies or Microsoft PowerPoint 4.0 presentation file Mod25.ppt

Note: Slides correspond to text as indicated by icon 

Laboratory Activities:
Activity 25-1: Instruction Critique
Activity 25-2: Instruction Practice
Activity 25-3: Evaluation Critique
Note: Lab activities correspond to text as indicated by icon 

Handouts:
Planning, Producing, and Using Materials for Instruction
Note: Handouts correspond to text as indicated by icon 

STUDENT MATERIALS/MEDIA NEEDED

Module 25: Training the Trainer

MODULE REVIEW ITEMS

The Module Review Items (MRI) are designed to allow for flexibility in their use. The exam may be utilized as a post-module review, pre/post test, part of a term examination, or it may be used by the student if the module is used as a self study text.

MASTER OVERHEAD TRANSPARENCIES

The printouts enclosed with this module are taken from the Microsoft PowerPoint 4.0 presentation file Mod25.ppt . Instructors planning to use overhead projectors should make transparencies from these printouts on a copier (or laser printer designed to safely print to acetate.

MODULE 25: TRAINING THE TRAINER

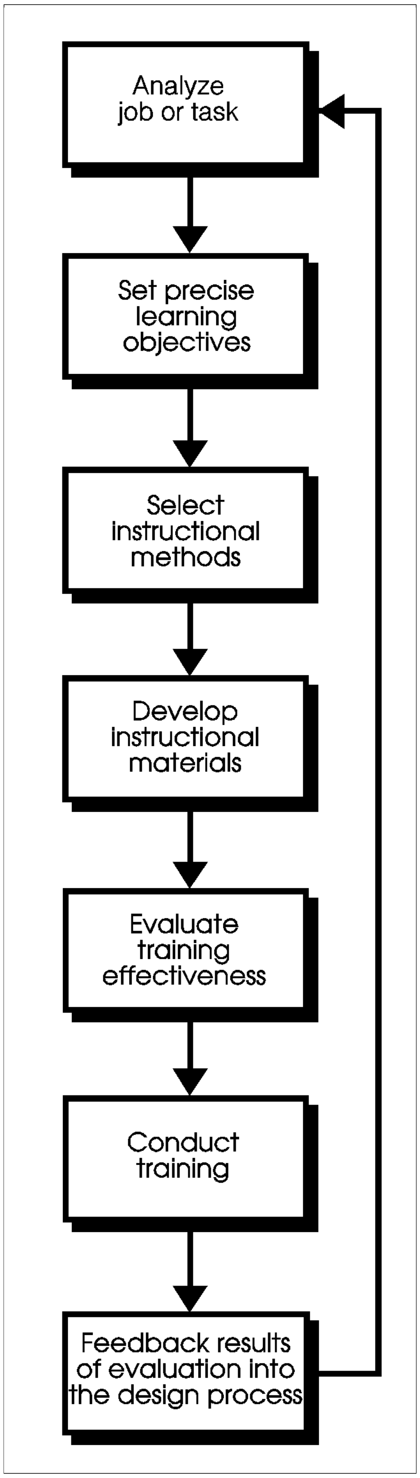
SKILL-BASED TRAINING

Skill-based training is becoming a necessary function of all industries in the work world. The automobile industry is no exception. The need for technical trainers qualified to assist and train mechanics and technicians in converting vehicles to alternative fuel technologies will continue to increase. This module is intended to help experienced trainers improve their skills and to help those with little or no training experience acquire the minimum skills necessary to train others effectively and efficiently.

A trainer helps people gain new awareness, knowledge, skills, and abilities by means of instruction and practice to achieve a desired standard of performance. The following are characteristics a trainer must possess:

- Trainers must have a thorough and comprehensive knowledge of the subject matter they are teaching.
- Trainers need to be aware of the technicians' level of experience and education and apply training methods suitable for their abilities.
- Trainers must have the special quality of presenting information in a clear manner using language, visual, and written materials geared to the technicians' level of comprehension.
- Trainers must be able to convey practical applications of the training by showing technicians how they can use their new knowledge and skills on the job.
- Trainers must demonstrate a sincere concern for and interest in the technician's progress.

Training professionals have identified characteristics and competencies for successful trainer, which can be developed by completing this training module and practicing its content on the job (Figure 25-1).



25-1 A planning model for training

Key Points & Notes

25-2

25-3

TRAINER COMPETENCIES

There are several competencies that an individual should possess in order to be considered an excellent trainer. Without them the trainer will have deficiencies that will cause him or her to be less effective. The remainder of this section will provide information, worksheets, and other support materials needed to help acquire these critical competencies. The competencies include:

- An understanding of **adult learning principles** – A trainer must understand how adults acquire and use knowledge, skills, and abilities.
- An understanding of **learner characteristics** – A successful trainer must understand differences in individual learning styles.
- An understanding of **training methods** – Because individuals learn in a variety of ways, an effective trainer must apply a variety of training methods to meet the needs of technicians.
- Successfully utilizing **presentation skills** – The trainer must verbally and visually present information so that the intended outcomes are achieved.
- Appropriately utilizing **training aids** – The trainer must be able to effectively incorporate flip charts, video tapes, handouts, overheads, video, satellite, computer technology, and other training aids into the training environment to more efficiently improve learner comprehension and performance.
- Applying **questioning skills** – A trainer must be proficient at gathering information and stimulating insight from technicians through the use of interviews and questionnaires.
- Performing **observation skills** – The trainer should be able to record and describe technicians' behaviors and their changes.
- Using **feedback skills** – The trainer should learn how and when to communicate information, opinions, observations, and conclusions so that they can plan and coordinate logistics in an efficient and cost effective manner.
- **Assessing and evaluating** – The trainer must be able to assess the effectiveness of the program and must be able to evaluate the technician learner outcomes.

THE ADULT LEARNER

People often teach in the same way they were taught. It is not uncommon for inexperienced trainers to present information in a manner consistent with their childhood education. There are important differences between children and adults as learners (Figure 25-2). To be effective, it is important for the trainer to be aware of these differences and to apply adult learning principles to adult training programs. Because of the differences between children and adults as learners, specific principles need to be followed when training adults. Training effectiveness can be improved by following these principles.

Key Points & Notes

25-4

25-5

CHILD LEARNERS	ADULT LEARNERS
Children rely on others to decide what is important.	Adults decide for themselves about the importance of learning.
Children accept presented information as fact.	Adults validate new information with their own values and experiences.
Children perceive little immediate need for the information being presented.	Adults have an immediate need for the information presented.
Children seldom have life experience in which to relate to new learning.	Adults have a greater range of experiences and are often more critical.
Children rarely contribute to the learning processs.	Adults have experiences that enable them to be resources to the trainer.

25-2 Comparison of child and adult learners.

TRAINING PRINCIPLES

- Apply all information to real-world problems.
- Elaborate on how the skills and knowledge being obtained can be integrated into the workplace.
- Relate learning to the goals and objectives.
- Connect new learning with past experiences.
- Allow for discussion of differing views, values, and ideas.
- Respect the opinions of the technicians – allow them to be creative.
- Allow the technicians to be resources – they can learn from each other.

LEARNING STYLES

Because individuals learn in different ways, modifying training methods to accommodate different learning styles is important for effective training. Learning styles can be defined as the ways that people acquire and make sense of information. The five primary types of learning styles that people use to acquire information are:

- Listening.
- Observing.
- Reading.
- Imitating/Doing.
- Discovering.

People who learn best by listening or reading tend to be highly verbal learners. They tend to retain more information when they listen to lectures or read information about work tasks. Those who learn best

Key Points & Notes

25-6

25-7

25-8

by observing or imitating tend to be highly visual learners. They find it easiest to retain information when it is presented using charts, videotapes, overheads, or demonstrations.

Those who learn best by discovery tend to be practical people who need to experience events and situations before they are able to absorb new ideas or skills. They find it easiest to retain information when they are provided hands-on experiences that utilize problem solving methods. Discovery learners must be given the freedom to experiment with tasks and acquire information through trial-and-error. Mechanics and technicians tend to be discovery type learners who need to experience hands-on techniques (Figure 25-3).

25-3 Discovery-type learner.

In summary, not all individuals learn in the same way. The more the trainer knows about an individual's best learning style, the easier it is to structure training for increased efficiency and effectiveness. Individual learning styles can be determined by conducting a written survey, engaging in a brief interview with the technician, observing the technician while on-the-job, or talking to others who know the technician. Commercially available learning style inventories may also be used.

TRAINING METHODS

Several training methods can be used to provide technical training and help technicians to learn specific training skills. A variety of methods should be used to keep the technician interested and involved in the training. Also, since people learn in different ways, frequently changing the training method will help facilitate many learning styles (Figures 25-4, 25-5, and 25-6). The most commonly used methods for technical training are:

• Presentation.

• Discussion.

Key Points & Notes

25-9

25-10

- Reading.
- Case Study.
- Demonstration.
- Lab Activity.

PRESENTATION

The trainer orally presents new information to the technicians using the presentation method. It is the most commonly used method and easiest to prepare and deliver. However, it may not be the most effective. The method can be dull and boring if opportunities for technician participation are not provided.

Studies indicate that the technician's retention is low when presentation is the primary method. Also, it is difficult for the trainer to determine if learning is taking place. However, it is a very efficient training method when groups of 20 or more technicians are participating or if a great deal of information must be communicated in a short time. A presentation allows the trainer to control time easily and keep all participants on the same task.

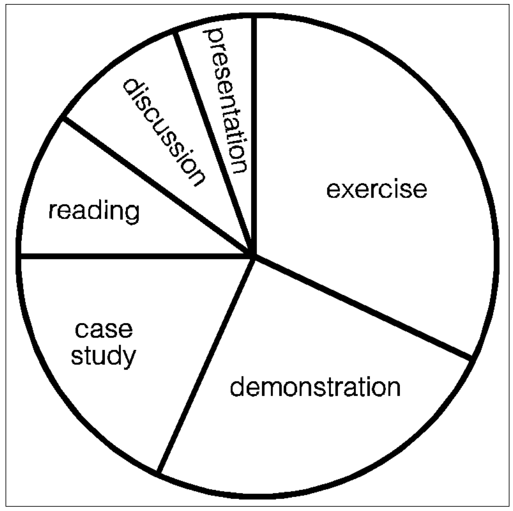
DISCUSSION

Using this method, the trainer facilitates group discussion about a particular topic. This method can be very effective when conducted properly with adult learners. It keeps them interested and involved. It also allows technicians to be resources to the group and to the trainer.

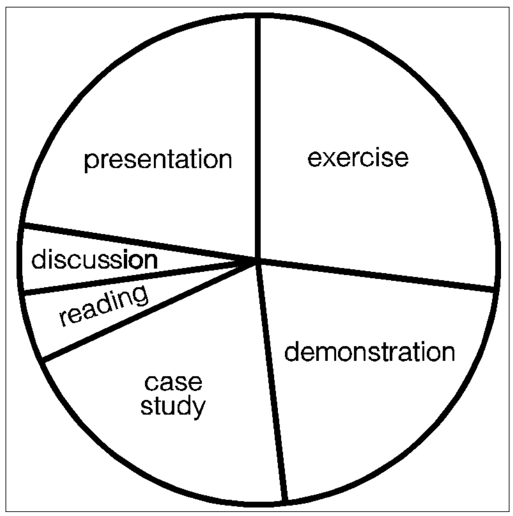
Using this method, the trainer can observe if learning is taking place. It is important to control the discussion so that learning objectives are not lost or confused. Controlling training time can be a factor since discussions can easily be lengthy. A good trainer should should get all participants involved and not let a few technicians to control the discussion.

READING

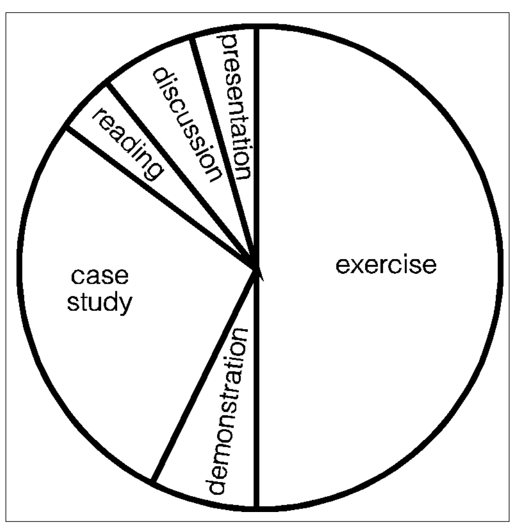
The trainer uses written material to present information to the technicians.



25-4 Learner retention.



25-5 Preparation time.



25-6 Ability to observe learning.

Key Points & Notes

25-11

25-14

25-12

25-15

25-13

25-16

Reading helps save time since most people can read faster than the trainer can speak. The method can be boring if used too long without interruption. As with the presentation method, it is difficult for the trainer to observe learning taking place. The control of time may be a factor since people read at different speeds.

Key Points & Notes

CASE STUDY

25-17

The case study method allows the trainer to present a situation or problem to the technicians. The case should include adequate details to allow the technician to understand and solve problems, which is why a case is usually presented in a written format. Unless it's very brief, a spoken case situation confuses the technician. The technicians must use the information presented to come to a decision or solve a problem relating to the situation.

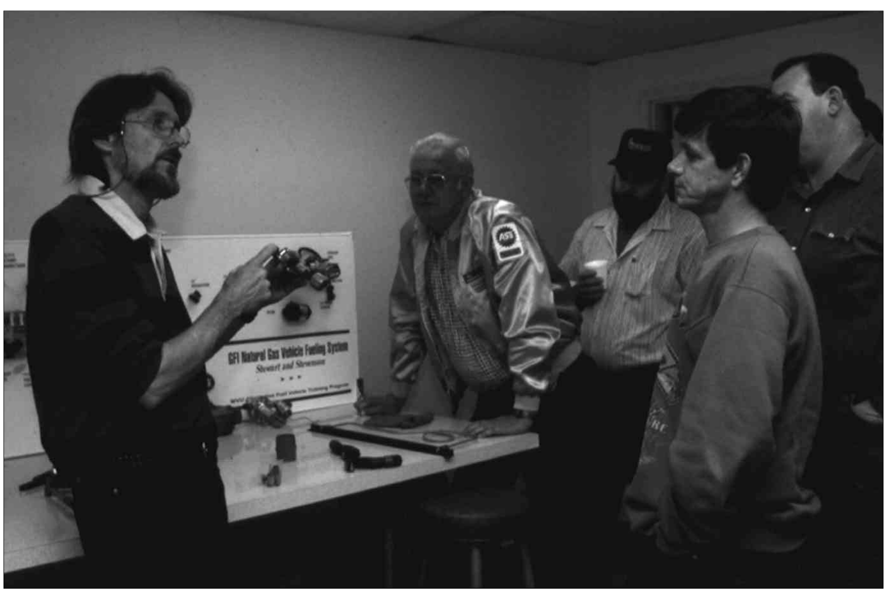
The case study is a very effective training method because it requires active technician involvement. The technicians may also simulate and utilize the case study after training is completed. Also, the trainer can observe if learning is taking place. A disadvantage to using the case study may be the time required to analyze the case. It is important that the case is meaningful to the technician's objectives.

DEMONSTRATION

25-18

The demonstration method allows the trainer to show the technicians the correct steps for completing a task. Research on the demonstration method indicates that it aids in technician understanding and information retention. It provides the technicians with a model to follow and stimulates and retains interest. However, it usually requires lengthy preparation time by the trainer. To be effective, the demonstration must be relative to the technicians' objectives and should be conducted so that all technicians can observe (Figure 25-7).

25-19



25-7 Demonstrations provide close-up inspection of devices.

LAB ACTIVITY

Using this method, the trainer facilitates a hands-on experience for the technicians to practice new skills. This method has several advantages over the others. The trainer can observe learning taking place. Technicians are actively involved and remain interested. Information retention is increased significantly. The technicians have the opportunity to practice new skills in a controlled environment. The major disadvantage of this method is the time required to prepare and conduct the activity.

PRESENTATION SKILLS

PLANNING

The first step is to plan the presentation. Planning begins by writing down objectives of what is to be accomplished during the presentation. Objectives should be stated simply and pertain directly to trainee needs. For example:

Objective 1. To develop an understanding of the six most commonly used technical training methods.

Objective 2. To discuss how each method can be used.

Objective 3. To identify advantages and disadvantages of each method.

Another component of planning the presentation is to analyze the audience. The trainer must understand the values, needs, and constraints of the audience. If the presentation is not planned according to the knowledge level of the audience, it will be less effective. Use the "Planning the Presentation" worksheet on the following page to help prepare for any presentation (Figure 25-8).

DEVELOPING

The first step to developing the presentation is to brainstorm for possible main ideas. Each idea can be recorded on an index card to help keep them organized. A good presentation should have between two to five main ideas.

If there are more than five main ideas, they should be reduced by making some of them sub-points. Sub-points are supporting ideas to reinforce the main ideas. After all relevant ideas have been recorded for the presentation, the body of the presentation can be written. The next step is to prepare the introduction. The introduction should get the audience's attention, introduce the trainer's qualifications, and provide background information about the topic. The last step is to develop the conclusion. A conclusion should summarize the main points in the introduction.

In summary, the presenter should develop the presentation to inform the audience of what he or she is going to tell them (introduction), information to present them (body), and then repeat what was told (conclusion).

Key Points & Notes

25-20

Activity 25-1

25-21

25-23

Key Points & Notes

25-22

WORKSHEET: PLANNING THE PRESENTATION

Completing this worksheet will help you plan efficiently for any presentation.

1. The objectives in relation to the audience include:
____
____
____
____

2. Values or opinions that should be considered with this audience are:
____
____
____

3. Special needs of the audience include:
____
____
____

4. Special constraints that must be recognized when speaking to the audience are:
____
____
____

5. The audience's knowledge of the topic and technical terminology is:
High________ Low________ Mixed_______

6. Expectations of the audience to accept the ideas presented are:
High________ Low________ Mixed_______

7. Examples of supporting ideas and arguments to reinforce the presentation include:
____
____
____
____

8. Expected audience size __________ 9. Length of presentation _________

25-8 Planning worksheet.

PREPARING

25-24

Two components of preparing for the presentation involve practicing the presentation and controlling the environment. Practice is necessary to reduce anxiety and to ensure that a presentation is professionally delivered. The following checklist can be used when practicing for a presentation.

In practicing for the presentation, the trainer should:

- Develop notes that contain only key words which are printed in large letters on index cards (Figure 25-9).

25-9 Practicing the presentation.

- Mentally review the presentation keeping each main idea in sequence.
- Repeat the review process until the presentation flows smoothly.
- Complete stand-up rehearsals of the presentation in an environment similar to that of the actual presentation. Practice answers to anticipated questions.
- Videotape the presentation before delivery and make any needed adjustments.

Controlling the presentation environment is another critical component to preparing the presentation and increasing professionalism. Before beginning a presentation, consider the following presentation aids:

Projectors

Be sure that the projector is in proper operating condition. Make sure that the bulbs are not burned out and that there are spare bulbs available. Clean the screen and lenses for a more clear image. The projector should be focused and ready to go.

Flip Charts

Be sure that the flip chart has enough paper. Several marking pens in different colors should be available. Check to make sure they are not dried out.

Handouts

Make sure all handouts and copies are properly ordered. Arrange to distribute handouts in the most timely and least disruptive manner.

Key Points & Notes

25-25

25-26

Lighting

Know where the light switches are located and how to dim them properly when using videos or projectors. All the bulbs and fixtures in the room should be working properly to provide maximum light when necessary. Visit the classroom and test the lights prior to the presentation if possible.

Seating Arrangement

If possible, arrange the seating so that the entrance and exit to the room are at the rear. This will reduce distractions from those participants coming and going. Try to provide only as many seats in the room as the expected number of participants. This will prevent people from sitting in the back of the room. Three seating arrangements to facilitate discussion during the presentation are shown in Figures 25-10 through 25-12. These are preferred over the traditional classroom style seating arrangements (Figure 25-13).

Environment

Make sure the heating, ventilating, and air conditioning systems are working and set comfortably for all. Have a backup room or facility available in case a system should fail.

Key Points & Notes

25-10

Figures 25-10, 25-11 & 25-12: Seating arrangements that facilitate discussion.

25-27

25-11

25-28

25-12

25-29

25-13 Traditonal seating arrangement.

25-30

DELIVERING THE PRESENTATION

The delivery of the presentation may make or break an effective training session. It is important to convey enthusiasm to the audience if you want them to be enthusiastic about the information presented. Standing motionless and speaking in a monotone voice without direct eye contact will always destroy a well prepared presentation. Nonverbal actions are extremely important in maintaining audience attention and redirecting the trainer's anxiety. Relate to the audience in a natural, conversational style. Practice being direct and personable with the audience. To ensure that the presentation is more animated, consider the following:

Posture

When conducting a formal presentation, posture should remain erect but relaxed. The feet should be facing the audience with the body weight evenly distributed. Shifting of body weight from hip to hip may distract the audience.

Movement

It is not good practice to stand directly in front of the audience without moving. Moving from side to side once in a while without pacing helps keep the audience alert. If using a lectern, place the lectern four to eight feet from the front row. Standing in front of the lectern is a good strategy to eliminate the sense of a barrier between the speaker and the audience. It is important to stay close, stay direct, and stay involved with the audience.

Gestures

Natural hand gestures used in everyday conversation should also be used during formal presentations. Gestures add emphasis to the presentation and indicate enthusiasm on the part of the presenter. Although gestures should be used throughout the presentation, avoid placing the hands in the pockets, keeping them cuffed behind the back, leaving them crossed in the front, or rubbing them together nervously.

Eye Contact

Direct eye contact with the audience is important for instilling confidence and credibility. Many trainers tend to look at the ground, at the back wall, or at a notepad. These are ineffective presentation methods. Eye contact opens a channel of communication between people. Good eye contact also helps relax the trainer by connecting him or her with the audience, thus reducing the feeling of isolation.

Try to focus on one person for one to three seconds before moving on to another. This will help bring them into the presentation without feeling uncomfortable. If the audience is too large to look at each individual separately, make eye contact with individuals in different parts of the group.

Controlling the Voice

A monotone voice, or voice that maintains the same pitch, is very boring. A monotone voice results from anxiety which causes the

Key Points & Notes

25-31

chest and throat to become less flexible resulting in airways becoming restricted. The trainer must relax and release tension in order to bring back animation in the voice. This can be accomplished by moving the upper and lower body. This will help loosen the muscles and allow normal breathing.

The pace of the presentation is also important. The trainer must be careful not to talk too fast. Anxiety may cause a person to speed up. During technical presentations, it is important to articulate clearly at a slow enough pace to allow note taking and comprehension. After an important point has been stated, pause and allow the audience to absorb what you have just said.

Volume is also important. Be sure to ask at the beginning of the presentation if everyone can hear adequately. Avoid a fading voice at the end of a sentence or speaking too softly. These may be interpreted by some as signs of insecurity. It is also important to make sure your voice is not too loud. A friend in the audience monitoring your voice volume and clarity is a good presentation strategy.

QUESTION AND ANSWER TECHNIQUES

Questions can be asked during the presentation. It is important to inform the audience that you will be asking questions. When the technician is answering a question, the trainer should direct about 25% of the eye contact to the person answering the question and about 75% to the rest of the audience. This allows the trainer to control the class and to focus on the answer given by the technician.

Open-Ended Question

This type of question forces the technician to rethink the problem or draw their own conclusion.

Example: "What are the advantages and disadvantages of placing the LPG tank in that location?"

Closed-Ended Question

This question helps the trainer guide discussion into a specific area.

Example: "What type of safety valve are you going to place on the LPG tank?"

Reflective Question

Here the question restates the technician's concern to prevent misunderstanding.

Example:

Technician: "The tank is slowly losing pressure."

Trainer: "You mean there is a leak in the system?"

Feedback is important for behavior modification. If the feedback creates defensiveness, withdrawal, or anger, coaching will not be effective. The trainer must offer specifics, not generalities. Describe exactly why a technician must change his/her behavior and be sure they understand why. It is also important that the trainer identifies only those shortcomings that the technician can do something about.

Key Points & Notes

25-32

Activity 25-2

TRAINING AIDS

Training aids are visual or written materials that support various training methods. They may serve several functions to help increase learning effectiveness. They focus the technicians' attention to the objectives being discussed. They increase interest in the training session by presenting information that is visually pleasing. They improve information retention by engaging more than one sense (sight and sound) in the learning process. The training aids most commonly used include: flip charts, videotapes, handouts, and transparencies/overhead presentations.

FLIP CHARTS

Flip charts are versatile in that they can be prepared in advance or during the training session. Prepared flip charts have the advantage of saving time during the training session and ensuring neatness. Recording on flip charts during the training session allows for immediate response to technician needs.

VIDEOTAPES AND FILMS

Videotapes and films are very useful training aids because they combine pictures and video with sound and bring experiences to the training environment that would otherwise be impossible to provide. They tend to stimulate interest and motivate technician to try new things. They also add professionalism to the training.

HANDOUTS

Handouts are written or published materials prepared before training and distributed during training. They can be used either during training or as a reference after training. Handouts allow technicians to absorb information at their own pace. They are also useful in eliminating the need for memorization and notetaking. Activity or work sheets are useful aids during the training session.

CREATING EFFECTIVE HANDOUTS:

- Handouts should be titled and dated
- The purpose should be identified
- Directions should be included
- Emphasize key points by using **bold print**, underlined text, or CAPITALIZATION
- Format so that it can be easily read
- Use short sentences
- Avoid unnecessary information

25-14 Pointers for effective handouts.

Key Points & Notes

25-33

25-34

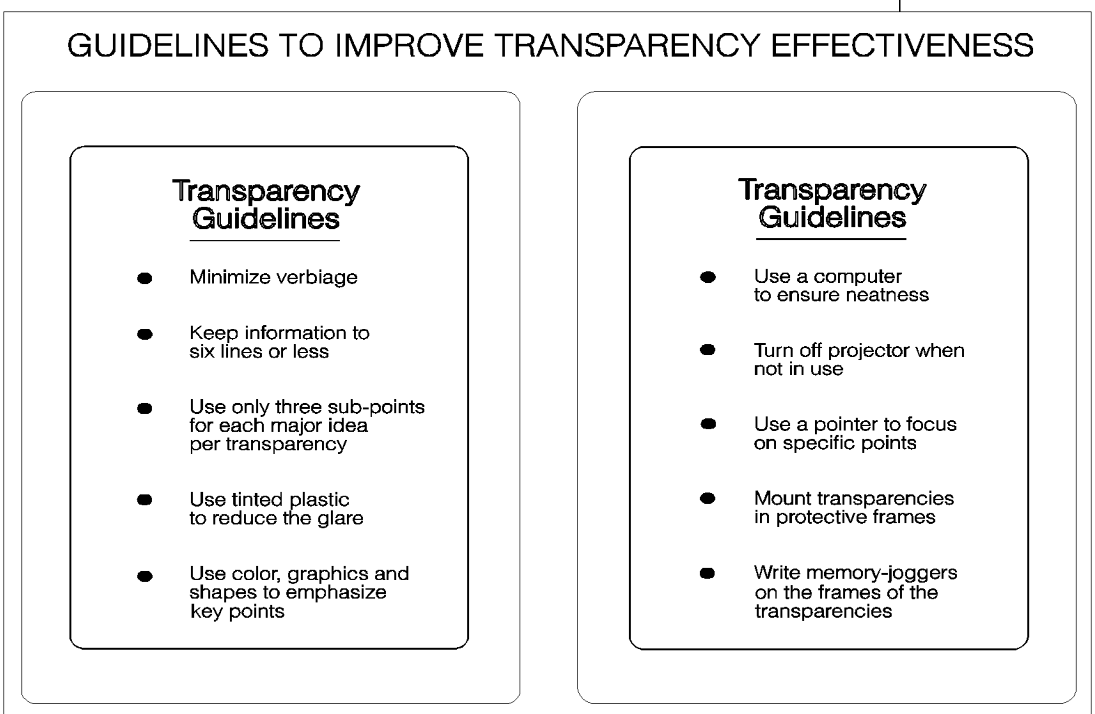
Key Points & Notes

Professionally prepared handouts are easy to read, effectively communicate ideas, and are visually pleasing. Guidelines for creating effective handouts are presented in Figure 25-14.

TRANSPARENCIES AND OVERHEAD PRESENTATIONS

Transparencies are acetate sheets containing information to be used with an overhead projector. They are easily used with a large or small group. Transparencies, when developed properly, add a professional touch to a training session. However, overuse and overly complex content can detract from the intent of the presentation.

Like flip charts, transparencies can be developed before training or during training. Transparencies developed before training require information to be placed on a piece of paper and then transferred to the acetate using a duplicating machine. Use a transparency marker to record information on the acetate when developing transparencies during a training session (Figure 25-15).



25-35

25-15 Creating effective transparencies.

Other types of overhead presentations include slide projections and computer screen projections. Slide projectors may use carousels of select slides prepared and organized into a presentation before the training session. Their advantage is a crisp, clear display when properly focused. Text, graphics, and photographs may be shot and reproduced on slides. Make sure to demo the presentation before the training session to check the slide orientation in the carousel. Some slide projectors may also utilize audiotapes and remote control units – check these during the demo period.

Laptop computers running presentation software with LCD projectors are popular with trainers who have access to such equipment. Displays may range from merely a reproduction of the computer screen to full multimedia/hypermedia presentation software. Trainers should be well aquainted with the hardware and software before using such a system. Contact your education technology or computer support department for further information regarding design, choices,and use.

ON-THE-JOB TRAINING

On-the-job training (OJT) is planned instruction that occurs at the worksite to teach new skills or to change/improve the performance of technicians. The goal of OJT is to get the technicians to perform at desired work standards and expectations. OJT is designed and conducted based on job requirements, the technicians' ability, and organizational needs.

OJT is important in any work environment that is frequently changing techniques and employee requirements. It reduces unproductive periods of breaking in technicians to new job requirements. It also assures that technicians conduct their work in a manner consistent with management expectations. OJT should be conducted when technicians are to begin a job change.

STEPS TO PREPARE FOR OJT

Step 1: Task Analyses

A. The first step to prepare for OJT is to analyze the job and its tasks. This includes preparing a detailed job description. The job description should include: the purpose of the task, what position supervises the task, what position provides support for the task, and the duties that must be devoted to the task. The job description will be used to select and train technicians, and appraise technicians' performance. An example of a task description for installing the LPG fuel tank could include:

Task Description: The purpose of this task is to install the LPG fuel storage tank so that it will function properly and safely. The head mechanic will oversee that all regulations are met and that the task is completed satisfactory. You, as the LPG conversion specialist, must follow the proper sequential steps to ensure that the tank is installed efficiently and effectively.

In order to prepare the task description, a task analysis must be completed. A task analysis is a detailed description of work procedures necessary to achieve desired results. The analysis is conducted by identifying a task process.

Example Task Process:

Installing the LPG fuel storage tank.

B. Listing the steps is second in the process sequence.

Example List of Steps:

1. Check that each part of the tank assembly will fit into the selected location.

Key Points & Notes

Planning, Producing, and Using Materials for Instruction

25-36

25-37

2. Mount the bottom support bracket.

3. Install the tank in the bracket.

4. Secure the top bracket.

5. Label the tank.

C. Describing what the technician should do during each step follows (Figure 25-16).

Once the task analysis is written and the job description is complete, the next step is to conduct a technician analysis.

Key Points & Notes

25-38

EXAMPLE OF TRAINEE STEPS

<u>Step 1</u>: Verify fit for tank assembly location

- Verify space for guards
- Verify space for mounting bolts
- Verify venting requirements
- Verify fit and accessibility of the tank valve
- Verify fuel line location
- Verify clearance for mounting brackets
- Verify location for ease of service

<u>Step 2</u>: Mount the bottom support bracket

- Drill holes for the bracket
- Glue rubber strip onto the bracket
- Mount the bracket to the vehicle

<u>Step 3</u>: Install the tank in the bracket

- Install the tank valve onto the tank
- Place the tank on the bottom bracket
- Rotate the tank so that the serial number and test date stamp are visible

<u>Step 4</u>: Secure the top bracket

- Glue rubber strip onto the bracket
- Mount the bracket securely to the bottom bracket

<u>Step 5</u>: Label the tank

- Label the tank with the words **LPG ONLY** using contrasting colors for letters at least one inch (25 mm) high

25-16 A technician checklist for installing an LPG fuel tank.

Step 2: Technician Analyses

The second step necessary to prepare for OJT is to obtain information about the technician to be trained. The technician's knowledge, skills, and attitudes may affect what training methods to use, the time needed for training, and the degree of information required. A technician analysis should include:

- Identifying what the technician already knows about the job or task
- Identifying the technician's skills and abilities
- Determining the technicians' attitudes about the job, organization, and himself or herself (Figure 25-17).

Key Points & Notes

25-39

EXAMPLES OF UNWANTED CONSEQUENCES

<u>Step 1</u>: Verify fit for tank assembly location

- Avoid drilling bracket holes into exhaust pipes or other important components that may be on the underside of the mounting surface
- Avoid placing the tank on a surface that may be weak from rust (a reinforcement plate may be necessary)
- A tank valve should be installed to vent the tank outside the vehicle
- Avoid installing the tank where the fuel line could be kinked, compressed, sheared, or obstructed

<u>Step 2</u>: Mount the bottom support bracket

- Avoid mounting the bracket on a weak surface; a reinforcement plate may be necessary

<u>Step 3</u>: Install the tank in the bracket

- Care must be taken to assure that important information on the tank will be visible after installation: the serial # and certification date, for example

<u>Step 4</u>: Secure the top bracket

- If the top bracket is not secured tightly enough, the tank may slip during an accident and cause the fuel line to stretch, compress, twist, kink, or break

<u>Step 5</u>: Label the tank

- Failure to label the tank could place an automotive technician or a layperson who is unfamiliar with liquid petroleum gas vehicles in a dangerous position when performing maintenance

25-17 A technician checklist for installing an LPG fuel tank.

Key Points & Notes

Trainers should modify training based on the results of the technician analysis. Once the trainer has completed a job description, conducted a task analysis, and obtained a technician analysis, the last step to preparing for OJT is to analyze the organization.

Step 3: Organization

The final step to planning OJT is to analyze the organization. This will ensure that the training is conducted in a manner consistent with the philosophy and goals of the organization. The trainer should consider the following recommendations when conducting the organization analysis:

- The technician should be aware of and abide by all organizational policies.
- The technician should acknowledge all work standards and expectations exhibited by the organization.
- The technician should be cognizant of special terminology used on the job.

25-41

A MODEL FOR CONDUCTING ON-THE-JOB TRAINING

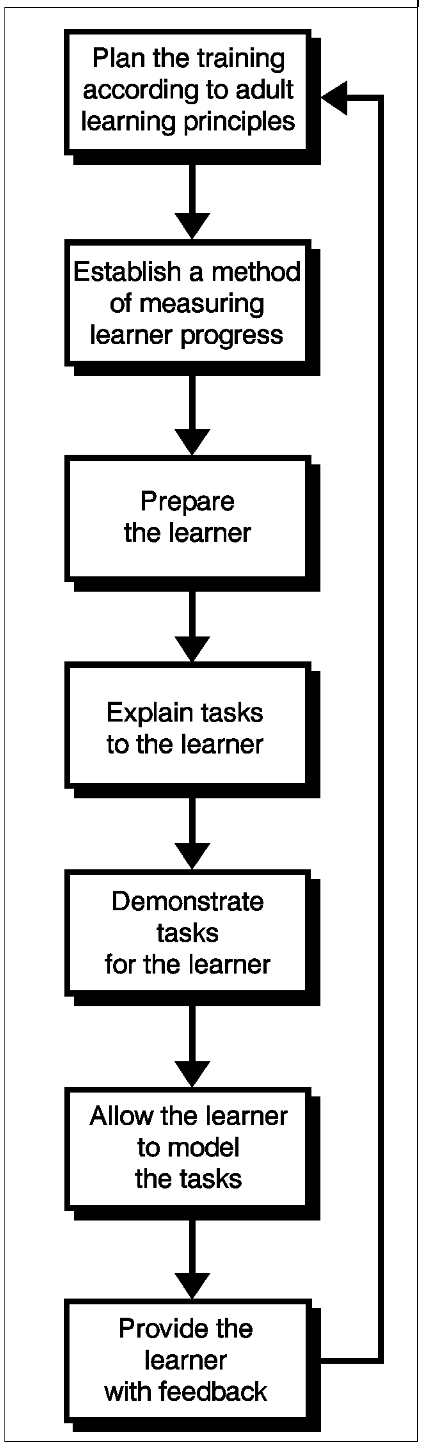
After completing the three steps for preparing for OJT, a model can be applied for conducting OJT. The OJT model is illustrated in Figure 25-18 and discussed below.

25-40

Step 1: Plan Training According to Adult Learning Principles

It is important that the first step in conducting OJT is to ensure that the training program prepared for the technician is designed to use adult learning principles. Consider the following:

- Adults are motivated to learn most when they are undergoing changes in their lives.
- Adults want to see a practical value in what they learn.
- Adults learn best when they are put at ease.



25-18 A model for conducting on-the-job training.

- Adults have trouble learning when information conflicts with their values or experiences.

Key Points & Notes

Step 2: Establish a Method of Measuring Adult Technician Progress

The second step in the model is to establish measurement techniques to monitor the success of the training. Monitoring progress will increase the efficiency of training efforts, hold technicians accountable for training, and indicate areas to improve for future training. Three ways to monitor technician progress are described below using the installation of the LPG fuel tank as an example of the task.

Establishing Estimated Times For Each Task

Example:

1. Verify that each part of the tank assembly will fit into the selected location. (20 minutes).
2. Mount the bottom support bracket (30 minutes).
3. Install the tank in the bracket (20 minutes).
4. Secure the top bracket (15 minutes).
5. Label the tank (5 minutes).

Developing Checklists For Each Task

Example: (check off each task as it is completed)

___ Verified space for guards.

___ Verified space for mounting bolts.

___ Verified venting requirements.

___ Verified fit and accessibility of the tank valve.

___ Verified fuel line location.

___ Verified clearance for mounting brackets.

___ Verified location for ease of service.

Developing Individualized Learning Plans That Are Contracts Geared Toward The Needs Of The Technicians

Example:

- I will take my time and make sure that all variables prior to the tank installation have been considered.
- I must complete a verification list and inform the head mechanic of any potential problems prior to installation.

Step 3: Prepare the Technician

The third step is to prepare the technician. This involves:

- Developing a good rapport with the technician.
- Orienting the technician with the work station.

• Explaining the purpose, objectives, and importance of the training.

• Motivating the technician.

In order to accomplish these goals, the trainer must establish a comfortable social setting. He or she must make an effort to find out about the person they will train. Engaging in small talk with the technician before training helps to break the ice. It is important that the trainer show enthusiasm and interest in the tasks the technician will be learning. Try to place yourself on the technician's level to show that you are not playing the part of his or her superior. Make all efforts to be recognized by the technician as a helper and not as a boss.

Step 4: Explain Tasks to the Technician

The fourth step is to explain tasks to the technician. This is the most important step of the model. It involves telling the technicians exactly what they are to do. More specifically, the trainer should:

• Tell the technician what tasks to perform.

• Tell the technician what results are expected.

• Describe as clearly as possible, what the technician has to do.

• Avoid using terminology that the technician may not know.

• Use a task analysis to explain the tasks in the sequence desired.

The greatest challenge for the trainer is to practice clarity when providing the training. The trainer usually knows much more about the subject than the technician. Therefore, the information must be delivered in such a way as to provide structure and simplicity. The training should be clear to the technician without insulting his or her intelligence.

Step 5: Demonstration

The fifth step is to demonstrate tasks to the technician (Figure 25-19). This involves showing the technician how to perform the task in a step-by-step manner. Many people learn best by observing and then imitating others. The demonstration should be performed while standing or sitting directly next to the technician. This will help technician observe more easily.

Step 6: Allow the Technician to Model the Task

The sixth step allows the technician to model the tasks that were just demonstrated. It is important that the technician master the simplest tasks first before proceeding to more complex tasks. The most important rule is to allow the technician to complete the task before critiquing his or her performance. If necessary, the trainer should record notes about what the technician does well or poorly.

Step 7: Provide Feedback

The seventh step of the model is to provide feedback. Feedback is

Key Points & Notes

25-19 Instructor demonstration.

Key Points & Notes

25-42

evaluative information given by the trainer to inform the technician of his or her performance. Feedback should be given immediately after the technician attempts a task. Effective feedback should be clear and unambiguous. The technician should have no doubts about how well tasks were completed.

Step 8: Testing

In the eighth and final step, technician will be administered a final examination to determine knowledge gained, skills adopted, and ability to perform.

CHECKLIST FOR PREPARING AND CONDUCTING ON-THE-JOB TRAINING

Directions: Refer to this checklist when preparing and implementing OJT. For each step listed in the left hand column, check off an appropriate response below (Figure 25-20).

COACHING

25-43

Coaching is the ongoing process of training that strives to improve performance through positive reinforcement. Coaching should always be friendly and practical. As a coach, a trainer attempts to help technicians reach their full potential. This requires that technicians must appreciate the need for doing a better job and obtain the means to do so. The coach must listen to the technicians empathically, probe them for their concerns, and hold back critical judgment.

Developing the proper environment for effective coaching is critical. It is important that coaches are non-threatening. Technicians will not perform adequately when they have to deal with stress and pressure. Trust, confidence, and respect are important coaching

Key Points & Notes

CHECKLIST: ON-THE-JOB TRAINING

Refer to this checklist when preparing and implementing OJT.
For each step listed below, check off an appropriate response.

DID YOU COMPLETE THE FOLLOWING?	YES	NO	N/A
1. Review or prepare a job description that is up-to-date?			
2. Analyze tasks for each major activity in the job description?			
3. Analyze the learner's present knowledge of the job and tasks?			
4. Modify the training plan based on the learner's knowledge?			
5. Analyze the organization's policies which may affect training?			
6. Modify the training plan based on the organization's policies?			
7. Prepare the outline for on the job training?			
8. Prepare instructional objectives to be achieved by the learner?			
9. List instructional methods for delivering the subject content?			
10. Plan for setting the learner at ease prior to on the job training?			
11 Clarify with the individual the reasons for learning?			
12. Position yourself next to the person during training?			
13. Establish a method for monitoring progress during training?			
14. Establish good interpersonal relations with the learner?			
15. Build the learner's motivation to learn the task?			
16. Explain clearly what task is to be performed?			
17. Explain the expected results of performing the task?			
18. Show the learner how to perform the task?			
19. Ask the learner to perform the task for you?			
20. Take note of the learner's performance?			
21. Allow the learner to perform all steps before critiquing?			
22. Correct mistakes immediately?			
23. Praise what the learner did correctly?			

25-20 OJT checklist

qualities to instill in a training environment. When technicians truly believe that a coach may help them, they will invest more effort into improving their performances.

Coaching should be performed in a private or non-distracting setting. It is more likely for technicians to respond positively when they are not exposed to judgment by their fellow technicians. Coaching should occur during times removed from critical events or the training of new skills. This enables coaching instruction to be absorbed more easily. It is also important that the technician views the coach as a helper and not as a boss. This can be accomplished by facilitating changes in behavior, not dictating them.

SKILLS OF A GOOD COACH

Research relating to the effectiveness of coaching in the workplace identifies four skills needed to be a good coach. The first is observational skills. Before a coach can make a formal evaluation of an technician's strengths and weaknesses, he or she must watch for opportunities for technician improvement. The second is analytical skills. Since coaching is not appropriate for every situation, it is important to determine what is influencing performance and when coaching may help. The coach must also suggest alternatives and specific skills to help technicians improve their work.

The third is interviewing skills. Effective coaches must know how to ask questions and how to listen. Open-ended questions, closed questions, and reflective questions must be asked according to specific needs. The fourth skill is feedback. Good coaches make effective use of feedback received from technicians.

Key Points & Notes

25-44

Activity 25-3

Key Points & Notes

TRAINING RESOURCES

ON-THE-JOB TRAINING (OJT)

Broadwell, M. (1986). The supervisor and on-the-job training (3rd ed.). Reading, MA: Addison Wesley. (BOOK)

Broadwell, M. & Broadwell, T. (1988). Effective training techniques. New York: AMA Film Video. (VIDEOTAPES, call 800-225-3215 to order)

Connor, J. (1983). On-the-job training. Boston, MA: International Human Resources Development Corporation. (BOOK)

Fisher, S. (1989). Adult learning principles workshop. Amherst, MA: Human Resource Development Press. (TRAINING PACKAGE)

Ittner, P. & Douds, A. (1988). Train-the-trainer: practical skills that work. 2 vols. Amherst, MA: Human Resource Development Press. (TRAINING PACKAGE)

Rothwell, W. (1990). Structured on-the-job training workshop. 2 vols. Amherst, MA: Human Resource Development Press. (TRAINING PACKAGE)

Zaccarelli, H. (1988). Training managers to train: a practical guide to improving employee performance. Los Altos, CA: Crisp Publications. (BOOK)

COACHING EFFECTIVENESS

Fournies, F. (1978). Coaching for improved work performance. New York: Van Nostrand Reinhold. (BOOK)

McKeachie, W.J. (1994). Teaching tips. Lexington, MA: D.C. Heath and Co. (BOOK)

Quick, T.L. (1985). The manager's motivation desk book. New York: John Wiley & Sons. (BOOK)

Rae, L. (1985). The skills of human relations training: a guide for managers and practitioners. New York: Nicols Publishing Company. (BOOK)

Stowell, J. & Starcevich, M. (1987). The coach: creating partnerships for a competitive edge. Salt Lake City, UT: The Center for Management and Organization Effectiveness. (BOOK)

ADULT LEARNING

Brookfield, S. (1986). Understanding and facilitating adult learning. San Francisco: Jossey-Bass. (BOOK)

McLagan, P. (1978). Helping others learn: designing programs for adults. Reading, MA: Addisson-Wesley. (BOOK)

Key Points & Notes

GLOSSARY

ADULT LEARNING PRINCIPLES - A trainer must understand how adults acquire and use knowledge, skills, and abilities.

ANALYTICAL SKILLS - Ability to determine what is influencing performance and when coaching may help.

ASSESSMENT AND EVALUATION - The trainer must be able to assess the effectiveness of the program, and the technicians must be able to evaluate the technician outcomes.

CASE STUDY - A method that allows the trainer to present a situation or problem to the technicians.

COACHING - The ongoing process of training that strives to improve performance through positive reinforcement. Coaching should always be friendly and practical.

COMPETENCY - Having the required ability to function or perform at the level required.

DEMONSTRATION - A method that allows the trainer to show the technicians the correct steps for completing a task.

DISCUSSION - A method in which the trainer facilitates group discussion about a particular topic. This method can be very effective when conducted properly with adult learners.

EVALUATION AND ASSESSMENT - The trainer must be able to assess the effectiveness of the program, and the technicians must be able to evaluate the technician outcomes.

EXERCISE - A method that the trainer uses which facilitates a hands-on experience for the technicians to practice new skills.

FEEDBACK - A skill derived from the ability to make effective use of responses received from technicians. Feedback is evaluative information given by the trainer to inform the technician of his or her performance and vice-versa.

FEEDBACK SKILLS - The trainer should learn how and when to communicate information, opinions, observations, and conclusions so that they can plan and coordinate logistics in an efficient and cost effective manner.

INTERVIEWING SKILLS - Ability to know how to ask questions and how to listen to technicians.

LEARNER CHARACTERISTICS - A successful trainer must understand differences in individual learning styles.

OBSERVATION SKILLS - The trainer should be able to track and describe technicians' behaviors and their changes.

OBSERVATIONAL SKILLS - Ability to watch for opportunities for technician improvement by recognizing their strengths and weaknesses.

OJT (ON-THE-JOB TRAINING) - Planned instruction that occurs at the worksite to teach new skills or to change/improve the performance of technicians.

PRESENTATION - A method in which the trainer orally presents new information to the technicians using the presentation method.

PRESENTATION SKILLS - The trainer must verbally and visually present information so that the intended outcomes are achieved.

QUESTIONING SKILLS - A trainer must be proficient at gathering information and stimulating insight from technicians through the use of interviews and questionnaires.

READING - A method the trainer uses with written material to present information to the technicians. Reading helps save time since most people can read faster than the trainer can speak.

TRAIN - To direct the growth by instruction, discipline, drill or to make the person prepared for a skill.

TRAINER - One who helps people gain new awareness, knowledge, skills, or abilities by means of instruction and practice to achieve a desired standard of performance.

TRAINER COMPETENCIES - Several competencies that an individual should possess in order to be considered an excellent trainer. Without these competencies, the trainer will have deficiencies that will cause him or her to be less effective. (See also: ADULT LEARNING PRINCIPLES, LEARNER CHARACTERISTICS, TRAINING METHODS, PRESENTATION SKILLS, TRAINING AIDS, QUESTIONING SKILLS, OBSERVATION SKILLS, FEEDBACK SKILLS, ASSESSMENT AND EVALUATION)

TRAINING AIDS - The trainer must be able to effectively incorporate flip charts, video tapes, handouts, overheads, video satellite and computer technology and other training aids into the training environment to more efficiently improve !earner comprehension and performance.

TRAINING AIDS - Visual or written materials that support various training methods.

TRAINING METHODS - Because individuals learn in a variety of ways, an effective trainer must apply a variety of training methods to meet the needs of learners.

MODULE REVIEW ITEMS

Note to Technician: Consider all choices carefully and select the best answer to each.

1. Through the means of instruction and practice, a trainer assists people in achieving a standard of performance by enhancing their levels of:
A. Competency, knowledge, and attitudes.
B. Skill, need, and ability.
C. Skills, knowledge, and abilities.
D. Schooling, know-how, and abilities.

2. To be an effective trainer, one must:
A. Successfully utilize presentation skills.
B. Understand training methods.
C. Perform observation skills.
D. All of the above.

3. There are several differences between children and adults as learners, including:
A. Children have an immediate need for the information but adults do not.
B. Children accept presented information but adults want to validate it.
C. Adults decide what is important while children rely on others to do so.
D. B and C only.

4. A trainer should modify training methods to accommodate the following five ways people acquire information in the learning process:
A. Listening, reading, discovering, imitating, and observing.
B. Speaking, listening, observing, learning, and writing.
C. Reading, writing, listening, speaking, and discovering.
D. Imitating, drawing, listening, reading, and observing.

5. A trainer can easily identify an individual's learning style by:
A. Conducting a written survey.
B. Observing the trainee while on the job.
C. Briefly interviewing the trainee.
D. All of the above.

6. Some of the most common training methods used for technical training include:
A. Presentation, case study, and reading.
B. Case study, demonstration, and discussion.
C. Exercise, reading, and presentation.
D. All of the above.

7. When a trainer asks participants to read material and then presents a situational problem that the technician must solve, which two types of training methods are combined?
A. Reading and performance.
B. Reading and case study.
C. Case study and discussion.
D. Retention and exercise.

8. In preparing for a presentation, a trainer should practice:
A. Controlling the environment.
B. Reducing anxiety.
C. The presentation.
D. All of the above.

9. Training aids are visual or written materials used in a presentation that have all of the following functions except:
A. Focusing the technician's attention to the objective being discussed.
B. Offering new information on the subject not featured in the session.
C. Improving information retention by engaging more than one sense.
D. Increasing interest in the training session.

10. All of the following are examples of training aids except:
A. Verbal explanations.
B. Flip charts.
C. Transparencies.
D. Handouts.

11. On the job training (OJT) is planned instruction whose goals are designed and based on the:
A. Job requirements, technician's ability, and organizational needs.
B. Learner's desires, technician's expectations, and job definitions.
C. Organizational requests, technician's abilities, and job requirements.
D. Technician's abilities, trainer's expectations, and employer's needs.

12. The process used to prepare for on the job training includes analysis of all of the following except:
A. The job and its tasks.
B. The technician.
C. The OJT model.
D. The organization.

13. Which of the following is not a common procedure to perform while conducting OJT?
A. Prepare the technician.
B. Determine the job description.
C. Provide feedback.
D. Demonstrate tasks.

14. A coach who conducts the on-going process of training must possess certain skills to be effective, including:
A. Observational skills.
B. Interviewing skills.
C. Feedback skills.
D. All of the above.

15. An effective coaching environment should include all of the following characteristics except for:
A. Providing a distraction-free room.
B. Offering critical jugment.
C. Instilling trust, confidence, and respect.
D. Portraying a helper mentality.

MRI SCORING KEY

1. C
2. D
3. D
4. A
5. D
6. D
7. B
8. D
9. B
10. A
11. A
12. C
13. B
14. D
15. B

ACTIVITY 25-1: INSTRUCTION CRITIQUE

OBJECTIVE

To analyze and critique other instructors as they instruct their classes.

MATERIALS NEEDED

"College Classroom Vignettes" videotapes (Please note- These videotapes are no longer available. A new set of videos is being produced and will be available in 1998. Please contact the Searle Center for Teaching Excellence at Northwestern University, 627 Darthmouth Place, Evanston, Il 60208-4181, http://president.scfte.nwu.edu/, (847) 467-2338, for the replacement set. The series is to be abailable at cost.)

Program Evaluations (from Module 25 Activity 25-3)

METHOD

The videotape series "College Classroom Vignettes" features unstaged classroom incidents with professors and students. Viewers are stimulated to think about their own teaching skills and further explore teaching methods.

Watch Segment XI: Teaching Styles, and/or Vignette V: Lecturing- The First Few Minutes. Using the Program Evaluations, fill out an evaluation for each instructor. While watching the segments, compare your teaching style to theirs. Compare the students' reactions and interactions to your students.

QUESTIONS

Compare evaluations for each instructor.

What did you like about each instructor? What were their strong points?

What didn't you like about each instructor? What were their weak points?

Were there any unique instructional techniques the instructors used?

Did the instructors adequately facilitate learning with their particular styles?

Do you feel you could integrate any of the techniques to benefit your instruction?

COMMENTS

You may wish to obtain the whole collection of "College Classroom Vignettes" to review for your benefit. Ask your library or instructional media department if its acquisition is possible when it is made available.

ACTIVITY 25-2: INSTRUCTION PRACTICE

OBJECTIVE

To practice instruction and analyze performance in a controlled environment.

MATERIALS NEEDED

Videocamera and monitor

Classroom, lab, etc., where training is to be conducted

Training materials to be used for instruction

Program Evaluations (from Module 25 Activity 25-3)

LPG II Module of your choice, or other desired topic for instruction.

METHOD

In these exercises you will videotape your presentation and analyze and critique it.

Exercise I. In this short exercise you will videotape yourself teaching to the camera. Set up the videocamera where the trainees would normally sit. If available, place the live monitor near the camera facing you so you can see yourself. If desired, establish a start and stop time. Teach the module. Rewind the tape and using the Program Evaluation, evaluate your performance. You might save this recording for future reference.

Exercise II. In this longer exercise you will complete the videotaping and critique sessions as directed in the enclosed activity. This activity is for shorter presentations but still provides for good practice. You may choose small groups or individual taping.

QUESTIONS

Watching yourself, are you satisfied with your performance?

What did you like most about your performance?

What did you like least about your performance? How would you correct your performance?

Did you follow the practices presented in the Delivering the Presentation section of Module 25?

If you are not satisfied with your performance, practice it again and videotape it. Practice makes perfect.

COMMENTS

You may want to videotape your actual classroom or lab instruction for future reference. Ask your instructional media department for assistance, as your primary responsibility should be teaching and not troubleshooting the videotaping.

You may want to have your peers evaluate your performance and discuss their reactions.

You may want to videotape a lab activity where items are assembled or disassembled in a specific order. Having this tape for review or as a record of the correct procedure may eliminate actual lab time wasted on incorrect or forgotten procedures.

ACTIVITY 25-3: EVALUATION CRITIQUE

OBJECTIVE

To expose the trainer to program evaluation instruments and how they can be used to improve training.

METHOD

The following sample evaluation is used for trainees to evaluate this program. This form may be used as a template to evaluate your program.

Analyze the questions. Note what aspects of the presentation they evaluate. Are the questions relevant to your presentation? Do you feel your training is strong in certain areas? Do you feel your presentation could be improved in certain areas?

Give a sample presentation to an audience of your peers using a module or two. Have the audience fill out these forms and collect them. Review the results.

QUESTIONS

According to the returns:

Are there any areas in which your training excels in? ____

____

____

Are there any areas in which your training is deficient in? ____________________________________

____

____

How can you correct the deficiencies?____

____

____

COMMENTS

You may wish to review Module 25 and its references to improve your training and skills.

Make notes in the Key Points and Notes columns for future emphasis, elaboration, special attention, etc.

Use your reviews and proposed modifications to improve your next training session.

PROGRAM EVALUATION

SESSION DATE: __________

Directions: Please circle the appropriate response for items 1-13, and check the appropriate responses for Item 14. 5=Excellent 4=Very Good 3=Good 2=Fair 1=Poor

1. The instructor's preparation for this course appeared to be:	1	2	3	4	5
2. The instructor's knowledge of this course's content appeared to be:	1	2	3	4	5
3. The instructor's clarity and completeness in answering questions were:	1	2	3	4	5
4. The instructor's interaction with participants (encouraged and motivated participation) was:	1	2	3	4	5
5. In general, the instructor's presentations were:	1	2	3	4	5
6. The content, organization, relevance, and timeliness of this course were:	1	2	3	4	5
7. This course, as far as being interesting and attention-holding, was	1	2	3	4	5
8. The coverage, organization, clarity, and timeliness of the training manual and other materials used in this course were:	1	2	3	4	5
9. The contribution of the course materials to your understanding of this course's content was:	1	2	3	4	5
10. The number, quality and usefulness of the visuals (videos, overhead transparencies, slides, etc.) were:	1	2	3	4	5
11. Overall, the time allotted to the classroom presentations and discussions versus the "hands-on" experience (in the lab) was:	1	2	3	4	5
12. The contribution of this course in increasing my knowledge and competence in this areas was:	1	2	3	4	5
13. The overall quality of this course was:	1	2	3	4	5
14. If a tour of other facilities was conducted, how would you rate the tour/field trip with respect to:					
A. It being interesting	1	2	3	4	5
B. It being informative	1	2	3	4	5
C. It being relevant	1	2	3	4	5
D. Its position on the program/time slot in the course	1	2	3	4	5

15. How would you rate the length of each day's program during the course and the length of total course. (Circle or check one response for each item)

Day 1	___ too long	___ too short	___ about right
Day 2	___ too long	___ too short	___ about right
Day 3	___ too long	___ too short	___ about right
Day 4	___ too long	___ too short	___ about right
Total Course	___ too long	___ too short	___ about right

Answer the following questions by circling or checking the appropriate response and/or writing your comments in the space provided.

16. Are there any specific topics that were not covered in this course that you would have liked discussed? YES NO
If YES, what are these topics? ____

____

17. Did this course meet your expectations based on the information/materials you received before attending? YES NO
If NO, why not? ____

____

18. Would you be interested in other courses covering other facets of alternative fuels? YES NO

19. What was the SINGLE BEST ASPECT of your experience during this course? Please be specific.

____

____

____

20. What was the SINGLE WORST ASPECT of your experience during this course? Please be specific.

____

____

____

21. What would you recommend to improve the quality of this course before it is offered again? Please be specific.

____

____

____

22. We would appreciate any additional comments you might have about this course and/or your needs for future courses on alternative fuels.

____

____

____

23. Finally, would you be interested in purchasing 35mm slides of this course if they were made available at a reasonable cost, or obtaining a copy of the Microsoft Powerpoint 4.0 presentations?

Slides ______

Presentations (IBM) _____

Presentations (Macintosh) _____

1 **MODULE 25:**
Training the Trainer

2 **SKILL-BASED TRAINING**

Trainers:

- Must have thorough knowledge of subject matter
- Need to be aware of technicians' experience & education
- Must present info geared to technicians' comprehension level
- Must show techs how they can use new knowledge & skills
- Must show concern & interest for technicians' progress

3 **25-1 PLANNING MODEL FOR TRAINING**

4 **TRAINER COMPETENCIES**

- Adult learning principles
- Learner characteristics
- Training methods
- Presentation skills
- Training aids
- Questioning skills
- Observation skills
- Feedback skills
- Assessing and evaluating

5 **THE ADULT LEARNER**

- People often teach the way they were taught
- Differences between children and adult learners
- Trainers must be aware of differences

6 **25-2 CHILD AND ADULT LEARNER COMPARISONS**

7 **TRAINING PRINCIPLES**

- Apply info to real-world problems
- Note how skills & knowledge apply to workplace
- Relate learning to goals & objectives
- Connect new learning with experiences
- Allow discussion of other views, opinions
- Respect technicians' opinions & creativity
- Allow techs to be resources - let them teach each other

8 **LEARNING STYLES**

- Listening
- Observing
- Reading
- Imitating/Doing
- Discovering

9 **25-3 DISCOVERY-TYPE LEARNER**

10 **TRAINING METHODS**

- Used to provide technical training
- Help technicians learn specific skills
- Variety of methods
- Facilitate different learning styles

11 **25-4 LEARNER RETENTION**

12 **25-5 PREPARATION TIME**

13 **25-6 ABILITY TO OBSERVE LEARNING**

14 **PRESENTATION**

- Oral presentation of new information
- Easy to prepare and deliver
- Retention may be low
- Learning feedback questions
- Useful for larger audiences or time limitations

15 **DISCUSSION**

- Facilitated group discussion
- Keeps interest and involvement
- Technicians as resources
- Learning observable
- Controlled discussion
- Involve all participants

16 **READING**

- Written material for presentation
- Saves time
- May be boring if overused
- Learning feedback questions
- Reading rates of technicians

17 **CASE STUDY**

- Detailed situation or problem
- Technicians analyze and solve problem
- Active technician involvement
- Simulations
- Time problem

18 **DEMONSTRATION**

- Trainer shows correct steps to complete task
- Aids in understanding and retention
- Long prep time
- Relevant to objectives

19 **25-7 DEMOS PROVIDE CLOSE-UP INSPECTIONS**

20 **LAB ACTIVITY**

- Hands-on to practice new skills
- Learning observable
- Controlled environment
- Prep time and lab time constraints

21 **PRESENTATION SKILLS**
PLANNING

- State objectives
- Simply stated
- Address needs
- Know values, needs, constraints of audience
- Use planning worksheet

22 **25-8 PLANNING WORKSHEET**

23 **DEVELOPING**

- Brainstorm 2-5 main ideas to
- Support with sub-points
- Write body of presentation
- Prepare introduction
- Develop conclusion
  - Summarize main points from introduction

24 **PREPARING**

- Make notes with keywords
- Mentally review the presentation
- Repeat until well-versed
- Stand-up rehearsals
- Videotape presentation for critique

25 **25-9 PRACTICING THE PRESENTATION**

26 **PRESENTATION AIDS**

- Projectors
- Flip Charts
- Handouts
- Lighting
- Seating Arrangements
- Environment

27 **25-10 CURVED SEATING ARRANGEMENT**

28 **25-11 CIRCULAR SEATING ARRANGEMENT**

29 **25-12 U-SHAPED SEATING ARRANGEMENT**

30 **25-13 TRADITIONAL SEATING ARRANGEMENT**

31 **DELIVERING THE PRESENTATION**

- Posture
- Movement
- Gestures
- Eye Contact
- Controlling the Voice

32 **QUESTION AND ANSWER TECHNIQUES**

- Open-Ended Question
- Closed-Ended Question
- Reflective Question

33 **TRAINING AIDS**

- Flip Charts
- Videotapes and Films
- Handouts
- Transparencies and Overhead Presentations

34 **25-14 POINTERS FOR EFFECTIVE HANDOUTS**

35 **25-15 CREATING EFFECTIVE TRANSPARENCIES**

36 **ON-THE-JOB TRAINING**

- Planned instruction at worksite
- Have technicians perform at desired standards and expectations
- For frequently changing techniques and requirements
- Reduce break-in times

37 **STEPS TO PREPARE FOR OJT**

1. Task Analysis
   - Task description
   - List steps
   - Describe task for each step
2. Technician Analysis
   - Technicians' knowledge, skills, attitudes
3. Organization
   - Training consistent with organizational goals

38 **25-16 CHECKLIST**

39 **25-17 CHECKLIST**

40 **MODEL FOR CONDUCTING OTJ TRAINING**

1. Plan According to Adult Learning Principles
2. Establish Method of Measuring Adult Technician Progress
3. Prepare the Technician
4. Explain Tasks to Technicians
5. Demonstration
6. Allow Technician to Model the Task
7. Provide Feedback
8. Testing

41 **25-18 OTJ MODEL**

42 **25-19 INSTRUCTOR DEMONSTRATION**

43 **COACHING**

- Training through positive reinforcement
- Technicians must want to do a better job and obtain means to do so
- Proper environment needed
  - Reduce stress, pressure
  - Increase trust, confidence, respect
- Mentor vs. boss role

44 **SKILLS OF A GOOD COACH**

- Observational skills
- Analytical skills
- Interviewing skills
- Feedback

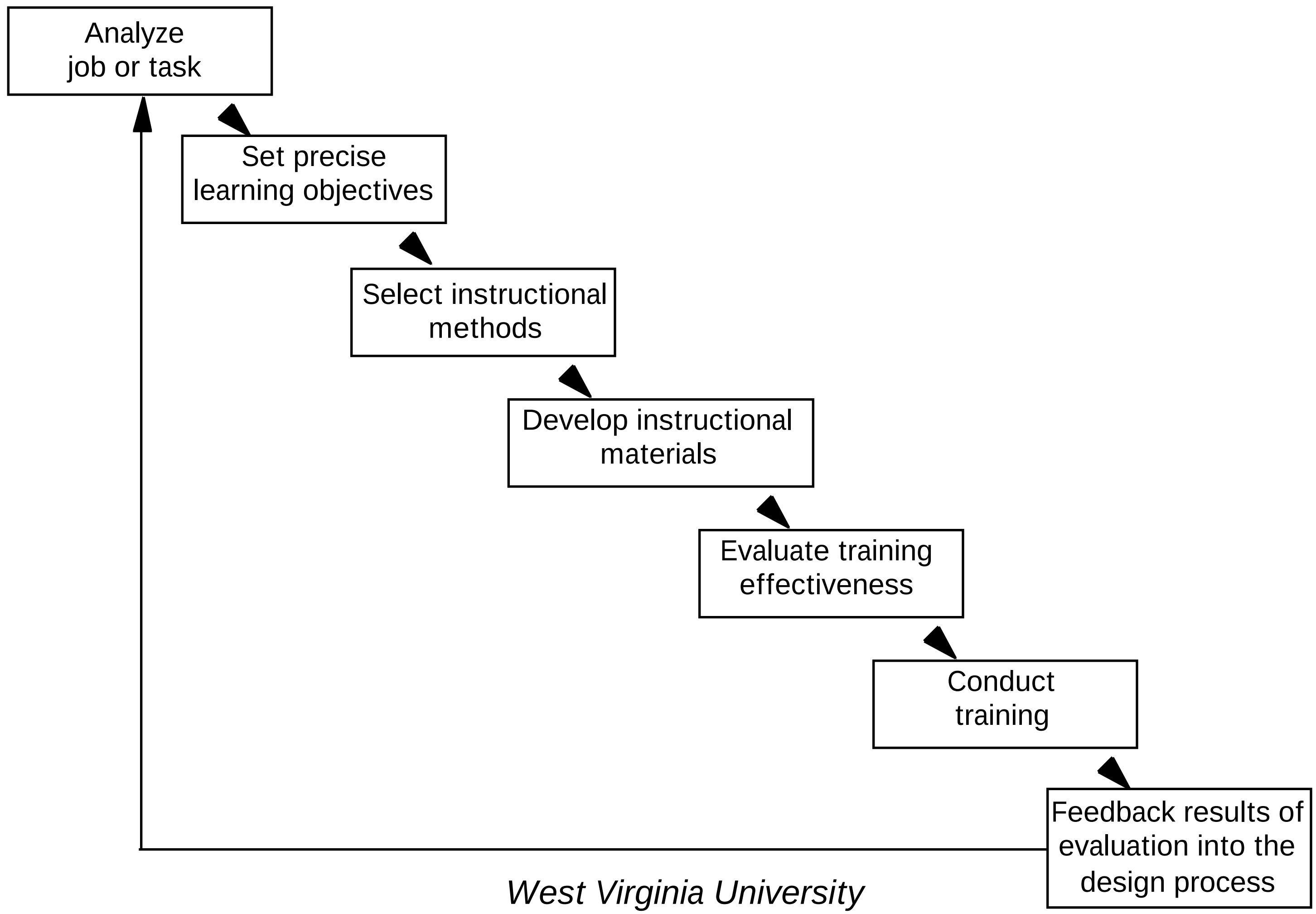
MODULE 25:
Training the Trainer

SKILL-BASED TRAINING

Trainers:

- Must have thorough knowledge of subject matter
- Need to be aware of technicians' experience & education
- Must present info geared to technicians' comprehension level
- Must show techs how they can use new knowledge & skills
- Must show concern & interest for technicians' progress

25-1 PLANNING MODEL FOR TRAINING



West Virginia University

TRAINER COMPETENCIES

- Adult learning principles
- Learner characteristics
- Training methods
- Presentation skills
- Training aids
- Questioning skills
- Observation skills
- Feedback skills
- Assessing and evaluating

THE ADULT LEARNER

- People often teach the way they were taught
- Differences between children and adult learners
- Trainers must be aware of differences

25-2 CHILD AND ADULT LEARNER COMPARISONS

CHILD LEARNERS	ADULT LEARNERS
Children rely on others to decide what is important.	Adults decide for themselves about the importance of learning.
Children accept presented information as fact.	Adults validate new information with their own values and experiences.
Children perceive little immediate need for the information being presented.	Adults have an immediate need for the information presented.
Children seldom have life experience in which to relate to new learning.	Adults have a greater range of experiences and are often more critical.
Children rarely contribute to the learning processs.	Adults have experiences that enable them to be resources to the trainer.

West Virginia University

TRAINING PRINCIPLES

- Apply info to real-world problems
- Note how skills & knowledge apply to workplace
- Relate learning to goals & objectives
- Connect new learning with experiences
- Allow discussion of other views, opinions
- Respect technicians' opinions & creativity
- Allow techs to be resources - let them teach each other

LEARNING STYLES

- Listening
- Observing
- Reading
- Imitating/Doing
- Discovering

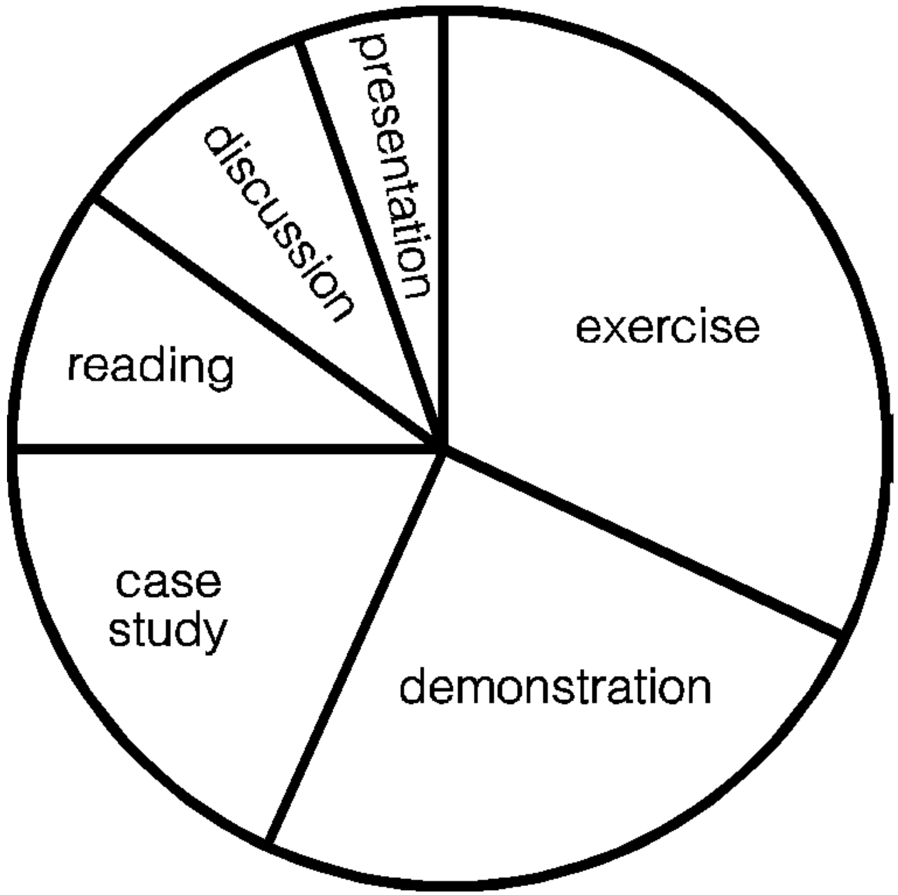
25-3 DISCOVERY-TYPE LEARNER

West Virginia University

TRAINING METHODS

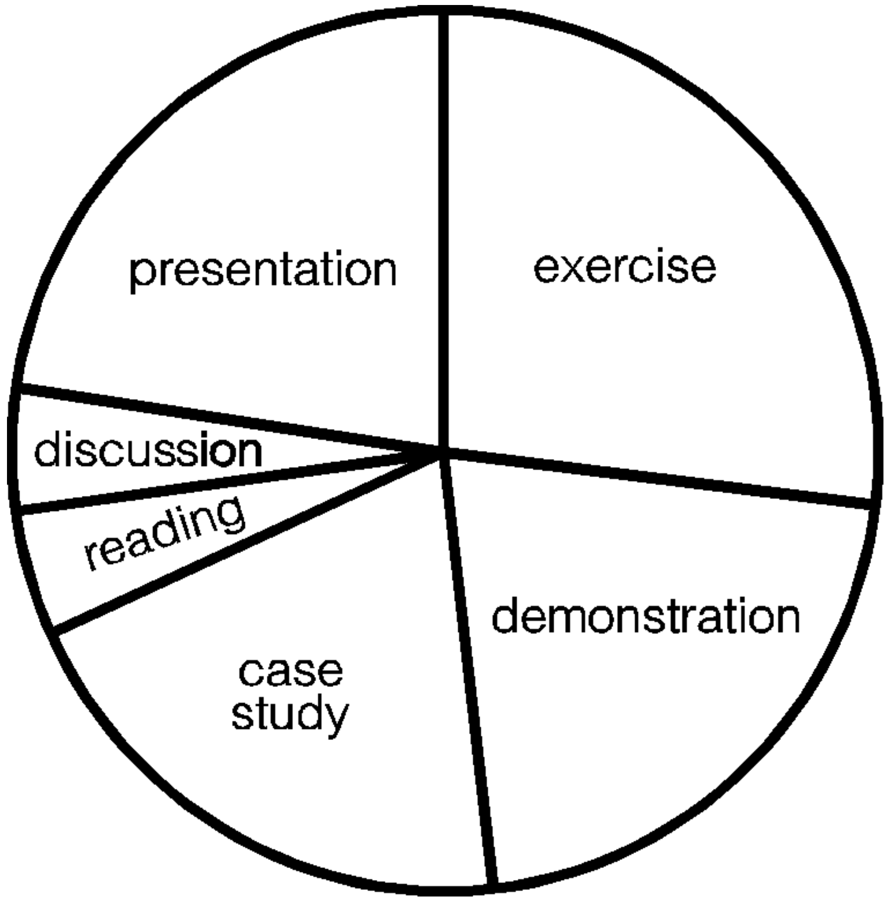
- Used to provide technical training
- Help technicians learn specific skills
- Variety of methods
- Facilitate different learning styles

25-4 LEARNER RETENTION



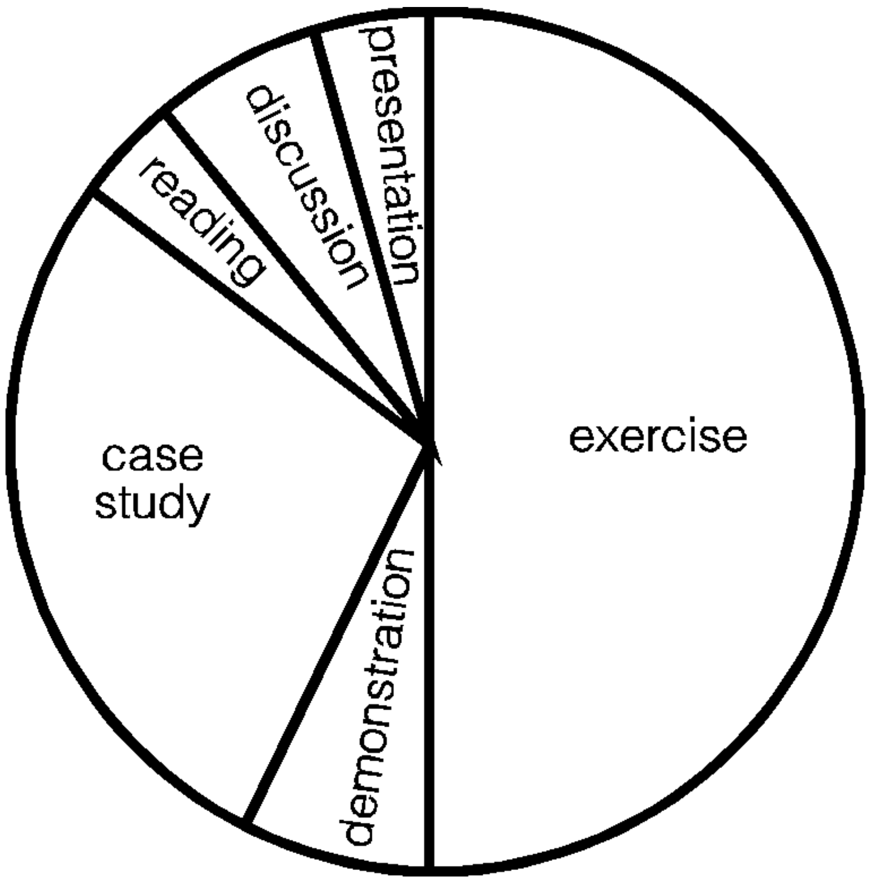
West Virginia University

25-5 PREPARATION TIME



West Virginia University

25-6 ABILITY TO OBSERVE LEARNING



West Virginia University

PRESENTATION

- Oral presentation of new information
- Easy to prepare and deliver
- Retention may be low
- Learning feedback questions
- Useful for larger audiences or time limitations

DISCUSSION

- Facilitated group discussion
- Keeps interest and involvement
- Technicians as resources
- Learning observable
- Controlled discussion
- Involve all participants

READING

- Written material for presentation
- Saves time
- May be boring if overused
- Learning feedback questions
- Reading rates of technicians

CASE STUDY

- Detailed situation or problem
- Technicians analyze and solve problem
- Active technician involvement
- Simulations
- Time problem

DEMONSTRATION

- Trainer shows correct steps to complete task
- Aids in understanding and retention
- Long prep time
- Relevant to objectives

25-7 DEMOS PROVIDE CLOSE-UP INSPECTIONS

West Virginia University

LAB ACTIVITY

- Hands-on to practice new skills
- Learning observable
- Controlled environment
- Prep time and lab time constraints

PRESENTATION SKILLS
PLANNING

- State objectives
- Simply stated
- Address needs
- Know values, needs, constraints of audience
- Use planning worksheet

25-8 PLANNING WORKSHEET

WORKSHEET: PLANNING THE PRESENTATION

Completing this worksheet will
help you plan efficiently for any presentation.

1. The objectives in relation to the audience include:
____
____
____
____

2. Values or opinions that should be considered with this audience are:
____
____
____

3. Special needs of the audience include:
____
____
____

4. Special constraints that must be recognized when speaking to the audience are:
____
____
____

5. The audience's knowledge of the topic and technical terminology is:
High________ Low________ Mixed_______

6. Expectations of the audience to accept the ideas presented are:
High________ Low________ Mixed_______

7. Examples of supporting ideas and arguments to reinforce the presentation include:
____
____
____
____

8. Expected audience size _________ 9. Length of presentation ________

West Virginia University

DEVELOPING

- Brainstorm 2-5 main ideas to
- Support with sub-points
- Write body of presentation
- Prepare introduction
- Develop conclusion
  - Summarize main points from introduction

PREPARING

- Make notes with keywords
- Mentally review the presentation
- Repeat until well-versed
- Stand-up rehearsals
- Videotape presentation for critique

25-9 PRACTICING THE PRESENTATION

West Virginia University

PRESENTATION AIDS

- Projectors
- Flip Charts
- Handouts
- Lighting
- Seating Arrangements
- Environment

25-10 CURVED SEATING ARRANGEMENT

West Virginia University

25-11 CIRCULAR SEATING ARRANGEMENT

West Virginia University

25-12 U-SHAPED SEATING ARRANGEMENT

West Virginia University

25-13 TRADITIONAL SEATING ARRANGEMENT

West Virginia University

DELIVERING THE PRESENTATION

- Posture
- Movement
- Gestures
- Eye Contact
- Controlling the Voice

QUESTION AND ANSWER TECHNIQUES

- Open-Ended Question
- Closed-Ended Question
- Reflective Question

TRAINING AIDS

- Flip Charts
- Videotapes and Films
- Handouts
- Transparencies and Overhead Presentations

25-14 POINTERS FOR EFFECTIVE HANDOUTS

CREATING EFFECTIVE HANDOUTS:

- Handouts should be titled and dated
- The purpose should be identified
- Directions should be included
- Emphasize key points by using **bold print**, underlined text, or CAPITALIZATION
- Format so that it can be easily read
- Use short sentences
- Avoid unnecessary information

West Virginia University

25-15 CREATING EFFECTIVE TRANSPARENCIES

GUIDELINES TO IMPROVE TRANSPARENCY EFFECTIVENESS

Transparency Guidelines

- Minimize verbiage
- Keep information to six lines or less
- Use only three sub-points for each major idea per transparency
- Use tinted plastic to reduce the glare
- Use color, graphics and shapes to emphasize key points

Transparency Guidelines

- Use a computer to ensure neatness
- Turn off projector when not in use
- Use a pointer to focus on specific points
- Mount transparencies in protective frames
- Write memory-joggers on the frames of the transparencies

West Virginia University

ON-THE-JOB TRAINING

- Planned instruction at worksite
- Have technicians perform at desired standards and expectations
- For frequently changing techniques and requirements
- Reduce break-in times

STEPS TO PREPARE FOR OJT

1. Task Analysis
   – Task description
   – List steps
   – Describe task for each step
2. Technician Analysis
   – Technicians' knowledge, skills, attitudes
3. Organization
   – Training consistent with organizational goals

25-16 CHECKLIST

EXAMPLE OF TRAINEE STEPS

<u>Step 1</u>: Verify fit for tank assembly location

- Verify space for guards
- Verify space for mounting bolts
- Verify venting requirements
- Verify fit and accessibility of the tank valve
- Verify fuel line location
- Verify clearance for mounting brackets
- Verify location for ease of service

<u>Step 2</u>: Mount the bottom support bracket

- Drill holes for the bracket
- Glue rubber strip onto the bracket
- Mount the bracket to the vehicle

<u>Step 3</u>: Install the tank in the bracket

- Install the tank valve onto the tank
- Place the tank on the bottom bracket
- Rotate the tank so that the serial number and test date stamp are visible

<u>Step 4</u>: Secure the top bracket

- Glue rubber strip onto the bracket
- Mount the bracket securely to the bottom bracket

<u>Step 5</u>: Label the tank

- Label the tank with the words **LPG ONLY** using contrasting colors for letters at least one inch (25 mm) high

25-17 CHECKLIST

EXAMPLES OF UNWANTED CONSEQUENCES

Step 1: Verify fit for tank assembly location

- Avoid drilling bracket holes into exhaust pipes or other important components that may be on the underside of the mounting surface
- Avoid placing the tank on a surface that may be weak from rust (a reinforcement plate may be necessary)
- A tank valve should be installed to vent the tank outside the vehicle
- Avoid installing the tank where the fuel line could be kinked, compressed, sheared, or obstructed

Step 2: Mount the bottom support bracket

- Avoid mounting the bracket on a weak surface; a reinforcement plate may be necessary

Step 3: Install the tank in the bracket

- Care must be taken to assure that important information on the tank will be visible after installation: the serial # and certification date, for example

Step 4: Secure the top bracket

- If the top bracket is not secured tightly enough, the tank may slip during an accident and cause the fuel line to stretch, compress, twist, kink, or break

Step 5: Label the tank

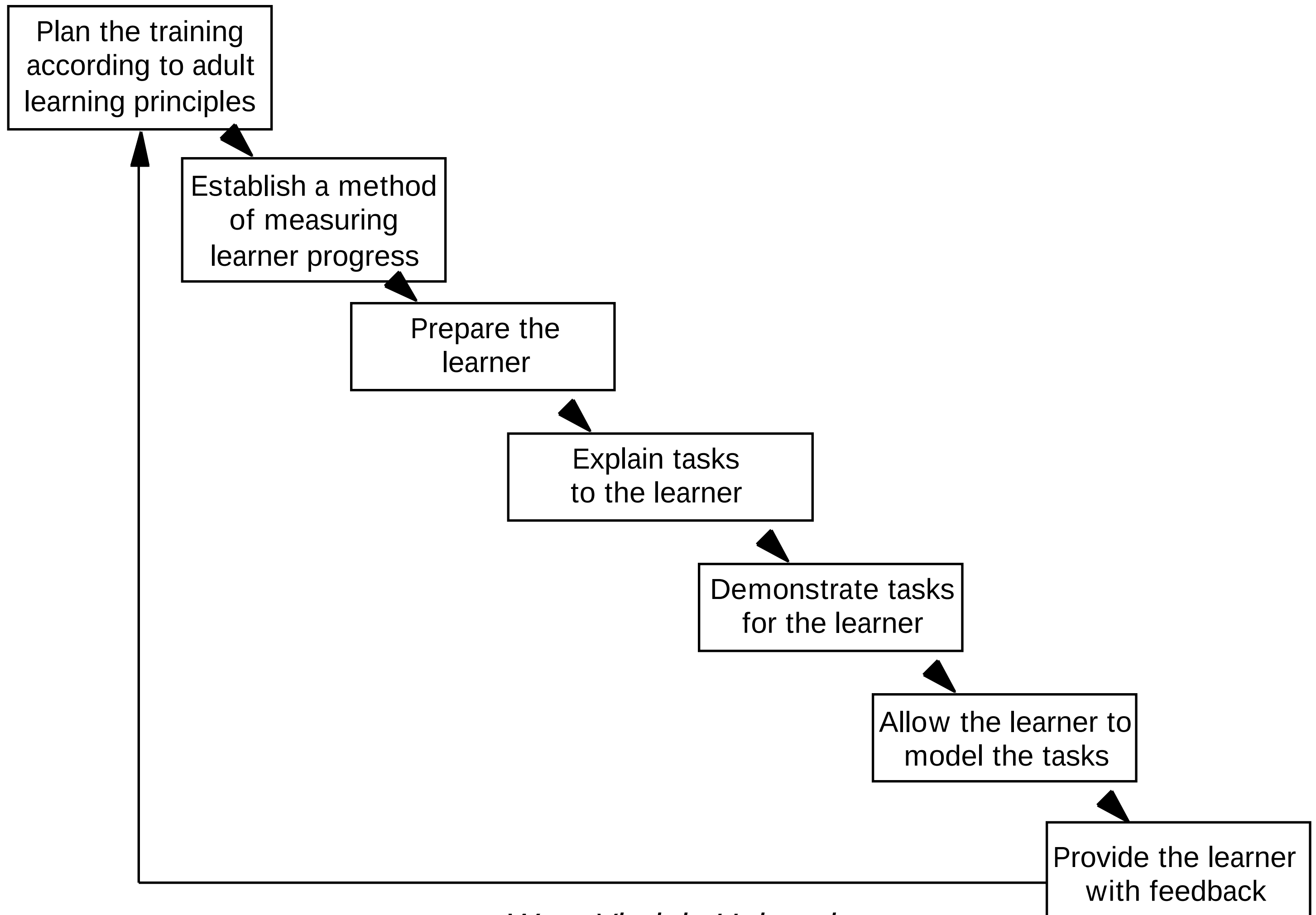
- Failure to label the tank could place an automotive technician or a layperson who is unfamiliar with liquid petroleum gas vehicles in a dangerous position when performing maintenance

West Virginia University

MODEL FOR CONDUCTING OTJ TRAINING

1. Plan According to Adult Learning Principles
2. Establish Method of Measuring Adult Technician Progress
3. Prepare the Technician
4. Explain Tasks to Technicians
5. Demonstration
6. Allow Technician to Model the Task
7. Provide Feedback
8. Testing

25-18 OTJ MODEL



West Virginia University

25-19 INSTRUCTOR DEMONSTRATION

West Virginia University

COACHING

- Training through positive reinforcement
- Technicians must want to do a better job and obtain means to do so
- Proper environment needed
  - Reduce stress, pressure
  - Increase trust, confidence, respect
- Mentor vs. boss role

SKILLS OF A GOOD COACH

- Observational skills
- Analytical skills
- Interviewing skills
- Feedback

GLOSSARY

State of Oklahoma
College of the Desert
West Virginia University

GLOSSARY

DEFINITION OF TERMS

This dictionary of words and phrases provides a reference for the student involved in the Alternative Fuel Systems curriculum. These are not intended to be all-inclusive but to cover what specifically applies in the installation, repair and maintenance of Propane (Liquefied Petroleum Gas – LPG) conversion systems.

A/F – Air-Fuel Ratio.

ABDC – After bottom dead center; any position of the piston between bottom dead center and top dead center, on the upward stroke.

ABNORMAL COMBUSTION – Combustion in which knock, preignition, run-on or surface ignition occurs; combustion which does not proceed in the normal way (where the flame front is initiated by the spark and proceeds throughout the combustion chamber smoothly and without detonation).

ABSOLUTE PRESSURE (PSIA) – Pressure shown on pressure gauge (psig) plus atmospheric pressure (psi). At sea level atmospheric pressure is 14.7 psi. Use absolute pressure in manifold absolute pressure (MAP) calculations.

ABSOLUTE TEMPERATURE – By definition, 0^{o} F plus 460^{o} F equals degrees Rankine (^{o}R). In metric units, ^{o}C plus 273^{o} C equals degrees Kelvin (^{o}K). Use absolute temperature in compressor calculations.

AC – Alternating current

ADAPTIVE SYSTEMS – Computer software systems that are said to be heuristic, or that "learn" to adjust program parameters to account for systematic variance in multisensor I/O systems operating over a wide variety of conditions (such as temperature, altitude, fuel composition, or age of components). The programming is said to be flexible and "learns" to adapt to changing conditions. All EFI systems use adaptive programming techniques to ensure precision and are generally referred to as "Block Learn," which is a General Motors term.

ADP – Advanced Digital Processor.

ADVANCE – When used in relation to the timing of a spark for initiating combustion, it is the number of degrees of crankshaft rotation that the spark fires earlier than a fixed or optimum setting.

ADVANCE DIGITAL PROCESSOR (ADP) – Electronic control for engine timing.

AFTER BOTTOM DEAD CENTER (ABDC) – Any position of the piston between bottom dead center and top dead center on the upward stroke.

AFTER TOP DEAD CENTER (ATDC) – Any position of the piston between top dead center and bottom dead center on the downward stroke.

AFV – Alternately Fueled Vehicle.

AIR – Air Injection Reactor System (also known as a smog pump).

AIR-FUEL MIXTURE – The amount of air and fuel that is blended for each power stroke of an engine.

AIR-FUEL RATIO – The proportions, by weight, of air and fuel supplied for combustion.

AIR-INJECTION SYSTEM – An exhaust-emission control system that injects air at low pressure into the exhaust manifold to help complete the combustion of unburned hydrocarbons and carbon monoxide in the exhaust gas.

AIR POLLUTION – Any contamination of the air that is harmful to animals, plant life and people.

GLOSSARY

AIR TOXINS – Compounds, such as benzene, formaldehyde, and 1,3 butadiene, for which no specific emissions regulations have been established, but which are suspected of causing cancer and have other toxic effects.

AIR VALVE – The mechanism in a mixer through which all intake air is introduced into an engine. The air valve contains air passages that communicate between the venturi and atmospheric air to create the slight pressure differential that causes the air valve to open and the fuel valve to lift as a result of venturi vacuum acting on the mixer diaphragm.

ALCOHOLS – A group of colorless organic compounds, each of which contains a hydroxyl (OH) group. The simplest alcohol is methanol CH_3OH.

ALCL – Assembly Line Communications Link (see Assembly Line Diagnostic Link).

ALDEHYDES – Partly oxidized hydrocarbons containing a terminal carbonyl group [HC (hydrocarbon residue) – C| | – H]. Products of partial combustion found in engine exhaust. These are strong irritants and suspected carcinogens.

ALDL – Assembly Line Diagnostic Link (diagnostic connector J1930).

ALGORITHM – A process or procedure used to solve a problem. Generally synonymous with “programs” in a computer system.

ALTERNATIVE FUEL – Fuels, such as propane, CNG, methane, ethane, hydrogen used instead of gasoline or diesel fuel in internal combustion engines.

AMBIENT TEMPERATURE – The temperature of air in its natural state in a given location. Normally refers to the temperature of the air surrounding the engine.

AMFA – Alternative Motor Fuels Act

A.N.S.I. – American National Standards Institute.

ANALOG SIGNAL – An electrical signal that varies in voltage within a given parameter.

ANTIFREEZE – A water soluble liquid usually composed of ethylene glycol or propylene glycol, designed to raise the boiling point and lower the freezing point of vehicle coolant. Antifreeze should account for 30% to 50% of the total coolant in the vehicle.

APPLIANCE – Any apparatus or fixture that uses or consumes liquefied petroleum gas (LP-gas or LPG) furnished or supplied by an LP-gas system to which it is connected or attached.

APPROVED – Acceptable to the authority having jurisdiction.

APERTURE – A hole or flange in a given surface, having a designated purpose.

A.S.M.E. – American Society of Mechanical Engineers.

ASME CODE – The American Society of Mechanical Engineers’ Boiler and Pressure Vessel Code.

ASME CONTAINER – Any container or tank manufactured to the specifications of the American Society of Mechanical Engineers Pressure Vessel Code.

ASSEMBLY LINE DIAGNOSTIC LINK (ALDL) – A device used at assembly to evaluate computer command control and for service to flash the “Service Engine Soon” light if there are trouble codes. Also used by “Scan” tools to obtain ECM serial data. Also referred to as a diagnostic connector.

ATDC – After top dead center; any position of the piston between top dead center and bottom dead center, on the downward stroke.

ATMOSPHERIC PRESSURE – The atmospheric pressure at sea level is calculated to be 29.92 inches of mercury column or 14.7 pounds per square inch at 59^o F. Any change in altitude, temperature or movement of atmospheric air masses will change this figure, as measured on a barometer, which usually registers in inches of mercury column.

ATMOSPHERIC SMOG – See Smog.

GLOSSARY

AUTHORITY HAVING JURISDICTION – The organization, office, or individual responsible for approving equipment, and installation, or procedure.

AUTOGAS – Liquefied petroleum gas motor fuel.

AUTOIGNITION – Also known as knock, detonation or preignition, it occurs after normal spark ignition when unburned gases ahead of the flame front (end gases) spontaneously ignite and cause a sudden rise in pressure accompanied by a characteristic pinging or pinking sound. Or before normal combustion, autoignition occurs when the fuel-air mixture ignites spontaneously caused by temperature or pressure. Both conditions of autoignition cause a loss of power and can lead to engine damage. See Detonation, Knock, Preignition, and Surface Ignition.

AUTOMATIC STOP FILL VALVE – A fill valve that automatically sets the fuel lines to 80% of water capacity of tank.

AUTOMOTIVE AIR POLLUTION – Evaporated and unburned fuel and other undesirable by-products of combustion which escape from a vehicle into the atmosphere; mainly carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NO_x), sulfur oxides (SO_x) and particulates.

BACKFIRE – The accidental explosion of an overly rich mixture in the exhaust manifold of a spark-ignition engine.

BACKFIRE-SUPPRESSOR VALVE – An antibackfire valve used in the air-injection system of exhaust emission control.

BACK PRESSURE – The level of pressure in the exhaust system, downstream of the exhaust valves, and usually referring to the pressure between the manifold and the catalytic converter.

BACKPRESSURE TRANSDUCER – A device that senses engine load by monitoring the back-pressure in the exhaust. This transducer is commonly used to control the EGR opening.

BANK FIRE – A strategy used to operate fuel injectors in which half of the injectors (e.g., 3 of 6 or 4 of 8) are grounded (operated) by the PCM to supply fuel to that group of cylinders. The opposite group of injectors are fired likewise. This system is managed by a speed density air flow design (MAP/Baro sensor).

BAR – Bureau of Automotive Repair, Department of Consumer Affairs, State of California.

BAROMETRIC ABSOLUTE PRESSURE – The pressure of the atmosphere measured from absolute or total vacuum. Barometric absolute pressure at sea level is 14.7 psia.

BAROMETRIC PRESSURE – Another term for atmospheric pressure typically expressed in inches of mercury (in.Hg).

BAROMETRIC PRESSURE SENSOR (BPS) – Used in some automotive ECS to improve airflow calculations by adding air density information to the algorithm in order to correct for differences in altitude or barometric pressure.

BASIC GAS LAWS – The relationships between pressure, temperature and volume of gas.

BDC – Bottom dead center is the piston position when the piston has reached the lower limit of its travel in the cylinder and the centerline of the connecting rod is parallel to the cylinder walls.

BEFORE TOP DEAD CENTER (BTDC) – Any position between bottom dead center and top dead center, on the upward stroke.

BENZENE – The simplest aromatic hydrocarbon, consisting of a single aromatic ring. A common constituent of gasoline and gasoline engine exhaust. It is a known carcinogen and is considered a toxic air contaminant.

BHP – See Brake Horsepower.

GLOSSARY

BI-FUEL VEHICLES – A system that can operate on two fuels, one at a time and not simultaneously, such as gasoline or LPG (or CNG).

BLENDING NUMBER – A value assigned to a compound or component that will enable it to be blended linearly with other fuel components so that the value of a finished blend can be predicted; can refer to a number of different properties such as octane, vapor pressure.

BLOCK LEARN – ECM memory that adjusts the air/fuel ratio on a semi-permanent basis.

BMEP – Brake Mean Effective Pressure.

BOILING POINT – The temperature at which a fuel changes from a liquid to a vapor state.

BOROSCOPE – Apparatus that enables detailed visual inspection of internal cylinder and tube surfaces, and allows for close-up inspection of affected areas.

BOTTOM DEAD CENTER (BDC) – The position of the piston when it is at the furthermost point down in the cylinder.

BOYLE S LAW – States that if temperature remains constant, the volume occupied by a given weight of a given amount of gas varies with its absolute pressure. As the volume of a gas is reduced, its pressure increases if the temperature remains constant.

BPS – Barometric Pressure Sensor.

BPT – Backpressure Transducer.

BRAKE HORSEPOWER (BHP) – The horsepower output of an engine. The term brake horsepower is derived from the use of a brake or dynamometer to measure the engine's power output.

BRAKE MEAN EFFECTIVE PRESSURE (BMEP) – The average pressure in the cylinder during the power stroke. A comparative measurement of how hard the engine is working.

BREAK-A WAY ADAPTER – An emergency device that breaks away and retains liquid propane on both sides of the break-away point. When installed on a tank relief valve, the threaded break-away adapter shall not interfere with the operation of the relief valve.

BTDC – Before top dead center; any position between bottom dead center and top dead center, on the upward stroke.

BRITISH THERMAL UNIT (BTU) – The quantity of heat required to raise the temperature of one pound of water 1^{o}F.

BTU – British Thermal Unit. See above.

BULKHEAD – An upright partition separating compartments, such as an engine firewall.

BULKHEAD FITTING – A fitting designed to support and connect tube or hose routed through a frame member or body sheet metal such as a bulkhead.

BULK PLANT – An installation for storing propane in large quantities before its delivery to the customer, essentially a warehouse for propane.

BULK STORAGE – Storage in pressure vessels other than cylinders.

BUTANE – One of the liquefied petroleum gases; it is liquid below 32^{o} F [0^{o} C] at atmospheric pressure.

BUTADIENE (1,3) – A four carbon hydrocarbon containing two double bonds (H_2C+CH-CH+CH_2). A highly reactive carcinogen found in automobile exhaust. It is considered a toxic air contaminant.

BUTTERFL Y – A type of valve used for the choke and throttle valve in a carburetor; a movable flat plate that governs the flow of air into the carburetor.

BUTYL RUBBER – A synthetic rubber used as an alternative to natural rubber in tires and molded items – very resistant to heat and weather.

GLOSSARY

BYPASS – A separate passage which permits a liquid, gas, or electric current to take a path other than that normally used.

CAA – Clean Air Act.

CALIBRATE – To measure, check or correct the initial setting of a test instrument.

CALIFORNIA AIR RESOURCES BOARD (CARB) – The California Air Resources Board certifies alternative fuel systems for adequate emissions performance. Any alternative fuel system conversions should employ only components approved by CARB, otherwise the EPA can require that the vehicle be returned to its original configuration.

CALPAK – A device used with fuel injection to allow fuel delivery in the event of a PROM or ECM malfunction.

CAM – A rotating lobe or eccentric that can be used with a cam follower to change rotary motion to reciprocating motion.

CAMSHAFT – The shaft in the engine which has a series of cams for operating the valve mechanisms. It is driven by gears, or sprockets and toothed belt or chain, from the crankshaft.

CANISTER – A cylindrical container, in an evaporative control system, that contains charcoal to trap vapors from the fuel system.

CAPACITY – The gross capacity of a container in standard cu. ft. (scf) or water capacity (wc).

CARB – California Air Resources Board.

CARBON (C) – A black deposit left on engine parts such as pistons, rings, and valves by the combustion of fuel.

CARBON DIOXIDE ($C0_2$) – A colorless, odorless gas that results from complete combustion; usually considered harmless.

CARBON MONOXIDE (CO) – A pollutant from engine exhaust that is a colorless, odorless, tasteless, poisonous gas that results from incomplete combustion.

CARBURETION – The actions that take place in the carburetor, converting liquid fuel to vapor and mixing it with air to form a combustible mixture.

CARBURETOR – The device in an engine fuel system that mixes fuel with air and supplies the combustible mixture to the intake manifold.

CARBURETOR HEATED AIR – A system in which heated air, radiated from the exhaust manifold, is routed to the carburetor for more complete combustion and better engine performance with a leaner air/fuel mixture.

CARBURETOR INSULATOR – A spacer, or insulator, used to prevent excess engine heat from reaching the carburetor.

CARBURETOR KICKDOWN – Moderate depressing of the accelerator pedal to change the engagement of the choke-fast-idle-speed screw from the high step to a lower step of the cam.

CARCINOGEN or CARCINOGENIC – A substance or agent that produces or incites cancer.

CAT – A slang term used to refer to a catalytic converter.

CATALYST – A substance that can speed or slow a chemical reaction between substances, without itself being consumed by the reaction. In the catalytic converter, platinum and palladium are usually the active catalysts.

CATALYTIC CONVERTER – A device in the exhaust system containing a catalyst that assists in the conversion of undesirable compounds in the exhaust gas into harmless gases and water.

CATALYTIC CRACKING – A refinery process in which heavy hydrocarbon streams are broken down into lighter streams by the use of a catalyst and high temperatures.

GLOSSARY

CATALYTIC DESULFURIZATION – A refinery process in which sulfur is removed from a hydrocarbon stream by combining it with hydrogen in the presence of a catalyst and then stripping out the hydrogen sulfide thus formed.

CATALYTIC REFORMING – A refinery process which converts low-octane quality naphtha to a high-octane blendstock in the presence of a catalyst.

CC – Cubic centimeter, a unit of volume in the metric system.

CENTRIFUGAL ADVANCE – A rotating-weight mechanism in the distributor; advances and retards ignition timing through the centrifugal force resulting from changes in the engine distributor rotation speed.

CERTIFIED – Authorized by an employer or state regulatory agency (where required) to perform LP-gas related work. Employee certification alone does not allow an individual to perform those activities which require licensing.

CETANE NUMBER – An indicator of the ignition quality of diesel fuel. A high-cetane fuel ignites more easily (at lower temperature) than a low-cetane fuel.

CF – Cubic foot of gas; a standard cubic foot is measured at 14.7 psia and 60^{o} F (101 kPa and 15.1^{o} C).

CFM (CUBIC FEET PER MINUTE) – the volume of air in one minute a carburetor can flow at maximum RPM. As revolutions per minute increase, the consumption of air in cubic feet (volume) increases.

CHARCOAL CANISTER – A container filled with activated charcoal, used to trap gasoline vapor from the fuel tank and carburetor while the engine is off.

CHARLES LAW – If pressure remains constant, the volume of a given amount of a gas increases proportionately with any increase in absolute temperature.

CHECK – To verify that a component, system, or measurement complies with specifications.

CHECK ENGINE LIGHT (MIL) – An emissions trouble light. Beginning with the 1990 model year, all new cars are required to be equipped with a “Malfunction Indicator Light” (MIL) that comes on when the computer detects a failure in the emission control system.

CHECK VALVE – A valve that opens to permit the passage of gas or liquid in only one direction, or operates to prevent (check) some undesirable action.

CHEMICAL REACTION – The formation of one or more new substances when two or more substances are brought together.

CHOKE – A device used when starting a cold engine; it chokes off the airflow through the air horn producing a partial vacuum in the air horn for greater fuel delivery, better fuel vaporization, and a richer mixture.

CI – Compression Ignition.

CID – Cubic-inch displacement.

CLEAN AIR ACT (CAA) – Legislation enacted to regulate emissions and air pollution.

CLIMATE CHAMBER – A room or chamber, usually containing a chassis dynamometer, in which various climatic conditions can be reproduced. Temperature control is most commonly used but humidity, air pressure, sunshine, and rain can also be reproduced in a repeatable manner.

CLOSED CRANKCASE VENTILATION SYSTEM – A system in which the crankcase vapors (blow-by gases) are discharged into the engine intake system and pass into the engine cylinders where they burn rather than being discharged into the air as vehicle exhaust.

CLOSED-LOOP CONTROL – A method of controlling the air-fuel mixture in an engine that uses an O_2 sensor and other sensors to provide data to an on-board computer to control air-fuel mixtures.

GLOSSARY

CM – centimeter; a unit of linear measure in the metric system: l centimeter equals approximately 0.390 inch; 2.54 cm equals 1 inch.

CNG – Compressed Natural Gas.

CNG CYLINDER – A cylinder or other container designed to store or contain CNG.

COALESCING FILTER – A filter designed to separate liquid from gas.

COIL – A transformer used to step up the battery voltage (by induction) to the high voltage required to fire the spark plugs.

COLD START – Starting of an engine at cold temperatures; typical cold-start tests are performed at -20^{o}F.

COMBUSTION – Burning; fire produced by the proper combination of fuel, heat, and oxygen. In the engine, the rapid burning of the air-fuel mixture is in the combustion chamber.

COMBUSTION CHAMBER – The space between the top of the piston and the cylinder head in which the air-fuel mixture is burned.

COMPRESSED NATURAL GAS (CNG) – A mixture of hydrocarbon gases and vapors, consisting principally of methane in gaseous form that has been compressed to enable a transportable supply of fuel.

COMPRESSED NATURAL GAS FUEL SYSTEM – A system of safety devices, cylinders, piping, fittings, valves, regulators, gauges, relief devices, vents, and installation fixtures for the use of a motor vehicle fueled by compressed natural gas.

COMPRESSION – (1) Reducing the volume of a gas by squeezing it into a smaller space. Increasing the pressure reduces the volume and increases the density and temperature of the gas. (2) The increase of pressure in an engine cylinder as the piston travels towards top dead center. See Compression Stroke.

COMPRESSION IGNITION – In a compression ignition (CI) engine, the fuel charge is ignited by the heat of compression. The combustion process in a diesel engine in which fuel is injected then ignited by compressed, heated air.

COMPRESSION PRESSURE – The pressure in the combustion chamber at the end of the compression stroke.

COMPRESSION RATIO – The volume of the cylinder when the piston is at BDC, divided by the volume of the cylinder when the piston is at TDC.

COMPRESSION RING – The upper ring or rings on a piston, designed to hold the compression in the combustion chamber and prevent blow-by.

COMPRESSION STROKE – The piston movement from BDC to TDC immediately following the intake stroke during which both the intake and exhaust valves are closed while the air-fuel mixture in the cylinder is compressed.

COMPRESSION TESTER – An instrument for testing the amount of pressure, or compression, developed in an engine cylinder during cranking.

COMPUTER – A programmable electronic device that can store, retrieve, and process data.

COMPUTER ENGINE MAP – Typically a three dimensional graph representing the engine control parameters such as ignition advance plotted against throttle opening and engine speed. A representation of engine specific operating points stored in and used by the engine computer to optimize fuel delivery, performance and emissions. These maps are very accurate and are the product of thousands of hours of engine dynamometer testing.

COMPUVALVE – A device that integrates a programmable computer, sensors and fuel injectors; the compuvalve is a speed density system, which estimates mass flow rate of air into the engine and meters fuel accordingly.

GLOSSARY

CONDENSATION – A change of state during which a gas turns to liquid, usually because of temperature or pressure changes.

CONSTANT VOLUME SAMPLING (CVS) – In EPA-approved emissions testing, the entire volume of the engine exhaust stream is mixed with a carefully controlled and measured volume of atmospheric air introduced by an electrically driven turbine fan to ensure the sample dilution is consistent for measurement.

CONTAINER – A pressure vessel or cylinder used to store compressed natural gas or liquefied petroleum gas.

CONTAINER APPURTENANCES – Devices connected to container openings for safety, control or operating purposes.

CONTAINER VALVE – A valve operated by hand, connected directly to a container outlet.

CONVERSION – The integration of the propane fuel system with a gasoline engine. The procedure to convert a vehicle to run on propane as well as gasoline or only propane.

CONVERTER – Also known as a vaporizer-regulator, its function is to convert tank pressure liquid propane into low pressure propane vapor before it enters the air-fuel mixer.

COOLANT – The liquid mixture of about 50% antifreeze and 50% water used to carry heat out of the engine.

COOLANT TEMPERATURE SENSOR (CTS) – A device that senses engine coolant temperature. This data is used by the electronic engine control module to meter fuel and adjust ignition timing for best economy, performance and emissions.

COOLING SYSTEM – The system (the water jackets, water, pump, radiator, and thermostat) that removes heat from the engine by the forced circulation of coolant, preventing the engine from overheating.

CR – Compression Ratio.

CRANKCASE – The lower part of the engine in which the crankshaft rotates; includes the lower section of the cylinder block and the oil pan.

CRANKCASE BREATHER – The opening or tube that allows air to enter and leave the crankcase and thus permit crankcase ventilation.

CRANKCASE DILUTION – Dilution of the lubricating oil in the oil pan caused by liquid gasoline condensing from the blow-by in a cold engine and seeping down the cylinder walls.

CRANKCASE EMISSIONS – Pollutants emitted into the atmosphere from any porting of the engine-crankcase ventilation or lubrication system.

CRANKCASE VENTILATION – The circulation of air through the crankcase of a running engine to remove water, blow-by, and other vapors; prevents oil dilution, contamination, sludge formation, and pressure buildup.

CRITICAL PRESSURE – The pressure that is required to liquefy the gas at its critical temperature.

CRITICAL TEMPERATURE OF GAS – The highest temperature at which a gas can be liquefied by increasing pressure alone.

CROSS-FIRING – Jumping of a high-voltage surge in the ignition secondary circuit to the wrong high-voltage lead, so that the wrong spark plug fires; often caused by improper routing of the spark-plug wires, faulty insulation, or a defective distributor cap or rotor.

CRUDE OIL – Naturally occuring hydrocarbon fluid containing small amounts of nitrogen, sulfur, oxygen and other materials. Crude oil compositions vary greatly from area to area.

CTC – Canadian Transportation Commission.

CTS – Coolant Temperature Sensor.

GLOSSARY

CUBIC CENTIMETER (cc) – A unit of volume in the metric system.

CUBIC INCH DISPLACEMENT – The cylinder volume swept out by the pistons of an engine as they move from BDC to TDC, measured in cubic inches.

CURB IDLE – The recommended idle speed of an engine when it is at normal operating temperature.

CUT OUT – To miss momentarily but not stall.

CVS – Constant Volume Sampling.

CYCLE – Any series of events that repeat continuously as in the engine: the four (or two) piston strokes that together produce the power.

CYLINDER – (1) A circular tubelike opening in an engine cylinder block or casting in which a piston moves up and down. (2) A container constructed, inspected, and maintained according to DOT or CTC regulations for the purpose of storing natural gas or liquefied petroleum gas and having not over 1,000 lb. (454 kg) of water capacity.

CYLINDER BLOCK – The basic framework of the engine (cylinders and the upper part of the crankcase) in and on which the other engine parts are attached.

CYLINDER HEAD – The part of the engine that seals and encloses the cylinders. It contains cooling fins or water jackets and, on I-head (overhead valve) engines, the valves.

CYLINDER LEAKAGE TESTER – A testing device that forces compressed air into the cylinder through the spark-plug hole, when the valves are closed and the piston is at TDC on the compression stroke. As compressed air leaks out, it is measured, and the source of the leak is located.

CYLINDER SERVICE V ALVE – A hand-wheel-operated valve connected directly to a propane tank or CNG cylinder.

DC – Direct current.

DECELERATION – A decrease in velocity or speed; allowing the car or engine to coast to idle speed from a higher speed with the acceleration at or near the idle position.

DEDICATED FUEL VEHICLES – A vehicle that can operate only on an alternative fuel. If the vehicle has been converted, the gasoline or diesel fuel system has been removed.

DENSITY – The weight of a specific hydrocarbon fuel for a volumetric measurement. See Weight and Density of Air.

DETERIORA TION FACTOR – The lessening of emissions reduction performance over time. Refers mainly to the change in catalyst performance with increased vehicle mileage.

DETONATION – Commonly referred to as spark knock or ping when used to describe abnormal combustion after normal spark occurs. Detonation is an uncontrolled and rapid combustion that can occur before the normal spark (autoignition preignition) or after the spark occurs at the spark plug (autoignition knock). See Autoignition, Knock, Preignition, Surface Ignition and Octane.

DEW POINT – The temperature at which water vapor in the air begins to condense.

DIAGNOSIS – A procedure followed in locating the cause of a malfunction.

DIAGNOSTIC CODE – A two or three number code obtained from flashing “Service Engine Soon” light, or displaying on a “Scan” tool. This code can be used to determine the system malfunction.

DIAPHRAGM – A thin dividing sheet or partition that separates an area into compartments; used in fuel pumps, modulator valves, vacuum-advance units, and other control devices.

DIESEL GALLON EQUIVALENCE (DGE) – A means of measuring natural gas by energy value (BTUs) or weight (Lbs. or Kgs.). In comparison to a gallon of diesel, the low heat value of natural gas is 128,400 Btu DGE; high heat value is 138,700 Btu DGE. By weight, natural gas DGE is 6.355 Lbs. (2.88 Kg.). 128,000 Btu DGE = 1.28 therms.

DIESEL CYCLE – A engine operating cycle in which air is compressed and diesel fuel is injected into the compressed air at the end of the compression stroke. The heat produced by the compression ignites the diesel fuel, eliminating the need for spark plugs or a separate ignition system.

DIESELING – A condition in which an automobile engine continues to run after the ignition is off; caused by carbon deposits or hot spots in the combustion chamber glowing sufficiently to furnish heat for combustion.

DIRECT IGNITION SYSTEM (DIS) – A computer controlled system that does not use an electromechanical rotary switch/distributor to fire the secondary ignition coils. Often one coil is used to fire each cylinder or groups of cylinders. See Distributorless Ignition System.

DIS – Direct Ignition System.

DISPENSING SYSTEM – A combination of valves, meters, hoses, piping, electrical connections, and/or fuel connections at a stationary installation used to distribute LPG to portable DOT/ASME mobile or motor fuel containers.

DISPLACEMENT – (1) The total volume an engine is capable of drawing into all cylinders during one operating cycle. (2) The volume swept out by the piston in moving from one end of a stroke to the other.

DISTRIBUTOR – In the ignition system, an electromechanical rotary switch that switches low voltage current and directs high-voltage current to the spark plugs in the correct firing order.

DISTRIBUTOR CAM – The cam on the top end of the distributor shaft that rotates to open and close the contact points.

DISTRIBUTOR PLATE – The plate in the ignition distributor that is fastened to the distributor housing and does not move.

DISTRIBUTORLESS IGNITION SYSTEM (DLI) – A system that uses magnetic signals from the crankshaft flywheel to provide cylinder order and piston location information to the ECS, used to calculate spark advance and fuel injector timing in multiport and sequential fuel-injection systems. See Direct Ignition System.

DLI – Distributorless Ignition System.

DIVERTER VALVE – In the air-injection system of exhaust-emission control, a valve that diverts air-pump output into the air cleaner of the atmosphere during deceleration; prevents backfiring and popping in the exhaust system.

D.O.T. – Department of Transportation.

DOUBLE-OVERHEAD-CAMSHAFT ENGINE – An engine with two camshafts in each cylinder head to actuate the valves; one camshaft operates the intake valves, and the other operates the exhaust valves.

DOWNDRAFT CARBURETOR – A carburetor in which the air horn is so arranged that the air passes down through it on its way to the intake manifold.

DRIVEABILITY – Evaluation of a vehicle, based on startability, operability and driveability: such as cold and hot starts, smoothness and temperature in idle position, acceleration, mileage, safety and emission efficiency.

DUAL-BED CATALYSTS – Reduction and oxidation converters combined in series to catalyze oxides of nitrogen (NO_x), hydrocarbon (HC), and carbon monoxide (CO). Secondary air is added between the reduction (NO_x) catalyst and the oxidation (HC, CO) catalyst to assist in oxidation.

GLOSSARY

DUAL-FUEL – A system that operates on two fuels simultaneously, such as a fumigated diesel engine that runs on diesel and natural gas (or propane). The term is also used to describe a system that runs on either propane or gasoline. See Bi-Fuel.

DURABILITY – The quality of being useful for a long period of time and service.

DUTY CYCLE – Used to describe the operation of computer-controlled output devices; the amount (percentage) of time the unit (solenoid or other device) is turned on, e.g., 60% duty cycle means 60% on.

DWELL – The amount of time the primary ignition is applied to the ignition coil energizing it. Measured in degrees, the duration of time a device — such as ignition contacts — is on relative to off time.

DWELL METER – A precision electrical instrument used to measure the dwell, or number of degrees during which the distributor points are closed while the engine is running.

DYNAMOMETER – A device for measuring the power output, or brake horsepower, of an engine at the flywheel; a chassis dynamometer measures the power output at the drive wheels.

ECA – Electronic Control Assembly.

ECM – Electric Control Module.

ECS – Engine Control System.

ECU – Electronic control unit: a solid-state device that receives information from sensors, programmed to operate various circuits and systems based on that information.

EFFICIENCY – The ratio of energy output to the energy input of a machine, or the percentage of a machine's theoretical performance. See Thermal Efficiency.

EGR SYSTEM – Exhaust-gas recirculation system: the recycling of some exhaust gas back into the inlet manifold to lower combustion temperature, thus reducing nitrogen-oxide emissions.

ELECTRODE – In a spark plug, either of the two metal conductors between which the spark is made to jump (ionize). The center electrode passes through the spark plug insulator, which has negative polarity with respect with the ground electrode. The ground electrode is welded to the spark-plug shell.

ELECTRONIC ENGINE CONTROL MODULE (ECM-COMPUTER) – A solid-state device that receives information from sensors and is programmed to operate various circuits and systems based on that information. Also known as the on-board computer.

ELECTRONIC FUEL-INJECTION SYSTEM – A system that injects gasoline into a spark-ignition engine, and that includes an electronic control to time and meter the fuel flow.

ELECTRONIC IGNITION SYSTEM – A transistorized ignition system that does not have mechanical contact points in the distributor, but which uses the distributor for distributing the secondary voltage to the spark plugs.

ELECTRONIC SPARK CONTROL (ESC) – A system that controls the vacuum to the distributor, preventing vacuum advance below a selected vehicle speed.

EMISSION – Any gas, vapor, or particulate loss to atmosphere.

EMISSION CONTROL – Any device or modification added onto or designed into motor vehicle for the purpose of reducing air-polluting emissions.

EMISSION STANDARDS – Allowable automobile emission levels, set by local, state, and federal regulations.

EMITTER – An engine with considerable exhaust emissions; sometimes preceded by the work high or low to indicate the degree of emission.

GLOSSARY

EMITTER (GROSS) – A vehicle that puts out considerable or excessive exhaust emissions.

ENERGY – The energy content of specific hydrocarbon fuel for volumetric measurement BTU/ft^3 (MJ/m^3) or by weight measurement BTU/lb (MJ/kg). Also see HIGH HEAT VALUE and LOW HEAT VALUE.

ENGINE – A machine that converts heat energy into mechanical energy. A device that burns fuel to produce mechanical power; sometimes referred to as a power plant.

ENGINE VACUUM – A low pressure produced by the engine when it is on its intake stroke. See Manifold Absolute Pressure.

ENVIRONMENT AL PROTECTION AGENCY (EP A) – The independent agency of the United States government sets standards and coordinates activities related to automotive emissions and the environment, among other responsibilities.

EQUIVALENCE RATIO – The ratio of the actual fuel-air ratio to the stoichiometric fuel-air ratio is the fuel-air equivalence ratio. (Fuel/Air actual/Fuel/Air stoichiometric) = fuel-air equivalence ratio = phi = (φ). Lean mixtures are described as less than $<1.0\ \lambda$ and rich mixtures are greater than $>1.0\ \lambda$. See Lambda λ.

ESC – Electronic spark control.

ETHANOL – An alcohol composed of carbon, hydrogen, and oxygen. It is a clear colorless liquid and is the same alcohol found in beer, wine, and whiskey. Ethanol is produced by fermenting a sugar solution with yeast. When used as vehicle fuel, gasoline is added to avoid alcohol-related taxes and regulations, and to prevent human consumption.

ETHYL MERCAPTAN – One of a number of thiol compounds that are removed from some fuels because of their offensive, distinctive odors. Mercaptans are added to gaseous fuels such as LPG and methane to warn of the presence of gas that is normally odorless.

EVAPORATION – The transformation of a liquid to the gaseous state.

EVAPORA TIVE EMISSIONS – Emissions from vehicle fuel systems of light hydrocarbons as a result of fuel evaporation caused by "breathing" of tanks or during refueling.

EVAPORA TIVE EMISSION CONTROL SYSTEM (EECS) – A system which prevents the escape of gasoline vapors from the fuel tank or carburetor to the atmosphere while the engine is off. The vapors are stored in a charcoal canister or in the engine crankcase until the engine is started.

EVAPORA TION CONTROL SYSTEM – A system which prevents the escape of gasoline vapors from the fuel tank or carburetor to the atmosphere while the engine is off. The vapors are stored in a charcoal canister or in the engine crankcase until the engine is started.

EXHAUST EMISSIONS – Components of engine exhaust, some of which are considered harmless, emitted into the atmosphere through any opening downstream of the exhaust ports of an engine.

EXHAUST -GAS ANALYZER – A device for sensing the amounts of air pollutants in the exhaust gas of a motor vehicle. The analyzers used in automotive shops check HC, CO_2 and CO; those used in testing laboratories and in auto shops with dynamometers can also check NO_x.

EXHAUST -GAS RECIRCULATION SYSTEM (EGR) – A NO_x control system that recycles a small part of the exhaust gas back through the intake manifold at all throttle positions except idle and wide open to lower the combustion temperature.

EXHAUST MANIFOLD – A device with several passages through which exhaust gases leave the engine combustion chambers and enter the exhaust piping system.

EXHAUST PIPE – The pipe connecting the exhaust manifold with the muffler.

EXHAUST STROKE – The piston stroke (from BDC to TDC) immediately following the power stroke, during which the exhaust valve opens so exhaust gases can escape from the cylinder to the exhaust manifold.

GLOSSARY

EXHAUST SYSTEM – The system through which exhaust gases leave the vehicle. Consists of the exhaust manifold, exhaust pipe, muffler, tail pipe and resonator if used.

EXHAUST VALVE – The valve that opens during the exhaust stroke to allow burned gases to flow from the cylinder to the exhaust manifold.

EXPANSION RATIO – When heated, liquid propane expands 270 times into a vapor; its expansion ratio is 1:270.

EXPANSION TANK – A tank at the top of an automobile radiator that provides room for expansion of heated coolant, releasing any air that may be trapped.

FAN – The bladed device on the front of the engine that rotates and draws cooling air through the radiator or around the engine cylinders.

FAST-IDLE CAM – A mechanism on the carburetor, connected to the automatic choke, that holds the throttle valve slightly open causing the engine to idle at a higher RPM as long as the choke is applied.

FEDERAL ENERGY POLICY ACT – FEPA-92 – Passed by Congress in 1992, the FEPA-92 is designed to initiate the development and implementation of alternative fuel technologies by requiring certain fleets and encouraging others to operate alternative fuels vehicles.

FERRULE – A metal band forming or strengthening a joint.

FILL VALVE – The valve through which the fuel tank is refueled, mounted directly to the tank or remotely away from the tank.

FILTER – A device through which air, gases, or liquids are passed to remove impurities.

FINAL APPROVAL – The authorization issued by the commission or authority having jurisdiction.

FIRING LINE – The high-voltage vertical spike, or line, that appears on the oscilloscope pattern of the ignition-system secondary circuit. The firing line shows when the spark plug begins to fire and the voltage required to fire it.

FIRING ORDER – The order in which the engine cylinders fire, or deliver their power strokes, beginning with No. 1 cylinder.

FITTINGS – Accessory parts used to connect components such as regulators, mixers or valves to hose ends or bulkheads.

FIXED LIQUID LEVEL GAUGE – A valve mounted into a propane tank used to determine when the tank has reached 80 percent of water capacity during refueling.

FLAMMABILITY LIMITS – The minimum or maximum percentage of fuel needed in an air-fuel mixture to support combustion.

FLANGE – A rib or rim added for strength. Also used for guiding or attaching another object (component).

FLASH POINT – The lowest temperature at which vapors from a petroleum product will ignite on application of a small flame under standard test conditions.

FLAT SPOT – Lack of normal acceleration or response to throttle opening; implies no loss of power but also no increase in power.

FLEXIBLE METAL AND WIRE BRAID HOSE – A metal hose made from continuous tubing that is corrugated for flexibility and that, for pressurized applications, has an external wire braid.

FLOAT BOWL – In a carburetor, the reservoir from which gasoline is metered into the passing air.

FLOAT LEVEL – The float position at which the needle valve closes the fuel inlet to the carburetor to prevent further delivery of fuel; in a LPG fuel tank, the liquid level of the fuel measured by a float inside the tank and displayed by an external magnetic gauge.

GLOSSARY

FLOAT SYSTEM – In the carburetor, the system that controls the entry of fuel and the fuel level in the float bowl; in an LPG tank, the mechanism used to measure the liquid level of the fuel.

FLOODED – Indication that the engine cylinders received raw or liquid gasoline or any air-fuel mixture that is too rich to burn.

FORMALDEHYDE – The simplest aldehyde, $H_2C{=}O$. A product of the partial combustion of gasoline, natural gas, and (especially) methanol. A powerful irritant and suspected carcinogen, it is an important toxic air contaminant.

FOUR-BARREL CARBURETOR – A carburetor with four throttle valves or two two-barrel carburetors in a single assembly.

FOUR-STROKE CYCLE – The four piston strokes – intake, compression, power, and exhaust – that make up the complete cycle of events in the four-stroke engine.

FREEZING POINT – The temperature at which a given liquid changes to a solid under a specified pressure, especially a pressure equal to that of the atmosphere.

FTP75 – Federal Test Procedure: a series of loaded-mode, variable mode and speed chassis dynamometer tests using Constant Volume Sampling (CVS) to measure the emissions from vehicles for certification. The test consists of three parts:

1. Cold-Start 505 seconds, 3.8 miles.
2. Hot-Stabilized 867 seconds, 3.8 miles.
3. Hot-Start 505 seconds, 3.8 miles.

FUEL – Any combustible substance. In an automobile engine, the fuel (vapor) is burned, and the heat of combustion expands the resulting gases, forcing the piston downward thus rotating the crankshaft and providing motive power.

FUEL FILTER – A device located in the fuel supply line between the tank and the fuel metering device that removes dirt and other contaminants from fuel passing through it.

FUEL GAUGE – A gauge that indicates the amount of fuel in the fuel tank.

FUEL-INJECTION SYSTEM – In gasoline, LPG or natural gas applications, fuel is delivered under pressure into the intake manifold by means of a electically contolled fuel injector. Injectors can be positioned at each cylinder and operated individually (port injection) or in groups (bank fire injection) or positioned centrally and fired for all cylinder distribution (central point injection). Diesel fuel injection delivers fuel directly into the cylinder or pre-chamber.

FUEL INJECTOR – A device for injecting fuel into a piston engine. They are used in all diesel engines and most gasoline engines in place of a carburetor.

FUEL (SUPPLY) LINE – The pipe or tube through which fuel flows from the fuel tank to the engine.

FUEL LOCK – An electromechanical device that shuts off the flow of fuel to the engine when the ignition is turned off or the engine is not operating.

FUEL NOZZLE – The tube in the carburetor through which gasoline feeds from the float bowl into the passing air. In a fuel-injection system, the tube that delivers the fuel into the intake manifold or elsewhere in the air induction system.

FUEL PUMP – The electrical or mechanical device in the fuel system that moves fuel from the fuel tank to the carburetor or fuel rail.

FUEL PUMP COVER PLATE – A device used to cover the hole in the engine block where a mechanical fuel pump was removed when an electrical fuel pump was installed or the vehicle was converted to run on LPG (monofuel).

FUEL RECEPTACLE – A device to which a fuel nozzle or refueling fitting is attached; the fitting on the vehicle that allows refueling.

GLOSSARY

FUEL SUPPLY CYLINDER – A container mounted upon a vehicle to store liquefied petroleum gas or natural gas as the fuel supply to the internal combustion engine of the vehicle.

FUEL SWITCHING DEVICE – An electrical or manual device that changes the type of fuel being supplied to the engine.

FUEL SYSTEM – The system (fuel tank, gauge, fuel pump, supply line, carburetor/venturi, fuel injectors, fuel metering device, fuel rail/manifold, related sensors and actuators) that delivers the correct amount of fuel to the air stream.

FUEL TANK – The storage tank for fuel on the vehicle.

FUEL (GAS) VALVE – The valve in an air-fuel mixer that is connected to the air valve and meters fuel in direct proportion to the position of the air valve and engine load.

FULL THROTTLE – Wide-open throttle position when the accelerator pressed all the way down to the floorboard.

FUMIGATION – A process whereby a secondary, substitution fuel such as LPG or natural gas is introduced into the air stream of a diesel engine to alter the combustion process. See Dual Fuel.

GAP – The air space between two electrodes, as the spark-plug gap or the contact-point gap.

GAS – A state of matter in which the matter has neither a definite shape nor a definite volume.

GAS LAWS – The relationship among pressure, volume, and temperature as described by Boyles, Charles and Ideal gas laws.

GASOHOL – A blend of gasoline and ethanol used as an automotive fuel.

GASKET – A layer of material that is placed between two machined surfaces to seal between them.

GASOLINE – A liquid blend of hydrocarbons, obtained from crude oil; used as the fuel in most automobile engines.

GASOLINE GALLON EQUIVALENCE (GGE) – A means of measuring natural gas by energy value (Btu) or weight (Lbs. or Kgs.) In comparison to a gallon of gasoline, the low heat value of natural gas is 115,000 Btu GGE; high heat value is 124,800 Btu GGE. Many utility companies use 118,000 Btu GGE as an average. By weight, natural gas GGE is between 5.168 – 5.660 Lbs. (2.344 – 2.567 Kg.). 118,000 Btu GGE = 1.18 therms. See Therm. Propane has a low heat value of approximately 83,500 Btu/gallon. Using the same conversion applied to natural gas (118,000 Btu/GGE), it would take 1.41 gallons of propane to make one GGE.

GAS-TURBINE ENGINE – A type of internal-combustion engine in which the shaft is spun by the pressure of combustion gases flowing against curved turbine blades located around the shaft.

GAUGE PRESSURE – A pressure, above or below existing atmospheric pressure , read on a gauge based at existing atmospheric pressure, e.g. 0 psig.

GENERAL CORROSION – Corrosion that covers considerable surface area of a container. It reduces the structural strength and is often accompanied by pitting.

GPM – Grams Per Mile.

GRAMS PER MILE – Unit of measurement for the amount (weight) of pollutants emitted into the atmosphere with the vehicle exhaust gases. Antipollution laws set maximum limits for each exhaust pollutant in grams per mile.

GREENHOUSE EFFECT – This effect occurs naturally and is similar to what happens in a greenhouse: solar radiation passes through the atmosphere to earth and is absorbed and radiated upwards but trapped by greenhouse gases. The tendency for the atmosphere to "hold in" infrared radiation, or heat, is increased by human created gases such as carbon dioxide (CO_2). See GREENHOUSE GASES.

GREENHOUSE GASES – Infrared absorbing gases that contribute to the greenhouse effect. While some of these gases occur naturally, it is believed that greenhouse gases generated by humans are increasing the greenhouse effect and warming the earth's surface. Man-made gases that contribute to the greenhouse effect are carbon dioxide (CO_2), chlorofluorocarbons (CFC), methane (CH_4) and nitrous oxide (N_2O), carbon monoxide (CO) and ozone (O_3).

GROMMET – A device, usually made of hard rubber or a similar material, used to encircle or support a component. Often used to allow a cable, hose or wire to pass through a panel or frame member to avoid chaffing and abrasion.

GROSS EMITTER – See Emitter.

GULP VALVE – In the air-injection system, type of anti-backfire valve that allows a sudden intake of fresh air through the intake manifold during deceleration; prevents backfiring and popping in the exhaust system.

H/C RATIO – The ratio of hydrogen to carbon in hydrocarbon fuels. Fuels with high H/C ratios such as CNG and LPG are less reactive in forming smog than are the heavier hydrocarbon molecules present in gasoline or diesel fuel.

HALL-EFFECT SENSOR – A magnetic sensor mounted inside the distributor or positioned next to a gear, pulley or shaft that sends cylinder order, engine speed and piston position information to the ESC or ECS for calculating spark advance. Hall-effect sensors replace conventional breaker points in spark distribution systems.

HARTRIDGE UNIT – A measurement of the black smoke emitted from a diesel engine in which the opacity of the smoke is determined.

HAZARDOUS – A substance or circumstance that may cause injury or damage by reason of being explosive, flammable, poisonous, corrosive, oxidizing, or otherwise harmful.

HC – Hydrocarbon: also used to represent emissions from an internal combustion engine.

HD-5 – A blend of high quality LP Gases for motor fuel use consisting of a minimum 90 percent propane and 2.5 percent butane and heavier hydrocarbons; it must be essentially free of oily residues and other contaminants such as sulfur. A vapor pressure standard effectively limits ethane content.

HEADER – Performance term for special exhaust manifold or exhaust tubes.

HEAT – A form of energy; heat is released by the burning of the fuel. In an engine, heat energy is converted to mechanical energy.

HEAT-CONTROL VALVE – In the engine, a thermostatically operated valve in the exhaust manifold; diverts heat to the intake manifold to warm it before the engine reaches normal operating temperature.

HEATED-AIR SYSTEM – A system in which a thermostatically controlled air cleaner supplies hot air from around the exhaust manifold to the carburetor during warm-up, used to improve cold-engine operation.

HEATING VALUE – Also known as heat release, it is the heat of combustion or the amount of heat released during combustion of fuel as measured by weight (BTUs/Lb.).

HEAT OF COMPRESSION – An increase in temperature brought about by the compression of air or air-fuel mixture.

HEAT OF VAPORIZATION – The amount of energy (BTUs) needed to convert the water in a fuel to steam, e.g., the high heat value of methane is 911 BTUs. The energy lost converting the water in methane to steam is 101 BTUs (1012 – 101 = 911 BTUs). See Latent Heat, High Heat Value, Low Heat Value, Specific Heat and BTUs.

HEI – High Energy Ignition.

HEMISPHERICAL COMBUSTION CHAMBER – A combustion chamber resembling a hemisphere or half a ball.

HESITATION – Momentary pause in the rate of acceleration; momentary lack of throttle response at some car speed other than acceleration from a standing start.

HEV – Hybrid Electric Vehicle.

HG – Chemical symbol for mercury.

HIGH-ENERGY IGNITION (HEI) SYSTEM – An electronic ignition system without contact points, having all ignition-system components contained in the distributor; capable of producing 35,000 volts.

HIGH HEAT VALUE – The gross/upper heat value of a fuel before energy losses from combustion.

HIGH PRESSURE CYLINDER – Cylinders with a marked service pressure 900 psi (6205 kPa) or greater.

HONDA SYSTEM – A type of controlled, stratified charge combustion system for spark ignition engines. Has a small chamber that surrounds the spark plug electrodes with a rich mixture; once the rich mixture ignites, it enters the main chamber, igniting the leaner air-fuel mixture in that chamber.

HORSEPOWER – A measure of mechanical power or the rate at which work is done. One horsepower equals 33,000 ft. lb. of work per minute; it is the energy necessary to raise 33,000 lb. a distance of 1 ft. in 1 min.

HOT-IDLE COMPENSATOR – A thermostatically controlled carburetor valve that opens whenever inlet air temperatures are high; allows additional air to discharge below the throttle plates at engine idle, improving idle stability and preventing overly rich air-fuel mixtures.

HOT SOAK – A condition that may arise when an engine is stopped for a prolonged period after a hard, hot run. Heat transferred from the engine evaporates fuel out of the carburetor, so that the carburetor needs priming before the engine will start and run smoothly.

H_2O – Chemical symbol for water.

HYBRID ELECTRIC VEHICLE (HEV) – A vehicle that is powered by both an electric drive system and an internal combustion engine.

HYDROCARBON (HC) – An organic compound containing only carbon and hydrogen, usually derived from fossil fuels such as petroleum, natural gas, and coal; an agent in the formation of photochemical smog.

HYDROCARBON REACTIVITY – A measure of the smog-forming potential of a particular hydrocarbon.

HYDROGEN – A colorless, odorless, highly flammable gas whose combustion produces water; the simplest and lightest element.

IAC (or ISC) – Idle Air Controller or Idle Speed Controller.

IAT – Intake Air Temperature.

IC – Internal Combustion.

IDEAL GAS LAW – Approximates the behavior of gases; combines Charles and Boyle's laws; not valid when gas nears condensation conditions.

IDI – Indirect Injection.

IDLE – Engine speed when the accelerator is fully released, and there is no load on the engine.

GLOSSARY

IDLE AIR CONTROLLER (IAC) – The IAC is controlled by the ECS to maintain consistent idle speed by varying the air admitted to the engine as auxiliary loads, devices such as AC compressor or alternator, engage and disengage.

IDLE LIMITER – A device that controls the maximum richness of the idle air-fuel mixture in the carburetor; also aids in preventing overly rich idle adjustments. Limiters are of two types: external plastic caps installed on the heads of the idle-mixture adjustment screws and internal needles located in the idle passages of the carburetor.

IDLE-LIMITER CAP – A plastic cap placed over the head of the idle-mixture adjustment screw to limit its travel and prevent the idle mixture from being set too rich or too lean.

IDLE MIXTURE – The air-fuel mixture supplied to the engine during idling.

IDLE-MIXTURE ADJUSTMENT SCREW – The adjustment screw (on some carburetors) that can be turned in or out to lean out or enrich the idle mixture.

IDLE PORT – The opening into the throttle body through which the idle system in the carburetor discharges fuel.

IDLE SPEED – The speed, revolutions per minute (RPM), at which an engine runs without load when the accelerator is released.

IDLE SPEED CONTROLLER (ISC) – See Idle Air Controller.

IDLE-STOP SOLENOID – An electrically operated two-position plunger used to provide a predetermined throttle setting at idle.

IDLE SYSTEM – The passages on a carburetor through which fuel is fed when the engine is idling.

IDLE VENT – An opening from an enclosed chamber through which air can pass under idle conditions.

IGNITION – The action of the spark in starting the burning of the compressed air-fuel mixture in the combustion chamber.

IGNITION ADVANCE – The moving forward, in time, of the ignition spark relative to the piston position. TDC or 1 degree BTDC is considered advanced as compared to 2 degree ATDC.

IGNITION COIL – The ignition-system component that acts as a transformer to increase the battery voltage to many thousands of volts; the high-voltage surge in the secondary circuit of the coil from the collapse of current through the primary circuit in the coil is transmitted to the spark plug to ignite the compressed air-fuel mixture.

IGNITION COMPONENTS – Components, including coils, wires, spark plugs and timing mechanisms, that provide a spark at the proper time to ignite the fuel air mixture in the cylinder of a SI engine.

IGNITION DISTRIBUTOR – A rotary switch in the ignition system that initiates the saturation and collapse of the primary circuit to the ignition coil and distributes the resulting high-voltage discharge from the ignition coil to the spark plug(s).

IGNITION DELAY – The period between the start of injection and ignition of a fuel in a diesel engine.

IGNITION ENERGY – Energy that is required for inflammation of the air-fuel mixture and is directly converted into heat. This energy typically amounts to 0.948 Btu (1 millijoule).

IGNITION RESERVE – Difference between the minimum available and maximum required voltages. An adequate ignition reserve is important if an engine is to be reasonably free from troubles caused by moisture or dirt losses, leaky secondary ignition leads and fouled spark plugs.

IGNITION RESISTOR – A resistance connected into the ignition primary circuit to reduce the battery voltage to the coil during engine operation.

IGNITION RETARD – The moving back, in time, of the ignition spark relative to the piston position. TDC or 1 degree ATDC is considered retarded as compared to 2 degrees BTDC.

IGNITION SWITCH – The switch in the ignition system (usually operated with a key) that opens and closes the ignition-coil primary circuit; may also be used to open and close other vehicle electrical circuits.

IGNITION SYSTEM – In an automobile, the system that furnishes high-voltage sparks to the engine cylinders to fire the compressed air-fuel mixture, consisting of the battery, alternator/generator, ignition coil, ignition distributor, ignition switch, wiring, and spark plugs.

IGNITION TIMING – The delivery of the spark from the coil to the spark plug at the proper time for the power stroke relative to the piston position.

I-HEAD ENGINE – An overhead-valve (OHV) engine; an engine with the intake and exhaust valves in the cylinder head.

INCREASED COMPRESSION – In a reciprocating engine, the ratio of cylinder plus combustion chamber volume at the bottom of the stroke (Bottom Dead Center) when the volume is greatest to the volume at top of stroke (Top Dead Center) when the volume is least. Increasing the compression ratio increases the efficiency of an engine.

INDICATOR – A device used to make some condition known by use of a light or a dial and pointer; for example, the temperature indicator or oil-pressure indicator.

INDIRECT INJECTION (IDI) – A type of diesel engine in which the fuel is sprayed into a prechamber to initiate combustion, rather than directly into the cylinder.

INERTIA – Property of an object that causes it to resist any change in its state of rest or speed or direction of travel.

INFRARED ANALYZER – A test instrument used to analyse exhaust gases (CO, CO_2, HC). Where an infrared beam is transmitted across the exhaust to read its composition based on the fact that each gas component aborbs radiation differently or has a characteristic wavelength that can be read.

INJECTOR – The tube or nozzle through which fuel is injected, usually under pressure, into the intake airstream or the combustion chamber.

IN-LINE ENGINE – An engine in which all the cylinders are located in a single row or line.

INPUT-OUTPUT (I/O) – Input systems are composed of sensors such as MAP, TPS, CTS, O_2 or mass-flow. Output systems are actuators such as fuel injectors, EGR valves or IAC.

INSULATION – Material that stops the travel of electricity or heat.

INTAKE AIR TEMPERATURE (IAT) – The intake air temperature is used in conjunction with the MAP and TPS sensors to calculate the total mass of oxygen in the intake air charge.

INTAKE MANIFOLD – A device with several passages through which the air-fuel mixture flows from air inlet and carburetor or injector to the combustion chambers.

INTAKE STROKE – The piston stroke (from TDC to BDC) immediately following the exhaust stroke during which the intake valve opens and the cylinder fills with air-fuel mixture from the intake manifold.

INTAKE VALVE – The valve that opens during the intake stroke to allow the air-fuel mixture to enter the cylinder from the intake manifold.

INTEGRAL – Built into, as part of the whole.

INTERNAL-COMBUSTION ENGINE (IC) – An engine in which the fuel is burned and energy is provided within the working chamber (rather than outside the engine) causing direct mechanical displacement of a piston, rotor, turbine or other mechanical element.

IN. HG (HG) – Inches of Mercury; a unit of pressure measurement.

IN. WC (WC) – Inches of Water Column; a unit of pressure measurement.

I/O (INPUT/OUTPUT) – Used to describe sensors or switches (inputs) that provide information to a microcomputer-based electronic control unit that in turn operates actuators such lights, relays, solenoids (outputs).

ISOTHERMAL & ADIABATIC COMPRESSION – Isothermal compression occurs when the heat of compression is removed as fast as it is generated, the gas temperature does not change during compression. Isothermal compression is not achieved in actual practice, since it is impossible (almost) to dissipate all the compression heat. Adiabatic compression occurs when all the heat of compression is retained in the gas, there is no other heat leaving or entering the gas.

JET – A calibrated passage in the carburetor through which fuel flows.

JOURNAL – The part of a rotating shaft that turns in a bearing.

KILOGRAM – In the metric system, unit of weight and mass; approximately equal to 2.2 pounds.

KILOMETER – In the metric system, a unit of linear measure; equal to 0.621 miles.

KILO PASCALS (kPa) – A metric measure of pressure. One psi is equal to 6.9 kPa. One inch of mercury (HG) is equal to 3.38 kPa.

KILOWATT – A unit of power, equal to about 1.34 HP.

KM/H – Kilometer Per Hour.

KNOCK – The autoignition (detonation) of the gas in the combustion chamber causing the knocking or pinging sounds; it can cause damage to the engine. Knock can be controlled by retarding ignition timing, inducting cooler air into the engine, increasing the octane number of the fuel or by modifying the engine. In diesel engines, knock is caused by excessive pressures in the combustion chamber and is avoided by the use of higher cetane number fuels.

KNOCK SENSOR – A detector, usually fixed to the cylinder head, that detects when knock is occurring in a spark ignition engine and actuates a mechanism, such as one which retards the ignition to overcome the knock.

KPa – Kilo Pascals.

KW – Kilowatt.

LABELED – Equipment or materials to which a label, symbol or other identifying mark has been attached, indicating its acceptability to the authority having jurisdiction. It is a mark concerned with product evaluation from organizations that maintain periodic inspection of production of equipment or materials by using the label to indicate manufacturer compliance with appropriate standards or performance.

LAMBDA – The ratio of the actual air-fuel ratio to the stoichiometric air-fuel ratio is Lambda. (Air-Fuel actual / Air-Fuel stoichiometric) = Lambda (λ). Lean mixtures are described as greater than >1.0 λ and rich mixtures are less than <1.0 λ. See Equivalence Ratio.

ESC – Electronic spark control.

LATENT HEAT – The heat associated with the change of phase such as going from a solid to a liquid or from a liquid to a gas (also called heat of vaporization). Latent heat is the amount of energy needed to vaporize the water created by combustion. Latent heat is the difference between high heat value and low heat value of a fuel, typically rated in BTUs. See Heat of Vaporization, High Heat Value, Low Heat Value and BTUs.

GLOSSARY

LBE – Lean Best Economy.

LEADED GASOLINE – Gasoline to which small amounts of tetra-ethyl lead are added to improve engine performance and reduce autoignition knock/detonation.

LEAK TESTING – Testing with the use of a solution, such as a leak detection soap, to observe leakage under pressure by the formation of bubbles as gas escapes from the leak source.

LEAN BEST ECONOMY (LBE) – The equivalence ratio at which spark-ignition engines with conventional ignition systems operate at maximum fuel efficiency (around .85) is referred to as LBE. The worst NO_x from spark ignition engines coincides with LBE.

LEAN BURN – An Otto cycle engine that has 30%-50% excess air after combustion. An engine designed for high thermal efficiency with low CO and NO_x emissions.

LEAN BURN COMBUSTION – Engine combustion optimized for a lean mixture with high turbulence in the combustion chamber, high compression ratios and cool inlet air temperatures.

LEAN MISFIRE – Engine combustion is irregular, caused by an air-fuel ratio with excess air -– not enough fuel to support normal combustion; the percentage of fuel in the mixture is too low or below the low flammability limit of the fuel.

LEAN MIXTURE – An air-fuel mixture that has a relatively low proportion of fuel. An air-fuel ratio of 18:1 indicates a lean mixture compared to an air-fuel ratio of 13:1. The stoichiometric air-fuel ratio (ideal combustion) for LPG is approximately 15.5:1. Also see STOICHIOMETRY.

LEV – Low Emission Vehicle.

L-HEAD ENGINE – An engine with its valves located in the cylinder block.

LIGHT -DUTY VEHICLE – A motor vehicle manufactured primarily for transporting persons or property and having a gross vehicle weight of 6,000 lb. [2,727.6 kg] or less.

LIMITED-COMBUSTIBLE MATERIAL – A material not complying with the definition of noncombustible material which, in the form in which it is used, has a potential heat value not exceeding 3500 Btu per lb. (8141kJ/kg).

LINE CORROSION – When pits are connected to others in a narrow band or line, such a pattern is termed line corrosion. This condition is more serious than isolated pitting.

LINKAGE – An assembly of rods, or links, used to transmit motion.

LIQUEFIED NATURAL GAS (LNG) – A motor fuel composed of 97 percent and higher content methane that has been liquefied.

LIQUEFIED PETROLEUM GAS (LPG) – A product composed predominantly of any of the following hydrocarbons or mixtures of hydrocarbons: propane, propylene, normal butane, isobutane, and butylenes.

LIQUEFIED PETROLEUM GAS FUEL SYSTEM – All piping, fittings, valves and equipment, excluding containers and appliances, that connect one or more containers to one or more appliances that use or consume liquefied petroleum gas (LPG).

LIQUID-COOLED ENGINE – An engine that is cooled by the circulation of liquid coolant around the cylinders.

LIQUID LEVEL GAUGE – Also known as bleed valve, spit valve, outage gauge or 80 percent valve, the valve is designed to indicate when the fuel tank has reached 80 percent of its WC (water capacity). A #54 oriface is drilled into the valve to allow vapor to spurt out when the level is reached; the visible white cloud is not propane but condensed water vapor caused by the chilling effect of propane flash vaporizing across the orifice.

LITER (L) – In the metric system, a measure of volume; approximately equal to 0.26 gallon (U.S.) or about 61 cubic inches. Also used as a metric measure of engine cylinder displacement.

LNG – Liquefied Natural Gas.

LOAD FACTOR – The ratio of an average load to the maximum load on an engine – average power output to maximum power output.

LOADING – An enrichment of the air-fuel mixture to the point of rough engine idle – sometimes causes missing and, depending on the fuel, may be accompanied by black smoke from the tail pipe. To demand power output from an engine or exceed its capabilities.

LOBE – A projecting part; for example, the rotor lobe or the cam lobe.

LOCKOFF – The device in an fuel system that prevents fuel from entering the converter or secondary regulator when the engine is not running.

LOW EMISSION VEHICLE – CARB has developed a four level low emission vehicle standard that was implemented in 1994. The four levels are:

Transitional Low Emission Vehicle (TLEV).
Low Emission Vehicle (LEV).
Ultra Low Emission Vehicle (ULEV).
Zero Emission Vehicle (ZEV).

LOW HEAT VALUE – The net/lower value of a fuel after energy losses from water vapor in the exhaust. The net heat value that the engine responds to.

LOW-LEAD FUEL – Gasoline that is low in tetraethyl lead, containing not more that 0.5g/gal.

LOW PRESSURE CYLINDER – Cylinders with a marked service pressure below 900 psi (6205 kPa).

LOW-SPEED SYSTEM – The system in the carburetor that supplies fuel to the air passing through during low-speed, part-throttle operation.

LOWER EXPLOSIVE LIMIT (LEL) – The lean air/fuel ratio where a mixture will not ignite completely in a spark ignition engine. See Flammability Limits.

LPG – Liquefied Petroleum Gas; any material having a vapor pressure not exceeding that allowed for commercial propane composed predominantly of the following hydrocarbons, either by themselves or as mixtures: propane, propylene, butane (normal butane or isobutane), and butylenes.

LUGGING – Low-speed, full-throttle engine operation when the engine is heavily loaded and overworked; usually caused by failure of the driver to shift to a lower gear when necessary; the ability of a vehicle to pull through a temporary overload.

M-85 – A mixture of 85% methanol and 15% unleaded gasoline.

MAF – Mass Airflow; a MAF sensor is used to measure mass air flow in relation to engine air induction.

MAIN JET – The fuel nozzle, or jet, in the carburetor that supplies fuel when the throttle is partially to fully open.

MALFUNCTION – Improper or incorrect operation.

MANDREL TYPE FITTINGS – A fitting that is barbed or threaded and tapered on its outer diameter and bored straight and smooth on the inner diameter. Designed to push or thread into a hose and be secured by a clamp, ferrule, sleeve or collar that fits over the outer diameter of the hose to make a leakproof fitting.

MANIFOLD – A device with several inlet or outlet passageways through which a gas or liquid is gathered or distributed.

MANIFOLD ABSOLUTE PRESSURE (MAP) – The mean gas absolute static pressure in an engine induction manifold, usually measured in inches of Mercury (in.Hg.) or pound per square inch absolute (psia). On a spark ignited engine, MAP is measured below the throttle. Barometric pressure minus manifold vacuum is manifold absolute pressure.

GLOSSARY

MANIFOLD VACUUM (VAC) – The vacuum in the intake manifold that develops as a result of the negative pressure in the cylinders on their intake strokes, usually measured in inches of Mercury (in.Hg.). Manifold vacuum is the depression or drop in pressure below atmospheric pressure measured below the throttle of a spark ignition engine. Barometric pressure minus manifold absolute pressure is manifold vacuum.

MANUFACTURER – Any person, firm, or corporation engaged in the production or assembly of motor vehicles or other products.

MAP – Manifold Absolute Pressure.

MASS AIR FLOW – A computer control fuel management system using information from an air flow meter or hot wire sensor, used to calculate the density of the air entering the engine.

MASS AIRFLOW SENSOR (MAF) – Measures the weight of air entering the engine in grams per second. Used in electronic fuel injection, on-board computer systems.

MAT – Manifold Absolute Temperature. Used in a speed density fuel injection system to determine the density of air inducted into the engine.

MBT – Minimum ignition timing for best torque.

MECHANICAL EFFICIENCY – In an engine, the ratio of delivered power, brake horsepower, and indicated horsepower or the power developed in the cylinders.

MECHANICAL PROPERTIES – Properties of a material that pertain to its elastic and plastic behavior when force is applied: yield strength, ultimate strength, elongation, hardness, etc.

METALLIC HOSE – A hose in which the strength of the hose depends primarily upon the strength of metallic parts; it may have metallic liners, covers or both.

METER (M) – The basic metric unit of length that is equivalent to 3.28 feet or 1.09 yards, or 39.37 inches.

METERING ROD AND JET – A device consisting of a small, movable, cone-shaped rod and a jet; increases or decreases fuel flow according to engine throttle opening, engine load, or a combination of both.

METHANOL – Methyl alcohol, CH3OH, the simplest of the alcohols. It has been used, together with some of the higher alcohols, as high-octane gasoline component and as an automotive fuel in its own right.

MIL – Malfunction indicator light.

MINIMUM ALLOWABLE WALL THICKNESS – Required by the specification under which the cylinder or tank was manufactured.

MILES PER HOUR (MPH) – A measure of speed expressed as the number of miles covered in one hour.

MILLIMETER – A unit of linear measure, approximately equal to 0.039 inch.

MISFIRE – In the engine, a failure to ignite the air-fuel mixture in one or more cylinders normally or without stalling the engine, usually caused by ignition failure or overly rich or lean air-fuel mixture.

MIXER – A device used in air-fuel systems to meter and combine the fuel with air into a near stoichiometric or lean burn mixture for introduction into the engine.

mm – Millimeter; a unit of linear measure, approximately equal to 0.039 inch.

MODE – Term used to designate a particular set of operating characteristics.

MODIFICATION – An alteration; a change from the original.

MOLECULE – The smallest particle of an element or compound that can exist in a free state and still retain the characteristic properties of the substance.

GLOSSARY

MOLECULAR STRUCTURE – In regard to hydrocarbons, the composition of hydrogen and oxygen molecules specific to each hydrocarbon.

MOLECULAR WEIGHT – Sum of the weights of atoms making up a molecule of a substance.

MON – Motor octane number; laboratory octane rating of a fuel established on a single-cylinder, variable- compression-ratio engine.

MONOLITHIC – Made as a single unit. In catalytic-converter construction, a substrate or supporting structure for the catalyst, made as a single unit (usually in the shape of a honeycomb), is monolithic; however, a coated- bead or pellet type catalytic converter is not monolithic.

MONOLITHIC TIMING – Making accurate spark-timing adjustments with an electronic timing device that can be used while the engine is running.

MOTOR OCTANE NUMBER (MON) – Laboratory octane rating of a fuel, established on single-cylinder variable-compression-ratio engine. A guide to anti-knock performance of a fuel under relatively severe driving conditions such as at full throttle when intake air temperature and engine speed are relatively high.

mph – Miles per hour; a unit of speed.

MPS – Multi-Port Sequential. Another name is sequential electronic fuel injection; where injectors are placed in the intake manifold upstream of the intake valve(s) of each cylinder and energized to deliver fuel at the exact moment in a precise quantity, determined by inputs to and calculations made by an electronic control unit, also know as multi-point sequential fuel injection.

MUFFLER – In the engine exhaust system, a device through which the exhaust gases must pass and which reduces the exhaust noise.

MULTIPLE-DISPLACEMENT ENGINE – An engine that can run either on all its cylinders, or for fuel economy, on a varying number of cylinders. An example is an eight-cylinder engine that can cut off the flow of fuel to four cylinders during idle causing the throttle to open and reduce engine pumping losses. As load and power are required, the engine switches to full cylinder operation.

MULTIPLE-VISCOSITY OIL – An engine oil that has a low viscosity during cold conditions for easier cranking and a higher viscosity during hot conditions to provide adequate engine lubrication. Also know as multi-grade oil, and oil that meets one or more relevant SAE viscosity standards.

MULTI-POR T ASYNCHRONOUS – Fuel injection systems that use individual injectors (one per cylinder) to introduce fuel at the intake valve.

MULTI-POR T SEQUENTIAL (MPS) – Fuel injection control systems that synchronize the injector opening with the opening of the intake valve on a cylinder-by-cylinder basis. See MPS.

NATIONAL FIRE PROTECTION AGENCY (NFPA) – Established in 1896, an association of industry professionals whose primary purpose is to develop and update standards covering all areas of fire safety.

NATURAL GAS – Mixtures of hydrocarbon gases and vapors consisting principally of methane in gaseous form. Other components might include small amounts of ethane, propane, butanes, nitrogen and carbon dioxide.

NATURALL Y ASPIRATED ENGINE – An engine in which the intake air entering the system is at atmospheric pressure.

NEEDLE VALVE – A small, tapered, needle-pointed valve that can move into or out of a valve seat to close or open the passage through the seat, used to control the carburetor float-bowl fuel level.

GLOSSARY

NEOPRENE – A synthetic rubber (chloroprene polymer) that is not affected by oils and solvents at moderate temperatures, resists compounds that harm natural rubber.

NITROGEN – A colorless, tasteless, odorless gas that constitutes 78 percent of the atmosphere by volume and 76 percent by weight; nitrogen is a part of all living tissues.

NITROGEN OXIDES (NO_x) – Any chemical compound of nitrogen and oxygen. Nitrogen oxides result from high temperature and pressure in the combustion chambers of automobile engines and other power plants during the combustion process. When combined with hydrocarbons in the presence of sunlight, nitrogen oxides form smog. A basic air pollutant, automotive exhaust-emission levels of nitrogen oxides are controlled by law.

NMHC – Non-Methane Hydrocarbons; total hydrocarbons excluding methane, which is considered as a non-reactive non-ozone creating hydrocarbon..

NMOG – Non-Methane Organic Gas; the sum of non-methane hydrocarbons and oxygenates, including aldehydes.

NO_x CONTROL SYSTEM – A device or system used to reduce the amount of NO_x produced by an engine.

NOBLE METALS – Metals (such as gold, silver, platinum, and palladium) that do not readily oxidize or enter into other chemical reactions but do promote reactions between other substances. Platinum and palladium are used as the catalysts in catalytic converters; silver and platinum are used in spark plug electrodes because they resist corrosion and conduct electricity well.

NON-METHANE HYDROCARBONS (NMHC) – Hydrocarbons other than methane (CH_4). Generally synonymous with “reactive hydrocarbons” – hydrocarbons that react in the atmosphere to create ozone.

NON-METHANE ORGANIC GAS (NMOG) – Non-methane hydrocarbons plus other organic chemicals, such as aldehydes and alcohols. NMOGs are not measured as hydrocarbons by present hydrocarbon test procedures.

NONCOMBUSTIBLE MATERIAL – A material which is used and under the conditions anticipated, will not ignite, burn, support combustion or release flammable vapors when subjected to fire or heat.

NON-REACTIVE HYDROCARBONS – Hydrocarbons that do not react in atmosphere to create ozone. Methane is a non-reactive hydrocarbon.

NOZZLE – The opening, or jet, through which fuel passes when it is discharged into the carburetor venturi.

NUCLEUS – The center of an atom; it has a positive charge.

OCTANE – A performance measurement of a fuels anti-knock characteristics.

OCTANE NUMBER – The number used to indicate the octane rating of a gasoline; the measure of anti-knock properties fuels used in spark ignition engines. The fuel tested is compared to iso-octane, which is given a value of 100.

OCTANE RATING – A measure of the antiknock properties of a gasoline. The higher the octane rating, the more resistant the fuel is to autoignition knock or detonation. Typically derived by the average of the Research and Motor Octane numbers.

OCTANE REQUIREMENT – The minimum-octane-number fuel required to enable a vehicle to operate without knocking.

ODORIZATION – A process of adding a distinctive odor to propane, LP-gas or natural gas to indicate the presence of the gas.

OEM – Original-equipment manufacturer.

OHM – A unit of electric resistance.

GLOSSARY

OHM'S LAW – This law explains the relationship of voltage, current, and resistance in a circuit. One volt of electrical pressure is needed to push one ampere of electrical current through one ohm of resistance (V = I x R).

OHMMETER – An instrument used to measure the number of ohms of resistance in an electric conductor or circuit.

OIL – A liquid lubricant; usually made from crude oil and used to provide lubrication between moving parts. In a diesel engine, a refined oil is used for fuel.

OIL PAN – The detachable lower part of the engine, made of sheet metal, that encloses the crankcase and acts an oil reservoir.

OIL PRESSURE – The pressure created by an oil pump and resistance to flow created by drillings and passages within the engine; typically measured in gauge pressure – the pressure above atmospheric.

OIL PRESSURE SWITCH -A switch that is turned on or off by oil pressure in the engine, used to operate warning lights or shut down devices such as a fuel lock-off or motor guard.

OLEFIN – An unsaturated hydrocarbon containing one or more double bonds.

OPEN LOOP – A system that does not use an oxygen sensor for ECM fuel control but refers to a lookup table in a ROM chip used to provide timing and fuel injection rates for engine operation; a fuel system that does not use electronic controls to determine ignition timing and fuel metering.

OPEN SYSTEM – A crankcase emission control system that draws air through the oil-filter cap and does not include a tube from the crankcase to the air cleaner.

ORIFICE – A small opening or hole into a cavity.

ORIFICE SPARK-ADVANCE CONTROL (OSAC) – A system used on some engines to aid in the control of NO_x; consists of a valve that delays the change in vacuum to the distributor vacuum-advance unit between idle and part throttle.

O-RING – A type of sealing ring – made of a special rubber-like material; in use, the O-ring is compressed into a groove to provide the sealing action.

OSCILLOSCOPE – A high-speed voltmeter that visually displays voltage variations on a television-type picture tube, used to check engine ignition systems, charging systems and electronic fuel-injection systems.

OTTO CYCLE – The cycle of events in a four-stroke-cycle engine. Named for the German inventor, Dr. Nikolaus Otto.

OVERHAUL – To completely disassemble a unit, clean and inspect all parts, reassemble it with the original or new parts and make all adjustments necessary for proper operation.

OVERHEAD-CAMSHAFT (OHC) ENGINE – An engine in which the camshaft is mounted over the cylinder head instead of inside the cylinder block.

OVERHEAD-VALVE (OHV) ENGINE – An engine in which the valves are mounted in the cylinder head above the combustion chamber instead of in the cylinder block; in this type of engine, the camshaft is usually mounted in the cylinder block, and the valves are actuated by pushrods.

OVERHEAT – To become excessively hot – above normal running temperatures.

OVERSQUARE – Term applied to an automotive engine in which the bore is larger than the stroke.

OXIDATION – Burning or combusting; the combining of material with oxygen. Rusting is slow oxidation, and combustion is rapid oxidation.

OXIDATION CATALYST – In a catalytic converter, a substance that promotes the combustion of exhaust-gas hydrocarbons and carbon monoxide at a lower temperature than combustion would ordinarily occur.

OXIDES OF NITROGEN (NO_x) – see Nitrogen Oxides.

OXYGEN – A colorless, tasteless, odorless, gaseous element that makes up about 21 percent of air by volume and 23 percent by weight. Capable of combining rapidly with all elements except inert gases in the oxidation process called burning. Combines very slowly with many metals in the oxidizing process called rusting.

OXYGEN SENSOR (O_2 SENSOR) – A sensor mounted in the vehicle exhaust near the catalytic converter that is used to provide input to the ECS in order to adjust the A/F mixture to stoichiometric. The output of the O_2 sensor is usually between .100 VDC and 1.0 VDC, with lower voltages indicating lean mixtures and higher voltages indicating rich mixtures.

OXYGEN SENSOR FEEDBACK FUEL CONTROL SYSTEM – A system that depends on an oxygen sensor to provide data to an ECM, signalling the presence or absence of oxygen in the exhaust stream. This information is used along with other sensor inputs and algorithms to calculate fuel metering and update data for short and long term computer memory.

OXYGENATE, OXYGENATED COMPOUND – Terms that have come to mean compounds of hydrogen, carbon and oxygen that can be added to gasoline to boost octane quality or to extend the volume of fuel available; alcohol based fuels.

OZONE – A radical oxygen molecule, O_3, found in the upper atmosphere that filters out ultraviolet solar radiation. Ground level ozone is man-made and formed by the reaction of NO_x and NMOGs in the presence of sunlight and is commonly referred to as smog.

PARADE PATTERN – An oscilloscope pattern showing the ignition voltages on one line, from left to right, across the scope screen in engine firing order.

PARALLEL CIRCUIT – The electric circuit formed when two or more electric devices have their terminals connected together, positive to positive and negative to negative, so that each may operate independently of the other from the same power source.

PARTICLE – A very small piece of metal, dirt or other impurity that may be contained in the air, fuel or lubricating oil used in an engine.

PARTICULATES – Solid particles in engine exhaust, mainly carbon (soot) and partially burned hydrocarbons.

PASSAGE – A small hole or gallery in an assembly or casting through which air, coolant, fuel or oil flows.

PCM – Power control module.

PCV – Positive crankcase ventilation.

PCV VALVE – The valve that controls the flow of crankcase vapors calibrated to vent dependant on different engine speeds and loads.

PERCOLATION – The condition in which a carburetor bowl vent fails to open when the engine is turned off and pressure in the fuel bowl forces raw fuel through the main jets into the manifold.

PETROLEUM – The crude oil from which gasoline, lubricating oil and other such products are refined and produced.

PHOTOCHEMICAL SMOG – Smog caused by hydrocarbons and nitrogen oxides reacting photochemically in the atmosphere. The reactions take place under low wind velocity, bright sunlight and an inversion layer in which the air mass is trapped (as between the ocean and mountains in Los Angeles). Can cause eye and lung irritation.

PHOTOCHEMICALLY REACTIVE – Said hydrocarbons such as NMOGs that react in the atmosphere causing Photochemical Smog.

GLOSSARY

PHYSICAL PROPERTIES – Those properties other than mechanical properties that characterize a material.

PISTON – A movable part, fitted to a cylinder, that can receive or transmit motion as a result of pressure changes in a fluid. In the engine, the cylindrical part that moves up and down within a cylinder as the crankshaft rotates, usually in the form of a cylinder.

PISTON DISPLACEMENT – The cylinder volume displaced by the piston as it moves from the bottom to the top of the cylinder during one complete stroke.

PISTON RINGS – Rings fitted into grooves in the piston. There are two types: compression rings for sealing the compression in the combustion chamber and oil rings to scrape excess oil off the cylinder wall.

POINT OF TRANSFER – The point where the fueling connection is made.

POLARITY – The condition in an electric component or circuit that determines the direction of current flow.

POLLUTANT – Any substance that adds to the contamination of the atmosphere. In a vehicle, any substance in the exhaust gas from the engine or evaporating from the fuel tank or carburetor that is harmful to the environment or human life.

POLLUTION – Any gas or substance in the air that makes it less fit to breathe; or in the water or soil that diminishes the ability for that substance to sustain life. Noise pollution is the name applied to excessive noise from machinery or vehicles; visual pollution refers to unsightly obstacles and lights installed for the benefit of automotive operations.

POLYNUCLEAR AROMATIC HYDROCARBONS (PAH) – Any of a class of organic compounds containing two or more aromatic rings. Many four- and five-ring compounds are known to be potent carcinogens or mutagens.

POLYURETHANE – A synthetic substance used in filtration materials, normally associated with the filtering of carburetor inlet air.

POP-BACK – Condition in which the air-fuel mixture is ignited in the intake manifold. Because combustion takes place outside the combustion chamber or in the combustion chamber when the intake valve is open, the combustion pops back through the carburetor.

PORT – In the engine, the opening in which the valve operates and through which the air-fuel mixture or burned gases pass – the valve port.

PORT FUEL INJECTION – Fuel injectors that inject into the intake port rather than directly into the cylinders. They can be electronically or mechanically operated.

PORTED VACUUM SWITCH – A water-temperature-sensing vacuum control valve used in distributor and EGR vacuum circuits (sometimes called vacuum control valve or coolant override valve).

POSITIVE CRANKCASE VENTILATION (PCV) – Crankcase ventilation system; uses intake-manifold vacuum to return the crankcase vapors and blow-by gases from the crankcase to the intake manifold to be burned, thereby preventing their escape into the atmosphere.

POWER OUTPUT – Power developed by an engine, normally qualified by the means of measurement or test specification and other parameters affecting operation.

POWER PISTON – In some carburetors, a vacuum-operated piston that allows additional fuel to flow at wide-open throttle; permits delivery of a richer air-fuel mixture to the engine.

POWER PLANT – The engine or power source of a vehicle.

POWER STROKE – The piston stroke from TDC to BDC immediately following the compression stroke, during which both valves are closed and air-fuel mixture burns, expands, and forces the piston down to transmit power to the crankshaft.

PPM – Parts per million; the unit used in measuring the level of hydrocarbons in exhaust gas with an exhaust-gas analyzer.

PRECOMBUSTION CHAMBER – In some diesel engines, a separate small combustion chamber into which the fuel is injected and where combustion begins.

PREFLAME REACTION – The chemical reaction that takes place in an air-fuel mixture prior to ignition.

PREIGNITION – Ignition of the air-fuel mixture in the combustion chamber by any means, before the ignition spark occurs, caused by surface ignition or autoignition. See Surface Ignition and Autoignition.

PREMIUM GASOLINE – The best of highest-octane gasoline available to the motorist.

PRESSURE – Force per unit area or force divided by area, usually measured in pounds per square inch (psi) and kilograms per square centimeter (kg/cm^2); force that is a result of the weight of a substance over a given area that the substance occupies.

PRESSURE DIFFERENTIAL – The difference between two pressures, generally with reference to atmospheric pressure as one of the two.

PRESSURE RELIEF DEVICE – Unit designed to prevent rupture from excessive internal pressure in a normally charged cylinder. Such devices include rupture disks, fusible plugs, combination rupture disks-fusible plugs, and pressure relief valves. The term pressure relief device is synonymous with safety relief device as used by the DOT and CTC regulations.

PRESSURE TRANSDUCER – A sensor that converts pressure readings to electrical signals.

PRESSURE VESSEL – A container or other component designed in accordance with the ASME Pressure Vessel Code.

PRESSURIZE – To apply more than atmospheric pressure to gas or liquid.

PREVENTIVE MAINTENANCE – The systematic inspection of a vehicle to detect and correct failures, either before they occur or before they develop into major defects. A procedure for economically maintaining vehicles in a satisfactory and dependable operating condition.

PRIMARY – The low-voltage circuit of the ignition system.

PRIMARY REGULATOR – A regulator in CNG systems that reduces the pressure of CNG coming from the cylinder to around 100 psig.

PRIMARY VOLTAGE – The voltage or electrical potential in the low voltage side of the ignition coil, typically battery voltage or slightly below. Part of a circuit that connects to the battery, used to energize and collapse the ignition coil controlling secondary ignition output.

PRIMARY WINDING – The outer winding in an ignition coil.

PRINTED CIRCUIT – An electric circuit path made by applying a conductive material to an insulating board in a pattern that provides electric circuits between components mounted on or connected to the board.

PROCO – Programmed combustion – a research type of stratified-charge engine.

PROGRAMMABLE READ ONLY MEMORY (PROM) – A computer memory chip that can be programmed once to store the computer's program. An electronic term used to describe the engine calibration unit.

PROGRAMMED PROTECTION SYSTEM – In a catalytic converter, a system employing bypass valves to protect the catalysts and their containers from destructive over temperature conditions that might result from certain modes of operation or engine malfunctions.

PROGRESSIVE LINKAGE – A carburetor linkage used with multiple-carburetor installations to progressively open the secondary carburetors.

PROM – Programmable Read Only Memory.

PROPANE – A component of LPG that is liquid below -44°F [-42° C] at atmospheric pressure.

PROTON – A particle in the nucleus of an atom; protons have a positive electric charge.

PSI – Pounds per square inch; a unit of pressure.

PSIA – Pounds per square inch as read on a gauge with atmospheric pressure as the base.

PSIG – Pounds per square inch as read on a gauge.

PULLEY – A metal wheel with a V-shaped groove around the rim that drives or is driven by a belt.

PUMP – A device that develops pressure or transfers gas or liquid from one place to another.

PUSHROD – In an overhead-valve engine, the rod between the valve lifter and the rocker arm that transmits cam-lobe lift.

PVS – Ported vacuum switch.

QUAD CARBURETOR – A four-barrel carburetor.

QUENCH – The removal of heat during combustion from the end gas or outside layers of air-fuel mixture by the cooler metallic surfaces of the combustion chamber, thus reducing the tendency for detonation to occur.

QUENCH AREA – The area of the combustion chamber near the cylinder walls that tends to cool (quench) combustion through the effect of the nearby cool water jackets.

RADIATOR – In the cooling system, the device that removes heat from coolant passing through it; the radiator takes hot coolant from the engine and returns the coolant to the engine at a lower temperature.

RADIATOR PRESSURE CAP – A type of cap placed on the radiator filler tube that seals and pressurizes the cooling system for more efficient operation – vapor from the coolant raises system pressure and the boiling temperature of the coolant.

RAM-AIR CLEANER – An air cleaner for high-performance engines that opens an air scoop on the hood, to provide a ram effect, when the throttle is wide open.

RASTER PATTERN – An oscilloscope pattern showing the secondary ignition voltages one above the other, arranged on the screen in the engine's firing order.

RATIO – Proportion; the relative amounts of two or more substances in a mixture such as air to fuel or volumes such as a piston at BDC compared to TDC. Usually expressed as a numerical relationship, as in 2:1.

RATIO OF COMPRESSION – Ratio of the absolute discharge pressure to absolute suction pressure as in a gas compressor. (200 PSIG suction to 500 PSIG discharge = 514.7 = 2.4 compression ratio).

REACTIVITY – The tendency of any HC emission to form ozone in the presence of NO_x. For any given mass of HCs, the reactivity increases with the molecular weight of the HC compounds.

REACTIVE HYDROCARBONS – Hydrocarbons that react with NO_x in the atmosphere to produce ozone. Generally considered to include all hydrocarbons except methane.

REACTIVE ORGANIC GAS (ROG) – Reactive hydrocarbons plus organic chemicals such as aldehydes and alcohols that are not measured as hydrocarbons by present test procedures; generally synonymous with NMOG.

RC ENGINE – Rotary-combustion engine – also known as Wankel engine.

RECIPROCATING COMPRESSOR – The reciprocating compressor is one in which rotary motion of the crankshaft effects a horizontal or vertical movement to the piston through a connecting rod, guided crosshead and piston rod.

GLOSSARY

REDUCTION CATALYST – A catalytic converter that operates at an air deficiency, used to reduce NO_x emissions separate from the oxidation catalyst or in the same housing as a dual bed catalyst.

REFORMULATED GASOLINE – Fuel containing: a minimum average of 2% by weight oxygen, a maximum average of 1% by volume benzene, no more than an average of 25% aromatic hydrocarbons and no lead.

REFRACTOMETER – An instrument that measures specific gravity of a liquid, such as battery electrolyte or engine coolant, which gives a reading already adjusted for the temperature of the liquid being tested.

REFUELING SYSTEM – A system of tanks, containers, cylinders, pressure vessels, compression or transfer equipment, buildings and structures and associated equipment used for storage and dispensing of LP-gas or compressed natural gas as an engine fuel in vehicle operations.

REGULATOR – A device that controls generator output to prevent excessive voltage or excessive current output or excessive air-gas pressure.

RELAY – An electrical device that opens or closes a circuit or circuits in response to a voltage signal.

RELIEF PORT – An opening, typically to atmosphere, that vents a higher pressure gas or liquid to atmosphere or into a reservoir.

RELIEF VALVE – A valve that opens when a preset pressure is reached. This relieves or prevents excessive pressures such as in an LPG fuel tank.

RELUCTOR – In an electronic ignition system, the metal rotor (with a series of tips) that replaces the conventional distributor cam.

REMOTE FILL CONNECTION – A filler valve that is piped and mounted away from the fuel tank along with the 80 percent valve – often enclosed in a box, integral with the body of the vehicle.

REMOTE RELIEF VALVE – A pressure relief valve that is piped away from the fuel tank and fitted with a breakaway device that is typically integral with the pressure relief valve but not interfering with its operation.

REMOVE AND REINSTALL (R&R) – To perform a series of servicing procedures on an original part or assembly, including removal, inspection, lubrication, all necessary adjustments and reinstallation.

REPLACE – To remove a used part or assembly and install a new part or assembly in its place, including cleaning, lubricating and adjusting as required.

REQUIRED VOLTAGE – The voltage required to fire a spark plug.

RESEARCH OCTANE NUMBER (RON) – A number used to describe the octane rating of fuel used in spark ignition engines; a guide to anti-knock performance of a fuel under mild driving conditions.

RESISTANCE – The opposition to the flow of current through an electric circuit or device measured in ohms. One volt will cause 1 ampere to flow through a resistance of 1 ohm. This is known as Ohm s law, which can be written in three ways: amperes = volts/ohms; ohms = volts/amperes; and volts = amperes x ohms.

RESONATOR – A device in the exhaust system that reduces the exhaust noise; an acoustic chamber with a specific resonant frequency.

RETARD – Usually associated with the spark-timing mechanisms of the engine or delay of the introduction of the spark into the combustion chamber – the opposite of spark advance.

RETROACTIVE – Having application to or effect on things prior to its enactment; going into effect as of a specified date in the past.

GLOSSARY

REVOLUTIONS PER MINUTE (RPM) – A measure of rotational engine speed.

RICH MIXTURE – An air-fuel mixture that has a relatively high proportion of fuel and a relatively low proportion of air. An air-fuel ratio of 13:1 indicates a rich mixture, compared to an air-fuel ratio of 16:1.

RING GAP – The gap between the ends of a piston ring when the ring is in place in the cylinder.

RING RIDGE – The ridge left at the top of a cylinder as the cylinder wall below is worn away by piston-ring movement.

ROAD CLEARANCE – The distance between the lowest point on a vehicle and the road.

ROAD-DRAFT TUBE – A method of scavenging the engine crankcase of fumes and pressure, used prior to the introduction of crankcase emission control systems.

ROAD LOAD – A constant vehicle speed on a level road.

ROG – Reactive Organic Gas.

RON – Research octane number; a number used to describe the octane rating of gasoline.

ROOM TEMPERA TURE – By common definition: 68° to 72° F [20° to 22° C].

ROTAR Y – Term describing the motion of a part that continually turns.

ROTOR – A revolving part of a machine, such as an alternator rotor, diskbrake rotor, distributor rotor or Wankel-engine rotor; a component or assembly that rotates about its own axis.

RPM – Revolutions per minute – a measure of rotational speed.

SA – Designation for lubricating oil that is acceptable for use in engines operated under the mildest conditions.

SAE – Society of Automotive Engineers, used to indicate a grade or weight of oil measured according to the SAE.

SAG – A momentary decrease in acceleration rate: does not occur immediately after throttle application (as in a hesitation), but after the vehicle has acquired some speed.

SB – Designation for lubricating oil that is acceptable for minimum-duty engines operated under mild conditions.

SC – Designation for lubricating oil that meets requirements for use in the gasoline engines in 1964 to 1967 passenger cars and trucks.

SCAN TOOL – A hand held tester used to recall trouble codes and to monitor sensor and actuator operation in a computerized engine control system – often capable of performing additional diagnostic test functions.

SCAVENGING – The displacement of exhaust gas from the combustion chamber by fresh air.

SCF – Standard Cubic Feet.

SD – Designation for lubricating oil that meets requirements for use in the gasoline engines in 1968 to 1971 passenger cars and some trucks.

SDV – Spark delay valve; a calibrated restrictor in the vacuum-advance hose that delays the vacuum spark advance.

SE – Designation for lubricating oil that meets requirements for use in the gasoline engines in 1972 and later cars and certain 1971 passenger cars and trucks.

SEAL – A part or material that is used to close off the area of contact between two machine parts, usually to prevent oil leakage.

SEAT – The surface upon which another part rests, as a valve seat; also, to wear into a good fit such as to seat new piston rings after a short period of operation.

GLOSSARY

SECONDARY AIR INJECTION – Air that is pumped to thermal reactors, catalytic converters, exhaust manifolds or the cylinder-head exhaust ports to promote the chemical reactions that reduce exhaust-gas pollutants.

SECONDARY AVAILABLE VOLTAGE – The voltage that is provided by the ignition coil or transformer that is available to be delivered to fire the spark plug(s).

SECONDARY CIRCUIT – The high-voltage circuit (the coil, rotor, distributor cap, spark plug and cables) of the ignition system.

SECONDARY IGNITION VOLTAGE SPARK – The electrical energy produced by the collapse of primary circuit current in the ignition coil that fires the spark plug(s) and ignites the combustible charge; the energy needed to ionize the electrode gap of the spark plug.

SEQUENTIAL INJECTION TIMING – Each injector pulse is phased in relation to intake valve opening.

SERIES CIRCUIT – An electric circuit in which the same current flows through all devices; positive terminals are connected to negative terminals.

SERIES-PARALLEL SYSTEM – A special starting system using, for example, a 24-volt starting motor, two 12-volt batteries and a 12-volt alternator. For starting, the two batteries are connected in series for 24 volts; for charging, the batteries are connected in parallel for 12 volts.

SERVICE PRESSURE – The settled pressure at a uniform gas temperature of 70°F (21°C) and full gas content. It is the pressure for which the equipment has been constructed, under normal conditions.

SERVICE VALVE – A valve operated by hand connected directly to the outlet of a container.

SHALL – Indicates a mandatory requirement with no deviation.

SHORT CIRCUIT – A defect in an electric circuit that permits current to take a short path, or circuit, instead of following the desired path.

SHOULD – Indicates a recommendation or that which is advised but not required.

SHROUD – A hood placed around an engine fan to improve fan action.

SHUNT – A parallel connection or circuit.

SIG RTN – Signal return from sensor to PCM.

SINGLE-OVERHEAD-CAMSHAFT (SOHC) ENGINE – An engine in which a single camshaft is mounted over each cylinder head instead of inside the cylinder block.

SKID VESSEL – A pressure vessel equipped with skids or feet used for transporting or storing a product, or a pressure vessel equipped with lugs to which skids shall be attached when used for transporting a product.

SLANT ENGINE – An in-line engine in which the cylinder block is tilted from the vertical plane.

SLOW-FILL – A type of refueling in which the cylinders are filled slowly over a period of hours. Since the compressed natural gas in the vehicle cylinder(s) has time to cool during the refueling process, the vehicle cylinder(s) can be filled more completely than with fast-fill refueling.

SLUDGE – Accumulation of water, dirt, and oil in the oil pan; sludge is very viscous and tends to reduce lubrication.

SMOG – A term coined from the words smoke and fog. First applied to the foglike layer that hangs in the air under certain atmospheric conditions; now generally used to describe any condition of dirty air, fumes or smoke. Smog is compounded from smoke, moisture and numerous chemicals that are produced by combustion.

GLOSSARY

SMOKE – Small gasborne or airborne particles, exclusive of water vapor, that result from combustion – particles emitted by an engine into the atmosphere in sufficient quantity to be observable.

SMOKE IN EXHAUST – A visible blue or black substance often present in automotive exhaust. In a spark ignition engine, blue colored smoke indicates excessive oil in the combustion chamber; black smoke indicates excessive fuel in the air-fuel mixture; white smoke might indicate coolant steam.

SOHC – Single-overhead-camshaft engine.

SOLENOID – An electromechanical device that, when connected to an electrical source such as a battery, produces a mechanical movement. This movement can be used to control a valve or to produce other movements.

SOLENOID SWITCH – A switch that is opened and closed electromagnetically by the movement of a solenoid core: the core also causes a mechanical action, such as the movement of a drive pinion into mesh with flywheel teeth for cranking.

SOLID-STATE REGULATOR – A regulator encapsulated in a plastic material and mounted in the alternator.

SOURCES OF IGNITION – Devices that, because of their modes of use or operation, are capable of providing sufficient thermal energy to ignite flammable gas-air mixtures when introduced into such a mixture or when such a mixture comes into contact with them.

SPARK DECEL VALVE – A vacuum-actuated valve, located between the carburetor and distributor, that advances the spark during deceleration to reduce emissions (should not be confused with the spark-delay valve).

SPARK DELAY VALVE – A calibrated restrictor in the vacuum advance hose that delays the vacuum spark advance.

SPARK DURATION – The length of time a spark is established across a spark gap, or the length of time current flows in a spark gap.

SPARK LINE – Part of the oscilloscope pattern of the ignition secondary circuit; the spark line shows the voltage required to sustain the spark at the spark plug and the number of distributor degrees through which the spark exists.

SPARK PLUG – A device that screws into the cylinder head of an engine and provides a spark to ignite the compressed air-fuel mixture in the combustion chamber.

SPARK-PLUG HEAT RANGE – The distance heat must travel from the center electrode to reach to outer shell of the spark plug and enter the cylinder head; a comparative number that indicates the thermal loading capacity of the spark plug – specified for an engine accounting for extreme conditions and long plug life.

SPARK TEST – A quick check of the ignition system; made by grounding a spark-plug tester that is connected to the end of a spark-plug cable and cranking the engine to check the presence and intensity of a spark.

SPECIFICATIONS – Information provided by the manufacturer, describing systems and their components, operations and clearances; the service procedures that must be followed for a system to operate properly.

SPECIFIC GRAVITY – For gases, the ratio of the density of a gas to the density of air. For liquids, the ratio of the density of the liquid to the density of water.

SPECIFIC HEAT – The amount of heat required to raise the temperature of a substance one degree. An example of this follows: One calorie will raise the temperature of one gram of water one degree centigrade, but the same one calorie will raise the temperature of one gram of iron ten degrees centigrade. This means that all solids and liquids that weigh the same will rise to different temperatures given the same heat input. Also see BTU.

GLOSSARY

SPEED – The rate of motion; for vehicles, measured in miles per hour or kilometers per hour.

SPEED DENSITY – A computer control fuel management system used to calculate the mass of air drawn into a cylinder, using displacement of the engine, volumetric efficiency of the engine (dependent of engine speed), manifold absolute pressure and a mathematical constant.

SPRAY BAR – A device used to deliver fuel, ususally under pressure, to the air inlet of the engine.

SQUARE ENGINE – An engine in which the cylinder bore and stroke are equal.

SQUISH – The action in some combustion chambers in which the last part of the compressed air-fuel mixture is pushed, or squirted, out of a decreasing space between the piston and cylinder head.

STANDARD CONDITIONS – 60^o F (520^o R) and 14.7 psia (sea level) whether for gases or liquids.

STIRLING ENGINE – A type of external combustion engine in which the piston is moved by changes in the pressure of a working gas that is alternately heated and cooled.

STOICHIOMETRIC – A chemically perfect combustion of fuel and air in an engine (the only products of combustion are water and carbon dioxide).

STOICHIOMETRIC AIR-FUEL RATIO – The exact air-fuel ratio required to completely combust a fuel to water and carbon dioxide.

STRATIFIED CHARGE – In a gasoline-fueled spark-ignition engine, an air-fuel charge with a small layer of very rich air-fuel mixture; the rich layer is ignited first, after which ignition spreads to the leaner mixture filling the rest of the combustion chamber. The diesel engine is a stratified-charge engine.

STROKE – In an engine cylinder, the distance that the piston moves in traveling from BDC to TDC or from TDC to BDC.

STUMBLE – A condition related to vehicle driveability; the tendency of an engine to falter and then catch, resulting in a noticeable hesitation felt by the driver — a momentary abrupt deceleration during an acceleration.

SUBSTRATE – In a catalytic converter, the supporting structure to which the catalyst is applied, usually made of ceramic material. Two types of substrate used in catalytic converters are the monolithic or one-piece substrate and the bead or pellet-type substrate.

SULFUR OXIDES – Sulfur compounds that can form in small amounts as the result of a reaction between hot exhaust gas and the catalyst in a catalytic converter. These compounds become acids in the presence of water droplets such as fog or rain.

SUPERCHARGER – In the intake system of the engine, a mechanical device, usually belt/pulley driven, that pressurizes the ingoing air-fuel mixture. This increases the density of the mixture delivered to the cylinders and increases engine output and efficiency. If the supercharger is driven by engine exhaust gas, it is called a turbocharger.

SUPERIMPOSED PATTERN – On an oscilloscope, a pattern showing the ignition voltages one on top of the other so only a single trace, and variations from it, can be seen.

SUPPLY LINE – The pipe, tubing or hose, including all related fittings, on a vehicle through which natural gas or liquefied petroleum gas passes.

SURFACE IGNITION – Ignition of the air-fuel mixture in the combustion chamber by a hot surface rather than by spark. See Preignition.

SURGE – Condition in which the engine speed increases and decreases slightly (but perceptibly) although the driver has not changed the throttle position.

S/V RATIO – The ratio of the surface area S of the combustion chamber to its volume V, with the piston at TDC. Often used as a comparative indicator of hydrocarbon emission levels from an engine.

SWITCH – A device that opens and closes an electric circuit.

TACHOMETER – A device for measuring engine speed, or revolutions per minute.

TANK PRESSURE – The pressure at which the fuel in the tank is maintained; tank pressure will vary with temperature and volume.

TANK TRUCK – A container installed on a truck, trailer or semi-trailer for shipping a product over a highway.

TBI – Throttle Body Injection.

TCS – Transmission-controlled spark system.

TDC (TOP DEAD CENTER) – The piston position when the piston has reached the upper limit of its travel in the cylinder and the centerline of the connecting rod is parallel to the cylinder walls.

TEL – Tetraethyl lead; a chemical that, when added to engine fuel, increases the fuel's octane rating or reduces its tendency to detonate and provides lubrication.

TEMPERA TURE GAUGE – A gauge that indicates the temperature of the coolant in the engine cooling system.

TETRAETHYL LEAD – A chemical that, when added to engine fuel, increases its octane rating.

THERM – 100,000 BTUs of natural gas.

THERMAL – Of or pertaining to heat.

THERMAL-CONDUCTIVITY GAS ANALYZER – The conventional exhaust-gas analyzer, used in service shops for many years to check and adjust the carburetor air-fuel mixtures.

THERMAL EFFICIENCY – Ratio of the energy output of an engine to the energy in the fuel required to produce that output; the ratio of work done by a heat engine to the mechanical equivalent.

THERMAL EXP ANSION – The increase in volume of the working fluid in an engine cylinder caused by combustion or external heat; the increase in one or more dimensions of a body caused by a rise in temperature.

THERMAL REACTOR – A large exhaust manifold in which unburned exhaust-gas hydrocarbons and carbon monoxide react with oxygen so that the pollutants burn up almost completely. It is simple and durable but must operate at very high temperatures.

THERMOST AT – A device for the automatic regulation of temperature, usually contains a temperature-sensitive element that expands or contracts to open or close off the flow of air, a gas or a liquid.

THERMOST ATIC VACUUM SWITCH – Temperature-sensing device screwed into the coolant system that connects full manifold vacuum to the distributor when its critical temperature is reached. The spark advance that results causes an increase in engine RPM, which cools the engine.

THERMOST ATICALL Y CONTROLLED AIR CLEANER – An air cleaner in which a thermostat controls the preheating of intake air.

THREE-MODE CYCLE – A quick test procedure used over the past several years to study the causes of high emissions and to compare different types of testers; consists of taking readings at idle speed and at 2,000 RPM and maximum readings on deceleration. The test can be performed on a dynamometer under load or in a service area without load.

THREE-BED CAT ALYST – A catalytic converter used with closed loop, lambda control fuel management systems; a catalyst that is capable of reducing the three principle pollutants in automotive exhaust — CO, HC and NO_x.

THREE WAY CATALYTIC CONVERTER (TWC) – A catalytic converter that uses platinum, rhodium, and palladium to reduce vehicle emissions. Three-way catalysts require mixtures extremely close to stoichiometric (lambda) for effective conversion of NO_x.

THROAT – Performance term for a carburetor venturi.

THROTTLE – A disk valve in the carburetor base that pivots in response to accelerator-pedal position – allows the driver to regulate the weight of air-fuel mixture entering the intake manifold, thereby controlling the engine speed.

THROTTLE BODY INJECTION (TBI) – A single port injection system that injects all the fuel into the air stream upstream of the throttle plates.

THROTTLE PLATE – A device in a spark ignition engine that controls the weight of air introduced to the engine.

THROTTLE POSITION SENSOR (TPS) – A device that is connected to the engine throttle plate shaft to signal load demands by the vehicle operator to the ECS. TPS input is used in the calculation of fuel rate and ignition spark timing.

THROTTLE SOLENOID POSITIONER – An electric solenoid that holds the throttle plate open (hot idle position) but also permits the throttle plate to close completely when the ignition is turned off, to prevent engine run on.

TIMING – In an engine, delivery of the ignition spark or operation of the valves (in relation to the piston position) for the power stroke. See Ignition Timing and Valve Timing.

TIMING LIGHT – A light that can be connected to the ignition system to flash each time the No. 1 spark plug fires; used for adjusting the timing of the ignition spark.

TOP DEAD CENTER (TDC) – The piston position when the piston has reached the upper limit of its travel in the cylinder, and the center line of the connecting rod is parallel to the cylinder walls.

TORQUE – Turning or twisting effort, usually measured in pound-feet or kilogram-meters. Also, a turning force such as that required to tighten a connection.

TORQUE WRENCH – A wrench that indicates the amount of torque being applied with the wrench.

TOTAL HYDROCARBONS – All hydrocarbons emitted from the engine. Reactive hydrocarbons are the portion of total hydrocarbons that react to create ozone. Methane is non-reactive but one of the total hydrocarbons measured.

TPS – Throttle Position Sensor.

TRANSDUCER – Any device that converts an input signal of one form into an output signal of a different form (the automobile horn converts an electric signal to sound).

TRANSFER SYSTEM – All piping, fittings, valves and equipment utilized in dispensing CNG or LPG between containers.

TRANSISTOR – An electronic device can be used as an electric switch, used to replace the contact points in electronic ignition systems.

TRANSMISSION-CONTROLLED SPARK (TCS) SYSTEM – A NO_x exhaust-emission control system that makes use of the transmission-gear position to allow distributor vacuum advance in high gear only.

TRANSMISSION-REGULATED SPARK (TRS) SYSTEM – An exhaust-emission control system, similar to transmission-controlled spark system, that allows distributor vacuum advance in high gear only.

TRANSPOR TATION VESSEL – A container installed on a truck, trailer or semitrailer for shipping a product over a highway and governed by U.S. DOT regulations.

TROUBLE CODES – The formation of electronic pulses that indicate abnormal conditions of an engine control system that is equipped for self-diagnosis.

TRS – Transmission-regulated spark system.

TUNEUP – A procedure for inspecting, testing and adjusting an engine; replacing worn parts and restoring an the engine to its best performance.

TURBOCHARGER – A supercharger driven by the engine exhaust gas pressure, for pressurizing the intake air or air-fuel charge of an engine to increase the density of the mixture delivered to the cylinders and increasing power output.

TURBULENCE – In the engine, the rapid swirling motion upon the working fluid (combustible mixture), created by features in the piston or cylinder head and activated by the rising motion of the piston.

TVS – Thermostatic vacuum switch.

TWC – Three-Way Catalytic Converter.

TWO-BARREL CARBURETOR – A carburetor with two throttle valves.

TWO-STROKE CYCLE – The two piston strokes during which fuel intake, compression, combustion, and exhaust take place in a two-stroke-cycle engine.

ULEV – Ultra Low Emissions Vehicle.

UNBURNED HYDROCARBONS – Hydrocarbons that are not burned during the combustion process; unburned HC are considered pollutants.

UNIT DISTRIBUTOR – An ignition distributor that uses a magnetic pickup coil and timer core instead of points and a condenser; the ignition coil is assembled into the distributor as a unit.

UNLEADED GASOLINE – Gasoline to which no lead compounds have been intentionally added. Gasoline that contains 0.05g or less of lead per gallon; required by law to be used in 1975 and later vehicles equipped with catalytic converters.

UNLOADER – A device linked to the throttle valve; opens the choke valve when the throttle is moved to the wide-open position.

UPPER EXPLOSIVE LIMIT (UEL) – The point above which the air-fuel mixture is too rich to burn.

VACUUM – Negative gauge pressure or a pressure less than atmospheric pressure. Vacuum can be measured in psi but is usually measured in inches or millimeters of mercury (Hg); a reading of 30 in Hg [762 mm Hg] would indicate a perfect vacuum. A poor way of describing manifold pressure below atmospheric.

VACUUM ADVANCE – The advancing (or retarding) of ignition timing by changes in intake-manifold vacuum, which reflect throttle opening and engine load. Also, a mechanism on the ignition distributor that uses intake-manifold vacuum to advance the timing of the spark to the spark plugs.

VACUUM-ADVANCE CONTROL – Any type of NO_x emission control system designed to allow vacuum advance only during certain modes of engine and vehicle operation.

VACUUM-ADVANCE SOLENOID – An electrically operated two-position valve that passes or blocks intake-manifold vacuum to the distributor vacuum-advance unit.

VACUUM-CONTROL TEMPERATURE-SENSING V ALVE – A valve that connects manifold vacuum to the distributor advance mechanism under hot-idle conditions.

VACUUM DELAY VALVE (VDV) – A mechanically operated two-position switch that controls the flow of vacuum from the intake manifold to the vacuum advance unit.

GLOSSARY

VACUUM GAUGE – In automotive-engine service, a device that measures intake-manifold vacuum and thereby indicates actions of engine components.

VACUUM LEAK – A negative pressure leak in a componant such as the intake manifold or hose that, when properly fuctioning, seals pressure lower than atmospheric. Vacuum leaks are most noticable at idle when manifold pressure is lowest and vacuum is highest.

VACUUM LIFT – The use of intake manifold vacuum, controlled by a vacuum control solenoid (VCS), to raise the air/gas valve assembly for gasoline operation on carbureted and feedback-carbureted dual fuel applications.

VACUUM MOTOR – A small motor, powered by intake-manifold vacuum, used to raise and lower headlight doors, for example.

VACUUM SWITCH – A switch that closes or opens its contacts in response to changing vacuum conditions.

VALVE – A device that can be opened or closed to allow or stop the flow of a liquid or gas.

VALVE OVERLAP – The number of degrees of crankshaft rotation during which the intake and exhaust valves are open together.

VALVE SEAT – The surface against which a valve comes to rest to provide a seal against leakage.

VALVE-SEAT RECESSION – The tendency for valves (in engines that run on unleaded gasoline) to contact the seat in such a way that the seat wears away, or recesses, into the cylinder head.

VALVE TIMING – The timing of the opening and closing of the valves in relation to the piston position.

VANE – Flat, extended surface that is moved around an axis by or in a fluid – part of the internal revolving portion of an air-supply pump.

VAPOR – A gas – any substance in the gaseous state, as distinguished from the liquid or solid state.

VAPOR BARRIER – A sealing device, such as an enclosed container, that isolates a fuel storage area from the passenger compartment.

VAPOR DENSITY – Weight of gaseous fuels in relation to air.

VAPORIZATION – A change of state from liquid to gas by evaporation or boiling — a general term including both evaporation and boiling.

VAPOR-LIQUID SEPARATOR – A device in the evaporative emission control system that prevents liquid gasoline from traveling to the engine through the charcoal-canister vapor line.

VAPOR LOCK – A condition in the fuel system in which gasoline vaporizes in the fuel line or fuel pump – bubbles of gasoline vapor restrict or prevent fuel delivery to the carburetor.

VAPOR-RECOVERY SYSTEM – An evaporative emission control system that recovers gasoline vapor escaping from the fuel tank and carburetor float bowl.

VAPORIZER-REGULATOR – A device that both converts liquid LPG into vapor and reduces its pressure for delivery to an air-fuel mixer.

VDC – Volts Direct Current.

VDV – Vacuum-delay valve.

VENT – An opening through which air can leave an enclosed chamber.

VENTILATION – The circulating of fresh air through any space to replace impure air – the basis of crankcase ventilation systems.

GLOSSARY

VENTURI – In the carburetor, a narrowed passageway or restriction that increases the velocity of air moving through it, producing the drop in pressure that is responsible for the discharge of gasoline from the fuel nozzle or the movement of diaphram and gas valve in a variable venturi mixer.

VENTURI VACUUM – The vacuum pressure signal created by the pressure drop of intake air passing through the venturi causing the opening of the mixer air valve and the delivery of fuel to the mixer.

VISCOSITY – A measure of the resistance to flow of a liquid.

VISCOUS – Thick, tending to resist flowing.

VOC – Volatile Organic Compounds.

VOLATILE – Evaporating readily at room temperature.

VOLATILE ORGANIC COMPOUNDS (VOC) – Hydrocarbons and related chemicals that are volatile (vaporize) at normal temperatures. Generally limited to reactive volatile organic compounds.

VOLATILITY – A measure of the ease with which a liquid vaporizes; it has a direct relationship to the flammability of a fuel.

VOLTAGE – The force which causes electrons to flow in a conductor. The difference in electrical pressure (or potential) between two points in a circuit.

VOLTMETER – An electric meter for measuring the voltage of an electric device, such as a battery or alternator, or for measuring the voltage between two points in an electric circuit.

VOLUME – It is constant, being a measurement of space rather than a condition of air or gas. (1) Since an engine of given displacement pumps air into cylinders of a constant size, the volume of air and gas required to fill those cylinders is constant. When the carburetor throttle valve is closed causing a high manifold depression (vacuum), the pistons continue to draw the same volume of air and gas into the cylinders, only the weight and density of the charge are less. A supercharged engine also draws the same volume into the engine, with the weight and density of the charge being greater. In the carburetor, the air valve opens in relation to throttle position the same distance, whether the engine is naturally aspirated or supercharged to several pounds above the atmospheric pressure. (2) The only change in total volume entering the cylinders occurs when RPM is changed. The same volume is drawn in per revolution; however, there are more or less revolutions in the allotted time.

VOLUMETRIC EFFICIENCY (VE) – The ratio of actual mass (weight) – not volume – of air taken into a cylinder when at bottom dead center compared to the mass that the cylinder would theoretically take in if there were no losses. Volumetric efficiency is expressed in percent.

VE – Actual mass – not volume – taken into an engine at bottom dead center compared to the mass that the engine theoretically could take in, usually expressed in percent.

VORTEX – A liquid with a whirling or circular motion that tends to form a cavity or vacuum in the center (whirlpool).

VREF OR VOLTAGE REFERENCE – A set voltage (usually 5V) that the PCM supplies to certain sensors, such as TPS and MAP. Voltage reference is an input to some sensors, while signal return is an output from these sensors. See SIG RTN.

V-TYPE ENGINE – An engine with two banks or rows of cylinders set at an angle to form a V.

VVR – Vehicle-vapor recovery.

WANKEL ENGINE – A rotary engine in which a three-lobe rotor turns in an oval chamber to produce power.

WASTEGATE – The pressure relief valve that vents excess exhaust pressure from the turbocharger to the exhaust pipe, controlling boost pressure.

GLOSSARY

WATER CAPACITY – The amount of water, in pounds or gallons, at 60° F required to fill a container liquid full of water.

WEDGE COMBUSTION CHAMBER – A combustion chamber resembling a wedge in shape.

WEIGHT AND DENSITY OF AIR – Weight and density of air of a given volume, vary proportionally with pressure. An air receiver tank filled with air at atmospheric pressure will float on water, whereas the same tank of air pressurized to 1000 pounds contains a more dense mass of air, and the increased weight will cause it to sink. (1) While total weight of the charge drawn into a cylinder does not increase, the charge becomes more dense as the piston compresses it. Consequently, the charge becomes heavier per cubic inch of volume when compressed. (2) Weight and density of the charge introduced into the cylinder on the intake stroke directly affect density upon compression. The more dense the mass is, within practical limits, the more power will be produced when ignition occurs. (3) A higher compression ratio may be used at high altitude, as the mass drawn into the cylinder weighs less and may be compressed more to reach practical limits of density when ignited.

WHITE SMOKE – The smoke emitted during a cold start from a diesel engine, consisting largely of unburnt fuel and particulate matter; smoke created by a spark ignition engine caused by coolant leaking into and turned into steam within the cylinders.

WORKING PRESSURE – The pressure for which the equipment was certified.

WOT – Wide-open throttle.

ZENER DIODE – When a reverse voltage is applied to it, the zener diode suddenly starts to respond in a nondestructive manner; it is used to control the direction of current flow and regulate and stabilize voltage as in a voltage regulator or other cicuit where fluctuations occur.

ZEV – Zero Emissions Vehicle.