SAE International™

# SURFACE VEHICLE RECOMMENDED PRACTICE

SAE J1256

CAN-CELLED OCT2002

Issued 1979-05
Cancelled 2002-10

Superseding J1256 JUN1995

## Fuel Economy Measurement—Road Test Procedure—Cold Start and Warm-Up Fuel Economy

***1.*** ***Scope—***This procedure is a modification of the urban driving cycles noted in SAE J1082 and which is run on a suitable road or test track. The procedure yields cold start/warm-up fuel economy values indicative of consumer level at the ambient condition of the test. Within referenced limitations, the procedure can be utilized to determine the fuel economy differential among vehicles or between vehicle changes.

**1.1** **Purpose—**This SAE Recommended Practice provides a uniform test procedure for measuring the fuel economy of light-duty vehicles during cold start and warm-up operation (motor vehicles designed primarily for transportation of persons or property and rated at 4500 kg GVW (10 000 lb) or less) on suitable roads.

***2.*** ***References***

**2.1** **Applicable Publications—**The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply.

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J1082—Fuel Economy Measurement Road Test Procedure
SAE J1263—Road Load Measurement and Dynamometer Simulation Using Coastdown Techniques

2.1.2 ASTM PUBLICATION—Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTMD4814—Standards Specification for Automotive Spark-Ignition Engine Fuel Petroleum Measurement Tables

2.1.3 OTHER PUBLICATION

Energy Policy and Conservation Act, Public Law 94-163, 94th Congress S.622, December 22, 1975.

***3.*** ***Definitions***

**3.1** **Driving Cycle—**The urban driving pattern is defined by 8.3.4.2. This driving pattern is a modification for cold starting of the SAE J1082 urban driving cycle.

**3.2** **Test Vehicle—**Passenger car and light truck prepared for test according to Section 7.





**TO PLACE A DOCUMENT ORDER:**
**Tel: 877-606-7323 (inside USA and Canada)**
**Tel: 724-776-4970 (outside USA)**
**Fax: 724-776-0790**
**Email: custsvc@sae.org**
**SAE WEB ADDRESS: http://www.sae.org**

**3.3 Test Vehicle Weight—**Unloaded vehicle weight (curb weight) plus 136 kg (300 lb).

3.3.1 CHASSIS DYNAMOMETER INERTIA WEIGHT AND HORSEPOWER SETTINGS—Should be established and set in accordance with SAE J1263.

**3.4 Observed Cold Fuel Economy—**Observed cold fuel economy will be reported for both 0 to 3.2 km (0 to 2mile) and 0 to 6.4 km (0 to 4 mile) cycles. The 0 to 3.2 km (0 to 2 mile) observed fuel economy will be determined by dividing the 3.2 km (2.0 mile) of the urban cycle by the fuel consumed during Cycle 1. The 0 to 6.4 km (0 to 4 mile) observed fuel economy will be determined by dividing 6.4 km (4.0 mile) by the total fuel consumed during Cycle 1 and Cycle 2. Economy will be expressed in kilometers per liter (miles per gallon).

**3.5 Corrected Cold Fuel Economy—**Corrected economy is the observed economy multiplied by the correction factors listed in Section 11 and Section 12. Corrected fuel economy will be expressed as kilometers per liter (miles per gallon).

**3.6 Correction Factors—**Factors which are used to adjust data to the standard ambient condition of 15.6 °C (60 °F) and reference fuel properties.

**3.7 Average Fuel Economy—**Average fuel economy is the total distance driven divided by the total volume of fuel consumed in a series of replicate tests. When the distance driven in each of the tests is identical, as may be assumed for this procedure, the average fuel economy is determined by taking the harmonic average of the individual economies. See Equation 1.

$$\text{Average Fuel Economy} = \frac{n}{1/\text{mpg}_1 + 1/\text{mpg}_2 + \ldots + 1/\text{mpg}_n} \qquad \text{(Eq. 1)}$$

**3.8 Test Repeatability Guidelines—**These guidelines are intended to provide an estimate of repeatability of test data for replicate tests (assumes a standard deviation equal to 1.9% of the mean).

3.8.1 ESTIMATE OF THE 95TH PERCENTILE RANGE FOR REPLICATE TESTS—The 95th percentile range (R) equals 0.019Q times the average fuel economy, where Q equals the critical value obtained from a table for the student t range and the average fuel economy for n tests.

Selected values for 0.019Q are shown in Table 1:

**TABLE 1—SELECTED VALUES FOR 0.019Q**

| n | 0.019Q |
|---|---|
| 2 | 0.053 |
| 3 | 0.063 |
| 4 | 0.069 |
| 5 | 0.073 |
| 10 | 0.085 |

Example 1 (SI units)—If a vehicle obtains 6.20 km/L and 6.60 km/L on two tests on the same cycle, the corrected average fuel economy would be 6.39 km/L and the 95th percentile range would be as shown in Equation 2:

$$R = 0.053 \times 6.39 = 0.34 \text{km/L} \qquad \text{(Eq. 2)}$$

The difference between the two tests is 0.4 km/L which is greater than the difference that would be expected for 95% of the cases in which two tests were conducted. Consequently, additional tests should be conducted to provide more confidence in the average fuel economy.

Example 2 (U.S. units) - If a vehicle obtains 14.5 mile/gal and 15.5 mile/gal on two tests on the same cycle, the corrected average fuel economy would be 15.0 mile/gal and the 95th percentile range would be as shown in Equation 3:

$$R = 0.053 \times 15.0 = 0.80 \text{mile/gal} \quad \text{(Eq. 3)}$$

The difference between the two tests is 1 mile/gal which is greater than the difference that would be expected for 95% of the cases in which two tests were conducted. Consequently, additional tests should be conducted to provide more confidence in the average fuel economy.

3.8.2 ESTIMATE OF THE AVERAGE FUEL ECONOMY AT A 90% CONFIDENCE INTERVAL—See Equation 4.

$$\text{Average at 90\% Confidence Interval} = \text{Average Fuel Economy} \pm \left[ \frac{0.031}{\sqrt{n}} \times \text{(Average Fuel Economy)} \right] \quad \text{(Eq. 4)}$$

Example 1 (SI Units)—If a vehicle obtained 6.29 km/L and 6.46 km/L on two tests on the same cycle, the average fuel economy would be 6.37 km/L and the 90% confidence interval would be as shown in Equation 5:

$$6.37 \pm \frac{0.031}{\sqrt{2}} \times 6.37 = 6.37 \pm 0.14 \text{km/L} \quad \text{(Eq. 5)}$$

Example 2 (U.S. Units)—If a vehicle obtained 14.8 mile/gal and 15.2 mile/gal on two tests on the same cycle, the average fuel economy would be 15.0 and the 90% confidence interval would be as shown in Equation 6:

$$15.0 \pm \left[ \frac{0.031}{\sqrt{2}} \times 15.0 \right] = 15.0 \pm 0.3 \text{ mile/gal} \quad \text{(Eq. 6)}$$

***4. Instrumentation—*** All instrumentation shall be calibrated.

**4.1 Fuel—** The fuel measurement device must be compatible with the vehicle fuel system and should alter the fuel temperature and pressure as little as practical. The fuel measurement system must be accurate to within 0.5% of the fuel used during a driving cycle.

**4.2 Speed—** The speed indicating device shall indicate vehicle speed in kilometers per hour (miles per hour) and be accurate within 1 km/h (0.5 mph).

**4.3 Acceleration—** The acceleration indicating device must be capable of indicating both positive and negative acceleration. It shall indicate acceleration/deceleration in $m/s^2$ ($ft/s^2$) and be accurate within 0.2 $m/s^2$ (0.5 $ft/s^2$). (Refer to 6.5 for Chassis Dynamometer Testing.)

**4.4 Time—** The time measuring instrument must be capable of measuring the time interval to 0.1 s and be accurate within 0.1 s in 1 min.

**4.5 Temperature—** The temperature indicating devices must be capable of measuring to the nearest 1 °C or 2 °F. Accuracy must be within ±1 °C or ±2 °F. The sensing element shall be shielded from radiant heat sources.

**4.6 Absolute Barometric Pressure—** An aneroid or mercury barometer should be used. This device should be accurate within 3 kPa or 0.1 in Hg.

**4.7 Wind—** Wind speed should be measured with a device that provides an indication of wind speed that is accurate within 3 km/h (2 mph). Wind direction should also be indicated.

**4.8 Distance—**A distance indicating device is required if the tests are not conducted on a premarked course. This device must be capable of indicating distance to within 5 m (15 ft) and must be capable of accuracy within 6 m in 1 km (30 ft in 1 mile).

**4.9 Vehicle Weight—**Vehicle weight should be measured with a device that is accurate within 0.5% with a resolution of 5 kg (10 lb) or less.

**4.10 Dynamometer Inertia Weight—**The dynamometer inertia weight is established reflecting the inertia of the nonrotating tires and the vehicle test weight. The inertia weight should be set to the nearest flywheel increment for mechanical inertia dynamometers, or within 5 kg (10 lb) for electrical inertia dynamometers.

## *5. Test Material*

**5.1 Test Vehicle—**The test vehicle shall be completely defined on the Test Vehicle Specifications and Preparation Form (Figure 1). (The test vehicle will normally be representative of a production built vehicle - any exceptions must be properly noted.)

**5.2 Test Fuel—**Normally, service station fuel will be satisfactory for test purposes, provided that it is consistent with the manufacturer's recommendations for the vehicle and with the ASTM D 4814 standards. Gasoline octane rating, $\left(\frac{R+M}{2}\right)$ specific gravity or API gravity for diesel fuel or gasoline used shall be recorded. Other properties such as distillation and Reid vapor pressure should be recorded when available.

**5.3 Lubricants—**Lubricants used shall conform to the manufacturer's recommendation for the predominant weather condition in which the vehicle is being tested.

## *6. Test Conditions*

**6.1 Ambient Temperature—**Tests and soaks should be conducted at ambient temperatures between –1 and 32 °C (30 and 90 °F). For temperatures below –1 °C (30 °F), the temperature correction factors may not be valid.

**6.2 Wind Speed—**Tests must not be conducted when average wind speed exceeds 24 km/h (15 mph) or when gusts exceed 32 km/h (20 mph). During the soak period, higher wind speed is allowable.

**6.3 Road Conditions—**Roads must be dry, clean, smooth, and not exceed 1.0% grade. If operating on a closed track, the start and stop points should be selected such that the schedule elevation difference is 3 m (10 ft) or less.

**6.4** It is recommended that roadside markers be used to indicate the points at which speed changes are to be made as indicated in 8.3.

**6.5 Driver's Aid—**A driver's aid is recommended for dynamometer operation reflecting the schedule in 8.3.

## *7. Test Vehicle Preparation*

**7.1 Break-In—**The vehicle should have accumulated a minimum of 3200 km (2000 miles) of operation prior to test. At least 1600 km (1000 miles) must have been driven at cycling speeds between 64 km/h (40 mph) and maximum legal highway speeds. If a closed track is available for break-in, the maximum speed should not exceed 160 km/h (100 mph). Chassis dynamometer break-in is acceptable. All of the tires must have operated at least 160 km (100 miles) road or track prior to the test. Tires must have at least 75% of the tread remaining and tread must be in good condition. Vehicles for dynamometer testing should have experienced at least 800 km (500 miles) of road cyclic operation.

**7.2 Inspection**—The vehicle must be inspected and adjusted where necessary to meet manufacturer's specifications. Checks are specified on the Test Vehicle Specifications and Preparation Form (see Figure 1).

FUEL ECONOMY TEST—LIGHT-DUTY VEHICLES
TEST VEHICLE SPECIFICATIONS AND PREPARATION

SPECIFICATION LIST
DATE _____
CAR NO. _____
YEAR AND MAKE _____
MODEL AND BODY _____
VEHICLE IDENT. NO. _____
PRODUCTION _____ OTHER _____
ENGINE TYPE _____ DISP. _____
NET hp (U.S.) _____ COMP.RATIO _____
ENGINE NO. _____
ENGINE EMISSION CALIBRATION NO. _____
EXHAUST SYSTEM TYPE _____
TRANSMISSION _____
DRIVE AXLE TYPE AND RATIO _____
BRAKES, (DISC OR DRUM) F R _____
STEERING _____
*TIRE MAKE _____ SIZE _____
LOAD RANGE _____ TYPE _____
% TREAD _____
COLD INFLATION-TIRE PRESSURE
LF _____ RF _____
LR _____ RR _____
TEST WEIGHT _____
*TIRES MUST HAVE A MINIMUM OF 100 miles (160 km)
BREAK-IN ON ROAD OR TRACK

CHECK LIST
_____ ENGINE OIL LEVEL OK
_____ COOLANT LEVEL OK
_____ TRANSMISSION FLUID LEVEL OK
_____ BELTS AND HOSES-TIGHT
_____ CHECK ENGINE CONTROL MODULE DIAGNOSTIC CODES
_____ THROTTLE OPERATION-FUNCTIONAL
_____ IGNITION WIRES-TIGHT
_____ BRAKE DRAG NOT EXCESSIVE
_____ TRANSMISSION OPERATION
_____ TIRE PRESSURE AND CONDITION
_____ ENGINE TUNE-PERFORMED
_____ WHEEL ALIGNMENT-PERFORMED
_____ AIR CLEANER-CLEAN

_____ A/C COMPRESSOR LOAD-REMOVED
_____ NO FUEL LEAKS
_____ FAN CLUTCH-FUNCTIONAL

$$\% \text{ TREAD} = \frac{\text{AVERAGE TREAD DEPTH OF TEST TIRES}}{\text{AVERAGE TREAD DEPTH OF IDENTICAL NEW TIRE}} \cdot 100$$

LIST POWER CONSUMING OPTIONAL EQUIPMENT
_____
_____
_____
_____
_____
_____
_____
_____
_____

COMMENTS: _____
_____
_____
_____
CAR CHECKED BY: _____
DATE: _____

TEST FUEL SPECIFICATIONS
FUEL TYPE AND GRADE _____
GRAVITY (API OR SPECIFIC _____ AT 15.6 °C (60 °F)
REID VAPOR PRESSURE _____ kPa (psi)
DISTILLATION 10% _____ °C (°F)
50% _____ °C (°F)
90% _____ °C (°F)
OCTANE $\frac{R+M}{2}$ _____

FIGURE 1—FUEL ECONOMY TEST—LIGHT-DUTY VEHICLES
TEST VEHICLE SPECIFICATIONS AND PREPARATION

**7.3 Instrumentation—**The fuel measuring device, temperature indicating devices, and other instrumentation, as necessary, must be installed in a manner not to hinder the vehicle operation or operating characteristics.

**7.4 Test Weight—**The vehicle weight must be adjusted to provide the test weight indicated in 3.3 (this test weight includes instrumentation and operator).

**7.5 Tire Pressure—**The cold tire pressure should be the minimum recommended by the manufacturer for the vehicle test weight.

## *8. Test Procedure*

**8.1 Preconditioning—**The vehicle must be driven a minimum of 32 km (20 miles) at 90 km/h (55 mph) or maximum legal highway speed to stabilize engine and driveline operating temperatures immediately prior to the cold soak.

8.1.1 COLD SOAK—The vehicle should be parked close enough to the start of the test course to fulfill the requirements of 8.3.4 and exposed to ambient weather for a period of not less than 12 h nor more than 24 h prior to the beginning of a cold urban test. The temperature of the engine oil, engine block coolant, and/or ambient air is to be recorded just prior to the start of the test. In areas of rapidly changing ambient temperature, all three temperatures should be recorded and should not vary by more than 6 °C (10 °F) for a valid test.

8.1.2 START PROCEDURES—SPARK IGNITION ENGINES

*8.1.2.1* *Manufacturer's Recommended Procedure*—Where the manufacturer has specified a vehicle starting procedure, that procedure should be followed.

*8.1.2.2* Where no recommended starting procedure is specified, the following procedure is recommended. Deviations or other starting procedures should be documented.

8.1.2.2.1 Manual Choke Equipped Vehicles—Vehicles equipped with manual chokes will be started by slowly depressing the accelerator pedal fully to the floor while simultaneously adjusting the choke to the fully closed position. Release the accelerator pedal and start the engine. When the engine is running, release the choke only to the point where the engine continues to run smoothly. The choke should continue to be released during the driving cycle as rapidly as possible while maintaining smooth operation.

8.1.2.2.2 Automatic Choke Equipped Vehicles—Vehicles equipped with automatic chokes will be started by turning the key to the ON position, then fully depressing the accelerator and releasing, and starting the vehicle. After the vehicle has been moved to the starting position, tap the throttle lightly to reduce the idle speed.

8.1.2.2.3 Fuel Injection Equipped Vehicles—Vehicles equipped with an FI system will be started by turning the key to the ON position, then starting the vehicle. No effort to reduce idle speed should be made.

8.1.3 START PROCEDURES—DIESEL ENGINES

*8.1.3.1* *Manufacturer's Recommended Procedure*—Where the manufacturer has specified a vehicle starting procedure, that procedure should be followed.

*8.1.3.2* Where no starting procedures are recommended, the starting procedure used should be documented.

8.1.3.2.1 Vehicles Equipped with Glow Plug Lights or Other Preheat Warning Devices—Glow plugs are normally preheated via a separate ignition switch position or a separate actuation switch. Actuate the glow plug. When the glow plug light goes out or otherwise indicates the preheat cycle is completed, depress the accelerator pedal to at least halfway to the floor and hold, and turn the ignition key to start position. Release the ignition switch and throttle pedal when the engine has reached a smooth running condition.

8.1.3.2.2 Vehicles NOT equipped with Glow Plug Lights or Other Preheat Warning Devices—Glow plug preheaters are required to start automotive type diesel engines. Sixty-second preheats will generally be satisfactory at –1 °C (30 °F). Fifteen seconds of preheat will be sufficient at 32 °C (90 °F) ambient. After the appropriate preheat cycle, the starting procedure will be followed as previously stated.

**8.2 Vehicle Controls—**Air conditioning compressor, headlamps, and other switched accessories that consume power should be turned off unless required for safe vehicle operation. Air conditioning or heater/defroster operation required to clear windows should be turned off as soon as safe vehicle operation is possible. Previous to the preconditioning cycle, the vehicle's battery should be in a fully charged state.

**8.3 Driving Schedules**

8.3.1 GENERAL DRIVING INSTRUCTIONS

*8.3.1.1* Vehicles incapable of attaining acceleration rates specified by the driving schedules will be driven at maximum acceleration until specified schedule speed is reached.

*8.3.1.2* Vehicles with automatic transmissions should be driven with the transmission in a range that insures all forward gears can be automatically engaged. If transmission hunting is encountered at a specified acceleration, the acceleration should be increased to maintain the transmission in the lower gear and this departure from the schedule noted on the data form (see Figure 2).

*8.3.1.3* Vehicles equipped with manual transmissions will be operated in the following manner: Idles will be made in gear, clutch disengaged. Decelerations will be made in gear, and the clutch will be disengaged at 24 km/h (15 mph) on a stop. All cruise operation should be in the highest gear that will prevent engine lugging. Downshifts will be permitted to obtain specified acceleration rates after a deceleration or to obtain a smooth engine operation at a slow speed. The following manual transmission shift speeds are guidelines only and may be modified up or down as necessary to ensure that the specified acceleration rates are attained and to avoid engine lugging or overspeed. Departure from the shift speeds specified in Table 2 should be noted on the data form (Figure 2).



**TABLE 2—MANUAL TRANSMISSION SHIFT SPEEDS (MPH)**

| Acceleration Upshifts | Vehicle Speed |
|---|---|
| 1–2 | 15 |
| 2–3 | 25 |

*8.3.1.4* Vehicle with truck-type manual transmissions containing a creeper gear will not use the creeper gear during the driving cycle.

*8.3.1.5* Vehicles with manual transmissions will be shifted during accelerations at the specified speed (mph) shown in Table 2. Manufacturer's alternative shift schedules or shift indicator light shifting can be used if the specified driving schedule can be maintained.

*8.3.1.6* During cruise modes, use the highest possible gear consistent with smooth engine operation.

DATA FORM
FUEL ECONOMY TEST—LIGHT-DUTY VEHICLES

CAR NO. _____ VIN _____
YEAR AND MAKE _____
MODEL AND BODY _____
ENGINE TYPE _____ DISP. _____
DRIVE AXLE RATIO _____
TRANSMISSION _____
TIRE MAKE _____ SIZE _____
TIRE PRESSURE:F _____ R _____
FUEL TYPE _____ SPECIFIC GRAVITY _____

TEST VEHICLE WEIGHT _____
TEST ROAD _____
TYPE OF SURFACE _____
INSTRUMENTATION _____
1. _____ NO. _____
2. _____ NO. _____
3. _____ NO. _____
4. _____ NO. _____

URBAN CYCLE (3.22 km) (2.00 mile) DATE _____ TIME _____
ODOMETER: START _____ FINISH _____

| | FUEL TEMPERATURE | | | | | | | AMBIENT CONDITIONS | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DIRECTION | 0.8 (0.5) | 1.6 (1.0) | `2.4 (1.5) | 3.2 (2.0) | km mile | ACCUM Time | ACCUM Fuel | TEMPERATURE Start | TEMPERATURE Fin. | BAROMETRIC Start | BAROMETRIC Fin. | WIND Start | WIND Fin. |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |

SUBURBAN CYCLE (3.22 km) (2.00 mile) DATE _____ TIME _____
ODOMETER: START _____ FINISH _____

| | FUEL TEMPERATURE | | | | | | AMBIENT CONDITIONS | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DIRECTION | 3.2 (2.0) | 5.3 (3.3) | 8.4 (5.2) | km mile | ACCUM Time | ACCUM Fuel | TEMPERATURE Start | TEMPERATURE Fin. | BAROMETRIC Start | BAROMETRIC Fin. | WIND Start | WIND Fin. |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |

_____ km/h (mph) INTERSTATE CYCLE (7.56 km) (4.7 miles) DATE _____ TIME _____
ODOMETER: START _____ FINISH _____

| | FUEL TEMPERATURE | | | | | AMBIENT CONDITIONS | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| DIRECTION | 0.0 (0.0) | 7.6 (4.7) | km mile | ACCUM Time | ACCUM Fuel | TEMPERATURE Start | TEMPERATURE Fin. | BAROMETRIC Start | BAROMETRIC Fin. | WIND Start | WIND Fin. |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

TESTED BY: _____

FIGURE 2—DATA FORM—FUEL ECONOMY TEST—LIGHT-DUTY VEHICLES

*8.3.1.7* On vehicles with an automatic transmission, brakes should be applied to maintain the schedule speed if the engine idle results in vehicle speed above that specified. For manual transmission vehicles, the transmission should be downshifted.

8.3.2 GENERAL CYCLE INSTRUCTIONS

*8.3.2.1* The cold start cycle follows the same driving cycle as the SAE J1082 urban cycle with special instructions for starting and movement prior to the start of the test. It should be noted on the test data sheet if defroster, heater, or air conditioning usage were required for safety; otherwise, they should not be used during this test.

*8.3.2.2* The cold start tests are conducted as a sequence of two urban cycles of 3.2 km (2.0 mile) each. The 0 to 3.2 km (0 to 2.0 mile) test is Cycle 1 and the 3.2 to 6.4 km (2.0 to 4.0 mile) test is Cycle 2. Fuel economy is reported for both the 0 to 3.2 km (0 to 2.0 mile) Cycle 1 and the 0 to 6.4 km (0 to 4.0 mile) Cycle 1 plus Cycle 2 test distances. (Additional cycles may be run to meet the warmed-up urban cycle requirements of SAE J1082.)

*8.3.2.3* The urban acceleration and deceleration should be maintained within 0.3 $m/s^2$ (1 $ft/s^2$) of that specified. Vehicle speeds should be maintained within 1.6 km/h (1 mph).

*8.3.2.4* Driving cycle maneuvers are initiated at the points indicated except for the stop at the end of the urban cycle, which is to be completed by the point indicated.

*8.3.2.5* Fuel temperature will be recorded on the data form (Figure 2) during all idle periods.

*8.3.2.6* Record weather data for each test cycle.

*8.3.2.7* At least two cold start tests will be conducted, each preceded by a 12 to 24 h soak period. Record the number of stalls which occur during the test and the total fuel used, including starts. Total elapsed time for each test, with time lost due to starting and stalls subtracted, must repeat within 1%. Additional tests are required until this criteria is met before calculating fuel economy. Observed cold fuel economy will be calculated for each test in accordance with 3.4.

8.3.3 GENERAL CYCLE SUMMARY TABLE—(See Table 3.) This cycle summary is exclusive of start, stall, and restart time or distance required to move the vehicle from the cold soak area to the driving course.



**TABLE 3—GENERAL CYCLE SUMMARY**

| Cycle | Average Speed km/h | Average Speed mph | Test Time s | Test Distance km | Test Distance mile | Idle Time s | Idle Stops |
|---|---|---|---|---|---|---|---|
| Cold start cycle 0–3.2 km (0–2 mile) | 25.1 | 15.6 | 463 | 3.22 | 2.0 | 60 | 8 |
| Cold Start Cycle 0–6.4 km (–4 mile) | 25.1 | 15.6 | 926 | 6.44 | 4.0 | 120 | 16 |

8.3.4 COLD START DRIVING CYCLE

*8.3.4.1* *Prestarting Instructions*—Fuel consumption for the Cycle 1 test will include all fuel used to start the vehicle and run the cycle including that fuel used for the carburetor bowl fill, if required, but excluding fuel line fill. Immediately prior to starting the vehicle, fill the fuel line and filter but not the carburetor float bowl. One method of accomplishing this would require the installation of a three-way valve as close to the carburetor as possible. A purge line, with a clear section of hose in it, could then be tapped off and an observer could tell when the fuel line was void of air. The fuel lines would then be filled through the three-way valve.

Fuel injected vehicles will require specialized fuel measurement instrumentation and should be addressed on an individual basis.

Note that this driving cycle commences with a 15-s idle. If it is necessary to move the vehicle from a cold soak parking area to the driving course, it must be accomplished during the initial 15-s idle period and while the engine is operating on fast idle. As an alternative, the test vehicle may be pushed from a cold soak area to the start of the driving course. This movement, however, should not be greater than the distance that the vehicle would travel under its own power as described previously.

*8.3.4.2* *Driving Cycle (0 to 3.2 km (0 to 2 mile) Cycle)*—(See Table 4.)



**TABLE 4—DRIVING CYCLE (0–3.2 KM (0–2 MILE) CYCLE)**

| Distance km (mile) | Operation |
|---|---|
| 0.0 (0.0) | Start fuel meter, timing device and engine, idle 15 s moving vehicle to the "0" mile marker if needed, accelerate to 24 km/h (15 mph) at 2.1 m/s$^2$ (7 ft/s$^2$). Proceed at 24 km/h (15 mph) to the 0.32 km (0.2 mile) marker. |
| 0.32 (0.2) | Stop at 1.2 m/s$^2$ (4 ft/s$^2$), accelerate to 24 km/h (15 mph) at 2.1 m/s$^2$ (7 ft/s$^2$). Proceed at 24 km/h (15 mph) to the 0.48 km (0.3 mile) marker. |
| 0.48 (0.3) | Decelerate to 8 km/h (5 mph) at 1.2 m/s$^2$ (4 ft/s$^2$), accelerate to 24 km/h (15 mph) at 2.1 m/s$^2$ (7 ft/s$^2$). Proceed at 24 km/h (15 mph) to the 0.80 km (0.7 mile) marker. |
| 0.80 (0.5) | Stop at 1.2 m/s$^2$ (4 ft/s$^2$), record fuel temperature and idle 15 s, accelerate to 32 km/h (20 mph) at 2.1 m/s$^2$) 7 ft/s$^2$). Proceed at 32 km/h (20 mph) to the 1.13 km (0.7 mile) marker. |
| 1.13 (0.7) | Stop at 1.2 m/s$^2$ (4 ft/s$^2$), accelerate to 32 km/h (20 mph) at 2.1 m/s$^2$ (7 ft/s$^2$). Proceed at 32 km/h (20 mph) to the 1.29 km (0.8 mile) marker. |
| 1.29 (0.8) | Decelerate to 16 km/h (10 mph) at 1.2 m/s$^2$ (4 ft/s$^2$), accelerate to 32 km/h (20 mph) at 1.5 m/s$^2$ (5 ft/s$^2$). Proceed at 32 km/h (20 mph) to the 1.61 km (1.0 mile) marker. |
| 1.61 (1.0) | Stop at 1.2 m/s$^2$ (4 ft/s$^2$), record fuel temperature and idle 15 s, accelerate to 24 km/h (15 mph) at 2.1 m/s$^2$ (7 ft/s$^2$), then to 40 km/h (25 mph) at 1.5 m/s$^2$ (5 ft/s$^2$). Proceed at 40 km/h (25 mph) to the 1.93 km (1.2 mile) marker. |
| 1.93 (1.2) | Stop at 1.2 m/s$^2$ (4 ft/s$^2$), accelerate to 24 km/h (15 mph) at 2.1 m/s$^2$ (7 ft/s$^2$), then to 40 km/h (25 mph) at 1.5 m/s$^2$ (5 ft/s$^2$). Proceed at 40 km/h (25 mph) to the 2.09 km (1.3 mile) marker. |
| 2.09 (1.3) | Decelerate to 24 km/h (15 mph) at 1.2 m/s$^2$ (4 ft/s$^2$), accelerate to 40 km/h (25 mph) at 1.5 m/s$^2$ (5 ft/s$^2$). Proceed at 40 km/h (25 mph) to the 2.41 km (1.5 mile) marker. |
| 2.41 (1.5) | Stop at 1.2 m/s$^2$ (4 ft/s$^2$), record fuel temperature and idle 15 s, accelerate to 24 km/h (15 mph) at 2.1 m/s$^2$ (7 ft/s$^2$), then to 48 km/h (30 mph) at 1.5 mps$^2$ (5 ft/s$^2$). Proceed at 48 km/h (30 mph) to the 2.74 km (1.7 mile) marker. |
| 2.74 (1.7) | Stop at 1.2 m/s$^2$ (4 ft/s$^2$), accelerate to 24 km/h (15 mph) at 2.1 m/s2 (7 ft/s$^2$), then to 48 km/h (30 mph) at 1.5 m/s$^2$ (5 ft/s$^2$). Proceed at 48 km/h (30 mph) to the 2.90 km (1.8 mile) marker. |
| 2.90 (1.8) | Decelerate to 32 km/h (20 mph) at 1.2 m/s$^2$ (4 ft/s$^2$), accelerate to 48 km/h (30 mph) at 1.5 m/s$^2$ (5 ft/s$^2$). Proceed at 48 km/h (30 mph). |
| 3.22 (2.0) | Begin braking at 1.2 m/s$^2$ (4 ft/s$^2$) to arrive at stop at 3.22 km (2.0 mile) marker. Stop fuel meter and timing device, record fuel consumed, elapsed time, and fuel temperature. |

*8.3.4.3* *Driving Cycle (0 to 6.4 km (0 to 4 mile) Cycle)*—The 3.2 to 6.4 km (2.0 to 4.0) mile test is the second half of the 0 to 6.4 km (0 to 4.0 mile) test, and is a repetition of the test cycle shown in 8.3.4.2. The 3.2 to 6.4 km (2.0 to 4.0 mile) test begins by restarting the fuel meter and timing device but not the engine, followed by the 15-s idle, and continues with the remaining driving cycle instructions. The 0.32 km (0.2 miles) stop, thus, begins at 3.54 km (2.2 mile) and the 0.48 km (0.3 mile) deceleration begins at 3.70 km (2.3 mile), etc.

***9.*** ***Data Recording—*** Data shall be entered as required on test data forms.

**9.1** Test Vehicle Specifications and Preparation List (Figure 1).

**9.2** Data Form (Figure 2).

**9.3** Summary Sheet (Figure 3).

**SUMMARY SHEET**
**FUEL ECONOMY TEST DATA—LIGHT-DUTY VEHICLES**

DATE _____

VEHICLE MAKE _____ ENGINE _____ CAR NO. _____

VIN _____ TRANSMISSION _____ AXLE RATIO _____

TIRE MAKE _____ SIZE _____ PRESSURE _____

VEHICLE TEST WEIGHT _____
TEST ROAD _____ SURFACE _____

| | FUEL ECONOMY | | | | | |
|---|---|---|---|---|---|---|
| | CORRECTED km/L (mpg) | OBSERVED km/L (mpg) | FUEL TEMP. °C (°F) | AIR TEMP. °C (°F) | BARO. PRESS. kPa (in Hg) | WIND SPEED-DIRECTION km/h (mph) |
| COLD START (0-3.2 km) (0-2 mile) | | | | | | |
| COLD START (0-6.4 km) (0-4 mile) | | | | | | |

TESTED BY: _____

FIGURE 3—SUMMARY SHEET—FUEL ECONOMY TEST DATA—LIGHT-DUTY VEHICLES

***10. Data Correction—General—***Fuel economy data is corrected with three factors: $C_1$, $C_2$ and $C_3$. Factors $C_2$ and $C_3$ account for differentials in fuel properties and should be applied to all data. $C_1$ corrects fuel economy on the basis of average vehicle temperature response.

NOTE—If fuel economy results are to be quoted as results indicative of values at the ambient temperature condition of the test, correction factor $C_1$ should not be applied. When comparing relative fuel economy, it is rare that tests will be run at the same ambient condition. For this comparison, correction factor $C_1$ can be applied. Where a vehicle is suspected to respond differently than as indicated by the supplied correction factor or where extreme accuracy is needed, comparative tests should be run over a temperature span and an independent correction factor, $C_1$, be developed. Where the supplied correction factor $C_1$ is used, it should be used with caution to correct for small changes in test temperature conditions. Correction factor $C_1$ represents an accumulation of test results on about 25 1975 to 1977 model year vehicles with as many as 60 tests on individual cars. This correction factor will not precisely correct any specific vehicle, over-correcting some and under-correcting others, and can induce error with attempts to correct over large temperature spans. The extreme of the data available indicates that one of the 25 test vehicles was over-corrected by 1.8% while another was undercorrected by 5.8% for a 6 °C (10 °F) change in ambient. It is, therefore, recommended that data for comparison purposes be run within a temperature span of 6 °C (10 °F) to minimize the likelihood of induced error.

***11. Data Correction (SI Units)***

**11.1 Reference Conditions**

a. Reference Temperature—15.6 °C
b. Fuel Temperature—15.6 °C
c. Fuel Gravity (Gasoline)—0.737 Specific Gravity
d. Fuel Gravity (ASTM 1D)—0.820 Specific Gravity
e. Fuel Gravity (ASTM 2D)—0.845 Specific Gravity
f. Fuel Net Heating Value

1. (ASTM 1D)—35.31 mJ/L
2. (ASTM 2D)—36.21 mJ/L

**11.2 Fuel Economy Correction (Gasoline)**

11.2.1 DEFINITIONS (UNITS)

Ta—Average ambient temperature during test cycle (°C)
Ff—Average fuel temperature during test cycle (°C)
$G_s$—Specific gravity of test fuel at 15.6 °C
$G_A$—API gravity of test fuel at 15.6 °C
$FE_o$—Observed fuel economy (km/L)
$FE_c$—Corrected fuel economy (km/L)

11.2.2 CORRECTION FORMULA—See Equation 7:

$$FE_c = FE_o \cdot C_1 \cdot C_2 \cdot C_3 \qquad \text{(Eq. 7)}$$

11.2.3 CORRECTION FACTORS

$C_1$ = 1 + 0.0090 (15.6 – $T_A$) 0 to 2 mile (See Note in Section 10.)
= 1 + 0.0079 (15.6 – $T_A$) 0 to 4 mile
$C_2$ = 1.0 + 0.8 (0.737 – $G_S$)
or
$C_2$ = 1.0 + 0.0032 (GA – 60.5)
$C_3$ is derived from Table A2 based on ASTM Fuel Group (see Table A1) and Tf or from Equation 8:

$$C_3 = a + bT_f + cT_f^2 \quad \text{(Eq. 8)}$$

where the coefficients a, b, c, are shown in Table 5:

**TABLE 5—COEFFICIENTS FOR FUEL TEMPERATURE CORRECTION EQUATION 8**

| Spec Gravity Range | ASTM Fuel Group 1 0.8499–0.9659 | ASTM Fuel Group 2 0.7754–0.8498 | ASTM Fuel Group 3 0.7239–07753 | ASTM Fuel Group 4 0.6723–07238 |
|---|---|---|---|---|
| Coefficient | | | | |
| a | $9.8892\ (10)^{-1}$ | $9.8626\ (10)^{-1}$ | $9.8333\ (10)^{-1}$ | $9.8067\ (10)^{-1}$ |
| b | $7.0693\ (10)^{-4}$ | $8.6875\ (10)^{-4}$ | $1.0487\ (10)^{-3}$ | $1.2090\ (10)^{-3}$ |
| c | $3.0370\ (10)^{-7}$ | $8.4745\ (10)^{-7}$ | $1.4107\ (10)^{-6}$ | $2.0290\ (10)^{-6}$ |

## 11.3 Fuel Economy Correction (Diesel)

NOTE—The method for correcting observed fuel economy for vehicles with diesel engines has not been investigated to the same degree that is has for gasoline-powered vehicles.

The correction factors for gasoline-powered vehicles are recommended for use.

11.3.1 DEFINITIONS—See 11.2.1.

11.3.2 CORRECTION FORMULA—See Equation 9.

$$FE_c = FE_o \cdot C_1 \cdot C_2 \cdot C_3 \quad \text{(Eq. 9)}$$

11.3.3 CORRECTION FACTORS

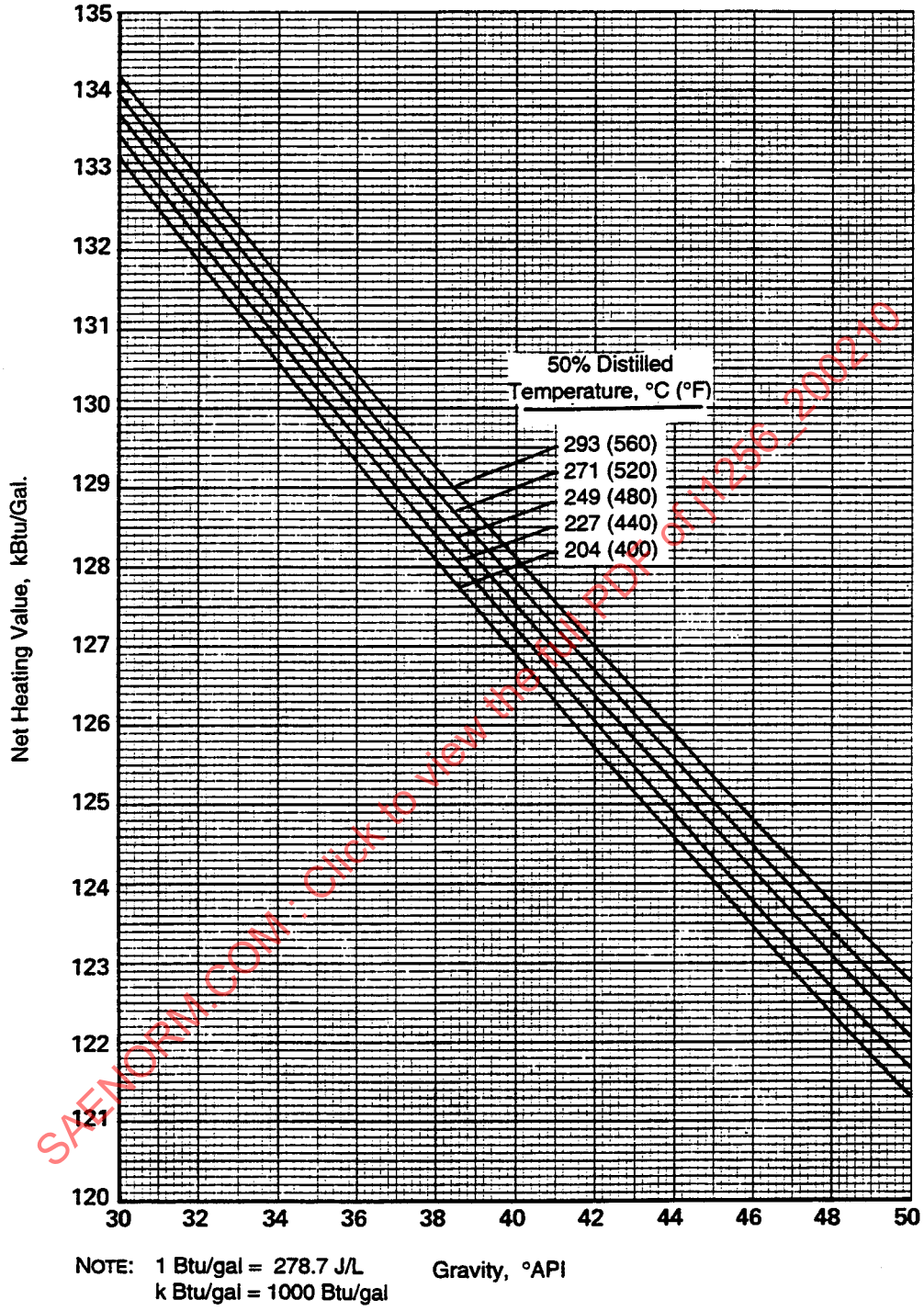
$C_1$ = 1.0 + 0.0090 (15.6 - $T_A$) 0 to 2 miles (see Note in Section 10.)
= 1 + 0.0079 (15.6 - $T_A$) 0 to 4 miles
$C_2$ = K/H
K = 35.31 MJ/L for ASTM 1D type fuel
= 36.21 MJ/L for ASTM 2D type fuel

H—shall be determined from Figure 4 by using the API gravity at 15.6 °C and 50% distillation point or from calorimeter tests.

$C_3$ is derived from Table A2 based on ASTM Fuel Group (see Table A1) and $T_f$ or from Equation 10:

$$C_3 = a + bT_f + cT_f^2 \quad \text{(Eq. 10)}$$

where the coefficient a, b, c are noted in Table 5.




NOTE: 1 Btu/gal = 278.7 J/L
k Btu/gal = 1000 Btu/gal

FIGURE 4—VOLUMETRIC NET HEAT CONTENT OF DIESEL FUELS

## *12. Data Correction (U.S. Units)*

### 12.1 Reference Conditions

a. Reference Temperature—60 °F
b. Fuel Temperature—60 °F
c. Fuel Gravity (Gasoline)—0.737 Specific Gravity, 60.5 °API Gravity
d. Fuel Gravity (ASTM 1D)—0.820 Specific Gravity, 41.0 °API Gravity
e. Fuel Gravity (ASTM 2D)—0.845 Specific Gravity, 36.0 °API Gravity
f. Fuel Net Heating Value

1. (ASTM 1D)—126 700 Btu/gal
2. (ASTM 2D)—129 900 Btu/gal

### 12.2 Fuel Economy Correction (Gasoline)

12.2.1 DEFINITIONS (UNITS)

$T_A$—Average ambient temperature during cold urban test cycle (°F)
$T_f$—Average fuel temperature at measuring instrument during test cycle (°F)
$G_S$—Specific Gravity of test fuel at 60 °F
$G_A$—API gravity of test fuel at 60 °F
$FE_o$—Observed fuel economy (mile/gal)
$FE_c$—Corrected fuel economy (mile/gal)

12.2.2 CORRECTION FORMULA—See Equation 11.

$$FE_c = FE_o \cdot C_1 \cdot C_2 \cdot C_3 \qquad \text{(Eq. 11)}$$

12.2.3 CORRECTION FACTORS

$C_1$ = 1+0.0050 (60-Ta) 0 to 2 mile (see note in Section 10)
= 1+0.0044 (60-Ta) 0 to 4 mile
$C_2$ = 1+0.8 (0.737-Gs) or
$C_2$ = 1+0.0032 (GA-60.5)
$C_3$ is derived from Table A3 based on ASTM Fuel Group (see Table A1) and $T_f$ or from Equation 12.

$$C_3 = a + bT_f + cT_f^2 \qquad \text{(Eq. 12)}$$

where the coefficients a, b, c are shown in Table 6:



**TABLE 6—COEFFICIENTS FOR FUEL TEMPERATURE CORRECTION EQUATION 12**

| Spec Gravity Range | ASTM Fuel Group 1 0.8499–0.9659 | ASTM Fuel Group 2 0.7754–0.8798 | ASTM Fuel Group 3 0.7239–0.7753 | ASTM Fuel Group 4 0.6723–0.7238 |
|---|---|---|---|---|
| Coefficient | | | | |
| a | $9.7645\ (10)^{-1}$ | $9.7108\ (10)^{-1}$ | $9.6513\ (10)^{-1}$ | $9.5982\ (10)^{-1}$ |
| b | $3.8674\ (10)^{-4}$ | $4.6590\ (10)^{-4}$ | $5.5473\ (10)^{-4}$ | $6.3156\ (10)^{-4}$ |
| c | $9.3735\ (10)^{-8}$ | $2.6156\ (10)^{-7}$ | $4.3541\ (10)^{-7}$ | $6.2624\ (10)^{-7}$ |

**12.3 Fuel Economy Correction (Diesel)**

NOTE—The method for correcting observed fuel economy for vehicles with diesel engines has not been investigated to the same degree that it has for gasoline-powered vehicles. The correction factors for gasoline-powered vehicles are recommended for use.

12.3.1 DEFINITIONS—See 12.2.1.

H = Volumetric heating value of diesel test fuel (Btu/gal)

12.3.2 CORRECTION FORMULA—See Equation 13.

$$FE_c = FE_o \cdot C_1 \cdot C_2 \cdot C_3 \qquad \text{(Eq. 13)}$$

12.3.3 CORRECTION FACTORS

$C_1 = 1 + 0.0050\ (60 - T_A)$ 0 to 2 mile (See Note in Section 10.)
$= 1 + 0.0044\ (60 - T_A)$ 0 to 4 mile
$C_2 = K/H$
K = 126 700 (ASTM 1D type fuels)
= 129 900 (ASTM 2D type fuels)

H—shall be obtained from Figure 4 by using the observed API gravity at 60 °F and the 50% distillation point or from calorimeter tests.
$C_3$ is derived from Table A3 based on ASTM Fuel Group (see Table A1) and $T_f$ or from Equation 14.

$$C_3 = a + bT_f + cT_f^2 \qquad \text{(Eq. 14)}$$

***13. Data Presentation***

**13.1** Test Vehicle Specifications and Preparation List (Figure 1)

**13.2** Fuel Economy Test—Data Form (Figure 2)

**13.3** Fuel Economy Test—Data Summary Sheet (Figure 3)



PREPARED BY THE SAE MOTOR VEHICLE COUNCIL