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SAE J1256 OCT88

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

SAE Recommended Practice
Revised October 1988

**S. A. E.
LIBRARY**

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an American National Standard

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**Ø FUEL ECONOMY MEASUREMENT - ROAD TEST PROCEDURE -
COLD START AND WARM-UP FUEL ECONOMY**

1. PURPOSE:

This 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 10 000 lb GVW (4500 kg) or less on suitable roads.

2. 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.

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.¹

¹Though this test cycle can be run on a chassis dynamometer, it does not apply to mandatory fuel economy standards or fuel economy labeling requirements for passenger vehicles first established by the "Energy Policy and Conservation Act", Public Law 94-163, 94th Congress S.622, December 22, 1975. Details of the mandatory dynamometer procedure can be obtained by contacting Environmental Protection Agency, Fourth and M Streets, S.W., Washington, DC 20460. It should be noted that correlation of this test cycle between chassis dynamometers and road test results has not been established.

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- 3.2 Test Vehicle: Passenger car or light truck prepared for test according to section 7.
- 3.3 Test Vehicle Weight: Unloaded vehicle weight (curb weight) plus 300 lb (136 kg).
- 3.3.1 Chassis Dynamometer Inertia Weight and Horse Power Settings: Should be established and set in accordance with SAE J1263, Road Load Measurement and Dynamometer Simulation Using Coastdown Techniques.
- 3.4 Observed Cold Fuel Economy: Observed cold fuel economy will be reported for both 0-2 mile (0-3.2 km) and 0-4 mile (0-6.4 km) cycles. The 0-2 mile (0-3.2 km) observed fuel economy will be determined by dividing the 2.0 mile (3.2 km) of the urban cycle by the fuel consumed during Cycle 1. The 0-4 mile (0-6.4 km) observed fuel economy will be determined by dividing 4.0 mile (6.4 km) by the total fuel consumed during Cycle 1 and Cycle 2. Economy will be expressed in miles per gallon (kilometers per liter).
- 3.5 Corrected Cold Fuel Economy: Corrected economy is the observed economy multiplied by the correction factors listed in sections 11 and 12. Corrected fuel economy will be expressed as miles per gallon (kilometers per liter).
- 3.6 Correction Factors: Factors which are used to adjust data to the standard ambient condition of 60°F (15.6°C) 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.

$$\text{Average Fuel Economy} = \frac{n}{1/\text{MPG}_1 + 1/\text{MPG}_2 + 1/\text{MPG}_n}$$

- 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:

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

Example 1 (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:

$$R = 0.053 \times 15.0 = 0.80 \text{ mile/gal}$$

The difference between the two tests is 1.0 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.

Example 2 (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:

$$R = 0.053 \times 6.39 = 0.34 \text{ km/L}$$

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.

3.8.2 Estimate of the average fuel economy at a 90% confidence interval.

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

n is the number of replicate tests.

Example 1 (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:

$$15.0 \pm \left[\frac{0.031}{\sqrt{2}} \times 15.0 \right] = 15.0 \pm 0.3 \text{ mile/gal}$$

Example 2 (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:

$$6.37 \pm \left[\frac{0.031}{\sqrt{2}} \times 6.37 \right] = 6.37 \pm 0.14 \text{ km/L}$$

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 miles per hour (kilometers per hour) and be accurate within 0.5 mile/h (1 km/h).
- 4.3 Acceleration: The acceleration indicating device must be capable of indicating both positive and negative acceleration. It shall indicate acceleration/deceleration in ft/s² (m/s²) and be accurate within 0.5 ft/s² (0.2 m/s²). (Refer to paragraph 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 2°F or 1°C. Accuracy must be within ±2°F or ±1°C. 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 0.1 in Hg or 0.3 kPa.

- 4.7 Wind: Wind speed should be measured with a device that provides an indication of wind speed that is accurate within 2 mile/h (3 km/h). 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 15 ft (5 m) and must be capable of accuracy within 30 ft in 1 mile (6 m in 1 km).
- 4.9 Vehicle Weight: Vehicle weight should be measured with a device that is accurate within 0.5% with a resolution of 10 lb (5 kg) or less.
- 4.10 Dynamometer Inertia Weight: The dynamometer inertia weight is established reflecting the inertia of the non-rotating tires and the vehicle test weight. The inertia weight should be set to the nearest flywheel increment for mechanical inertia dynamometers, or within 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. (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 439 Volatility Guidelines. 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 30 and 90°F (-1 and 32°C). For temperatures below 30°F (-1°C), the temperature correction factors may not be valid.
- 6.2 Wind Speed: Tests must not be conducted when average wind speed exceeds 15 mile/h (24 km/h) or when gusts exceed 20 mile/h (32 km/h). 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 10 ft (3 m) 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 2000 miles (3200 km) of operation prior to test. At least 1000 miles (1600 km) must have been driven at cycling speeds between 40 mile/h (64 km/h) and maximum legal highway speeds. If a closed track is available for break-in, the maximum speed should not exceed 100 mile/h (160 km/h). Chassis dynamometer break-in is acceptable. All of the tires must have operated at least 100 road or track miles (160 km) 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 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.
- 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 20 miles (32 km) at 55 mile/h (90 km/h) 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 10°F (6°C) 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 the 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 30°F (-1°C). Fifteen seconds of preheat will be sufficient at 90°F (32°C) ambient. After the appropriate preheat cycle, the starting procedure will be followed as above.

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.

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 15 mile/h (24 km/h) 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 below should be noted on the data form. Manufacturer's recommended shift speeds/shift indicator lights may be used providing their use is noted on the data form.

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 (mile/h) shown below. Manufacturer's alternative shift schedules or shift indicator light shifting can be used if the specified driving schedule can be maintained.

ACCELERATION UPSHIFTS	TRANSMISSION TYPE		
	3	4	5
1 - 2	15	15	15
2 - 3	25	25	25

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

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 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 2 urban cycles of 2.0 mile (3.2 km) each. The 0-2.0 mile (0-3.2 km) test is Cycle 1 and the 2.0-4.0 mile (3.2-6.4 km) test is Cycle 2. Fuel economy is reported for both the 0-2.0 mile (0-3.2 km) Cycle 1 and the 0-4.0 mile (0-6.4 km) 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 1 ft/s^2 (0.3 m/s^2) of that specified. Vehicle speeds should be maintained within 1 mile/h (1.6 km/h).

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 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 12-24 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: 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.

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

8.3.4 Cold Start Driving Cycle:

- 8.3.4.1 Pre-Starting 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 above.

8.3.4.2 Driving Cycle (0-2 mile (0-3.2 km) Cycle):

Distance

Operation

mi (km)

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 15 mile/h (24 km/h) at 7 ft/s² (2.1 m/s²). Proceed at 15 mile/h (24 km/h) to the 0.2 mile (0.32 km) marker.

8.3.4.2 (Continued):

- 0.2 (0.32) Stop at 4 ft/s² (1.2 m/s²), accelerate to 15 mile/h (24 km/h) at 7 ft/s² (2.1 m/s²). Proceed at 15 mile/h (24 km/h) to the 0.3 mile (0.48 km) marker.
- 0.3 (0.48) Decelerate to 5 mile/h (8 km/h) at 4 ft/s² (1.2 m/s²), accelerate to 15 mile/h (24 km/h) at 7 ft/s² (2.1 m/s²). Proceed at 15 mile/h (24 km/h) to the 0.5 mile (0.80 km) marker.
- 0.5 (0.80) Stop at 4 ft/s² (1.2 m/s²), record fuel temperature and idle 15 s, accelerate to 20 mile/h (32 km/h) at 7 ft/s² (2.1 m/s²). Proceed at 20 mile/h (32 km/h) to the 0.7 mile (1.13 km) marker.
- 0.7 (1.13) Stop at 4 ft/s² (1.2 m/s²), accelerate to 20 mile/h (32 km/h) at 7 ft/s² (2.1 m/s²). Proceed at 20 mile/h (32 km/h) to the 0.8 mile (1.29 km) marker.
- 0.8 (1.29) Decelerate to 10 mile/h (16 km/h) at 4 ft/s² (1.2 m/s²), accelerate to 20 mile/h (32 km/h) at 5 ft/s² (1.5 m/s²). Proceed at 20 mile/h (32 km/h) to the 1.0 mile (1.61 km) marker.
- 1.0 (1.61) Stop at 4 ft/s² (1.2 m/s²), record fuel temperature and idle 15 s, accelerate to 15 mile/h (24 km/h) at 7 ft/s² (2.1 m/s²), then to 25 mile/h (40 km/h) at 5 ft/s² (1.5 m/s²). Proceed at 25 mile/h (40 km/h) to the 1.2 mile (1.93 km) marker.
- 1.2 (1.93) Stop at 4 ft/s² (1.2 m/s²), accelerate to 15 mile/h (24 km/h) at 7 ft/s² (2.1 m/s²), then to 25 mile/h (40 km/h) at 5 ft/s² (1.5 m/s²). Proceed at 25 mile/h (40 km/h) to the 1.3 mile (2.09 km) marker.
- 1.3 (2.09) Decelerate to 15 mile/h (24 km/h) at 4 ft/s² (1.2 m/s²), accelerate to 25 mile/h (40 km/h) at 5 ft/s² (1.5 m/s²). Proceed at 25 mile/h (40 km/h) to the 1.5 mile (2.41 km) marker.
- 1.5 (2.41) Stop at 4 ft/s² (1.2 m/s²), record fuel temperature and idle 15 s, accelerate to 15 mile/h (24 km/h) at 7 ft/s² (2.1 m/s²), then to 30 mile/h (48 km/h) at 5 ft/s² (1.5 m/s²). Proceed at 30 mile/h (48 km/h) to the 1.7 mile (2.74 km) marker.
- 1.7 (2.74) Stop at 4 ft/s² (1.2 m/s²), accelerate to 15 mile/h (24 km/h) at 7 ft/s² (2.1 m/s²) and then to 30 mile/h (48 km/h) at 5 ft/s² (1.5 m/s²). Proceed at 30 mile/h (48 km/h) to the 1.8 mile (2.90 km) marker.

- 1.8 (2.90) Decelerate to 20 mile/h (32 km/h) at 4 ft/s² (1.2 m/s²), accelerate to 30 mile/h (48 km/h) at 5 ft/s² (1.5 m/s²). Proceed at 30 mile/h (48 km/h).
- 2.0 (3.22) Begin braking at 4 ft/s² (1.2 m/s²) to arrive at stop at the 2.0 mile (3.22 km) marker. Stop fuel meter and timing device, record fuel consumed, elapsed time, and fuel temperature.

8.3.4.3 Driving Cycle (0-4 mile (0-6.4 km) Cycle): The 2.0-4.0 mile (3.2-6.4 km) test is the second half of the 0-4.0 mile (0-6.4 km) test, and is a repetition of the test cycle shown in 8.3.4.2. The 2.0 and 4.0 mile (3.2-6.4 km) test begins by re-starting 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 0.2 miles (0.32 km) stop, thus, begins at 2.2 mile (3.54) and the 0.3 mile (0.48 km) deceleration begins at 2.3 mile (3.70 km), etc.

9. DATA RECORDING:

Data shall be entered as required on test data forms.

- 9.1 Test Vehicle Specifications and Preparation List
- 9.2 Data Form
- 9.3 Summary Sheet

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.

10. (Continued):

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 1975-1977 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 10°F (6°C) change in ambient. It is, therefore, recommended that data for comparison purposes be run within a temperature span of 10°F (6°C) to minimize the likelihood of induced error.

11. DATA CORRECTION (U.S. UNITS):11.1 Reference Conditions:

Reference Temperature	60°F
Fuel Temperature	60°F
Fuel Gravity (Gasoline)	0.737 Specific Gravity, 60.5° API Gravity
Fuel Gravity (ASTM 1D)	0.820 Specific Gravity, 41.0° API Gravity
Fuel Gravity (ASTM 2D)	0.845 Specific Gravity, 36.0° API Gravity
Fuel Net Heating Value	
(ASTM 1D)	126 700 Btu/gal
(ASTM 2D)	129 900 Btu/gal

11.2 Fuel Economy Correction (Gasoline):

11.2.1 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)

11.2.2 Correction Formula:

$$FE_C = FE_O \cdot C_1 \cdot C_2 \cdot C_3$$

11.2.3 Correction Factors:

$$C_1 = 1 + 0.0050 (60 - T_A) \text{ 0-2 mile (See Note in Section 10.)}$$

$$= 1 + 0.0044 (60 - T_A) \text{ 0-4 mile}$$

$$C_2 = 1.0 + 0.8 (0.737 - G_s)$$

or

$$C_2 = 1.0 + 0.0032 (G_A - 60.5)$$

C_3 is derived from Table 1 based on gravity of fuel at 60°F and T_f or from the following analytical equation:

$$C_3 = a + bT_f + cT_f^2$$

where the coefficients a, b, c, are:

ASTM Fuel Group

	1	2	3	4
Spec Gravity Range	0.8499 - 0.9659	0.7754 - 0.8498	0.7239 - 0.7753	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	$9.3735 (10)^{-8}$	$2.6156 (10)^{-7}$	$4.3541 (10)^{-7}$	$6.2624 (10)^{-7}$

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

11.3.1 Definitions: See 11.2.1.

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

11.3.2 Correction Formula:

$$FE_C = FE_O \cdot C_1 \cdot C_2 \cdot C_3$$

11.3.3 Correction Factors:

$C_1 = 1 + 0.0050 (60 - T_A)$ 0-2 mile (See Note in Section 10.)

$= 1 + 0.0044 (60 - T_A)$ 0-4 mile

$C_2 = K/H$

K = 126 700 (ASTM 1D type fuels)

= 129 900 (ASTM 2D type fuels)

H - shall be obtained from Fig. 1 by using the observed API gravity at 60°F and the 50% distillation point or from calorimeter tests.

C_3 is derived from Table 1 based on gravity of fuel at 60°F and T_f or from the following analytical equation:

$$C_3 = a + bT_f + cT_f^2$$

where the coefficients a, b, c are noted in 11.2.3.

12. DATA CORRECTION (SI) UNITS:

12.1 Reference Conditions:

Reference Temperature	15.6°C
Fuel Temperature	15.6°C
Fuel Gravity (Gasoline)	0.737 Specific Gravity
Fuel Gravity (ASTM 1D)	0.820 Specific Gravity
Fuel Gravity (ASTM 2D)	0.845 Specific Gravity
Fuel Net Heating Value	
(ASTM 1D)	35.31 MJ/L
(ASTM 2D)	36.21 MJ/L

12.2 Fuel Economy Correction (Gasoline):

12.2.1 Definitions (Units):

- T_A - Average ambient temperature during test cycle ($^{\circ}\text{C}$)
 T_f - Average fuel temperature during test cycle ($^{\circ}\text{C}$)
 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)

12.2.2 Correction Formula:

$$FE_C = FE_O \cdot C_1 \cdot C_2 \cdot C_3$$

12.2.3 Correction Factors:

$$C_1 = 1 + 0.0090 (15.6 - T_A) \text{ 0-2 mile (See Note in section 10.)}$$

$$= 1 + 0.0079 (15.6 - T_A) \text{ 0-4 mile}$$

$$C_2 = 1.0 + 0.8 (0.737 - G_s)$$

or

$$C_2 = 1.0 + 0.0032 (G_A - 60.5)$$

C_3 is derived from Table 1A based on gravity of fuel at 15.6°C and

T_f or from the following analytical equation:

$$C_3 = a' + b'T_f + c'T_f^2$$

where the coefficients a' , b' , c' are:

ASTM Fuel Group

	1	2	3	4
Spec Gravity Range	0.8499 - 0.9659	0.7754 - 0.8498	0.7239 - 0.7753	0.6723 - 0.7238
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'	$3.0370 (10)^{-7}$	$8.4745 (10)^{-7}$	$1.4107 (10)^{-6}$	$2.0290 (10)^{-6}$

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 test fuel (MJ/L)

12.3.2 Correction Formula:

$$FE_c = FE_o \cdot C_1 \cdot C_2 \cdot C_3$$

12.3.3 Correction Factors:

$$C_1 = 1.0 + 0.0090 (15.6 - T_A) \text{ 0-2 miles (see Note in section 10.)}$$

$$= 1 + 0.0079 (15.6 - T_A) \text{ 0-4 miles}$$

$$C_2 = K/H$$

$$K = 35.31 \text{ MJ/L for ASTM 1D type fuel}$$

$$= 36.21 \text{ MJ/L for ASTM 2D type fuel}$$

H - shall be determined from Fig. 1 by using the API gravity at 15.6°C and 50% distillation point or from calorimeter tests.

C₃ is derived from Table 1A based on gravity of fuel at 15.6°F and

T_f or from the following analytical equation:

$$C_3 = a' + b'T_f + c'T_f^2$$

where the coefficients a', b', c' are noted in 12.2.3.

13. DATA PRESENTATION:

13.1 Test Vehicle Specifications and Preparation List

13.2 Fuel Economy Test-Data Form

13.3 Fuel Economy Test-Data Summary Sheet

The phi (Ø) symbol is for the convenience of the user in locating areas where technical revisions have been made to the previous issue of the report. If the symbol is next to the report title, it indicates a complete revision of the report.

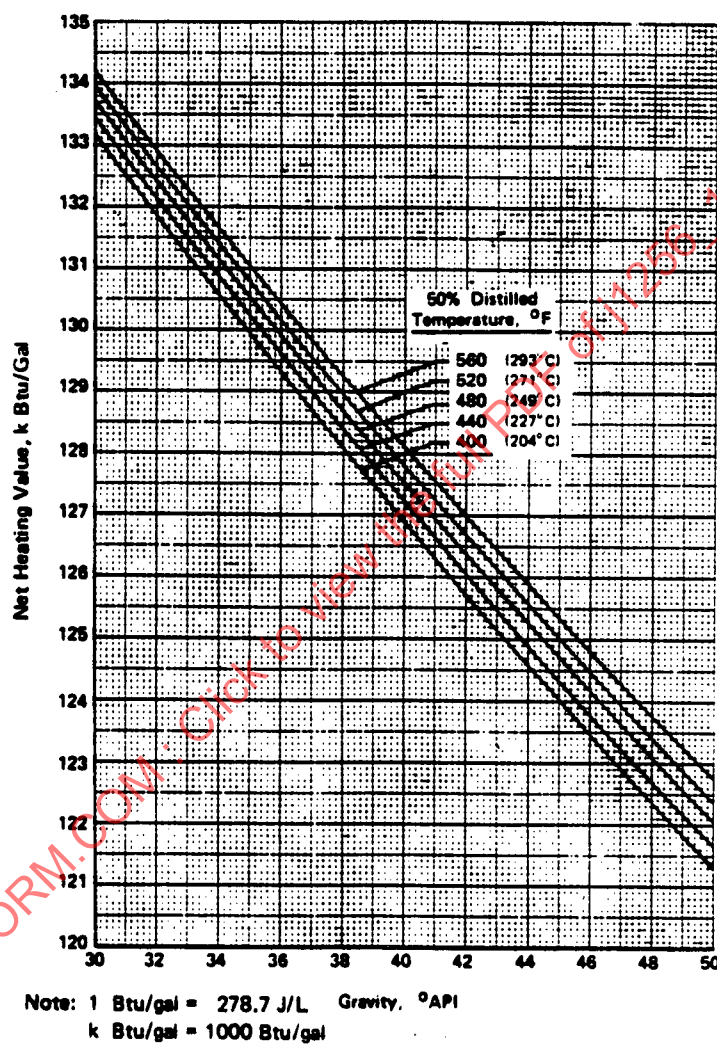


FIGURE 1 - Volumetric Net Heat Content of Diesel Fuels

TABLE 1—C₃—FUEL TEMPERATURE CORRECTION FACTOR¹

ASTM Group Number	Specific Gravity Range		API Gravity Range, °API	
	1	2	3	4
1	0.8499-0.9659	0.7754-0.8498	15.0-34.9	35.0-50.9
2	0.7754-0.8498	0.7239-0.7753	51.0-63.9	64.0-78.9
3	0.7239-0.7753	0.6723-0.7238		
4	0.6723-0.7238			

Fuel Temp., °F	C ₃				Fuel Temp., °F	C ₃			
	Group 1	Group 2	Group 3	Group 4		Group 1	Group 2	Group 3	Group 4
0	0.9765	0.9711	0.9651	0.9598	70	1.0040	1.0050	1.0061	1.0072
1	0.9768	0.9715	0.9656	0.9604	71	1.0044	1.0055	1.0067	1.0079
2	0.9772	0.9720	0.9662	0.9611	72	1.0048	1.0060	1.0074	1.0086
3	0.9776	0.9725	0.9667	0.9616	73	1.0052	1.0065	1.0080	1.0093
4	0.9780	0.9730	0.9673	0.9623	74	1.0056	1.0070	1.0086	1.0100
5	0.9784	0.9734	0.9679	0.9629	75	1.0060	1.0076	1.0092	1.0107
6	0.9788	0.9739	0.9684	0.9636	76	1.0064	1.0081	1.0098	1.0114
7	0.9791	0.9743	0.9690	0.9642	77	1.0068	1.0085	1.0104	1.0121
8	0.9795	0.9748	0.9696	0.9649	78	1.0071	1.0090	1.0110	1.0129
9	0.9799	0.9753	0.9701	0.9655	79	1.0076	1.0095	1.0116	1.0136
10	0.9803	0.9758	0.9707	0.9661	80	1.0080	1.0100	1.0122	1.0143
11	0.9807	0.9763	0.9713	0.9668	81	1.0084	1.0105	1.0129	1.0151
12	0.9811	0.9768	0.9718	0.9675	82	1.0088	1.0110	1.0136	1.0158
13	0.9814	0.9772	0.9724	0.9681	83	1.0092	1.0115	1.0142	1.0166
14	0.9818	0.9777	0.9730	0.9688	84	1.0096	1.0120	1.0148	1.0173
15	0.9822	0.9782	0.9735	0.9695	85	1.0100	1.0126	1.0154	1.0180
16	0.9826	0.9787	0.9741	0.9701	86	1.0104	1.0131	1.0160	1.0187
17	0.9830	0.9790	0.9747	0.9708	87	1.0108	1.0136	1.0167	1.0195
18	0.9835	0.9795	0.9753	0.9714	88	1.0112	1.0141	1.0173	1.0202
19	0.9839	0.9800	0.9759	0.9721	89	1.0116	1.0146	1.0179	1.0209
20	0.9843	0.9805	0.9765	0.9728	90	1.0120	1.0151	1.0185	1.0218
21	0.9846	0.9810	0.9770	0.9734	91	1.0124	1.0156	1.0192	1.0225
22	0.9850	0.9814	0.9776	0.9741	92	1.0129	1.0162	1.0198	1.0232
23	0.9854	0.9819	0.9782	0.9748	93	1.0133	1.0167	1.0205	1.0240
24	0.9858	0.9824	0.9788	0.9753	94	1.0137	1.0172	1.0211	1.0247
25	0.9862	0.9829	0.9793	0.9760	95	1.0141	1.0177	1.0218	1.0254
26	0.9866	0.9834	0.9799	0.9767	96	1.0145	1.0182	1.0224	1.0262
27	0.9870	0.9839	0.9805	0.9773	97	1.0148	1.0187	1.0230	1.0269
28	0.9874	0.9843	0.9811	0.9780	98	1.0152	1.0193	1.0236	1.0276
29	0.9878	0.9848	0.9816	0.9787	99	1.0156	1.0198	1.0243	1.0285
30	0.9881	0.9853	0.9822	0.9793	100	1.0160	1.0203	1.0249	1.0292
31	0.9885	0.9858	0.9828	0.9800	101	1.0165	1.0208	1.0255	1.0300
32	0.9889	0.9863	0.9834	0.9807	102	1.0169	1.0213	1.0262	1.0307
33	0.9893	0.9868	0.9840	0.9814	103	1.0173	1.0219	1.0269	1.0314
34	0.9897	0.9873	0.9845	0.9820	104	1.0177	1.0224	1.0275	1.0322
35	0.9901	0.9878	0.9851	0.9827	105	1.0181	1.0229	1.0282	1.0330
36	0.9905	0.9882	0.9857	0.9834	106	1.0185	1.0234	1.0288	1.0338
37	0.9909	0.9887	0.9863	0.9841	107	1.0190	1.0240	1.0294	1.0346
38	0.9913	0.9892	0.9869	0.9847	108	1.0194	1.0245	1.0301	1.0353
39	0.9917	0.9897	0.9875	0.9854	109	1.0198	1.0250	1.0307	1.0360
40	0.9921	0.9902	0.9880	0.9861	110	1.0201	1.0255	1.0314	1.0368
41	0.9925	0.9907	0.9886	0.9868	111	1.0205	1.0261	1.0320	1.0376
42	0.9928	0.9912	0.9892	0.9875	112	1.0209	1.0266	1.0327	1.0384
43	0.9932	0.9917	0.9898	0.9881	113	1.0213	1.0271	1.0334	1.0392
44	0.9936	0.9922	0.9904	0.9888	114	1.0218	1.0276	1.0340	1.0399
45	0.9940	0.9926	0.9910	0.9895	115	1.0222	1.0282	1.0347	1.0407
46	0.9944	0.9930	0.9916	0.9902	116	1.0226	1.0287	1.0353	1.0414
47	0.9948	0.9935	0.9922	0.9910	117	1.0230	1.0291	1.0359	1.0422
48	0.9952	0.9940	0.9928	0.9917	118	1.0234	1.0296	1.0366	1.0431
49	0.9956	0.9945	0.9933	0.9924	119	1.0238	1.0302	1.0372	1.0438
50	0.9960	0.9950	0.9939	0.9930	120	1.0243	1.0307	1.0380	1.0446
51	0.9964	0.9955	0.9946	0.9937	121	1.0246	1.0312	1.0386	1.0454
52	0.9968	0.9960	0.9952	0.9944	122	1.0250	1.0318	1.0393	1.0461
53	0.9973	0.9965	0.9958	0.9951	123	1.0254	1.0323	1.0399	1.0469
54	0.9977	0.9971	0.9964	0.9958	124	1.0258	1.0328	1.0406	1.0478
55	0.9981	0.9976	0.9971	0.9965	125	1.0263	1.0334	1.0412	1.0485
56	0.9984	0.9980	0.9977	0.9973	126	1.0267	1.0339	1.0419	1.0493
57	0.9988	0.9985	0.9983	0.9980	127	1.0271	1.0344	1.0425	1.0501
58	0.9992	0.9990	0.9988	0.9986	128	1.0275	1.0350	1.0433	1.0509
59	0.9996	0.9995	0.9994	0.9993	129	1.0279	1.0355	1.0440	1.0517
60	1.0000	1.0000	1.0000	1.0000	130	1.0283	1.0360	1.0446	1.0525
61	1.0004	1.0005	1.0006	1.0007	131	1.0287	1.0366	1.0452	1.0533
62	1.0008	1.0010	1.0012	1.0014	132	1.0291	1.0371	1.0459	1.0541
63	1.0012	1.0015	1.0018	1.0021	133	1.0295	1.0377	1.0466	1.0548
64	1.0016	1.0020	1.0024	1.0028	134	1.0300	1.0382	1.0473	1.0557
65	1.0020	1.0025	1.0030	1.0035	135	1.0304	1.0387	1.0480	1.0565
66	1.0024	1.0030	1.0036	1.0042	136	1.0308	1.0393	1.0486	1.0573
67	1.0028	1.0035	1.0042	1.0049	137	1.0312	1.0398	1.0493	1.0581
68	1.0032	1.0040	1.0049	1.0056	138	1.0316	1.0404	1.0500	1.0589
69	1.0036	1.0045	1.0055	1.0064	139	1.0320	1.0409	1.0506	1.0598

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