The Engineering Society
For Advancing Mobility
Land Sea Air and Space®

A Product of the
Cooperative Engineering Program

SAE J1082 JAN89

Fuel Economy Measurement Road Test Procedure

SAE Recommended Practice
Revised January 1989

Submitted for Recognition as an American National Standard

The Engineering Society For Advancing Mobility Land Sea Air and Space ®
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HIGHWAY VEHICLE PRACTICE

SAE J1082

Issued April 1974
Revised January 1989

Superseding J1082 SEP80

Submitted for recognition as an American National Standard

Ø FUEL ECONOMY MEASUREMENT ROAD TEST PROCEDURE

1. PURPOSE:

This SAE Standard provides uniform testing procedures for measuring the fuel economy of light duty vehicles (motor vehicles designed primarily for transportation of persons or property and rated at 10 000 lb (4500 kg) or less) on suitable roads. (The development of the new SAE Motor Vehicle Fuel Economy Measurement Procedures - SAE 75000b.)

2. SCOPE:

This procedure incorporates driving cycles that produce fuel consumption data relating to Urban, Suburban, and Interstate driving patterns and is intended to be used to determine the relative fuel economy among vehicles and driving patterns under warmed-up conditions on test tracks, suitable roads or chassis dynamometers.[1] The urban driving cycle forms the basis of a Cold-Start Test Procedure described in SAE J1256.

3. DEFINITIONS:

3.1 Driving Cycles:

3.1.1 Urban Cycle: Driving pattern defined by 8.3.4 which is similar to driving conditions in the central business district of a large city.

3.1.2 Suburban Cycle: Driving pattern defined by 8.3.5 which is similar to driving conditions in suburban areas of a large city.

[1]Though these tests cycles can be run on a chassis dynamometer, this procedure cannot be used for compliance with mandatory fuel economy standards or fuel economy labelling for light duty 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 Street, S.W., Washington, DC 20460. It should be noted that correlation between chassis dynamometer and road test results has not been established.

3.1.3 Interstate Cycle: Driving patterns defined by 8.3.6 and 8.3.7 which are similar to driving conditions on expressways.

3.2 Test Vehicle: Passenger car or light truck prepared for test according to section 7.

3.3 Test Vehicle Weight: Unloaded vehicle weight plus 300 lb (136 kg).

3.3.1 Unloaded Vehicle Weight (Curb Weight): The weight of the vehicle as built to production parts list with maximum capacity of all fluids necessary for operation of the vehicle.

3.3.2 Driver and Passenger or Ballast Weight: 300 lb (136 kg) includes occupants, instrumentation, and ballast, if necessary.

NOTE: This weight will be distributed to properly simulate passenger locations and vehicle attitude (one passenger in driver's position, and one passenger or equivalent weight in front seat passenger position).

3.3.3 Chassis Dynamometer Inertia Weight and Horsepower Settings: These settings should be established and set in accordance with SAE J1263 - Road Load Measurement and Dynamometer Simulation Using Coastdown Techniques.

3.4 Observed Economy: Observed economy is the fuel economy measured during a driving cycle. It is determined by dividing the actual miles (kilometers) driven on the cycle by the number of gallons (liters) consumed. Economy should be expressed as miles per gallon (kilometers per liter).

3.5 Corrected Economy: Corrected economy is the observed economy multiplied by the correction factors listed in section 10. The corrected fuel economy should be expressed as miles per gallon (kilometers per liter).[2]

3.6 Correction Factors: Factors which are used to adjust data to the standard ambient condition of 60°F (15.6°C) and 29.00 in Hg (98.2 kPa) 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.

$$\text{Average Fuel Economy} = \frac{n}{\frac{1}{MPG_1} + \frac{1}{MPG_2} + \frac{1}{MPG_n}}$$

n = the number of replicate tests

[2]The corrected economy and average fuel economy may be expressed in terms of fuel consumption, for example, L/100 km, if the appropriate conversions are made. When average fuel economy is expressed as consumption, the average fuel consumption is the arithmetic average of the individual consumptions.

3.8 Test Repeatability Guidelines: These guidelines are intended to provide an estimate of repeatability of test data for replicate tests and are based on 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 Studentized[3] 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 average fuel economy would be 14.98 mile/gal and the 95th percentile range would be:

$$R = 0.053 \times 14.98 = 0.79 \text{ mile/gal}$$

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 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:

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

[3]D. B. Owen, "Handbook of Statistical Tables" Reading, MA: Addison Wesley Publishing Co., Inc. 1962, pp 144-148

3.8.2 (Continued)

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:

$$15.0 \pm \left[\frac{0.031}{\sqrt{2}} \times 15.0\right] = 15.0 \pm 0.33 \text{ mile/gal}$$

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/s^2 (m/s^2) and be accurate within 0.5 ft/s^2 (0.2 m/s^2). (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 minimum resolution of 10 lb (5 kg).

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 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. Specific gravity or API gravity for both gasoline and diesels shall be recorded. Also gasoline octane (R + M)/2 shall be recorded and 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 should be conducted at ambient temperatures between 30°F (-1°C) and 90°F (32°C).

6.2 Wind Velocity: Urban cycle 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). For the Suburban and Interstate Cycle tests, these limits should be reduced to 10 mile/h (16 km/h) average and 15 mile/h (24 km/h) gusts.

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 paragraph 8.3.

6.5 A driver's aid is recommended for dynamometer operations reflecting the test cycles described in paragraph 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). Unless the testing is specifically evaluating lubricant effects of fuel economy, care should be taken to ensure that lubricant changes or additions do not take place over the duration of the test, and that engine oil has a minimum of 2000 miles use prior to testing. 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. For dynamometer testing, the vehicle should have experienced at least 500 miles of cyclic break-in for the tires and brakes.

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 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 paragraph 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 and should be set before vehicle operation immediately prior to the vehicle warm up at the beginning of the test.

8. TEST PROCEDURE:

8.1 Warm-Up: 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 before running the first driving cycle.

8.2 Vehicle Controls:

8.2.1 Air conditioning compressor, headlamps, and other accessories that consume power should be turned off unless required for safe vehicle operation. The battery should be fully charged to minimize alternator loading.

8.2.2 Vehicle windows must remain closed while fuel consumption is being measured during the Suburban and Interstate Cycles.

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 ensures 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 shift speeds specified below should be noted on the data form. Manufacturer's recommended shift speed/shift lights may be used providing their use is noted on the data form.

8.3.1.4 Vehicles 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 speeds (mile/h) shown below.

	Transmission Type		
Shifts	3	4	5
1-2	15	15	15
2-3	25	25	25
3-4	--	35	40
4-5	--	--	45

Note any deviations from this schedule on the data form.

8.3.1.6 Shift into the highest possible gear whenever a specified cruise speed is reached. For example, the 20 mile/h (32 km/h) cruise after accelerating at the 0.5, 0.7, and 0.8 mile (0.80, 1.13, and 1.29 km) markers in the urban cycle would be conducted in the highest gear that will prevent engine lugging.

8.3.1.7 Vehicles with overdrive transmissions where the overdrive unit engages automatically are to be driven with the actuator switch in a position which ensures engagement when conditions for operation are reached. On vehicles where overdrive is engaged manually (such as designated overdrive gear), upshift to overdrive at the manufacturer's recommended speed for smooth operation. Where specified accelerations cannot be maintained in overdrive, make the complete acceleration in the conventional gear and engage overdrive upon reaching the specified speed.

8.3.1.8 On vehicles with 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 Urban Cycle will normally be run on a 2 mile (3.2 km) straightaway. The Suburban and Interstate Cycles may be run on either a closed track or on a straightaway. For tests on a straightaway less than 2 mile (3.2 km) long, turn-arounds may be made at normal stop intervals. A test on a straightaway shall consist of successive cycles run in opposite directions to minimize wind and grade effects. A test on a closed track shall consist of one cycle.

8.3.2.2 Effort should be made to perform the Interstate Schedule acceleration and decelerations as specified. The Urban and Suburban acceleration and decelerations 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).

8.3.2.3 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.

8.3.2.4 Fuel temperature will be recorded on the data form during all idle periods or at the beginning and end of the cycle on the Interstate Schedules.

8.3.2.5 Record weather data for each test cycle.

8.3.2.6 Ambient conditions should be such that repeatability may be attained in as few cycles as possible.

8.3.2.7 Fuel consumed for each schedule, as indicated by a fuel meter, should be the average of at least two consecutive tests that repeat within 2%. If the measured fuel readings are not within 2%, additional tests are required until this criteria is met before calculating the fuel economy. Elapsed time should repeat within 1%.

8.3.2.8 The driving cycles are to be conducted on warmed-up vehicles (refer to initial warm-up procedure in paragraph 8.1).

8.3.3 General Cycle Summary Table:

Cycle	Average Speed mile/h	(km/h)	Nominal Test Time s	Test Distance mile	(km)	Time s	Stops
Urban	15.6	(25.1)	463	2.0	(3.22)	60	8
Suburban	41.1	(66.1)	455	5.2	(8.37)	14	2
55 mile/h Interstate	55.0	(88.5)	308	4.7	(7.56)	--	--
70 mile/h Interstate	70.0	(112.6)	242	4.7	(7.56)	--	--

8.3.4 Urban Driving Cycle:

Distance mile	(km)	Operation
0.0	(0.0)	Start fuel meter and timing device, idle 15 s, accelerate to 15 mile/h (24 km/h) at 7 ft/s^2 (2.1 m/s^2). Proceed at 15 mile/h (24 km/h) to the 0.2 mile (0.32 km) marker.
0.2	(0.32)	Stop at 4 ft/s^2 (1.2 m/s^2), accelerate to 15 mile/h (24 km/h) at 7 ft/s^2 (2.1 m/s^2). 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/s^2 (1.2 m/s^2), accelerate to 15 mile/h (24 km/h) at 7 ft/s^2 (2.1 m/s^2). 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/s^2 (1.2 m/s^2), record fuel temperature and idle 15 s, accelerate to 20 mile/h (32 km/h) at 7 ft/s^2 (2.1 m/s^2). 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/s^2 (1.2 m/s^2), accelerate to 20 mile/h (32 km/h) at 7 ft/s^2 (2.1 m/s^2). Proceed at 20 mile/h (32 km/h) to the 0.8 mile (1.29 km) marker.

8.3.4 Urban Driving Cycle: (Continued)

Distance mile	Distance (km)	Operation
0.8	(1.29)	Decelerate to 10 mile/h (16 km/h) at 4 ft/s^2 (1.2 m/s^2), accelerate to 20 mile/h (32 km/h) at 5 ft/s^2 (1.5 m/s^2). 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/s^2 (1.2 m/s^2), record fuel temperature and idle 15 s, accelerate to 15 mile/h (24 km/h) at 7 ft/s^2 (2.1 m/s^2), then to 25 mile/h (40 km/h) at 5 ft/s^2 (1.5 m/s^2). 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/s^2 (1.2 m/s^2), accelerate to 15 mile/h (24 km/h) at 7 ft/s^2 (2.1 m/s^2), then to 25 mile/h (40 km/h) at 5 ft/s^2 (1.5 m/s^2). 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/s^2 (1.2 m/s^2), accelerate to 25 mile/h (40 km/h) at 5 ft/s^2 (1.5 m/s^2). 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/s^2 (1.2 m/s^2), record fuel temperature and idle 15 s, accelerate to 15 mile/h (24 km/h) at 7 fts/s^2 (2.1 m/s^2), then to 30 mile/h (48 km/h) at 5 ft/s^2 (1.5 m/s^2). 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/s^2 (1.2 m/s^2), accelerate to 15 mile/h (24 km/h) at 7 ft/s^2 (2.1 m/s^2) and then to 30 mile/h (48 km/h) at 5 ft/s^2 (1.5 m/s^2). 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/s^2 (1.2 m/s^2), accelerate to 30 mile/h (48 km/h) at 5 ft/s^2 (1.5 m/s^2). Proceed at 30 mile/h (48 km/h).
2.0	(3.22)	Begin braking at 4 ft/s^2 (1.2 m/s^2) to arrive at stop at 2.0 mile (3.22 km) marker. Stop fuel meter and timing device at stop, record fuel consumed, elapsed time, and fuel temperature.
0.0	(0.0)	Run Recheck cycle.

8.3.5 Suburban Driving Cycle:

Distance mile	Distance (km)	Operation
0.0	(0.0)	Approach starting line at 40 mile/h (64 km/h). At line, start fuel measuring and timing devices, accelerate to 60 mile/h (97 km/h) at 3 ft/s^2 (0.9 m/s^2). Proceed at 60 mile/h (97 km/h) to the 0.7 mile (1.13 km) marker.
0.7	(1.13)	Decelerate to 30 mile/h (48 km/h) at 4 ft/s^2 (1.2 m/s^2). Accelerate to 50 mile/h (80 km/h) at 3 ft/s^2 (0.9 m/s^2). Proceed at 50 mile/h (80 km/h) to the 2.0 mile (3.22 km) marker.
2.00	(3.22)	Stop at 4 ft/s^2 (1.2 m/s^2), record fuel temperature and idle 7 s, accelerate to 15 mile/h (24 km/h) at 7 ft/s^2 (2.1 m/s^2). Continue accelerating to 25 mile/h (40 km/h) at 5 ft/s^2 (1.5 m/s^2). Continue accelerating to 40 mile/h (64 km/h) at 3 ft/s^2 (0.9 m/s^2). Proceed at 40 mile/h (64 km/h) to the 2.6 mile (4.18 km) marker.
2.60	(4.18)	Accelerate to 50 mile/h (80 km/h) at 3 ft/s^2 (0.9 m/s^2). Proceed at 50 mile/h (80 km/h) to the 3.3 mile (5.31 km) marker.
3.30	(5.31)	Stop at 4 ft/s^2 (1.2 m/s^2), record fuel temperature and idle 7 s, accelerate to 15 mile/h (24 km/h) at 7 ft/s^2 (2.1 m/s^2). Continue accelerating to 25 mile/h (40 km/h) at 5 ft/s^2 (1.5 m/s^2). Continue accelerating to 40 mile/h (64 km/h) at 3 ft/s^2 (0.9 m/s^2). Proceed at 40 mile/h (64 km/h) to the 5.2 mile (8.37 km) marker.
5.2	(8.37)	Stop fuel measuring and timing devices while driving at 40 mile/h (64 km/h) at 5.2 mile (8.37 km). Record fuel consumed, elapsed time, and fuel temperature.
0.0	(0.0)	Run recheck cycle.

8.3.6 Interstate Cycle 55 mile/h (89 km/h):

Distance mile	Distance (km)	Operation
0.0	(0.0)	Approach the starting line at 55 mile/h (89 km/h). Record fuel temperature at line, start fuel measuring and timing devices. Proceed at 55 mile/h (89 km/h) to the 0.2 mile (0.32 km) marker.

8.3.6 Interstate Cycle 55 mile/h (89 km/h): (Continued)

Distance mile	Distance (km)	Operation
0.20	(0.32)	Accelerate to 60 mile/h (97 km/h) at 1 ft/s^2 (0.3 m/s^2). Immediately decelerate to 50 mile/h (80 km/h) at 1 ft/s^2 (0.3 m/s^2). Immediately accelerate to 55 mile/h (89 km/h) at 1 ft/s^2 (0.3 m/s^2). Proceed at 55 mile/h (89 km/h) to the 1.2 mile (1.93 km) marker.
1.2	(1.93)	Repeat accelerations and deceleration as at 0.20 mile (0.32 km). Proceed to the 2.2 mile (3.54 km) marker.
2.2	(3.54)	Repeat accelerations and decelerations as to 0.20 mile (0.32 km). Proceed to the 3.2 mile (5.15 km) marker.
3.2	(5.15)	Repeat accelerations and decelerations as to 0.20 mile (0.32 km). Proceed to the 4.7 mile (7.56 km) marker.
4.7	(7.56)	Stop fuel measuring and timing device while driving at 55 mile/h (89 km/h) at 4.7 mile (7.56 km). Record fuel consumed, elapsed time, and fuel temperature.
0.0	(0.0)	Run recheck cycle.

8.3.7 Interstate Cycle 70 mile/h (113 km/h):

Distance mile	Distance (km)	Operation
0.0	(0.0)	Approach the starting line at 70 mile/h (113 km/h). Record fuel temperature at line, start fuel measuring and timing devices. Proceed at 70 mile/h (113 km/h) to the 0.2 mile (0.32 km) marker.
0.20	(0.32)	Accelerate to 75 mile/h (121 km/h) at 1 ft/s^2 (0.3 m/s^2). Immediately decelerate to 65 mile/h (105 km/h) at 1 ft/s^2 (0.3 m/s^2). Immediately accelerate to 70 mile/h (113 km/h) at 1 ft/s^2 (0.3 m/s^2). Proceed at 70 mile/h (113 km/h) to the 1.2 mile (1.93 km) marker.
1.2	(1.93)	Repeat accelerations and decelerations as at 0.20 mile (0.32 km). Proceed to the 2.2 mile (3.54 km) marker.
2.2	(3.54)	Repeat accelerations and decelerations as at 0.20 mile (0.32 km). Proceed to the 3.2 mile (5.15 km) marker.
3.2	(5.15)	Repeat accelerations and decelerations as at 0.20 mile (0.32 km). Proceed to the 4.7 mile (7.56 km) marker.

8.3.7 Interstate Cycle 70 mile/h (113 km/h): (Continued)

Distance mile	Distance (km)	Operation
4.7	(7.56)	Stop fuel measuring and timing device while driving at 70 mile/h (113 km/h) at 4.7 mile (7.56 km). Record fuel consumed, elapsed time, and fuel temperature.
0.0	(0.0)	Run recheck cycle.

9. DATA RECORDING: Data shall be entered as required on test data forms.

9.1 Test Vehicle Specifications and Preparation Form:

9.2 *Data Form:

9.3 *Summary Sheet:

10. DATA CORRECTION (U.S. UNITS):

10.1 Reference Conditions:

Ambient Temperature		60°F
Fuel Temperature		60°F
Barometric Pressure		29.00 in Hg (wet)
Fuel Gravity (Gasoline)		0.737 Specific Gravity, 60.5° API Gravity
Fuel Gravity (ASTM 1D)		0.820 Specific Gravity, 41.0° API 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

10.2 Fuel Economy Correction (Gasoline):

10.2.1 Definitions (Units:

T_A - Average ambient temperature during test cycle (°F)

T_f - Average fuel temperature at measuring instrument during test cycle (°F)

P - Average barometric pressure during test cycle (in Hg)

*Data Form & Summary Sheet will be on separate pages for clarity.

10.2.1 Definitions (Units: (Continued)

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)

10.2.2 Correction Formula:

$$FE_C = FE_O \cdot C_1 \cdot C_2 \cdot C_3 \cdot C_4$$

10.2.3 Correction Factors:

$C_1 = 1.0 + 0.0014\ (60 - TA)$

$C_2 = 1.0$ Urban Cycle

$= 1.0 + 0.0072\ (P - 29.00)$ Suburban Cycle

$= 1.0 + 0.0084\ (P - 29.00)$ 55 mile/h Interstate Cycle

$= 1.0 + 0.0144\ (P - 29.00)$ 70 mile/h Interstate Cycle

$C_3 = 1.0 + 0.8\ (0.737 - Gs)$

$C_3 = 1.0 + 0.0032\ (GA - 60.5)$

C_4 is derived from Table 1 based on gravity of fuel at 60°F and T_f or from the following analytical equation:

$$C_4 = a + bT_f + cT_f^2$$

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	$9.3735\ (10)^{-8}$	$2.6156\ (10)^{-7}$	$4.3541\ (10)^{-7}$	$6.2624\ (10)^{-7}$

10.3 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. However, the ambient temperature and barometric pressure corrections are primarily for changes in air density and its effect on aerodynamic drag. Hence, the correction factors for gasoline powered vehicles are recommended for use.

10.3.1 Definitions: See paragraph 10.2.1.

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

10.3.2 Correction Formula:

$$FE_c = FE_o \cdot C_1 \cdot C_2 \cdot C_3 \cdot C_4$$

10.3.3 Correction Factors:

$C_1 = 1.0 + 0.0014\ (60 - T_A)$

$C_2 = 1.0$ Urban Cycle

$= 1.0 + 0.0072\ (P - 29.00)$ Suburban Cycle

$= 1.0 + 0.0084\ (P - 29.00)$ 55 mile/h Interstate Cycle

$= 1.0 + 0.0144\ (P - 29.00)$ 70 mile/h Interstate Cycle

$C_3 = K/H$

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_4 is derived from Table 1 based on gravity of fuel at 60°F and T_f or from the following analytical equation:

$$C_4 = a + bT_f + cT_f^2$$

where the coefficients a, b, c are as shown in paragraph 10.2.3.

11. DATA CORRECTION (SI UNITS):

11.1 Reference Conditions:

Ambient temperature	15.6°C
Fuel temperature	15.6°C

11.1 Reference Conditions: (Continued)

Barometric pressure		98 kPa
Fuel gravity (gasoline)		0.737 specific gravity
Fuel gravity (ASTM 1D)		0.820 specific gravity
	(ASTM 2D)	0.845 specific gravity
Fuel Net Heating Value		
	(ASTM 1D)	35.31 MJ/L
	(ASTM 2D)	36.21 MJ/L

11.2 Fuel Economy Correction (Gasoline):

11.2.1 Definitions (Units):

T_A - Average ambient temperature during test cycle (°C)
T_f - Average fuel temperature during test cycle (°C)
P - Average barometric pressure during test cycle (kPa)
G_s - Specific 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:

$$FE_c = FE_o \cdot C_1 \cdot C_2 \cdot C_3 \cdot C_4$$

TABLE 1—C_4—FUEL TEMPERATURE CORRECTION FACTOR[a] (U. S. UNITS)

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

Fuel Temp., °F	C_4 Group 1	Group 2	Group 3	Group 4	Fuel Temp., °F	C_4 Group 1	Group 2	Group 3	Group 4
0	0.9765	0.9711	0.9651	0.9598	76	1.0064	1.0081	1.0098	1.0114
1	0.9768	0.9715	0.9656	0.9604	77	1.0068	1.0085	1.0104	1.0121
2	0.9772	0.9720	0.9662	0.9611	78	1.0071	1.0090	1.0110	1.0129
3	0.9776	0.9725	0.9667	0.9616	79	1.0076	1.0095	1.0116	1.0136
4	0.9780	0.9730	0.9673	0.9623	80	1.0080	1.0100	1.0122	1.0143
5	0.9784	0.9734	0.9679	0.9629	81	1.0084	1.0105	1.0129	1.0151
6	0.9788	0.9739	0.9684	0.9636	82	1.0088	1.0110	1.0136	1.0158
7	0.9791	0.9743	0.9690	0.9642	83	1.0092	1.0115	1.0142	1.0166
8	0.9795	0.9748	0.9696	0.9649	84	1.0096	1.0120	1.0148	1.0173
9	0.9799	0.9753	0.9701	0.9655	85	1.0100	1.0126	1.0154	1.0180
10	0.9803	0.9758	0.9707	0.9661	86	1.0104	1.0131	1.0160	1.0187
11	0.9807	0.9763	0.9713	0.9668	87	1.0108	1.0136	1.0167	1.0195
12	0.9811	0.9768	0.9718	0.9675	88	1.0112	1.0141	1.0173	1.0202
13	0.9814	0.9772	0.9724	0.9681	89	1.0116	1.0146	1.0179	1.0209
14	0.9818	0.9777	0.9730	0.9688	90	1.0120	1.0151	1.0185	1.0218
15	0.9822	0.9782	0.9735	0.9695	91	1.0124	1.0156	1.0192	1.0225
16	0.9826	0.9787	0.9741	0.9701	92	1.0129	1.0162	1.0198	1.0232
17	0.9830	0.9790	0.9747	0.9708	93	1.0133	1.0167	1.0205	1.0240
18	0.9835	0.9795	0.9753	0.9714	94	1.0137	1.0172	1.0211	1.0247
19	0.9839	0.9800	0.9759	0.9721	95	1.0141	1.0177	1.0218	1.0254
20	0.9843	0.9805	0.9765	0.9728	96	1.0145	1.0182	1.0224	1.0262
21	0.9846	0.9810	0.9770	0.9734	97	1.0148	1.0187	1.0230	1.0269
22	0.9850	0.9814	0.9776	0.9741	98	1.0152	1.0193	1.0236	1.0276
23	0.9854	0.9819	0.9782	0.9748	99	1.0156	1.0198	1.0243	1.0285
24	0.9858	0.9824	0.9788	0.9753	100	1.0160	1.0203	1.0249	1.0292
25	0.9862	0.9829	0.9793	0.9760	101	1.0165	1.0208	1.0255	1.0300
26	0.9866	0.9834	0.9799	0.9767	102	1.0169	1.0213	1.0262	1.0307
27	0.9870	0.9839	0.9805	0.9773	103	1.0173	1.0219	1.0269	1.0314
28	0.9874	0.9843	0.9811	0.9780	104	1.0177	1.0224	1.0275	1.0322
29	0.9878	0.9848	0.9816	0.9787	105	1.0181	1.0229	1.0282	1.0330
30	0.9881	0.9853	0.9822	0.9793	106	1.0185	1.0234	1.0288	1.0338
31	0.9885	0.9858	0.9828	0.9800	107	1.0190	1.0240	1.0294	1.0346
32	0.9889	0.9863	0.9834	0.9807	108	1.0194	1.0245	1.0301	1.0353
33	0.9893	0.9868	0.9840	0.9814	109	1.0198	1.0250	1.0307	1.0360
34	0.9897	0.9873	0.9845	0.9820	110	1.0201	1.0255	1.0314	1.0368
35	0.9901	0.9878	0.9851	0.9827	111	1.0205	1.0261	1.0320	1.0376
36	0.9905	0.9882	0.9857	0.9834	112	1.0209	1.0266	1.0327	1.0384
37	0.9909	0.9887	0.9863	0.9841	113	1.0213	1.0271	1.0334	1.0392
38	0.9913	0.9892	0.9869	0.9847	114	1.0218	1.0276	1.0340	1.0399
39	0.9917	0.9897	0.9875	0.9854	115	1.0222	1.0282	1.0347	1.0407
40	0.9921	0.9902	0.9880	0.9861	116	1.0226	1.0287	1.0353	1.0414
41	0.9925	0.9907	0.9886	0.9868	117	1.0230	1.0291	1.0359	1.0422
42	0.9928	0.9912	0.9892	0.9875	118	1.0234	1.0296	1.0366	1.0431
43	0.9932	0.9917	0.9898	0.9881	119	1.0238	1.0302	1.0372	1.0438
44	0.9936	0.9922	0.9904	0.9888	120	1.0243	1.0307	1.0380	1.0446
45	0.9940	0.9926	0.9910	0.9895	121	1.0246	1.0312	1.0386	1.0454
46	0.9944	0.9930	0.9916	0.9902	122	1.0250	1.0318	1.0393	1.0461
47	0.9948	0.9935	0.9922	0.9910	123	1.0254	1.0323	1.0399	1.0469
48	0.9952	0.9940	0.9928	0.9917	124	1.0258	1.0328	1.0406	1.0478
49	0.9956	0.9945	0.9933	0.9924	125	1.0263	1.0334	1.0412	1.0485
50	0.9960	0.9950	0.9939	0.9930	126	1.0267	1.0339	1.0419	1.0493
51	0.9964	0.9955	0.9946	0.9937	127	1.0271	1.0344	1.0425	1.0501
52	0.9968	0.9960	0.9952	0.9944	128	1.0275	1.0350	1.0433	1.0509
53	0.9973	0.9965	0.9958	0.9951	129	1.0279	1.0355	1.0440	1.0517
54	0.9977	0.9971	0.9964	0.9958	130	1.0283	1.0360	1.0446	1.0525
55	0.9981	0.9976	0.9971	0.9965	131	1.0287	1.0366	1.0452	1.0533
56	0.9984	0.9980	0.9977	0.9973	132	1.0291	1.0371	1.0459	1.0541
57	0.9988	0.9985	0.9983	0.9980	133	1.0295	1.0377	1.0466	1.0548
58	0.9992	0.9990	0.9988	0.9986	134	1.0300	1.0382	1.0473	1.0557
59	0.9996	0.9995	0.9994	0.9993	135	1.0304	1.0387	1.0480	1.0565
60	1.0000	1.0000	1.0000	1.0000	136	1.0308	1.0393	1.0486	1.0573
61	1.0004	1.0005	1.0006	1.0007	137	1.0312	1.0398	1.0493	1.0581
62	1.0008	1.0010	1.0012	1.0014	138	1.0316	1.0404	1.0500	1.0589
63	1.0012	1.0015	1.0018	1.0021	139	1.0320	1.0409	1.0506	1.0598
64	1.0016	1.0020	1.0024	1.0028	140	1.0324	1.0414	1.0513	1.0606
65	1.0020	1.0025	1.0030	1.0035	141	1.0328	1.0420	1.0520	1.0613
66	1.0024	1.0030	1.0036	1.0042	142	1.0333	1.0425	1.0527	1.0621
67	1.0028	1.0035	1.0042	1.0049	143	1.0337	1.0431	1.0534	1.0630
68	1.0032	1.0040	1.0049	1.0056	144	1.0341	1.0436	1.0541	1.0638
69	1.0036	1.0045	1.0055	1.0064	145	1.0345	1.0442	1.0547	1.0646
70	1.0040	1.0050	1.0061	1.0072	146	1.0350	1.0447	1.0554	1.0654
71	1.0044	1.0055	1.0067	1.0079	147	1.0353	1.0452	1.0561	1.0662
72	1.0048	1.0060	1.0074	1.0086	148	1.0357	1.0458	1.0568	1.0671
73	1.0052	1.0065	1.0080	1.0093	149	1.0362	1.0464	1.0575	1.0679
74	1.0056	1.0070	1.0086	1.0100	150	1.0366	1.0469	1.0582	1.0687
75	1.0060	1.0076	1.0092	1.0107					

[a] This table is based on Tables 25 and 7 of "Petroleum Measurement Tables" published by the American Society for Testing and Materials, 1916 Race St., Philadelphia, PA, 19103. Values given are reciprocals of the multiplier values in Tables 25 and 7 as:

$$C_4 = \frac{1}{\text{multiplier for volume reduction to 60°F}}$$

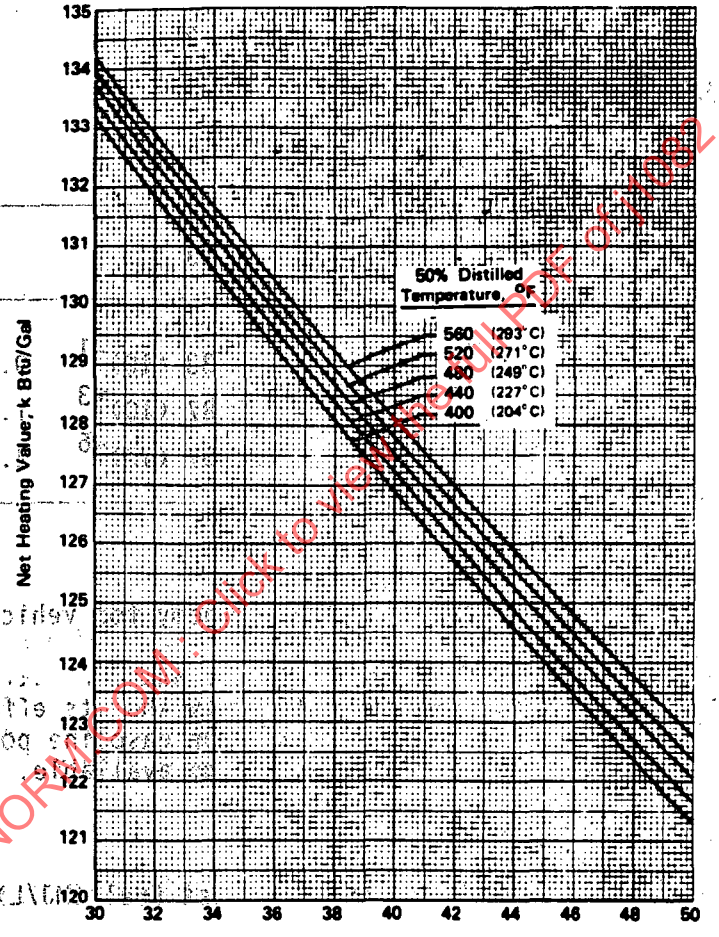
TABLE 1A—C_4—FUEL TEMPERATURE CORRECTION FACTOR[a] (SI UNITS)

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

Fuel Temp., °C	C_4 Group 1	Group 2	Group 3	Group 4	Fuel Temp., °C	C_4 Group 1	Group 2	Group 3	Group 4
−15	0.9784	0.9734	0.9679	0.9629	25	1.0068	1.0085	1.0104	1.0121
−14	0.9791	0.9742	0.9689	0.9641	26	1.0075	1.0095	1.0115	1.0134
−13	0.9798	0.9751	0.9699	0.9653	27	1.0083	1.0104	1.0127	1.0147
−12	0.9805	0.9760	0.9710	0.9664	28	1.0090	1.0113	1.0138	1.0161
−11	0.9812	0.9768	0.9720	0.9676	29	1.0097	1.0122	1.0150	1.0174
−10	0.9818	0.9777	0.9730	0.9688	30	1.0104	1.0131	1.0161	1.0187
−9	0.9826	0.9785	0.9741	0.9700	31	1.0112	1.0141	1.0172	1.0201
−8	0.9833	0.9794	0.9751	0.9712	32	1.0119	1.0150	1.0184	1.0214
−7	0.9840	0.9803	0.9761	0.9724	33	1.0126	1.0159	1.0195	1.0228
−6	0.9847	0.9811	0.9772	0.9736	34	1.0133	1.0168	1.0207	1.0241
−5	0.9854	0.9819	0.9782	0.9748	35	1.0141	1.0177	1.0218	1.0254
−4	0.9861	0.9828	0.9792	0.9760	36	1.0148	1.0187	1.0229	1.0268
−3	0.9868	0.9837	0.9803	0.9771	37	1.0155	1.0196	1.0241	1.0281
−2	0.9875	0.9845	0.9813	0.9783	38	1.0162	1.0205	1.0252	1.0295
−1	0.9882	0.9854	0.9823	0.9795	39	1.0170	1.0214	1.0264	1.0308
0	0.9889	0.9863	0.9834	0.9807	40	1.0177	1.0224	1.0275	1.0322
1	0.9896	0.9871	0.9844	0.9820	41	1.0184	1.0233	1.0287	1.0336
2	0.9903	0.9880	0.9854	0.9832	42	1.0191	1.0243	1.0299	1.0350
3	0.9910	0.9889	0.9865	0.9844	43	1.0199	1.0252	1.0310	1.0364
4	0.9918	0.9898	0.9876	0.9856	44	1.0206	1.0262	1.0322	1.0378
5	0.9925	0.9907	0.9886	0.9868	45	1.0213	1.0271	1.0334	1.0392
6	0.9932	0.9916	0.9897	0.9881	46	1.0221	1.0281	1.0346	1.0406
7	0.9939	0.9924	0.9908	0.9893	47	1.0228	1.0290	1.0358	1.0419
8	0.9946	0.9933	0.9918	0.9906	48	1.0235	1.0300	1.0370	1.0433
9	0.9953	0.9942	0.9929	0.9918	49	1.0243	1.0309	1.0381	1.0447
10	0.9960	0.9950	0.9939	0.9930	50	1.0250	1.0318	1.0393	1.0461
11	0.9968	0.9960	0.9950	0.9943	51	1.0258	1.0328	1.0405	1.0475
12	0.9975	0.9969	0.9961	0.9956	52	1.0265	1.0338	1.0417	1.0490
13	0.9982	0.9978	0.9972	0.9968	53	1.0272	1.0347	1.0429	1.0504
14	0.9989	0.9986	0.9983	0.9981	54	1.0280	1.0357	1.0441	1.0519
15	0.9996	0.9995	0.9994	0.9993	55	1.0287	1.0366	1.0453	1.0533
16	1.0003	1.0004	1.0005	1.0005	56	1.0294	1.0376	1.0465	1.0548
17	1.0010	1.0013	1.0016	1.0018	57	1.0302	1.0385	1.0477	1.0562
18	1.0018	1.0022	1.0027	1.0031	58	1.0309	1.0395	1.0489	1.0577
19	1.0025	1.0031	1.0038	1.0044	59	1.0316	1.0404	1.0501	1.0592
20	1.0032	1.0040	1.0049	1.0056	60	1.0324	1.0414	1.0513	1.0606
21	1.0039	1.0049	1.0060	1.0069	61	1.0332	1.0424	1.0526	1.0621
22	1.0046	1.0058	1.0071	1.0082	62	1.0339	1.0434	1.0538	1.0635
23	1.0054	1.0067	1.0082	1.0095	63	1.0347	1.0444	1.0550	1.0650
24	1.0061	1.0076	1.0093	1.0108	64	1.0354	1.0454	1.0562	1.0664

[a]This table is based on Tables 25 and 7 of "Petroleum Measurement Tables" published by the American Society for Testing and Materials, 1916 Race St., Philadelphia, PA, 19103. Values given are reciprocals of the multiplier values as:

$$C_4 = \frac{1}{\text{multiplier for volume reduction to 15.6°C}}.$$



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

FIGURE 1 - Volumetric Net Heat Content of Diesel Fuels

11.2.3 Correction Factors:

$C_1 = 1 + 0.0025\ (15.6 - T_A)$

$C_2 = 1.0$ Urban Cycle
$= 1.0 + 0.0021\ (P - 98)$ Suburban Cycle
$= 1.0 + 0.0025\ (P - 98)$ 89 km/h Interstate Cycle
$= 1.0 + 0.0043\ (P - 98)$ 113 km/h Interstate Cycle

$C_3 = 1.0 + 0.8\ (0.737 - G_S)$

C_4 is deried from TAble 1A based on gravity of fuel at 15.6°C and T_f or from the following analytical equation:

$$C_4 = a' + b'T_f + c'T_f^2$$

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

	ASTM Fuel Group			
Coefficient	1	2	3	4
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 it has for gasoline powered vehicles. However, the ambient temperature and barometric pressure corrections are primarily for changes in air density and its effect on aerodynamic drag. Hence, the correction factors for gasoline powered vehicles are recommended for use until additional data become available.

11.3.1 Definitions (See paragraph 11.2.1):

H = Volumetric heating value of test fuel (MJ/L)

11.3.2 Correction Formula:

$$FE_c = FE_0 \cdot C_1 \cdot C_2 \cdot C_3 \cdot C_4$$