SAE The Engineering Society For Advancing Mobility Land Sea Air and Space® INTERNATIONAL
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SURFACE VEHICLE STANDARD

Submitted for recognition as an American National Standard

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FUEL ECONOMY MEASUREMENT ROAD TEST PROCEDURE

Foreword—This Document has also changed to comply with the new SAE Technical Standards Board format.

1. Scope—This SAE Standard 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.

1.1 Purpose—This document 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 4500 kg (10 000 lb) or less) on suitable roads.

2. References

2.1 Applicable Publications—The following publications form a part of the specification to the extent specified herein. Unless otherwise indicated the latest revision of SAE publications shall apply.

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

SAE J1256—Fuel Economy Measurement—Road Test Procedure—Cold Start and Warm-up Fuel Economy
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.

ASTM D 4814—Standards Specification for Automotive Spark-Ignition Engine Fuel

1. Though these test 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. 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.

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 136 kg (300 lb).

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—136 kg (300 lb) 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.

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

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 kilometers per liter (miles per gallon).[2]

3.6 Correction Factors—Factors which are used to adjust data to the standard ambient condition of 15.6 °C (60 °F) and 98.2 kPa (29.0 in Hg) 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.

$$\text{Average Fuel Economy} = \frac{n}{1/MPG_1 + 1/MPG_2 + \ldots + 1/MPG_n} \quad \text{(Eq. 1)}$$

$n =$ 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 (L/100 km = 235.265/mpg). 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 value for 0.019Q are as 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

a. 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 average fuel economy would be 6.39 km/L and the 95th percentile range would be as shown in Equation 2:

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

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.

b. 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 average fuel economy would be 14.98 mile/gal and the 95th percentile range would be as shown in Equation 3:

$$R = 0.053 \times 14.98 = 0.79 \text{ mile/gal} \quad \text{(Eq. 3)}$$

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.

3.8.2 ESTIMATE OF THE AVERAGE FUEL ECONOMY AT A 90% CONFIDENCE INTERVAL—(SEE EQUATION 4.)

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

a. 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:

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

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

b. 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 0.3 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 minimum resolution of 5 kg (10 lb).

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 4814 standards. Specific gravity or API gravity for both gasoline and diesels shall be recorded.

Also gasoline octane rating $\frac{R + M}{2}$ 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 -1 °C (30 °F) and 32 °C (90 °F).

6.2 **Wind Velocity**—Urban cycle tests must not be conducted when average wind speed exceeds 24 km/h (15 mph) or when gusts exceed 32 km/h (20 mph). For the Suburban and Interstate Cycle tests, these limits should be reduced to 16 km/h (10 mph) average and 24 km/h (15 mph) 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 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 A driver's aid is recommended for dynamometer operations reflecting the test cycles described 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). 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 3200 km (2000 miles) use prior to testing. Chassis dynamometer break-in is acceptable. All of the tires must have operated on a road or track at least 160 km (100 miles) 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 800 km (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 (Figure 1).

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 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 32 km (20 miles) at 90 km/h (55 mph) or maximum legal highway speed to stabilize engine and driveline operating temperatures immediately before running the first driving cycle.

SPECIFICATION LIST
DATE ____
CAR NO. ____
YEAR AND MAKE ____
MODEL AND BODY ____
VEHICLE INDENT. 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 160 km (100 miles)
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—TEST VEHICLE SPECIFICATIONS AND PREPARATION FORM

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 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 manual transmission shift speeds in Table 2 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 in Table 2 should be noted on the data form (see Figure 2). 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 in Table 2:

TABLE 2—MANUAL TRANSMISSION SHIFT SPEEDS

Shifts	Number of Forward Gears 3	Number of Forward Gears 4	Number of Forward Gears 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 (see Figure 2).

8.3.1.6 Shift into the highest possible gear whenever a specified cruise speed is reached. For example, the 32 km/h (20 mph) cruise after accelerating at the 0.80, 1.13, and 1.29 km (0.5, 0.7, and 0.8 mile) 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.

CAR NO.______________ VIN________________ TEST VEHICLE WEIGHT_________________________
YEAR AND MAKE___________________________ TEST ROAD_____________________________
MODEL AND BODY__________________________ TYPE OF SURFACE____________________________
ENGINE TYPE__________ DISP.______________ INSTRUMENTATION
DRIVE AXLE RATIO__________________________ 1. ______________ NO. ______________
TRANSMISSION____________________________ 2. ______________ NO. ______________
TIRE MAKE___________ SIZE_______________ 3. ______________ NO. ______________
TIRE PRESSURE: F_______ R________________ 4. ______________ NO. ______________
FUEL TYPE___________ SPECIFIC GRAVITY_____

URBAN CYCLE (3.22 km) (2.00 mile) DATE_____________________ TIME____________________
ODOMETER: START______________ FINISH_____________________

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

SUBURBAN CYCLE (8.37 km) (5.2 mile) DATE_____________________ TIME____________________
ODOMETER: START______________ FINISH_____________________

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

_______________________ km/h (mph) INTERSTATE CYCLE 7.56 km (4.7 miles) DATE__________ TIME____________________
ODOMETER: START ______________________________________ FINISH ______________________________

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

TESTED BY ____

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

8.3.2 GENERAL CYCLE INSTRUCTIONS

8.3.2.1 The Urban Cycle will normally be run on a 3.2 km (2 mile) straightaway. The Suburban and Interstate Cycle may be run on either a closed track or on a straightaway. For tests on a straightaway less than 3.2 km (2 mile) 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 0.3 m/s^2 (1 ft/s^2) of that specified. Vehicle speeds should be maintained within 1.6 km/h (1 mph).

8.3.2.3 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 (see Figure 2) during all idle periods at 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 criterion 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 8.1).

8.3.3 GENERAL CYCLE SUMMARY—(See Table 3.)

TABLE 3—CHARACTERISTICS OF EACH DRIVING CYCLE

Cycle	Average Speed km/h	Average Speed (mph)	Nominal Test Time s	Test Distance km	Test Distance (mile)	Idle Time s	Stops
Urban	25.1	(15.6)	463	3.22	(2.0)	60	8
Suburban	66.1	(41.1)	455	8.37	(5.2)	14	2
55 mile/h Interstate	88.5	(55.0)	308	7.56	(4.7)	0	0
70 mile/h Interstate	112.6	(70.0)	242	7.56	(4.7)	0	0

8.3.4 URBAN DRIVING CYCLE—(See Table 4.)

TABLE 4—URBAN DRIVING CYCLE

Distance km	Distance (mile)	Operation
0.0	(0.0)	Start fuel meter and timing device, idle 15 s, acceleratet o 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 (0.5 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 2.4 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 m/s^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/s^2 (7 ft/s^2) and 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 at stop, record fuel consumed, elapsed time, and fuel temperature.
0.0	(0.0)	Run recheck cycle.

8.3.5 SUBURBAN DRIVING CYCLE—(See Table 5.)

TABLE 5—SUBURBAN DRIVING CYCLE

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

8.3.6 INTERSTATE CYCLE 89 KM/H (55 MPH)—(See Table 6.)

TABLE 6—INTERSTATE CYCLE 89 km/h (55 mph)

Distance km	Distance (mile)	Operation
0.0	(0.0)	Approach the starting line at 89 km/h (55 mph). Record fuel temperature at line, start fuel measuring and timing devices. Proceed at 89 km/h (55 mph) to the 0.32 km (0.2 mile) marker.
0.32	(0.20)	Accelerate to 97 km/h (60 mph) at 0.3 m/s^2 (1 ft/s^2). Immediately decelerate to 80 km/h (50 mph) at 0.3 m/s^2 (1 ft/s^2). Immediately accelerate to 89 km/h(55 mph) at 0.3 m/s^2 (1 ft/s^2). Proceed at 89 km/h (55 mph) to the 1.93 km (1.2 mile) marker.
1.93	(1.2)	Repeat accelerations and decelerations as at 0.32 km (0.20 mile). Proceed to the 3.54 km (2.2 mile) marker.
3.54	(2.2)	Repeat accelerations and decelerations as to 0.32 km (0.20 mile). Proceed to the 5.15 km (3.2 mile) marker.
5.15	(3.2)	Repeat accelerations and decelerations as to 0.32 km (0.20 mile). Proceed to the 7.56 km (4.7 mile) marker.
7.56	(4.7)	Stop fuel measuring and timing device while driving at 89 km/h (55 mph) at 7.56 km (4.7 mile). Record fuel consumed, elapsed time, and fuel temperature.
0.0	(0.0)	Run recheck cycle.

8.3.7 INTERSTATE CYCLE 113 KM/H (70 MPH)—(See Table 7.)

TABLE 7—INTERSTATE CYCLE 113 km/h (70 mph)

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

9.2 *Data Form—(See Figure 2.)

9.3 *Summary Sheet—(See Figure 3.)

10. Data Correction (SI Units)

10.1 Reference Conditions

a. Ambient Temperature—15.6 °C
b. Fuel Temperature—15.6 °C
c. Barometric Pressure—98 kPa
d. Fuel Gravity (gasoline)—0.737 specific gravity
e. Fuel Gravity (ASTM 1D)—0.820 specific gravity
   (ASTM 2D)—0.845 specific gravity
f. Fuel Net Heating Value
   (ASTM 1D)—35.31 MJ/L
   (ASTM 2D)—36.21 MJ/L

10.2 Fuel Economy Correction (Gasoline)

10.2.1 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)

DATE

VEHICLE MAKE ____________ ENGINE ____________ CAR NO. ____________

VIN ____________ TRANSMISSION ____________ AXLE RATIO ____________

TIRE MAKE ____________ SIZE ____________ PRESSURE ____________

VEHICLE TEST WEIGHT ____________

TEST ROAD ____________ SURFACE ____________

FUEL ECONOMY[1]

	CORRECTED[2] km/L (mile/gal)	OBSERVED km/L (mile/gal)	FUEL TEMP. °C (°F)	BARO. PRESS. kPa (in Hg)	AIR TEMP °C (°F)	WIND SPEED-DIRECTION km/h (mile/h)
URBAN CYCLE						
SUBURBAN CYCLE						
89 km/h (55 mph) INTERSTATE CYCLE						
113 km/h (70 mph) INTERSTATE CYCLE						

[1] Cross out those units not used.
[2] The Corrected Fuel Economy may be expressed in terms of fuel as consumed liters per 100 km.

COMMENTS ____________

TESTED BY ____________

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

10.2.2 CORRECTION FORMULA—(See Equation 7.)

$$FE_c = FE_o \cdot C_1 \cdot C_2 \cdot C_3 \cdot C_4 \quad \text{(Eq. 7)}$$

10.2.3 CORRECTION FACTORS

$C_1 = 1.0 + 0.0025\,(15.6 - T_A)$

$C_2 = 1.0$ 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 derived from Table 9 based on ASTM Fuel Group (see Table 8) and T_f or from the following analytical equation:

$$C_4 = a' + b'T_f + c'T_f^2 \quad \text{(Eq. 8)}$$

where the coefficients a', b', and c' are as shown in Table 10:

TABLE 8—ASTM FUEL GROUPS

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

TABLE 9—FUEL TEMPERATURE CORRECTION FACTOR[1] (SI UNITS)

Fuel Temp., °C	C_4 Group 1	C_4 Group 2	C_4 Group 3	C_4 Group 4	Fuel Temp., °C	C_4 Group 1	C_4 Group 2	C_4 Group 3	C_4 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

TABLE 9—FUEL TEMPERATURE CORRECTION FACTOR[1] (SI UNITS) (CONTINUED)

Fuel Temp., °C	C_4 Group 1	C_4 Group 2	C_4 Group 3	C_4 Group 4	Fuel Temp., °C	C_4 Group 1	C_4 Group 2	C_4 Group 3	C_4 Group 4
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

1. This table is based on Tables 27 and 7 of "Petroleum Measurement Tables" published by the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959. Values given are reciprocals of the multiplier values as:

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

TABLE 10—COEFFICIENTS FOR FUEL TEMPERATURE CORRECTION (EQUATION 8)

Coefficient	ASTM Fuel Group 1	ASTM Fuel Group 2	ASTM Fuel Group 3	ASTM Fuel Group 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

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 until additional data become available.

10.3.1 DEFINITIONS (SEE 10.2.1)—See Equation 9.

$$H = \text{Volumetric heating value of test fuel (MJ/L)} \qquad \text{(Eq. 9)}$$

10.3.2 CORRECTION FORMULA—See Equation 10.

$$FE_c = FE_o \cdot C_1 \cdot C_2 \cdot C_3 \cdot C_4 \qquad \text{(Eq. 10)}$$

10.3.3 CORRECTION FACTORS

C_1 = 1.0 + 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 = 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_4 is derived from Table 9 based on ASTM Fuel Group (see Table 8) and T_f or from the following analytical equation:

$$C_4 = a' + b'T_f + c'T_f^2 \quad \text{(Eq. 11)}$$

where the coefficients a′, b′, and c′ are as shown in Table 10.

11. Data Correction (U.S. Units)

11.1 Reference Conditions

a. Ambient Temperature—60 °F
b. Fuel Temperature—60 °F
c. Barometric Pressure—29.00 in Hg (wet)
d. Fuel Gravity (gasoline)—0.737 Specific Gravity, 60.5° API Gravity
e. Fuel Gravity (ASTM 1D)—0.820 Specific Gravity, 41.00° API Gravity
(ASTM 2D)—0.845 Specific Gravity, 36.0° API Gravity
f. Fuel Net Heating Value
(ASTM 1D)—126 700 Btu/gal
(ASTM 2D)—129 900 Btu/gal

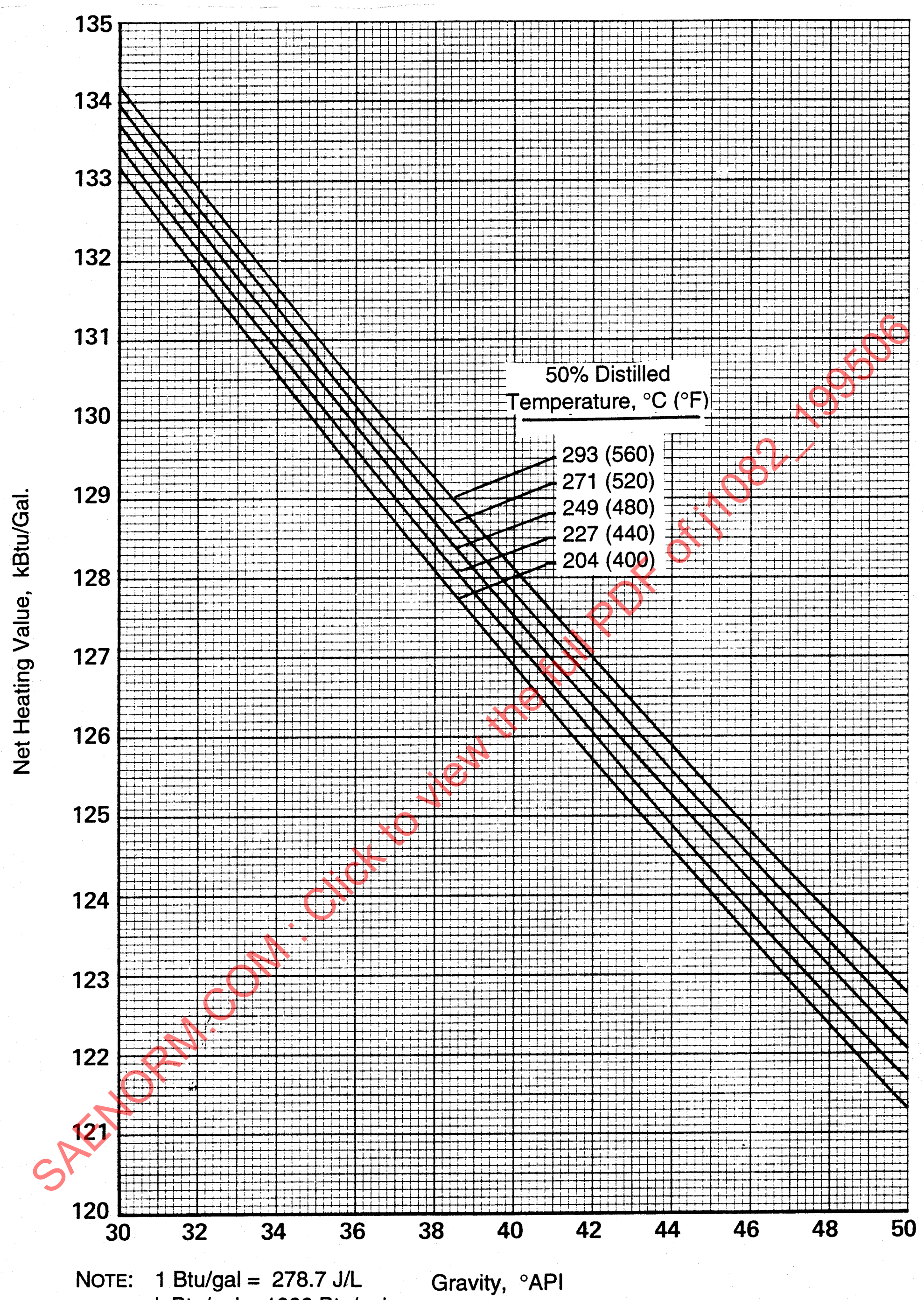
11.2 Fuel Economy Correction (Gasoline)

11.2.1 DEFINITION (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)
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

$$FE_c = FE_o \cdot C_1 \cdot C_2 \cdot C_3 \cdot C_4 \quad \text{(Eq. 12)}$$



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

FIGURE 4—VOLUMETRIC NET HEAT CONTENT OF DIESEL FUELS