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INTERNATIONAL
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SURFACE VEHICLE RECOMMENDED PRACTICE

An American National Standard

SAE J1635

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SAE Cold Start and Driveability Procedure

1. Scope

1.1 To subjectively evaluate engine starting behavior and driveability characteristics of a motor vehicle which has been soaked at ambient temperature for a given time period after attaining a stabilized engine coolant temperature. This SAE Recommended Practice also defines driveability defects and the rating system.

1.2 This evaluation may be affected by ambient temperature, altitude, fuel, and the road system.

1.2.1 The vehicle should be evaluated with all fuels recommended by the manufacturer. A partial list comprises reformulated gasoline, ethanol/gasoline and methanol/gasoline blends of various proportions, diesel #1, and diesel #2.

2. References—There are no referenced publications specified herein.

3. Test Conditions

3.1 The test road should be paved, level, smooth, and dry. If the vehicle is evaluated on a public road, traffic should be light.

3.2 Tests may be conducted at any ambient temperature, but it is recommended that average winds not exceed 25 km/h (15 mph) or gusts not exceed 40 km/h (25 mph). Winds mask defects such as surge, hesitation, and bucking. Precipitation or fog may affect traction and must be avoided.

3.3 Nomenclature for transmission gear shall be as follows:

3.3.1 Automatic transmission is designated as A; the gear is represented by the first letter of the appropriate word (i.e., A-D is Drive).

3.3.2 Manual transmission is designated as M; the gear is represented by the appropriate number (i.e., M-1 is First). For idle rating purposes, the clutch is to be disengaged.

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4. Equipment

4.1 Stop watch

4.2 Engine tachometer

4.3 Intake manifold absolute pressure (MAP) gauge

5. Vehicle Preparation

5.1 The vehicle must be properly equipped, maintained, and adjusted for ambient temperature operation. This includes the use of recommended:

5.1.1 Fuel (at least 1/4 tank)

5.1.2 Weight and viscosity of engine oil

5.1.3 Coolant composition

5.1.4 Thermostat

5.1.5 Spark plug type and gap

5.1.6 Tires, at proper cold inflation pressure

5.1.6.1 When the ambient temperature at which the test is to be conducted differs more than 14 °C (26 °F) from that at which the vehicle is being prepared, it is recommended that the inflation pressure be altered by the following pressure increment:

$$P = k\,(\text{Prep Temp} - \text{Test Temp}) \qquad \text{(Eq. 1)}$$

where:

P = Change in pressure
k = 1 kPa/°C or 1 psi/13 °F

5.1.6.2 If the ambient test temperature is higher than the preparation area temperature, then subtract the tire pressure correction factor from the specified tire pressure.

5.1.6.3 If the ambient test temperature is lower than the preparation area temperature, then add the tire pressure correction factor to the specified tire pressure, e.g.,

a. Prep Temp 21 °C (70 °F)
b. Test Temp 13 °C (56 °F)
c. (21 °C to 13 °C) 1 kPa/°C = +8 kPa or (70 °F to 56 °F) 1 psi/13 °F = +1.1 psi

5.1.7 Battery and battery cable sizes

5.1.8 Cold weather starting aids

5.1.9 Transmission fluid

5.1.10 Air cleaner

5.1.11 Air cleaner hot-air stove

5.2 The vehicle is to be loaded 136 kg ±11.4 kg (300 lb ±25 lb) above curb weight, inclusive of weight of driver and test equipment.

5.3 Prepare the vehicle for a cold/partial cooldown/hot start as follows:

5.3.1 If the engine coolant temperature is not at a stable value when the vehicle is delivered, then prepare the vehicle by driving at a steady state. At a time equal to the desired soak period before the start test, bring engine to stabilized coolant temperature by driving for at least 16 km (10 mile) at 70 to 90 km/h (45 to 55 mph). At temperatures lower than −18 °C (0 °F), drive for a minimum of 32 km (20 mile). See Table 1.

TABLE 1—LENGTH OF SOAK PERIOD

Type of Start Test	Soak Period
Cold	8 to 36 h (12 h nominal)
Partial cooldown	1.5 to 4 h
Hot	5 to 30 min

5.3.2 Record manifold absolute pressure (kPa) for stabilized engine idle (for use in 7.3) and RPM (gears A-D, A-P or M-1, M-0) at conclusion of warm-up for use with Table 2.

TABLE 2—DEFINITION OF ACCELERATION

Description	Manifold Pressure (DRIVE)	Fraction of Full Pedal Travel
Light accel	40.4 + 0.60 * Idle kPa	1/4
Moderate accel	60.6 + 0.40 * Idle kPa	1/4 < Pedal < 1/2
Heavy accel	85.8 + 0.15 * Idle kPa	1/2 < Pedal < 7/8
Wide Open Throttle (WOT)	101 kPa	Full

5.3.3 Place gear selector in PARK (A-P) or NEUTRAL (M-0) and turn off engine. Set the parking brake.

5.3.4 Set the heater/air conditioner controls as follows, with the blower switch in HIGH (if selectable) and the temperature set to a maximum tolerable level.

a. Non A/C—Defrost, LOW fan, maximum tolerable temperature (MTT)
b. Manual A/C—Defrost, LOW fan, MTT
c. Semi-auto A/C—Defrost, LOW fan, MTT
d. Automatic A/C—Automatic LOW fan, MTT

5.3.5 Allow the vehicle to soak at ambient temperature for the desired period.

6. Cold Start Procedure

6.1 Record all test information on the Cold Start and Driveability data sheet. See Figure 1.

6.2 For diesel engines, turn ignition key to RUN position and record "WAIT" light on-time.

6.3 Start engine per Owner's Manual/visor information procedure. Record start time.

6.4 If engine fails to start after 15 s, stop cranking. Follow Owner's Manual procedure for a no start. Begin cranking and record total cranking time until engine starts. After three failures to start, the vehicle should be withdrawn from testing for diagnosis and repair.

VEHICLE INFORMATION

Vehicle Identification _____ (VIN)

Model Year _____ Manufacturer _____

Model _____ Odometer _____ km

Body Style _____ (2D, 4D, SW, TR = truck)

Engine Displacement: _____ (Liters) Configuration _____ (L4, V6, V8)

Induction System _____ (Normal, Turbocharged, Supercharged)

Fuel Delivery System _____ (CARB, TBI, DIE, PFI)

Transmission _____(A3, A4, A5, M5, M6)

Final Drive Ratio _____ Drive Axle _____ (Front, Rear, AWD)

Test Weight: _____ kg Fuel Type _____

Tire Brand & Model _____

Tire Size _____ Cold Tire Press ___ kPa front ___ kPa rear

Comments _____

TEST INFORMATION

Date _____ Driver _____

Observer _____

Soak Time _____ Soak Temperature _____ °C.

Acceleration based on ___ Manifold Pressure ___ Throttle Pedal travel

Manifold Pressure at Idle _____ kPa

Condition	Start Rating	Idle Rating Idle Neutral Reverse / Idle Drive / Idle	Drive Rating	Ambient Temp (C)	Soak Time (hr)
Cold Drive		/ /			
Comments					
Warm Drive	--------	/ /			-----
Comments					
Hot Drive		/ /			
Comments					
Partial Cool Dwn		/ /			
Comments					

FIGURE 1—COLD START AND DRIVEABILITY DATA SHEET

6.5 As soon as the engine starts, turn on headlights and backlight defroster (if so equipped). The defroster is not to be reset if it shuts off automatically.

6.5.1 Fan is kept at low setting throughout test to provide a quiet ambient for assessing engine roughness, knock, and engine run-on.

6.5.2 If vehicle is tested with heated windshield activated, note this condition on the data sheet. See Figure 1.

6.6 Record the following readings (as applicable) in gear A-P or M-0 immediately after start. Do not force the idle; engine is to idle at closed throttle. For a manual transmission, record data with clutch engaged and disengaged.

6.6.1 Idle speed, RPM

6.6.2 Manifold absolute pressure, kPa

6.6.3 Idle quality (see Appendix A).

6.7 If engine stalls, repeat Steps 6.2 through 6.4. Record number of stalls and starting times. After three failures to start, the vehicle should be withdrawn from testing for diagnosis and repair.

6.8 Allow engine to idle 15 s in gear A-P or M-0. Apply brake, shift to gear A-D or M-1 (clutch disengaged) range, idle for 10 s, and record information in 6.6. If engine stalls, restart immediately. Do not record restart time. Record number of stalls.

7. Driveability Procedure

7.1 After the cold start evaluation, the vehicle is driven according to Cycle 1, then Cycle 2, followed by a repeat of Cycle 1 and Cycle 2.

7.2 Record the frequency and severity of the following defects:

7.2.1 Backfire (note whether induction or exhaust)

7.2.2 Bucking

7.2.3 Detonation

7.2.4 Harshness

7.2.5 Hesitation/Stumble

7.2.6 Stall

7.2.7 Surge

7.2.8 Vibration

7.3 Accelerations are calculated as a function of:

7.3.1 Manifold absolute pressure at idle (gear A-D or M-1, clutch disengaged). (See 5.3.2).

OR

7.3.2 Full pedal travel (Diesel engine or when no MAP gauge available/erratic MAP at idle).

7.4 All automatic transmissions are to be operated in highest drive/overdrive position (D/D3/D4/OD). Manual transmissions are to be shifted when signaled by a Shift Indicator Light (SIL) or at speeds specified in the Owner's Manual for normal driving. Upshifts may be lower than the recommended speeds if the vehicle will be cruising at a speed below the recommended acceleration shift points. For accelerations from a rest with a manual transmission, clutch should be released simultaneously with throttle application. Idle stops are to be made at a normal rate, with the clutch depressed on manual transmission vehicles.

7.5 Place transmission in REVERSE, and back vehicle for 15 m (50 ft). Evaluate driveability for smoothness and note any stalls (see Appendix A for rating methods). Idle for 10 s in gear A-R or M-R. Record idle parameters (see 6.6). Select gear A-D or M-1. Idle for 10 s. Record idle parameters (see 6.6).

7.6 After 10 s in gear A-D or M-1, drive schedule (Cycle 1) in Table 3 and Figure 2. Record idle parameters at the 0.5 km (0.3 mile) stop. See Table 2 for definition of throttle setting.

TABLE 3—SCHEDULE DRIVEABILITY—CYCLE 1

Distance km	Distance (mile)	Operation and Throttle Setting	Speed km/h	Speed (mph)
0.0–0.2	0.0–0.1	Light accel	0–40	0–25
0.2–0.3	0.1–0.2	Steady state	40	25
0.3	0.2	Heavy accel	40–55	25–35
0.3–0.5	0.2–0.3	Steady state	55	35
0.5	0.3	BRAKE	55-0	35-0
0.5	0.3	10 s idle	0	0
0.5	0.3	WOT accel	0–55	0–35
0.5	0.3	Closed-throttle decel	55–15	35–10
0.5–0.6	0.3–0.4	Steady state	15	10
0.6	0.4	Moderate accel	15–40	10–25
0.6–0.8	0.4–0.5	Steady state	40	25
0.8	0.5	BRAKE	40–0	25–0
0.8	0.5	30 s IDLE	0	0
0.8	0.5	Lock-to-lock steering maneuver		

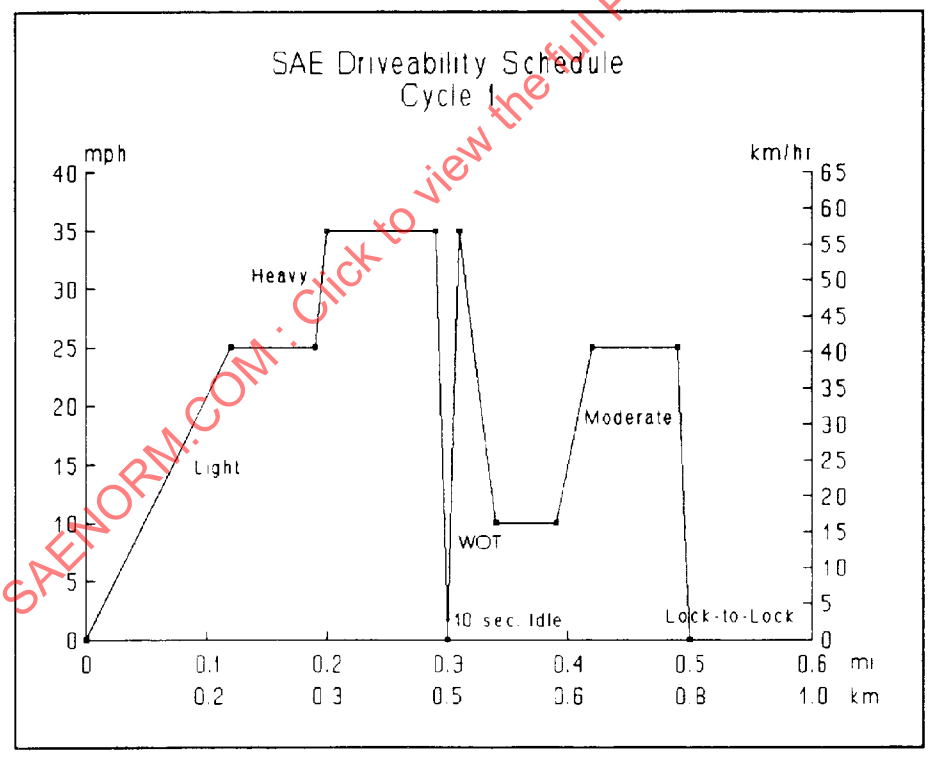

FIGURE 2—DRIVEABILITY SCHEDULE—CYCLE 1

7.7 At the 0.8 km (0.5 mile) marker, brake to a stop off the roadway. Idle for 30 s in gear A-D or M-1. Record idle parameters.

7.7.1 If vehicle has power steering, at end of idle period, turn steering wheel to full left steering stop, then to full right steering stop, and return to center. Note any stalls or changes in engine RPM.

7.8 Cycle 2 is illustrated in Table 4 and Figure 3. Rate and record defects in these maneuvers as in 7.5. Idle 30 s in gear A-D or M-1 at end of Cycle 2. See Table 2 for definition of throttle setting.

TABLE 4—SCHEDULE DRIVEABILITY-CYCLE 2

Distance km	Distance (mile)	Operation and Throttle Setting	Speed km/h	Speed (mph)
0.8–1.1	0.5–0.7	Crowd accel	0–70	0–45
1.1–1.4	0.7–0.9	Steady state	70	45
1.4	0.9	Closed-throttle decel	70–40	45–25
1.4	0.9	Heavy accel	40–55	25–35
1.4–1.6	0.9–1.0	Steady state	55	35
1.6	1.0	BRAKE	55–0	35–0
1.6	1.0	5 s IDLE	0	0
1.6	1.0	Interrupted accel	N/A	N/A
1.6–1.7	1.0–1.05	Moderate accel	0–40	0–25
1.7	1.05	BRAKE	40–0	25–0
1.7	1.05	30 s IDLE	0	0

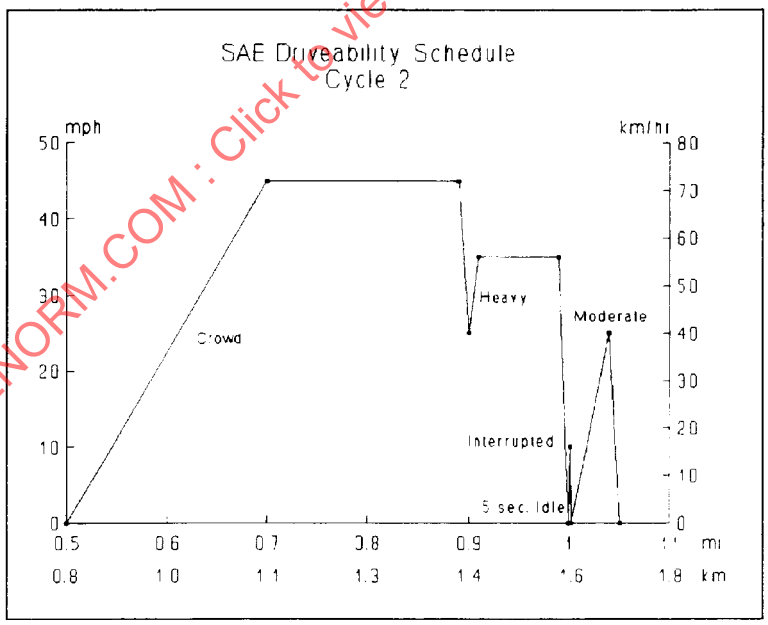

FIGURE 3—DRIVEABILITY SCHEDULE—CYCLE 2

7.8.1 CROWD ACCELERATION—Maintain a constant intake manifold absolute pressure by continually increasing the throttle opening with increasing engine speed.

7.8.2 INTERRUPTED ACCELERATION—Moderate throttle acceleration, followed immediately by a quick brake stop. Total vehicle travel must be 0.5 to 1.5 m (1.5 to 5.0 ft).

7.9 Repeat Cycle 1 (Step 7.6).

7.10 Repeat Cycle 2 (Step 7.8).

7.11 If the warm driving characteristics are to be evaluated, return to 7.5.

7.12 Shift the transmission into gear A-P or M-0 and shut off engine. Check for engine run-on. If the engine does run-on, place left foot on brake and shift transmission into gear A-D or M-5 (let clutch out). Note if run-on continues.

PREPARED BY THE SAE LIGHT-DUTY VEHICLE PERFORMANCE AND ECONOMY MEASUREMENT STANDARDS COMMITTEE

APPENDIX A

RATING SYSTEM

A.1 The "SID" (Start, Idle, Drive) Rating System

A.1.1 A "1" to "9" (9 is the best) numerical rating system is used in rating the following vehicle functions under specific operating conditions:

A.1.1.1 FUNCTIONS

a. Engine starting (S)
b. Idle Quality Rating (I)
c. Vehicle Driveability Rating (D)

A.1.1.2 CONDITIONS

a. Cold Drive, including warm-up (CD)
b. Warm Drive (WD)
c. Hot Drive (HD)
d. Partial Cooldown Drive (PCD)

A.1.2 Rating Index and Criteria—See Table A1.

TABLE A1—RATING INDEX AND CRITERIA

1	2	3	4	5	6	7	8	9
Unreliable	Unreliable	Lack of Confidence	Disturbing	Borderline	Marginal	Fair	Very Good	Excellent

A.1.3 Rating Calculation—Final Rating = 9 - (Rating Downgrades)

A.1.4 Rating Matrix—See Table A2.

TABLE A2—RATING MATRIX

Condition	Start Rating	Idle Rating Idle Neutral	Idle Rating Idle Drive	Idle Rating Idle Rev	Drive Rating	Ambient Temp (°C)	Soak Time (h)
Cold Drive			/	/			
Warm Drive	--------		/	/			------
Hot Drive			/	/			
Partial Cooldown			/	/			

Warm drive is conducted immediately following the cold drive.

A.2 Determination of the START Rating

A.2.1 The definition of engine STARTING is found in the Section A.5.

A.2.2 Vehicle start ratings are based on the actual start time (seconds) of a gasoline-fueled engine under specific ambient temperature conditions. The following matrix is used to determine start ratings when a stall has not occurred. All start times will be to the closest whole second.

A.2.3 Cold Start Ratings—See Table A3.

TABLE A3—COLD START RATING AT AMBIENT TEMPERATURE

Start Time (s)	Below −18 °C (0 °F)	At or above −18 °C (0 °F)
1.0 or less	9	9
2.0	9	7
3.0	8	5
4.0	7	4
5.0	6	3
6.0	5	2
7.0	4	1
8.0	3	1
9.0	2	1
10.0 or more	1	1

A.2.3.1 HOT AND PARTIAL COOLDOWN START RATINGS—See Table A4.

TABLE A4—HOT AND PARTIAL COOLDOWN START RATINGS

Start time	Start Rating
1.0 or less	9
2.0	7
3.0	5
4.0	3
5.0	2
6.0 or more	1

A.2.4 Start Rating Downgrades Due to Stall

A.2.4.1 1 STALL—2.0 point downgrade

A.2.4.2 2 STALLS—5.0 point downgrade

A.2.4.3 OVER 2 STALLS—Automatic rating of "1"

A.2.4.4 FALSE START—(Same as Stall)

A.3 Determination of the IDLE Rating

A.3.1 The definition of engine IDLE is found in the Section A.5.

A.3.2 Engine idle quality is rated subjectively in idle neutral (IN), idle drive (ID), and idle reverse (IR) shift lever positions. Idle ratings are determined using the criteria in Table A5:

TABLE A5—IDLE RATINGS

Rating	Definition
9	Excellent idle quality, cannot feel engine running.
8	Engine operation smooth, flawless, barely perceptible
7	Engine vibration noticeable, but unobjectionable.
6	Slight engine roughness, but speed remains relatively constant.
5	Moderately rough engine, irritating condition.
4	Disturbing engine roughness, but still confident of continual operation.
3	Uncertainty that engine will stay running; heavy roughness.
2	Frequent stalls, will not operate consistently.
1	Multiple stalls, uncontrolled operation, throttle manipulation required to keep running.

A.3.3 IDLE Rating Downgrades due to Specific Defects (note gear in which stall occurs, such as A-D, A-R, or A-P):

A.3.3.1 1 STALL AT IDLE—Automatic "3" rating

A.3.3.2 ≥2 STALLS AT IDLE—Automatic "1" rating

A.3.3.3 IDLE FLUCTUATION

a. Heavy—1.0 point downgrade
b. Trace/Light—0.5 point downgrade

A.3.3.4 AFTER-RUN—2.0 point downgrade

A.4 Determination of the DRIVEABILITY Rating

A.4.1 The definition of specific DRIVEABILITY defect terms are found in Section A.5.

A.4.2 Vehicle driveability is a subjective "worst case" judgment of the vehicle's ability to perform under all styles of driving maneuvers. Specific driveability defects, if found during the driveability evaluation, will result in rating degradation (detract from "9" rating). Driveability ratings are determined using the criteria in Table A6:

TABLE A6—DRIVEABILITY RATINGS

Rating	Definition
9	Excellent driveability, no trace of defects, solid/responsive.
8	No noticeable defects, less responsive or flat performance.
7	One or more slight defects present; barely noticeable.
6	One or more defects present; very noticeable, not objectionable.
5	Obvious defects present; irritating, will probably generate complaints.
4	Disturbing defects present, but still confident of continual operation.
3	Undermines driver confidence, not reliable.
2	Failure to stay running, will not operate consistently.
1	Uncontrollable, unpredictable operation.