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

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Low-Temperature Cranking Load Requirements of an Engine—Air Starter Method

1. Scope—The air cranking system components, which include the tank, valve, hose, and starter, must be carefully selected to provide the necessary speed to start an engine under the most severe climatic conditions for which the system is intended. Engine cranking loads increase with cold temperatures, therefore, the initial selection of these components, needs to consider low-temperature engine torque requirements. To insure an adequate air cranking system is obtained, it is important that proper test procedures are used for obtaining the cranking load requirements of the engine.

2. References

2.1 Applicable Publications—The following publication forms a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

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

SAE J300—Engine Oil Viscosity Classification

2.2 Related Publications—The following publications are provided for information purposes only and are not a required part of this document.

2.2.1 SAE PUBLICATIONS

SAE J1253—Low Temperature Cranking Load Requirements of an Engine
SAE J2437—Air Starter Motor Test Procedure

3. Description

3.1 Engine Preparation—The engine to be tested should be equipped with all accessories that provide parasitic loads, such as, power steering pump, automatic transmission, gear motor sets, etc.

3.1.1 The engine, if new, should be "run in" to stabilize friction loads—equivalent to 2400 km (1500 miles) or 18 h at normal engine speed.

3.1.2 The engine is winterized with antifreeze solution for the temperature at which the test will be run.

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3.1.3 The engine oil selected for the low-temperature test should be representative of the high limit viscosity for the SAE grade recommended by the engine manufacturer for the operating temperature range (refer to SAE J300). Sufficient oil of the same viscosity should be obtained for the complete test program so variations in test results can be minimized.

3.1.4 Fuel dilution of the engine oil will reduce it's viscosity; therefore, to avoid this possibility, the cranking test is run without fuel in the carburetor, or with the fuel system cut off.

3.1.5 To prepare the engine for the test, the engine is warmed up and oil drained hot. This procedure should be repeated two times to assure complete change of oil when oil grade change is made. The oil filter is changed for the final fill. When the same grade of oil is used for other test temperatures and/or additional test days, the engine warm up procedure is repeated and only one drain is required.

3.1.6 Install a thermocouple in the center of the greatest mass of oil, so soak temperatures can be monitored.

3.1.7 Equip engine with necessary instrumentation to provide cranking speed starter inlet pressure, tank pressure, air flow (optional).

3.1.8 Prior to starting the cold soak period, warm up the engine for approximately 5 to 10 min to circulate oil, run carburetor bowl dry and disable ignition or cut off fuel system, and adjust throttle plate to the idle position.

3.1.9 The engine with the calibrated motor is soaked at the test temperature for a period of 16 to 24 h, which can be monitored by the oil thermocouple.

3.2 Cranking Motor Preparation—The cranking motor is used to measure the engine cranking torque. To minimize performance variances, a new cranking motor should be "run in" until the motor performance becomes stabilized prior to calibration which is determining the speed, torque, and starter inlet pressure under load. Air flow can be used in some cases to provide a data accuracy cross check. After completion of the cranking load tests, a re-calibration curve should be run to verify initial performance.

NOTE—Since torque is proportional to cranking motor air inlet pressure, determination of engine torque can be calculated by obtaining the cranking motor running torque corresponding to the cranking motor air inlet pressure and rpm from the performance characteristics of the calibrated cranking motor and multiplying this value by the proper flywheel ring gear to cranking motor pinion gear ratio.

3.3 Cranking Load Tests

3.3.1 A sufficient number of cranking tests should be run to obtain a curve of average torque versus average engine speed over an approximate range of 30 to 120 engine rpm for gasoline engines, 50 to 150 rpm for direct injection diesel engines, and 120 to 220 rpm for small indirect injection diesel engines.

3.3.2 To obtain the range of speeds required to plot the torque curve, the air inlet pressure is varied. Air should not be cold soaked for this test. The air source should be within 5 °C (77 °F) of the air temperature used to calibrate the cranking motor to minimize differences in energy supplied to the motor.

3.3.3 The cranking time for each test should be approximately 5 s with the readings between 0 and 5 s used as the plotting points. Allow a minimum of 30 min additional soak time before performing the next cranking test.

3.3.4 Using the test data, calibrated cranking motor performance characteristics and engine ring gear to cranking motor pinion gear ratio, calculate the engine torque requirements for each test speed and plot an engine torque requirement curve.

3.3.5 It should be noted that since gear efficiencies have been neglected, the torque measured is not true engine torque but that as seen by the cranking motor. However, this is the correct torque for design and application data for determining cranking motor requirements.

3.3.6 Once the engine torque requirement curve has been determined and the speed required to start the engine is known, cranking motor performance requirements for the engine application can be determined.

3.3.7 A correctly sized air cranking system should provide a minimum of 5 s cranking time above the manufacturer's minimum unaided cranking speed at the minimum unaided start design temperature. The 5 s crank duration represents the capacity from a 60 gallon air tank on a vehicle with a typical air starting system. The minimum cranking speed is generally between 100 and 120 rpm. Engine manufacturers recommend starting aids below 4 °C (40 °F), however, end users expect unaided starts above –7 °C (20 °F).

PREPARED BY THE SAE STARTER MOTOR STANDARDS COMMITTEE