Passenger Car and Truck Automatic Transmission Test Code—SAE J651c

SAE Recommended Practice
Completely Revised June 1979

THIS IS A PREPRINT WHICH IS SUBJECT TO REVISIONS AND CORRECTIONS. THE FINAL VERSION WILL APPEAR IN THE 1980 EDITION OF THE SAE HANDBOOK.

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LAND SEA AIR SPACE

PREPRINT

PASSENGER CAR AND TRUCK AUTOMATIC ϕTRANSMISSION TEST CODE—SAE J651c

SAE Recommended Practice

Report of Hydrodynamic Drive and Transmission Committee approved February 1956 and completely revised by Transmission and Drivetrain Technical Committee June 1979.

1. Purpose—The purpose of this code is to provide a means of comparing automatic transmissions. It outlines a series of dynamometer tests which will cover the range of operation of the transmissions and it provides a method of presenting the data from these tests. This procedure should be followed and the facility used should be comparable, so that results obtained from different laboratories can be compared.

For this SAE Recommended Practice the transmission is defined as the complete assembly driven by the engine and used to effect a ratio change in transmitting power to the final drive system.

2. Scope of Tests—The range of test conditions on the dynamometer shall be sufficient to determine the primary operating characteristics corresponding to the full range of vehicle operations.

The transmission characteristics to be determined for all driving ranges or gears are:

1. Efficiency versus output speed.
2. Torque ratio versus output speed.
3. Input speed versus output speed.
4. Output torque versus output speed.
5. Parasitic losses versus input speed.

3. Equipment and Test Procedure

3.1 Driving and absorbing dynamometers capable of speed measurement within ±5 rpm and torque measurement within ±0.7 N·m or ±0.5% of full load are to be used for all tests except Test 7 (paragraph 5.3.1). Test 7 (parasitic losses) is to be performed using a driving dynamometer capable of speed measurement within ±5 rpm and torque measurement within ±0.3 N·m or ±1% of maximum value, whichever is greater.

3.2 The transmission must be fitted with suitable pressure and temperature indicators in order to insure proper control of transmission test conditions.

3.3 Before starting tests for the transmission characteristics, calibration curves should be obtained on the dynamometers and instruments to be used for the measurement of torque, speed, pressure, and temperature.

3.4 A fluid of known physical and chemical characteristics and approved by the manufacturer of the unit should be used, and the fluid level maintained according to the manufacturer's specifications.

3.5 Fluid temperatures for all standard tests should be 90–100°C at the sump and 130°C maximum at the outlet of the hydrodynamic drive. Temperature for the hydraulic retarder coast test must not exceed 175°C. Higher or lower temperatures may be used if recommended by the manufacturer. At or near stall, the sump temperature may be reduced to maintain outlet temperature.

3.6 Suitable additional heat exchangers must be used to control sump temperature and avoid altering transmission performance.

3.7 Equipment may be required to control or position the transmission torque sensing device for line pressure control.

3.8 All readings should be taken simultaneously with loads, speeds, temperatures, and pressures stabilized when possible. When such stabilization is not possible, the time interval between readings and the rate of change must be noted.

3.9 The automatic action of shift valves may require blocking to prevent the transmission from shifting during the test, since the characteristics of the test dynamometer during a shift may not be comparable to those of the vehicle for which the transmission is designed.

3.10 To insure proper functioning before the recording of test data, it may be advisable to establish a pre-run at the approximate test conditions.

3.11 Added run-in time on the transmission may be required to achieve the desired degree of break-in.

3.12 It may be necessary to orient the transmission in its normal vehicle position to obtain proper operating conditions.

3.13 It may be necessary to add supplementary lubrication at certain points, such as the extension bearing and seal.

3.14 For coast tests, it may be necessary to provide initial system oil pressure from an external source.

4. Operating Modes—There are three performance modes for which data must be obtained:

4.1 **Drive Performance**—Normal rotation with normal power flow (transmission input driving).

4.2 **Coast Performance**—Normal rotation with reverse power flow (transmission output shaft driving) as in vehicle closed-throttle coasting operation, with and without hydraulic retarder functioning (if included with transmission).

4.3 **Parasitic Losses**—Normal rotation with no power output (transmission output shaft free).

5. Standard Tests—All tests are to be run in all forward driving ranges or ratios, including converter clutch applied, if applicable. Reverse tests are optional.

5.1 **Drive Performance**

5.1.1 Test 1—Full-Throttle Performance—This test is run by setting the input dynamometer speed and torque to corresponding values on the full-throttle-installed net torque curve of an engine used in a typical application of the automatic transmission. The output speed for the lowest gear range is set at or near stall and increased in selected increments to span the full range of vehicle speeds. Data for the other gear ranges shall be taken from speeds above which the full throttle down-shift occurs. The transmission torque sensing device (throttle valve and/or vacuum modulator) shall be locked in the full throttle position.

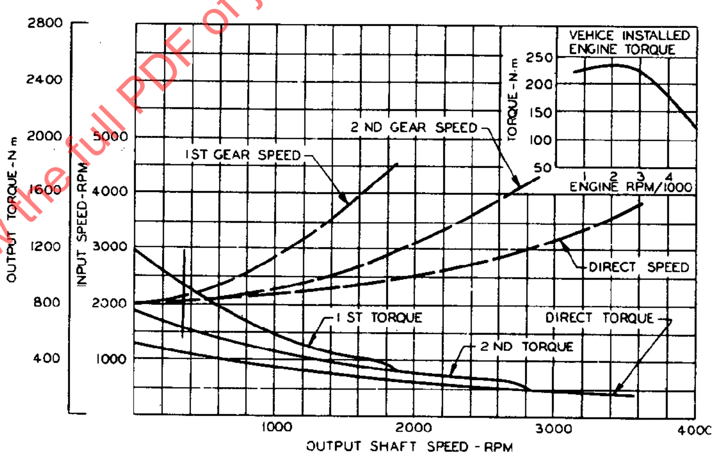

FIG. 1—TEST 1 - TYPICAL OUTPUT SPEED PLOT OF TRANSMISSION FULL THROTTLE PERFORMANCE

5.1.2 Test 2—Constant Input Torque (Optional for Trucks)—This test is run by controlling the speed of the driving dynamometer to obtain the torque selected for the test while controlling the output dynamometer speed. The output speed is varied in selected increments, keeping the input torque constant. The procedure is repeated for several input torque values. Torque values are commonly chosen as approximate percentages of the maximum full-throttle, vehicle-installed engine torque for a typical application of the automatic transmission being tested—for example, 100, 50, and 25%. For passenger cars, the lowest torque value is approximately that required for level road operation at constant speed in the middle of the vehicle speed range.

Output speed values are chosen to span the full range of vehicle operating conditions. The transmission torque sensing device must be set to provide proper pressures for the torque input used.

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

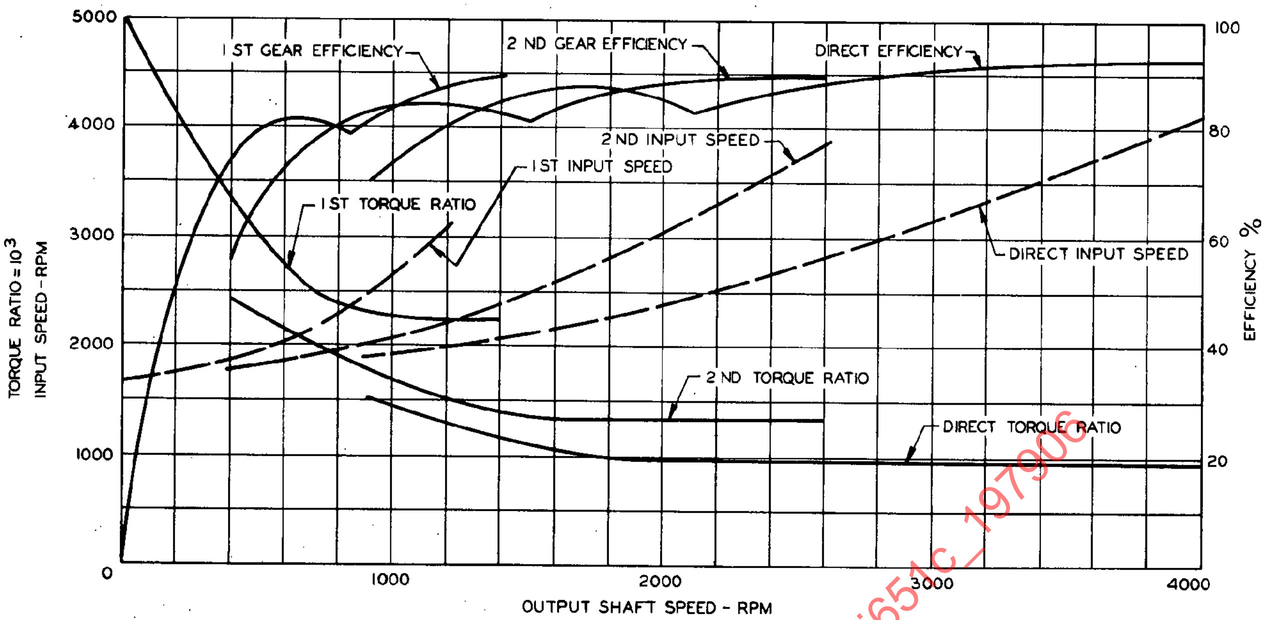

FIG. 2—TEST 2 - TYPICAL OUTPUT SPEED PLOT OF TRANSMISSION CHARACTERISTICS CONSTANT INPUT TORQUE (150 N·m)

5.1.3 Test 3—Cross-Sectional Road Load Performance (Passenger Car)—This test is to be run when the transmission is used in many vehicle applications. With the information obtained, it is possible to evaluate transmission performance for any specific vehicle road load requirement. The test is run by setting the output dynamometer to a constant torque and varying its speed in increments. The test is repeated for several output torques. Output torque values are chosen to span the full range of vehicle road load requirements. A minimum value of (25 N·m) and a maximum of (200 N·m) is a suitable range for most transmission installations. The speed range tested for each output torque should be consistent with vehicle road-load requirements. For example, at 25 N·m the output speed range could be 600—1800 rpm, whereas for 100 N·m the range could be 3000—4200 rpm. For each torque, the transmission torque sensing device is adjusted to the position setting it would have in a typical vehicle installation when driven at a constant speed equivalent to the mean of the speed for that torque.

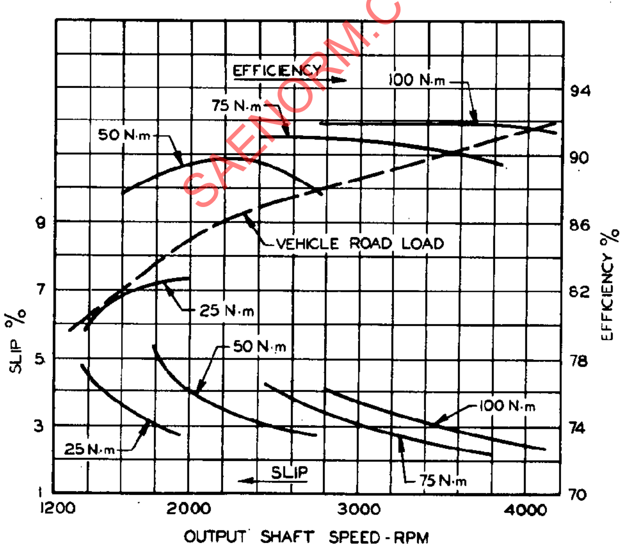

FIG. 3—TEST 3 - TYPICAL OUTPUT SPEED PLOT OF TRANSMISSION CROSS SECTIONAL ROAD LOAD PERFORMANCE

5.1.4 Test 4—Specific Road Load Performance (Passenger Car)—This test is to be used for a specific or very limited number of transmission-vehicle applications. It is run by adjusting the input dynamometer speed and torque to obtain the required output speed and torque values corresponding to zero acceleration requirements of the vehicle on level ground for the full range of vehicle speeds. For each speed, the transmission torque sensing device is adjusted to the position setting it would have in the vehicle when driven at that constant speed.

5.2 **Coast Performance**

Note: For coast tests, it may be necessary to provide initial system oil pressure from an external source.

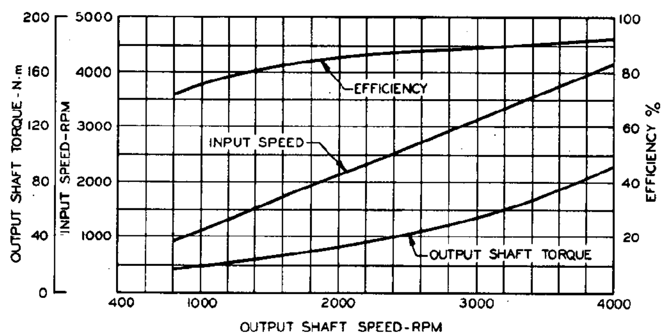

FIG. 4—TEST 4 - TYPICAL OUTPUT SPEED PLOT OF TRANSMISSION, SPECIFIC ROAD LOAD PERFORMANCE - DIRECT GEAR

5.2.1 Test 5—Cross-Section Coast Performance—This test is run when the transmission is used in vehicles that have a variety of engine sizes. With the information obtained, it is possible to evaluate the coasting performance of any specific transmission-engine combination. For this test, the driving dynamometer powers the transmission output shaft. The test is run by controlling the absorbing dynamometer to hold constant torque at the transmission input member (usually the torque converter impeller) while varying its speed incrementally. It is repeated for several torque values. The torque values are selected to cover the full range of engine friction torques. For example (for passenger cars), at 20 N·m engine torque the engine speed might range from 1000—2000 rpm, and at 60 N·m the engine speed might range from 3000—4000 rpm. The transmission torque sensing device is set to engine idle condition during the entire test.

5.2.2 Test 6—Specific Coast Performance—This test is to be used for a specific vehicle application and the test set-up is the same as for Test 5 (paragraph 5.2.1). It is run by driving the output shaft while absorption dynamometer speed and torque are adjusted to a closed-throttle engine torque curve with ignition on. The transmission torque sensing device is to be locked in closed-throttle position throughout the test. A standard vehicle engine may be used instead of the absorption dynamometer.

5.3 **Parasitic Losses**

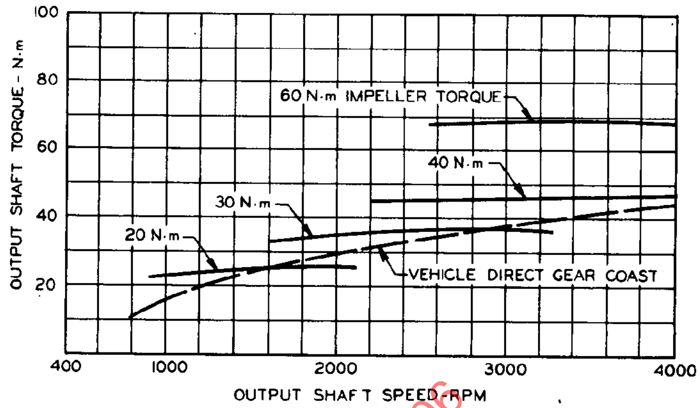

FIG. 5—TEST 5 - TYPICAL OUTPUT SPEED PLOT OF TRANSMISSION CROSS SECTIONAL COAST PERFORMANCE

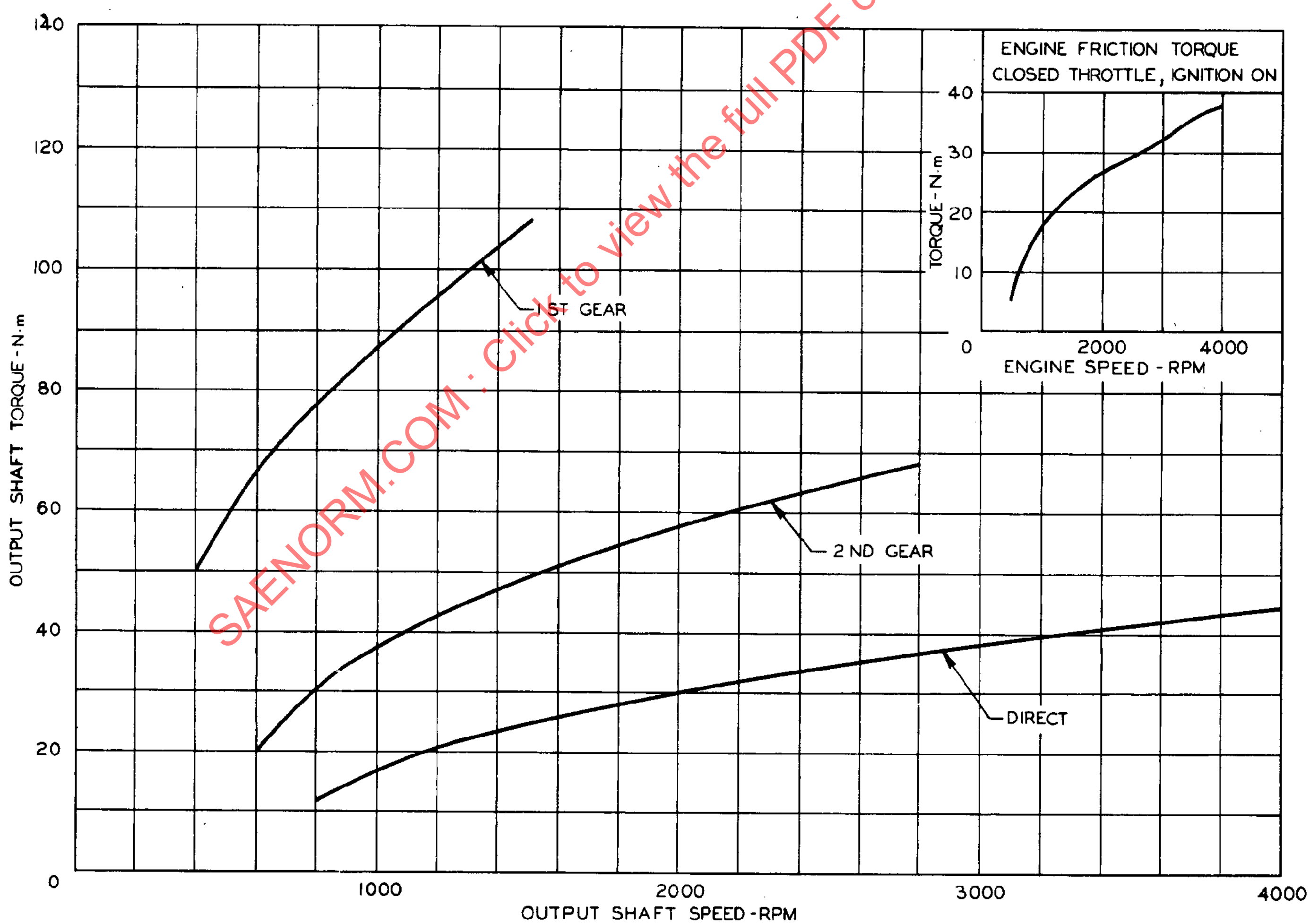

FIG. 6—TEST 6 - TYPICAL OUTPUT SPEED PLOT OF SPECIFIC TRANSMISSION COAST PERFORMANCE

5.3.1 Test 7—The parasitic loss test is run in all driving ranges or gears with the transmission output shaft permitted to turn freely.

The torque and speed of the driving dynamometer indicate the losses attributable to pumping, windage, and friction within the transmission. The transmission torque sensing device is locked in the no load position during the test. If transmission line pressure is affected by the torque signal, the test should be repeated with the torque sensing device locked at maximum and any desired intermediate torque positions.

It is frequently desirable to distinguish between losses which are a function of engine speed and those which are related kinematically to vehicle speed. This is of most significance when the test results will be used for any sort of mathematical analysis which addresses the speed differential across the hydrodynamic unit.

When the losses are to be separated, the test is run in two parts. Engine related losses are determined by modifying the transmission such that there is no connection between the hydrodynamic unit output member and the transmission gearbox. Vehicle speed related losses are determined by driving the hydrodynamic unit output shaft directly with dynamometer. This may be done with the hydrodynamic unit removed or with the unit locked and all engine speed losses disconnected. If the transmission pump is inoperable during the test, the transmission is pressurized by an external source.

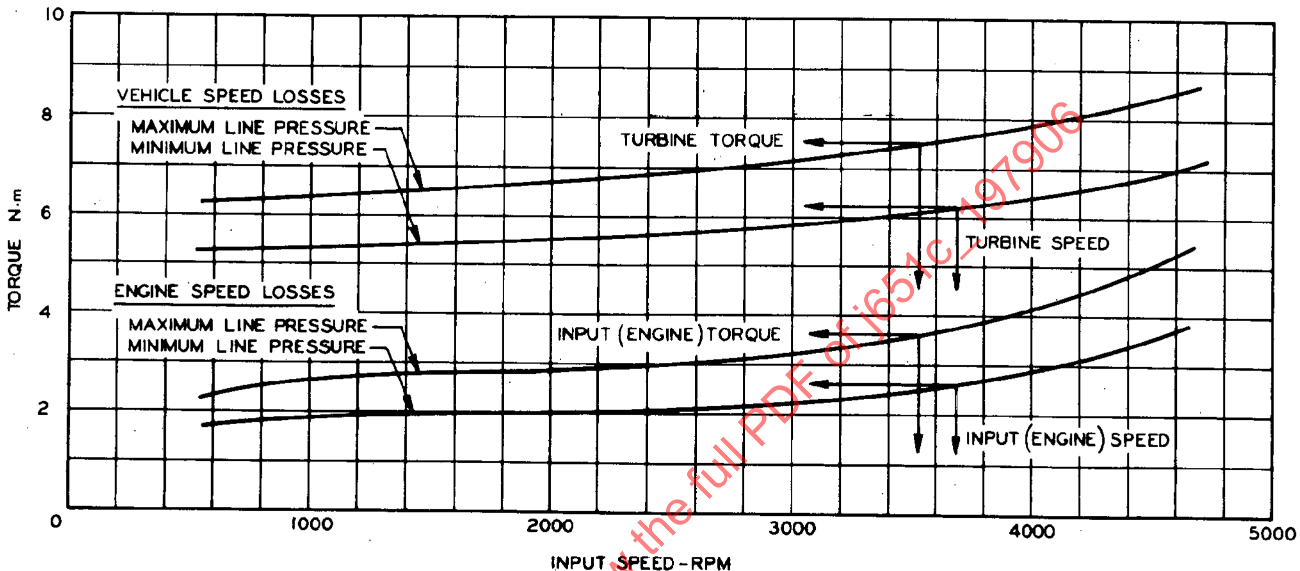

FIG. 7—TEST 7 - TYPICAL INPUT SPEED PLOT OF TRANSMISSION PARASITIC LOSSES - DIRECT GEAR

6. *Required Data*

Performance	Test Conditions
Input torque	Specification number or trade name of the fluid
Input speed	Transmission line pressure
Output torque	Pressure and flow to cooler
Output speed	Position of torque sensing device
	Temperature in and out of cooler
	Sump temperature
	Hydrodynamic unit outlet temperature

7. *Presentation of Results*

7.1 Completely identify the transmission unit and record test conditions on all data and curve sheets.

7.2 Develop the desired performance curves. Examples of typical plots of these are shown on Figs. 1–7. These plots (for passenger cars) are for a three-speed torque converter transmission without lock-up. Other transmissions may have 4–6 speeds and lock-up. In preparing curves using engine and vehicle data, it is essential that the data precisely describe the net power to and from the transmission; that is, all corrections for accessories, air temperature, barometer reading, air cleaners, mufflers, and fan losses must be considered. The words *vehicle-installed* engine torque and horsepower are intended to express this condition.

7.3 Include copies of the data or identify the data sheets with the reported results.

8. *Computations*

1. Speed ratio $= \dfrac{\text{output speed}}{\text{input speed}}$

2. Torque ratio $= \dfrac{\text{output torque}}{\text{input torque}}$

3. Transmission efficiency, % = (Speed ratio) X (Torque ratio) X (100)

4. Power Input =

SI Units:

$$P_I = \frac{T_I N_I \pi}{30\,000}$$

P_I = input power, KW

T_I = input torque, N·m

N_I = input speed, rpm

U.S. Customary Units:

$$P_I = \frac{T_I N_I}{5252}$$

P_I = input power, hp

T_I = input torque, lb-ft

N_I = input speed, rpm

5. Power loss = (input power) X (1.00 - transmission efficiency/100)
6. Tractive effort attributable to drivetrain
   a. Tractive effort (driving) $= \dfrac{\text{engine torque X TTR X RAR X RAE/100}}{\text{RR}}$