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Continuously Variable Transmission Test Code For Passenger Cars

RATIONALE

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1. **Scope**—To measure the performance characteristics of Continuously Variable Transmissions (CVT). It outlines dynamometer tests that cover the range of operation and provides a method of presenting the test data. This procedure must be followed with similar test facilities so that results obtained from different laboratories are comparable.
2. **References**—There are no referenced publications specified herein.
3. **Tests**—The test conditions on the dynamometer must be sufficient to determine the characteristics corresponding to the a range of vehicle operations.

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

- a. Efficiency versus output speed
- b. Torque ratio versus output speed
- c. Input speed versus output speed
- d. Output torque versus output speed
- e. Parasitic losses versus input speed

#### 4. **Equipment and Test Procedure**

- 4.1 Driving and absorbing dynamometers must be capable of speed measurement within  $\pm 5$  rpm and torque measurement within  $\pm 0.7$  N·m or  $\pm 0.5\%$  of full load except on Test 7 (6.3.1). Test 7 (parasitic losses) is to be performed using a driving dynamometer capable of speed measurement within  $\pm 5$  rpm and torque measurement within  $\pm 0.3$  N·m or  $\pm 1\%$  of maximum value, whichever is greater.
- 4.2 The transmission must be fitted with suitable pressure and temperature indicators to assure proper control of transmission test conditions.
- 4.3 Before starting tests or the transmission characteristics, calibration curves must be obtained on the dynamometers and instruments used for the measurement of torque speed pressure, and temperature.
- 4.4 A fluid of known physical and chemical characteristics and approved by the manufacturer of the transmission must be used, and the fluid level maintained to manufacturer's specifications.

- 4.5 Fluid temperatures for all standard tests must be 90 to 100 °C at the sump and 130 °C maximum at the outlet of the hydrodynamic drive. 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.
- 4.6 Suitable heat exchangers must be used to control sump temperature and avoid altering transmission performance.
- 4.7 Equipment is required to control or position the transmission torque-sensing device for line pressure control.
- 4.8 All readings must be taken simultaneously after loads, speeds, temperatures, and pressures are stabilized. If such stabilization is not possible, the time interval between readings and rate of change must be noted.
- 4.9 The automatic action of shift valves may require blocking to prevent the transmission from shifting during the test, because the characteristics of the test dynamometer during a shift may not be comparable to those of the vehicle for which the transmission is designed.
- 4.10 To assure proper functioning before the recording of test data, it is advisable to pre-run the test conditions.
- 4.11 Additional run-in time on the transmission may be necessary to achieve the desired break-in characteristics.
- 4.12 Orient the transmission in its normal vehicle position to assure similar operating conditions.
- 4.13 Add supplementary lubrication at certain points, such as the extension bearing and seal.
- 4.14 On coast tests, provide initial system oil pressure from an external source.
5. **Three Operating Modes**—There are three operational modes for which data must be obtained:
- 5.1 **Drive**—Normal rotation and “power flow” (transmission input driving).
- 5.2 **Coast**—Normal rotation with “reverse power flow” (transmission output shaft driving) as in vehicle closed-throttle coasting operation.
- 5.3 **Parasitic Losses**—Normal rotation with no “power flow” (transmission output shaft free).
6. **Seven Standard Tests**—All tests are to be run with the shift selector in drive and at ratios of full low and full overdrive. Middle ratio and reverse tests are optional.
- 6.1 **Four Drive Modes**
- 6.1.1 **TEST 1—FULL THROTTLE PERFORMANCE**—Set 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 CVT. The output speed for low ratio is set at or near stall and increased in selected increments to span the full range of vehicle speeds. Data for full overdrive must be taken from stall speed to maximum vehicle speed achievable in overdrive. The transmission torque-sensing device must be set to full throttle position for all tests.

6.1.2 TEST 2—CONSTANT INPUT TORQUE—Adjust speed of driving dynamometer to obtain torque selected 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 CVT being tested—for example, 100, 50, and 25%. The lowest torque value is the torque required for level road operation at constant speed in the middle of the vehicle speed range.

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

6.1.3 TEST 3—CROSS-SECTIONAL ROAD LOAD PERFORMANCE (PASSENGER CAR)—For multi-vehicle applications, the information obtained makes it possible to evaluate transmission performance for any specific vehicle road-load requirement. Set output dynamometer to constant torque and vary its speed in increments and repeat for several output torques. Output torque values are chosen to span the entire 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 300 to 1000 rpm, whereas for 75 N·m the range could be 300 to 1400 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.

6.1.4 TEST 4—SPECIFIC ROAD LOAD PERFORMANCE—For limited transmission-vehicle applications, adjust the input dynamometer speed and torque to obtain required output speed and torque values corresponding to zero acceleration of vehicle on level ground for 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.

## 6.2 Two Coast Modes

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

6.2.1 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 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, at 20 N·m engine torque the output speed range could be 100 to 700 rpm. The transmission torque-sensing device is set to engine idle condition during the entire test.

6.2.2 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 (6.2.1). 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 must be locked in closed-throttle position throughout the test. A standard vehicle engine may be used instead of the absorption dynamometer.

### 6.3 One Parasitic Loss

- 6.3.1 TEST 7—The parasitic loss test is run in full low and full overdrive ratios with the transmission output shaft permitted to turn freely. Middle ratio testing is optional.

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 must be repeated with the torque-sensing device locked at maximum and 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 a dynamometer. This may be done with the hydrodynamic unit removed or with the unit locked and all engine accessories generating speed losses disconnected. If the transmissions pump is inoperable during the test, the transmission is pressurized by an external source.

7. **Required Data**—See Table 1.

**TABLE 1—REQUIRED DATA**

Performance	Test Condition
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
Variator ratio	Temperature in and out of cooler
	Sump temperature
	Hydrodynamic unit outlet temperature
	Sheave pressures
	Clutch pressure (if applicable)

### 8. Presentation of Results

- 8.1 Completely identify the transmission unit and record test conditions on all data and curve sheets.
- 8.2 Develop the desired performance curves. Examples of typical plots are shown in Figures 1 to 7 for a CVT. Other CVTs may have more than one range 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, corrections for accessories, air temperature, barometer reading, air cleaners, mufflers, and fan losses must be considered. The words "vehicle-installed" engine torque and horsepower express this condition.
- 8.3 Include copies of the data or identify the data sheets with the reported results.

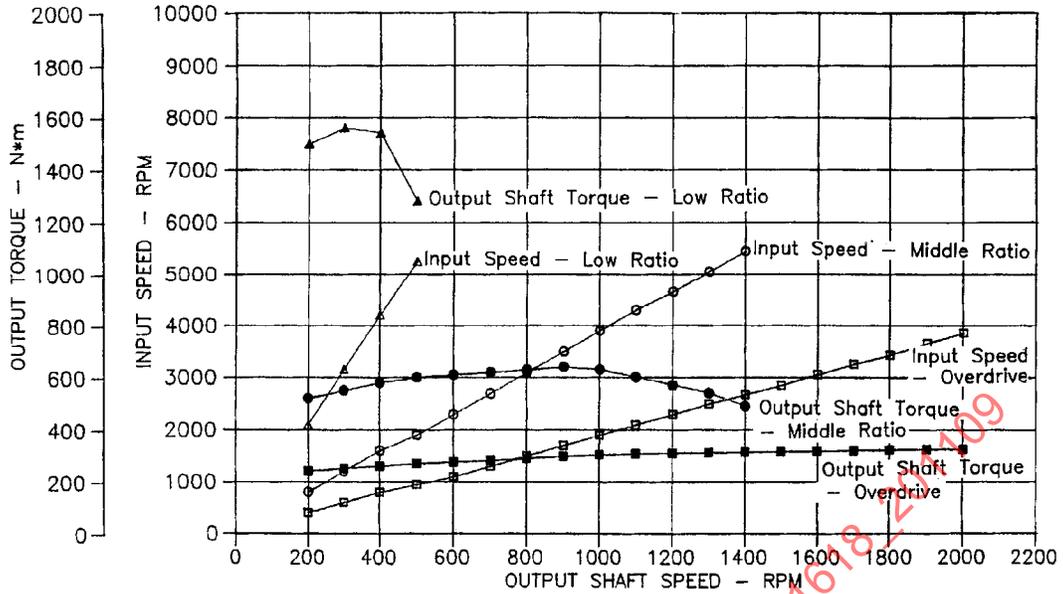


FIGURE 1—TEST 1—TYPICAL OUTPUT SPEED PLOT FULL THROTTLE PERFORMANCE

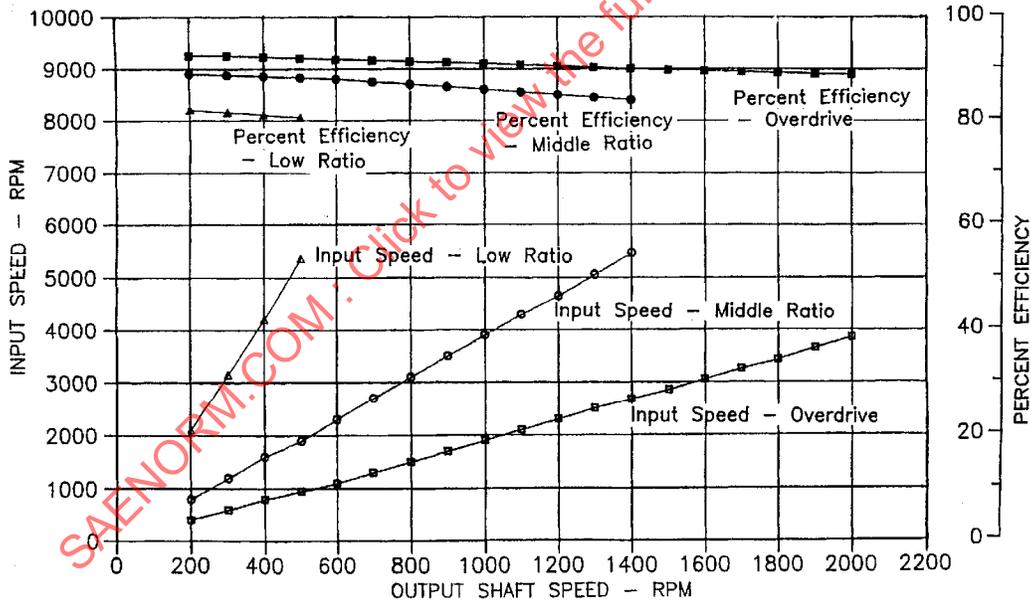


FIGURE 2—TEST 2—TYPICAL OUTPUT SPEED PLOT CONSTANT INPUT TORQUE—160 N\*m

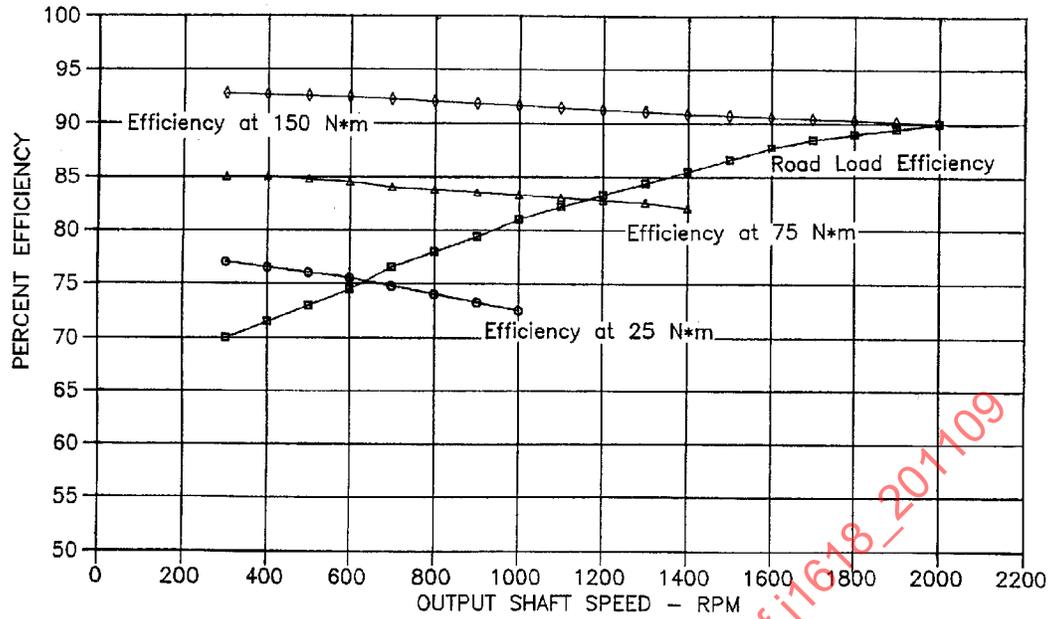


FIGURE 3—TEST 3—TRANSMISSION OUTPUT SPEED PLOT  
CROSS-SECTIONAL ROAD LOAD PERFORMANCE

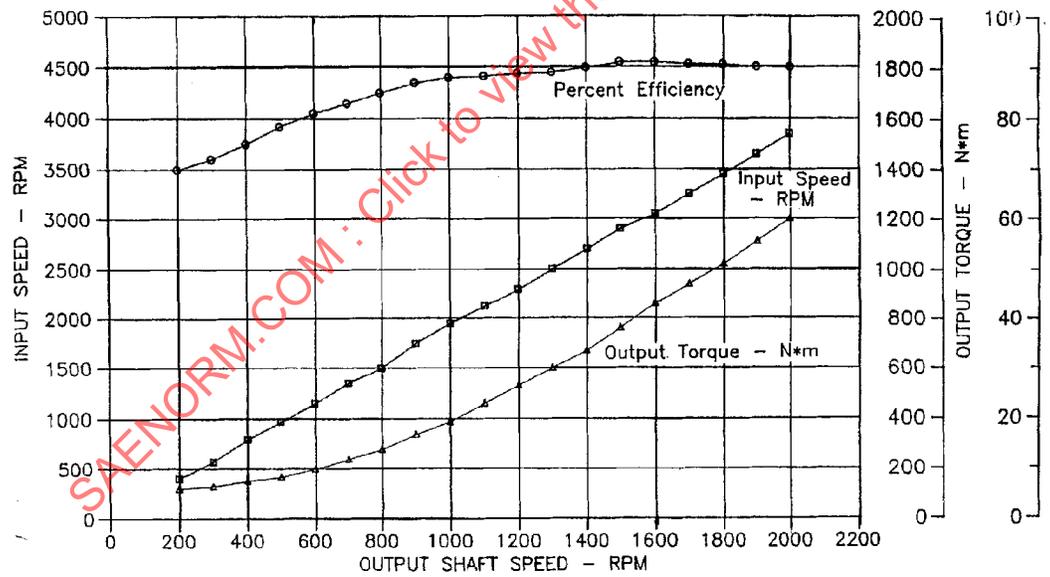


FIGURE 4—TEST 4—SPECIFIC ROAD LOAD PERFORMANCE

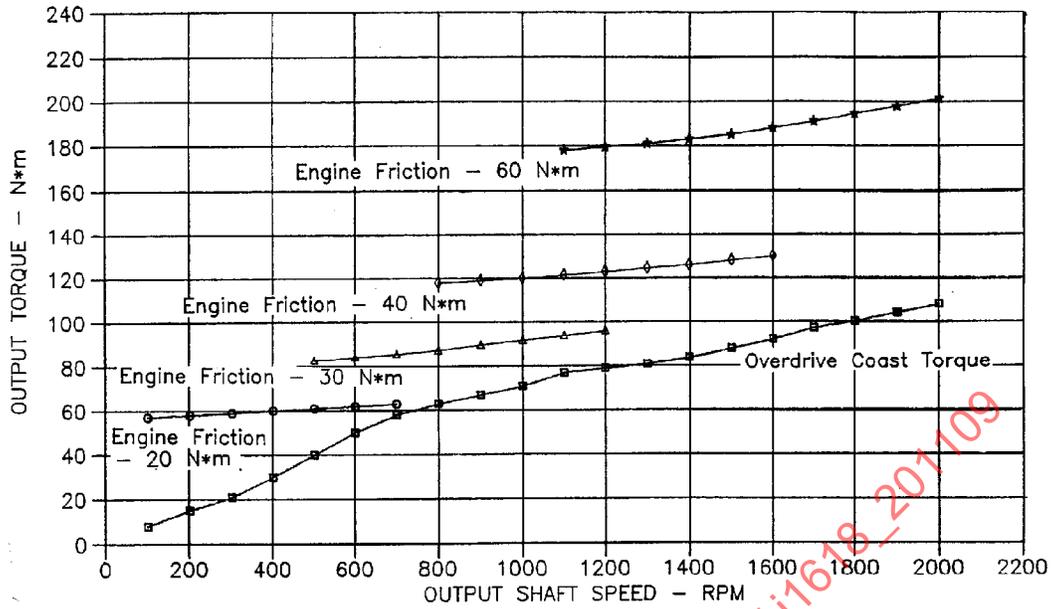


FIGURE 5—TEST 5—TYPICAL OUTPUT SPEED PLOT CROSS-SECTIONAL COAST PERFORMANCE

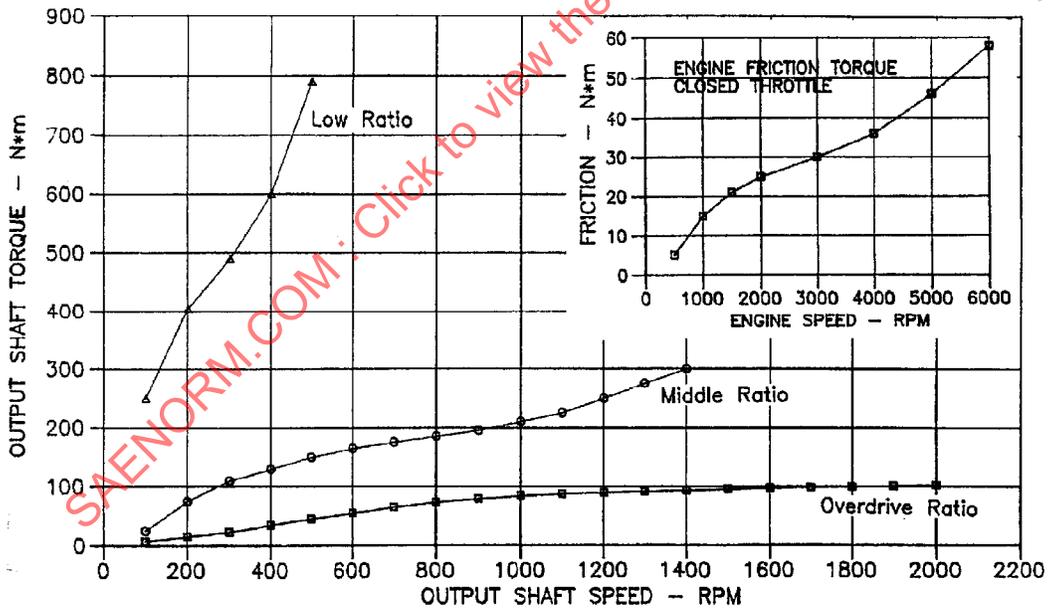


FIGURE 6—TEST 6—TRANSMISSION COAST PERFORMANCE

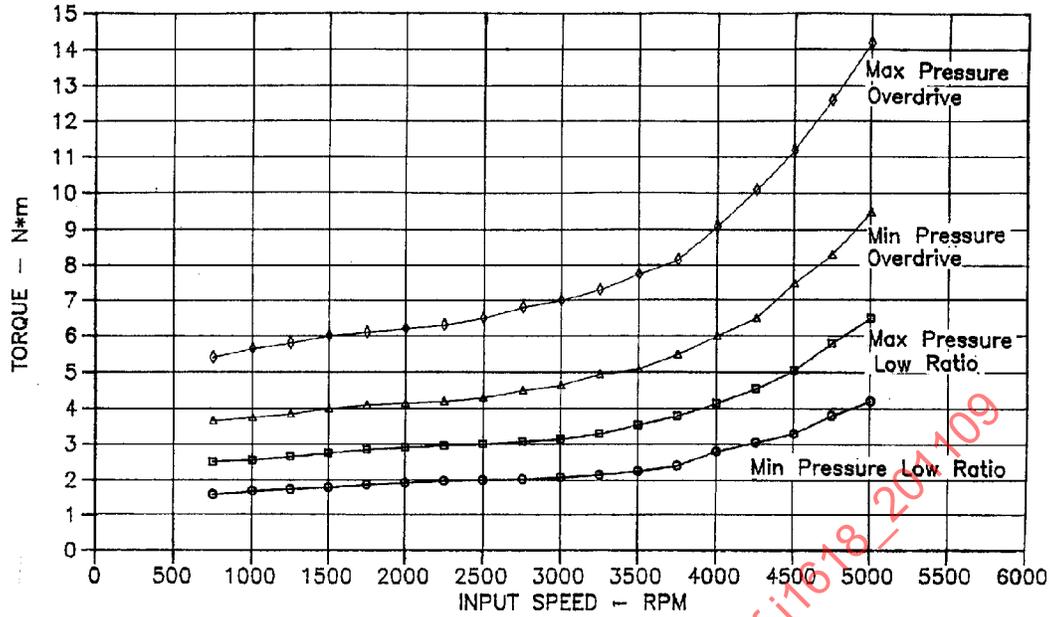


FIGURE 7—TEST 7—TRANSMISSION PARASITIC LOSSES

9. **Computations**—See Equations 1 to 7.

$$\text{Speed ratio} = \frac{\text{Output speed}}{\text{Input speed}} \tag{Eq. 1}$$

$$\text{Torque ratio} = \frac{\text{Output torque}}{\text{Input torque}} \tag{Eq. 2}$$

$$\text{Transmission efficiency, \%} = (\text{Speed ratio}) (\text{Torque ratio})(100) \tag{Eq. 3}$$

Power Input = SI Units (Eq. 4)  
 $P_i = T_i N_i / 30\,000$   
 $P_i$  = input power, kW  
 $T_i$  = input torque, N · m  
 $N_i$  = input speed, rpm

Power Input = U.S. Units (Eq. 5)  
 $P_i = T_i N_i / 5252$   
 $P_i$  = input power, hp  
 $T_i$  = input torque, lbf · ft  
 $N_i$  = input speed, rpm

$$\text{Power loss} = (\text{input power}) \frac{(1.00 - \text{transmission efficiency})}{100} \tag{Eq. 6}$$