SURFACE VEHICLE RECOMMENDED PRACTICE

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Hydrodynamic Drive Test Code

RATIONALE

The technical report covers technology, products, or processes which are mature and not likely to change in the foreseeable future. The technical committee makes a conscious decision not to maintain the document any longer.

STABILIZED NOTICE

This document has been declared “STABILIZED” by SAE Automatic Transmission and Transaxle Committee and will no longer be subjected to periodic reviews for currency. Users are responsible for verifying references and continued suitability of technical requirements. Newer technology may exist.

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1. SCOPE

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 characteristics to be determined are:

a. Torque ratio versus speed ratio and output speed

b. Input speed versus speed ratio and output speed

c. Efficiency versus speed ratio and output speed

d. Capacity factor versus speed ratio and output speed

e. Input torque versus input speed

NOTE: For more information about these characteristics and the design of hydrodynamic drives, refer to “Design Practices: Passenger Car Automatic Transmissions,” SAE Advances in Engineering, AE-18 (Third Ed.) or AE-29 (Fourth Ed.).

1.1 Purpose

This code provides a means of determining operating characteristics of hydrodynamic drives used in motor vehicle applications. It outlines a series of dynamometer tests and provides a method of presenting data from these tests. The results obtained are complete enough to provide a basis for estimating vehicle performance. Other special tests, such as centrifugal bursting, heat rejection, extreme temperature, cavitation, and charging pressure, may be required to evaluate the unit for particular applications or conditions.

2. REFERENCES

2.1 Applicable Documents

The following publications form 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 Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE J651 Passenger Car and Light Truck Automomatic Transmission and Automatic Transaxle Test Code

"Design Practices: Passenger Car Automatic Transmissions," SAE Advances in Engineering, AE-18 or AE-29

3. EQUIPMENT AND TEST PROCEDURES

3.1 Driving and absorbing dynamometers capable of torque measurements within ±0.7 N·m and speed measurements within ±5 rpm are to be used (same as required in SAE J651).

3.2 An independently operating fluid supply system with provisions for pumping, heating, cooling, and regulating the flow and pressure of the fluid to the test unit shall be used, unless otherwise specified.

3.3 Instrumentation for measuring temperature, pressure, and flow of the fluid at the inlet and outlet of the hydrodynamic drive is required.

3.4 Before starting tests for the characteristics, calibration curves should be obtained on the dynamometers and instruments indicating torque, speed, pressure, and temperature.

3.5 A fluid approved by the manufacturer of the unit shall be used.

3.6 Fluid temperatures for all standard tests should be 90 to 100 °C at the inlet, and 130 °C maximum at the outlet of the hydrodynamic drive. Higher or lower temperatures may be used if requested by the manufacturer. At or near stall, the inlet temperature may be reduced to maintain the specified outlet temperature. As an alternative method, in order to reduce shear heating and maintain relatively constant temperatures, cooling periods where synchronous lock-up is held at discrete speed ratios may be used. Each cooling period should be held until the output temperature falls below a predetermined value equal to or less than the maximum allowable, providing for an operating tolerance band. With either method, the pressures at the inlet and outlet across the hydrodynamic unit should be set at values consistent with what is normally obtained in the targeted as-installed transmission application. One level of pressure settings should be used throughout the test unless otherwise specified.

3.7 Unless otherwise specified, fluid pressures for standard tests shall be sufficient to avoid cavitation. Sufficient pressure differentials between the relevant fluid circuits should be maintained to prevent any clutch drift-on conditions. Where possible, fluid bulk modulii and air entrainment should be measured and recorded.

3.8 All readings shall 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.

4. STANDARD TESTS

4.1 Operating Modes

There are two performance modes for recording and collecting data.

a. Drive Performance - Normal rotation with normal power flow (impeller driving).

b. Coast Performance - Normal rotation with reverse power flow (turbine driving) as in vehicle closed throttle coasting operation.

Required Data:

Fluid flow rates
Fluid specifications
Inlet fluid pressure
Inlet fluid temperature
Input speed
Input torque
Outlet fluid pressure
Outlet fluid temperature
Output speed
Output torque

For designs with more than two fluid circuits, the other fluid pressures and temperatures should be recorded.

4.1.1 Drive Performance (Test Series 1)

In drive mode, input is taken as impeller, output is taken as turbine.

4.1.1.1 Constant Input Torque

This test is run by increasing the speed of the driving dynamometer to obtain the torque selected for the test, while keeping the output dynamometer speed at or near zero. The output speed is next increased in the specified number of equal increments, keeping the input torque constant. The procedure is repeated for the specified input torque values. Torque values are chosen that represent the full range of the hydrodynamic unit being tested. The speed and torque values must be selected to span the full range of vehicle operating speed ratios.

4.1.1.2 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 the specified engine application. The output speed is set at or near stall and increased at selected increments to span the full range of vehicle speeds. Pressures at the inlet and outlet of the hydrodynamic unit are set equal to values existing in the transmission at the corresponding operating conditions.

4.1.1.3 Road Load Performance

This test is run by adjusting the input dynamometer speed and torque to obtain the required output speed and torque values. These values correspond to zero acceleration requirements of the vehicle on level ground for the full range of vehicle speeds. Pressures are set equal to values existing in the transmission at corresponding operating conditions.

NOTE: Full throttle and road load performance are frequently calculated from test (see 4.1.1.1).

4.1.2 Coast Performance (Test Series 2)

In coast mode, input is taken as turbine, output is taken as impeller.

4.1.2.1 Constant Input Torque

The test method is the same as Test Series 1 (see 4.1.1.1). Values are chosen to span the range of engine closed throttle motoring torque for a typical application of the hydrodynamic unit.

4.1.2.2 Engine Motoring Friction

The test method is to set the absorbing dynamometer speed and torque to corresponding values on the curve of friction torque versus speed.

This friction curve is obtained on a previous test by driving the engine at various speeds after setting the engine at its standard idling condition.

NOTE: Vehicle coast performance is frequently calculated from Test Series 2 data.

4.1.3 Computations

1. Speed ratio = Output speed/Input speed
2. Torque ratio = Output torque/Input torque
3. Efficiency = (Speed ratio)·(Torque ratio)
4. Capacity factor (input) K = $\frac{\text{Input speed}}{\sqrt{\text{Input torque}}}$, units to be recorded in $r \cdot min^{-1} \cdot (N \cdot m)^{-1/2}$

5. PRESENTATION OF RESULTS

5.1 Completely identify the hydrodynamic unit, and record test conditions on all data and curve sheets.

5.2 Develop performance curves of the primary characteristics. Examples of typical plots of these are shown on Figures 1 to 4. Additional useful engineering curves using data from these performance tests are shown on Figures 5 and 6. The data precisely describe the net power to and from the hydrodynamic unit. All corrections for accessories, air temperature and pressure, air cleaners, mufflers, fans, and transmission input and output losses must be considered. The words “installed net” torque and power are intended to express this condition.

5.3 Include copies of the data, or identify the location of the data sheets with the reported results.

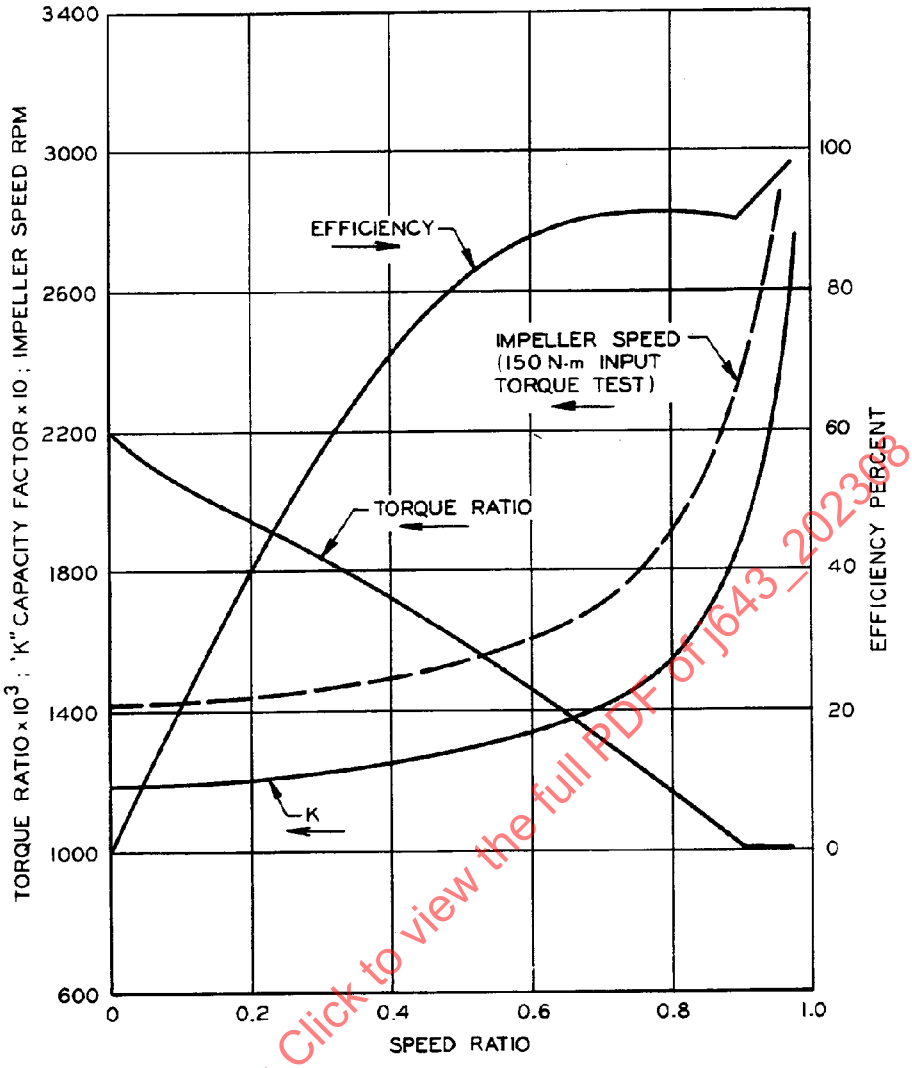

Figure 1 - Typical speed ratio plot of converter characteristics in drive

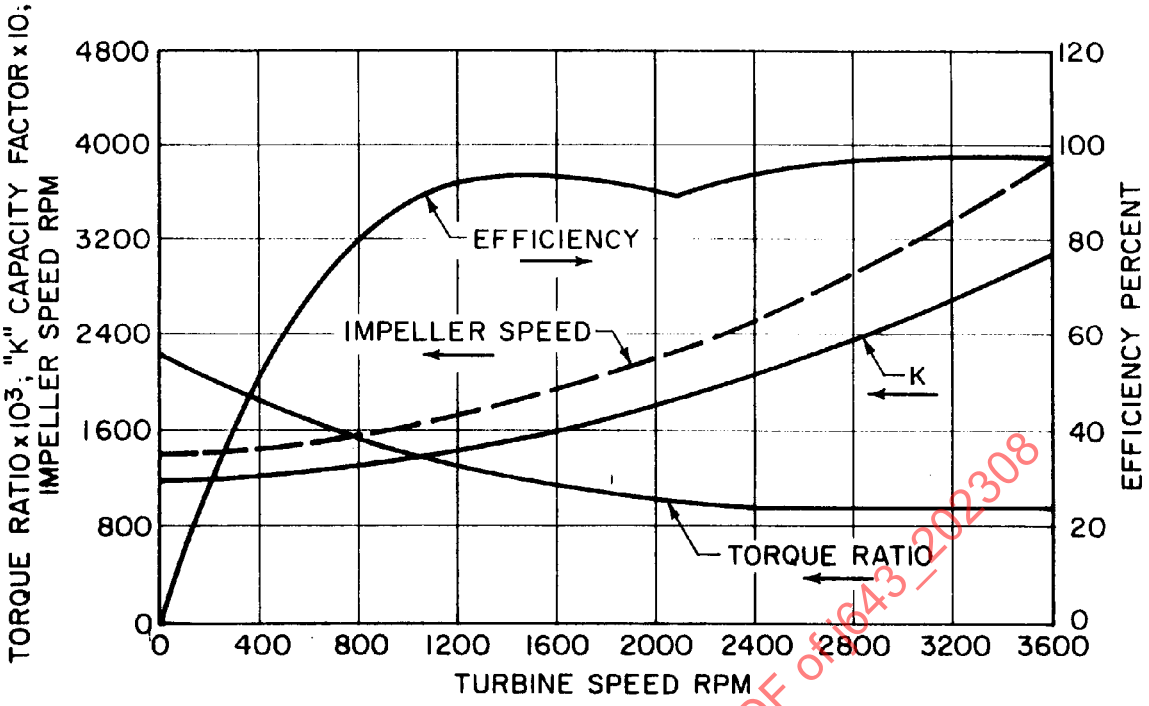

Figure 2 - Typical output speed plot of converter characteristics (150 N·m input torque)

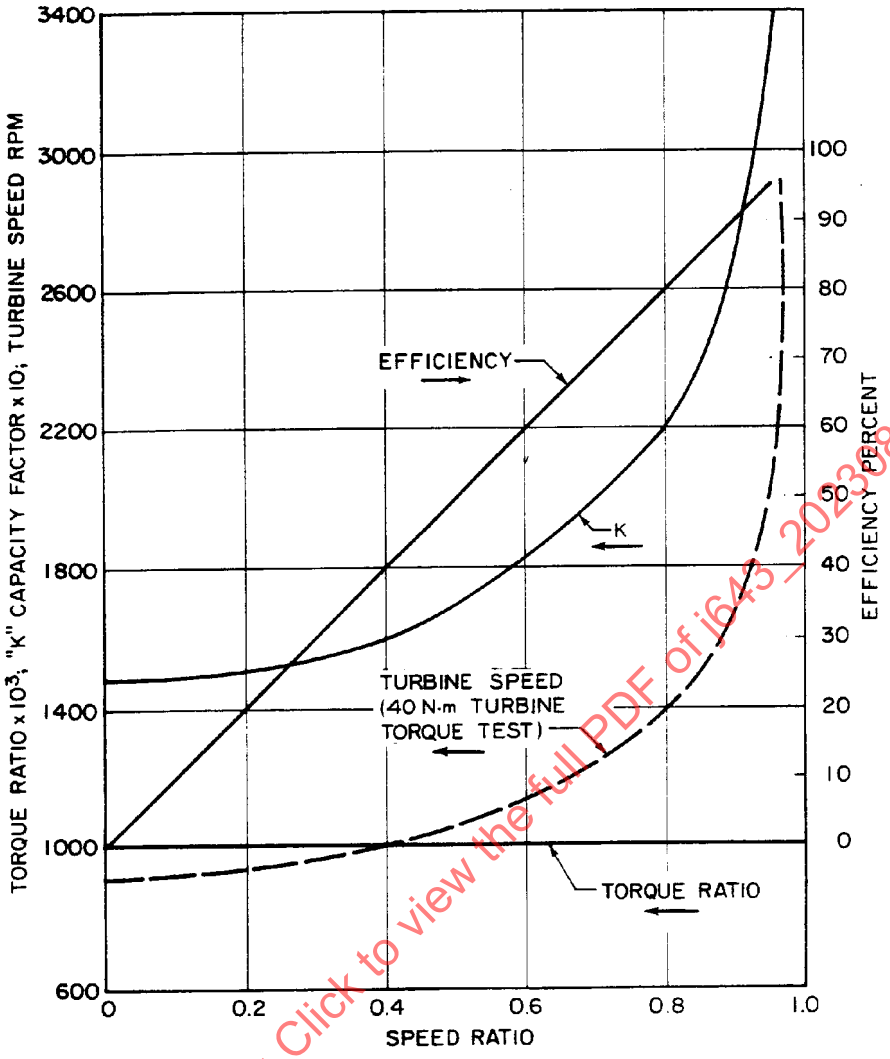

Figure 3 - Typical speed ratio plot of converter characteristics in coast