Axle Efficiency Test Procedure — SAE J1266

SAE Recommended Practice
Approved 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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PREPRINT

AXLE EFFICIENCY TEST PROCEDURE—SAE J1266

SAE Recommended Practice

Report of Transmission and Drivetrain Technical Committee approved June 1979.

This SAE Recommended Practice is intended as a guide toward standard practice but may be subject to frequent change to keep pace with experience and technical advances, and this should be kept in mind when considering its use.

1. Objectives

1.1 To provide a means for measuring and comparing axle efficiency, and the influence of materials, lubricants, and design factors on axle efficiency.

1.2 To outline a series of tests which encompass the typical range of axle operation in terms of load, speed, and lubricant temperature.

1.3 To result in data which are comparable from one test to another and between laboratories.

2. Scope

2.1 Data from this procedure permits mapping axle efficiency and/or waste energy over the operating range of passenger cars, trucks, busses, and other highway vehicles to which axles are applied.

2.2 The procedure can be applied to single axles; tandem axles as a system; or other systems by combining separate tests, such as tests of the front axle and power divider and rear axle of tandem or tri-drive type.

2.3 A uniform method of establishing output torque at 100% of gross combination weight, (GCW) rating of the test axle is defined. If known, the endurance limit of the axle is an alternative to the foregoing. These definitions are used to establish torques for these tests and are not intended as criteria for axle rating practice.

3. Equipment Requirement

3.1 An axle dynamometer with torque and speed capabilities consistent with the size axle or tandem axle system being tested. Separate absorbers for each output are preferred.

3.2 A separate test stand without absorbers for the no-load portion of the test is optional.

3.3 Capability of measuring input speed with an accuracy of ±1% of the actual speed.

3.4 Capability of measuring all torques specified with an accuracy of ±0.5% of the actual torque.

Note: Fig. 1 illustrates possible error in energy loss determinations with ±0.5% error in torque measurement. Evaluations requiring greater accuracy would require greater accuracy in torque measurement.

3.5 Means for measuring and controlling sump lubricant temperatures to ±10.0°F (+6.0°C) for steady state temperature test sequences.

3.6 Means for cold soaking the axle assembly to -30.0°F (-34.0°C).

4. Test Preparation

4.1 Test axles are to be representative of the particular axle design. Setting of bearing preloads, backlash, etc., outside of design specification limits is permissible only if that is the purpose of the test. This applies to production and experimental designs.

4.2 To preclude differential gear rotation as a source of inefficiency, all differentials are to be locked or mechanically blocked from rotating.

Note: Some dynamometers with automatic feedback systems to control relative speeds of absorbers may require deactivation of the feedback system.

4.3 The axles are to be equipped to measure sump temperature.

4.4 Axles are to be installed on the dynamometer with the drive pinion horizontal, unless otherwise specified.

4.5 The axles are to be filled with lubricant recommended for in-vehicle use or the specific lubricant being evaluated.

4.6 Lubricant quantities are to be the axle manufacturer's recommendation by mass or volume.

4.7 Calculate rated torque, output speeds, and output torque for the break-in and test sequence. See Table 1 and paragraph 6.3.

4.8 Calculate horsepower requirements and determine if break-in or test sequence must be modified as outlined in paragraphs 5.1 and 6.3.

Note: If a tandem front axle is to be tested separately from the rear, the rated test torque for each axle would be one-half the tandem rating.

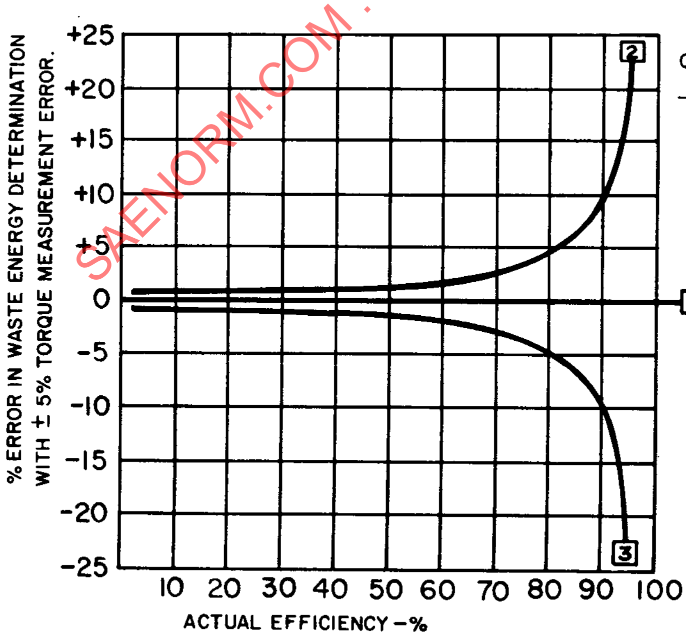
5. Break-In—An axle is said to have passed through the break-in period when the efficiency of the axle has stabilized. To minimize the running time required for axles to achieve efficiency stabilization select the appropriate schedule from paragraphs 5.1 and 5.2. Previously run axles and axles in which the lubricant has been changed may not be completely stabilized. Therefore, all test axles are to be stabilized in the selected break-in schedule before final testing.

5.1 If 125% of rated torque at 40.0 mile/h (64.40 km/h) does not exceed realistic in-service horsepower for the axles, run new axles for break-in to the following sequence at 40.0 mile/h (64.40 km/h):

50% of rated output torque for 90 min.
100% of rated output torque for 120 min.
125% of rated output torque for 90 min.

5.2 If horsepower requirements for the above schedule exceed realistic horsepower for in-service applications, run new axles to the following schedule:

25% of rated output torque—60.0 miles (96.0 km) at horsepower limit.
50% of rated output torque—40.0 miles (64.0 km) at horsepower limit.
100% of rated output torque—20.0 miles (32.0 km) at horsepower limit.



CURVE NO.	TORQUE INPUT	ERROR % OUTPUT
1	0%	0%
2	+.5%	−.5%
3	−.5%	+.5%

FIG. 1

5.3 To determine friction stability, measure the efficiency at the start, middle, and end of each break-in load setting run. If friction has not stabilized during the highest load run, repeat the total break-in schedule.

5.4 Control total output torque and speed to ±5% of target values established in paragraph 4.7.

5.5 Cool lubricant as required to maintain 150.0 ± 10.0° F (65.0 ± 6.0° C) sump temperature.

6. *Efficiency Tests*—Four conditions of operation are recognized. These are (listed in order of importance relative to energy use and durability):

Correlation	Power Flow	Rotation
Forward drive	Engine to axle	Primary design
Forward coast	Wheels to axle	Primary design
Reverse drive	Engine to axle	Opposite to primary design
Reverse coast	Wheels to axle	Opposite to primary design

The procedure has been developed for the forward driving mode only because that is by far the dominant condition of operation in the typical over-the-road application. As a guide to extending the procedure to the forward coasting mode the suggested approach is to: Run break-in at one condition, 25% of rated output torque (computed in paragraph 5.1) and 40.0 mile/h (64.40 km/h) until stabilized, then; follow the test schedule in paragraph 6.3 but limit the maximum axle shaft torque to 25% of the rated output torque. Output refers to the axle shaft total. For this coast test, the axle shaft is the driving member and the propeller shaft (or equivalent) is the driven member. Because fuel economy is influenced to a minor degree by forward coasting, and to an insignificant degree by the reverse modes in typical over-the-road use, these procedures have not been developed. The committee welcomes comments from users regarding the procedures outlined and the need to extend the procedures.

6.1 Efficiency is calculated by the formula in Table 1, Item 7. Use the precise ratio computed from tooth combinations rather than a nominal ratio.

6.2 Measured output torque and speed is to be within ±5% of the target value and temperature within ±10.0° F (±6.0° C) of the target value.

6.3 Axle efficiency for a given lubricant and axle may vary with torque, speed, and temperature. Complete determination at 6 torques, 6 speeds, and 5 temperatures would require 180 data points. For some purposes, mapping efficiency with load and speed variations at one steady state temperature will be adequate. This standard test is to be at 150.0° F (65.0° C) with output torque and speed sequences as in following table:

6.4 Other evaluations may require similar testing over a broader range of steady state temperatures. If so, it is recommended that the above sequence be repeated at the temperatures of interest or in 50.0° F (28.0° C) increments from the standard 150.0° F (65.0° C) temperature.

6.5 For cold start, short duration trip evaluations an optional transient temperature test is recommended. Standard speed for this test is 50.0 mile/h (80.50 km/h) and standard output torque is 25% of rating. Additional speeds and torques are optional. The procedure for this optional test follows:

6.5.1 Thoroughly cold soak the test axle to approximately -30.0° F (-34.0° C).

6.5.2 Accelerate and stabilize at test speed and torque.

6.5.3 Determine input and output torque as soon as stabilization is achieved with 0.0° F (-18.0° C) as a target for the first readings.

6.5.4 Record torques at 25.0° F (14.0° C) increments as the axle warms up from the friction being generated.

6.5.5 Continue the test through 250.0° F (121.0° C) or the maximum anticipated operating temperature (whichever is lower). Auxiliary heating may be required for low load, high temperature testing.

7. *Data Presentation*—(See typical graphs).

7.1 Specific end uses of this procedure and the forms in which data may be best presented for specific purposes are so varied that a standardized recommended data sheet is not provided. Figs. 2—5 illustrate typical reduction of data to performance curves.

7.1.1 No-load drive pinion torque versus speed (Fig. 2).

7.1.2 Family of efficiency versus torque curves at each output speed for each steady state temperature test (Fig. 3).

7.1.3 Efficiency versus temperature for optional transient temperature tests (Fig. 4).

7.1.4 Parasitic losses and efficiency converted to waste energy per mile or kilometer (Fig. 5).

7.2 Detail information to be included in data presentation when pertinent to the purpose of the test includes: test agency, test date, test identification number, axle model and part number, axle ratio, axle rating, gear geometry detail, bearing detail, lubricant identification, lubricant detail specifications, lubricant quantity, drive pinion angle, test torques and speeds, lubricant temperatures, test purpose, axle or lubricant application, numerical values for test results, conversion of data to preferred form, statistical significance of results, and prior use of axle or lubricant. Users of the procedure can choose data most appropriate for specific purposes.

Output Torque % of Rating	Output Speed Increments mile/h (km/h)—See Note (1)					
100%	10.0 (16.10)	20.0 (32.20)	30.0 (43.30)	40.0 (64.40)	50.0 (80.50)	60.0 (96.50)
50%	10.0 (16.10)	20.0 (32.20)	30.0 (43.30)	40.0 (64.40)	50.0 (80.50)	60.0 (96.50)
25%	10.0 (16.10)	20.0 (32.20)	30.0 (43.30)	40.0 (64.40)	50.0 (80.50)	60.0 (96.50)
15%	10.0 (16.10)	20.0 (32.20)	30.0 (43.30)	40.0 (64.40)	50.0 (80.50)	60.0 (96.50)
10%	10.0 (16.10)	20.0 (32.20)	30.0 (43.30)	40.0 (64.40)	50.0 (80.50)	60.0 (96.50)
0%	10.0 (16.10)	20.0 (32.20)	30.0 (43.30)	40.0 (64.40)	50.0 (80.50)	60.0 (96.50)

Note (1)—If the realistic in-service power limitations restrict test speed, run to the highest speed at which the table output torque and speed values produce power equal to the limiting power.

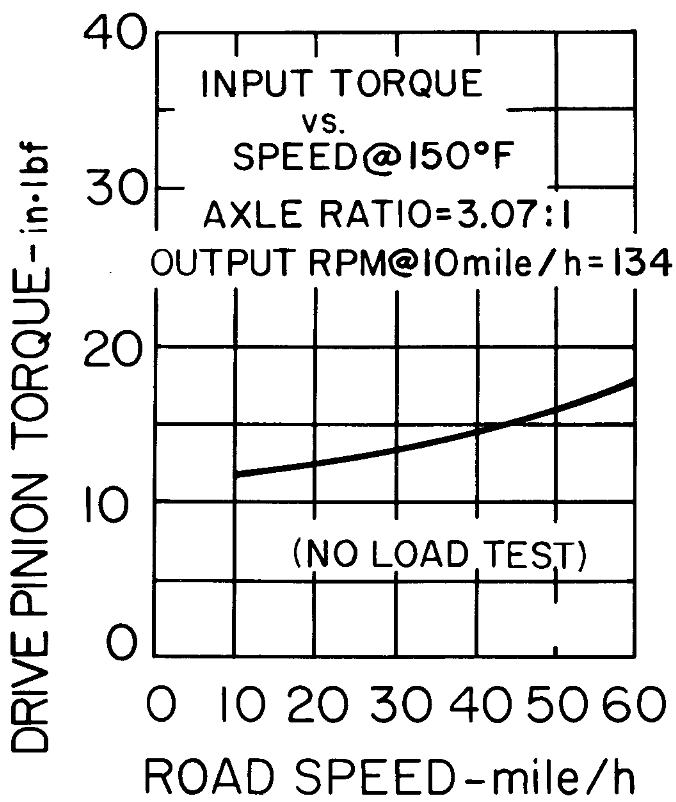


FIG. 2

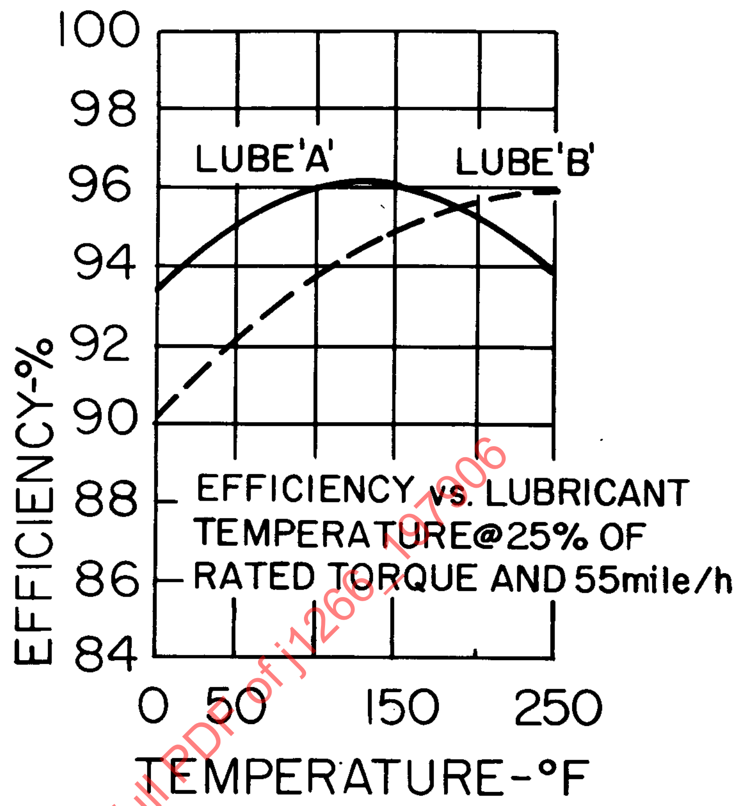


FIG. 4

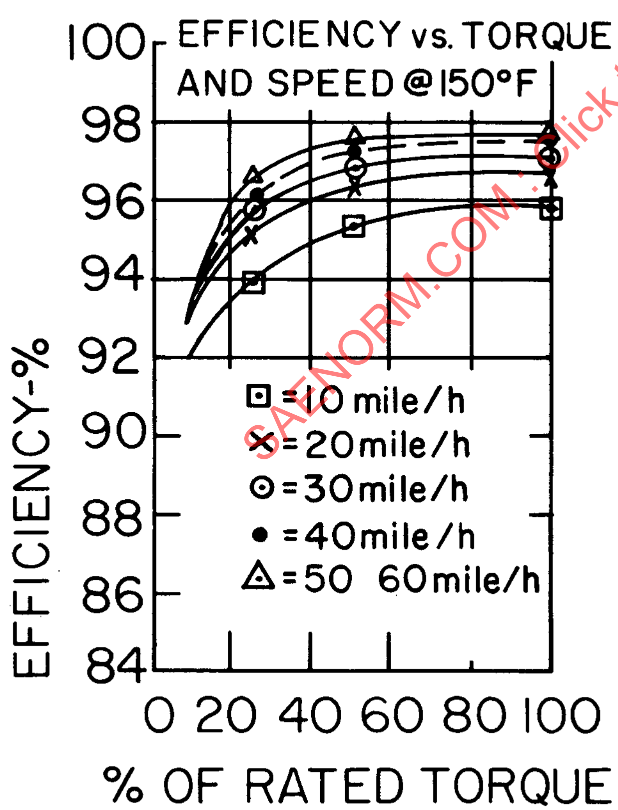


FIG. 3

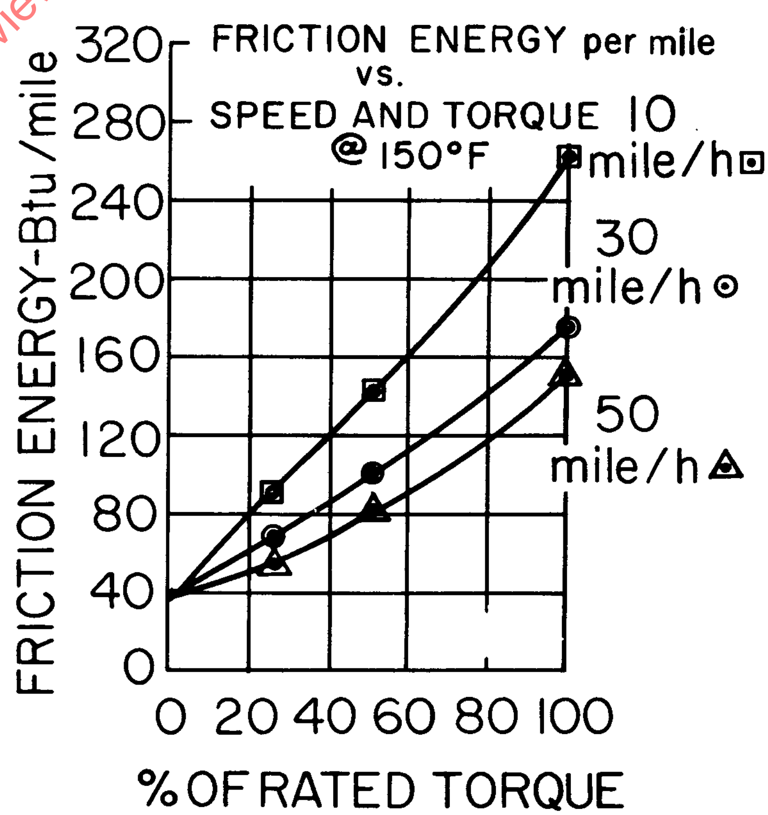


FIG. 5