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LAND SEA AIR SPACE

TECHNICAL REPORT J286

SAE NO. 2 CLUTCH FRICTION TEST MACHINE TEST PROCEDURE—SAE J286

SAE Recommended Practice

Report of Transmission and Drivetrain Committee approved January 1972.

1. Scope—The SAE No. 2 clutch friction test machine is used to evaluate the dynamic and static friction coefficients of automatic transmission clutch friction materials when submerged in various working fluids. It can also be used to conduct life tests on friction materials and working fluids.

2. Test Equipment

2.1 SAE No. 2 clutch friction test stand with cycle timer and static breakaway accessory.

2.2 Flywheels to deliver desired kinetic energy.

2.3 Recording oscillograph with at least three channels and with a system response as follows:

Torque channel—Flat frequency response, 0-30 Hz.
Pressure channel—Flat frequency response, 0-11 Hz.
Speed channel—Flat frequency response, 0-11 Hz.
Temperature channel—Flat frequency response, 0-11 Hz.

2.4 Torque transducer—Full-bridge, strain gage type, combined nonlinearity and hysteresis effects not to exceed 0.5% full range.

2.5 Apply pressure transducer—Full-bridge, strain gage type, combined nonlinearity and hysteresis effects not to exceed 0.5% full range.

2.6 Speed transducer—Direct-current tachometer generator, ±2% accuracy of full-scale.

2.7 Test fluid temperature indicator—Iron constantan thermocouple with high-impedance amplifier and cold-junction compensator; thermocouple located 0.050 in (1.3 mm) from outside diameter of clutch steel separator plates.

2.8 Jacket heater and/or cooler for test fluid temperature control using oil, water, steam, or compressed air.

2.9 Adapters and spacers—Splined hub for friction discs, splined retainer for steel separators, pressure plate connected to apply piston and single spacer to provide proper clutch peak clearance; path for fluid flow to be provided from inside diameter to outside diameter of clutch pack through properly oriented holes in splined clutch adapters; flatness of pressure plate and spacers to be within 0.0005 in (0.013 mm) total indicator reading across the diameter of the plate.

3. General Operating Conditions and Test Parameters

3.1 Piston area—23.42 in² (15 110 mm²).

3.2 Piston available travel—0.180 in (4.51 mm).

3.3 Piston apply pressure—As required to produce desired unit loading, 40-200 psi (276-1380 kPa) based on net unit area of friction material; tolerance on desired pressure to be ±1.0 psi (±7.0 kPa).

3.4 Piston apply pressure rise rate—150-180 psi/s (1034-1241 kPa/s).

3.5 Piston release pressure—5.0 psi (34 kPa) (to be 0 during apply cycle).

3.6 Total inertia range—2.9 lb-ft² (0.12 kg·m²) (rotor only) 30.0 lb-ft² (1.26 kg·m²) (with large flywheel).

3.7 Dynamic engagement speed—3545 rpm (60 Hz a-c), max.

3.8 Kinetic energy—6220-64,400 ft-lb (8.43-87.3 kJ).

3.9 Average power per unit area = $\frac{\text{KE (total in ft-lb (J))}}{\text{Area (in}^2\text{ (m}^2\text{))} \times \text{time (s)} \times 550}$

3.9.1 Friction test—Less than 1 hp/in² (1.15 W/mm²) of net area.

3.9.2 Abuse test—More than 1 hp/in² (1.15 W/mm²) of net area.

3.10 Static breakaway speed—0.72 rpm or variable.

3.11 Test fluid quantity—20 fl oz (0.6 l) min, 30 fl oz (0.9 l) max.

3.12 Test fluid temperature—220 ±5 F (105 ±3 C).

3.13 Clutch running clearance—Min 0.005 in (0.13 mm)/friction surface.

3.14 Cycle time, dynamic coefficient—20-60 s, depending on inertia.

3.14.1 Motor on time—14-50 s.

3.14.2 Piston apply time—4-8 s.

3.15 Cycle time, static breakaway—15 s.

3.15.1 Motor on time—1.0 s min.

3.15.2 Pressure apply time—2.0 s min.

3.16 Oscillograph paper speed

3.16.1 Dynamic tests—2 ips (50 mm/s) min.

3.16.2 Static tests—1 ips (25 mm/s).

3.17 Oscillograph amplitude calibration

3.17.1 Torque—150 lb-ft/in (8.0 N·m/mm) max.

3.17.2 Pressure—50 psi/in (13.6 kPa/mm) max.

3.17.3 Speed—2000 rpm/in (80 rpm/mm) max.

3.18 Test duration—As required; duration needed depends on test objectives as well as the cycles required to stabilize the coefficient.

3.19 Test cavity pressure—2.5 psi (17 kPa) max.

3.20 Cooling jacket pressure—1.0 psi (7 kPa) max.

4. Test Preparation

4.1 Clean and flush head of test fixture with test fluid. If the previous test was run with a fluid of different specification, clean the head with mineral spirits. Then flush once with new test fluid.

4.2 Soak lined plates in the test fluid for 10 min minimum at room temperature. Blot the oil, do not use a degreaser.

4.3 Measure and record the thickness of each lined disc before test and again after test.

4.4 Select proper spacer to obtain the specified clutch running clearance.

4.5 Mark mating surfaces on the tab face of splines in sequence of assembly.

4.6 Assemble the pack as follows: Install a steel separator plate to contact the pressure plate. Then follow with a lined disc, another separator, and so on. The last plate to be installed must be a steel separator plate. The spacer selected in paragraph 4.4 is then installed.

4.7 Replace cover on test cavity.

4.8 Fill test cavity with specified amount of fluid. Bleed the cavity while filling.

5. Testing and Recording

5.1 Turn on power to recording equipment and provide proper warmup time.

5.2 Calibrate recording equipment to insure total torque and pressure system error not to exceed 1% full-scale.

5.3 Actuate temperature control system. This system may be manually or automatically controlled.

5.3.1 If the energy to be dissipated is sufficient to bring the temperature of the test fluid to the desired level in 10 cycles, no preheating should be necessary. Observe the temperature when the motor is running and the clutch is released.

5.3.2 Regardless of the heating-cooling medium used (oil, water, steam, or air), pressure within the jacket surrounding the test cavity should not exceed 1 psi (7 kPa) to prevent the cooling medium from entering the test cavity past the cover seal.

5.3.3 Heating or cooling oil circulating through the test cavity is permitted but is not recommended, since purging and cleaning of the entire system after contamination from a test specimen is difficult.

5.4 Set the pressure level required for the test.

5.5 When the test temperature has stabilized, take oscillograph recordings as required. Record or mark the temperature on each record along with the cycle number.

5.6 When obtaining data for a master curve, take five consecutive records after the minimum number of cycles required for break-in. Do this for each of six different samples.

5.7 Take five static records after each set of five dynamic records.

5.8 When a series of records is completed, mark the following information on the back of the last record:

5.8.1 Transmission model.
5.8.2 Clutch type.
5.8.3 Friction material and manufacturer.
5.8.4 Oil-groove pattern.
5.8.5 Number of lined discs.
5.8.6 Previous testing history of lined discs.
5.8.7 Test fluid specification.
5.8.8 Test fluid temperature.
5.8.9 Number of test.
5.8.10 Purpose of test.
5.8.11 Test date.

6. Calculations

6.1 Dynamic Coefficient—Master Curve

6.1.1 On the five traces for each of the six samples, mark the speed points at 100, 500, 1000, 2000, and 3000 rpm.

6.1.2 Calculate the coefficient at each speed, using the following relation:

$$\mu = \frac{T}{NRF}$$

where:

μ = coefficient of friction
T = value of torque from trace, lb-ft (N·m)
N = number of friction surfaces
R = mean radius of friction surface, ft (m) = $(R_o + R_i)/2$
F = applied normal force, lb (N)

6.1.3 For each sample (six), determine the average coefficient at each speed point. Use the following relation:

$$\mu_A = \frac{1}{n}\sum_{i=1}^{n} \mu_i$$

where:

μ_A = average coefficient of one sample at one speed point
μ_i = coefficient from one torque reading at one speed point
n = number of torque readings at one speed point (5)

6.1.4 Check to determine if the six average coefficients, μ_A, at each speed point belong to a normal probability distribution as follows: Arrange the six coefficients in order from lowest to highest. Plot these values on normal probability paper (for example, K & E 468003), according to L. G. Johnson's Median Rank Values for a six-member sample, as given below:

Coefficient Rank	Median Rank, %
1 (lowest)	10.91
2	26.55
3	42.18
4	57.82
5	73.45
6 (highest)	89.09

6.1.5 If the plot (Fig. 1) on normal probability paper deviates markedly from a straight line, other than random errors are influencing the data. A check should be made for system errors.

6.1.6 Determine the standard deviations at *each* speed point as follows:

$$\sigma = \left[\frac{\sum_{i=1}^{N} \mu^2_{Ai} - \frac{1}{N}\left(\sum_{i=1}^{N} \mu_{Ai}\right)^2}{N-1}\right]^{1/2}$$

where:

σ = standard deviation
μ_{Ai} = individual average coefficient for each sample at the speed point
N = number of samples (six)

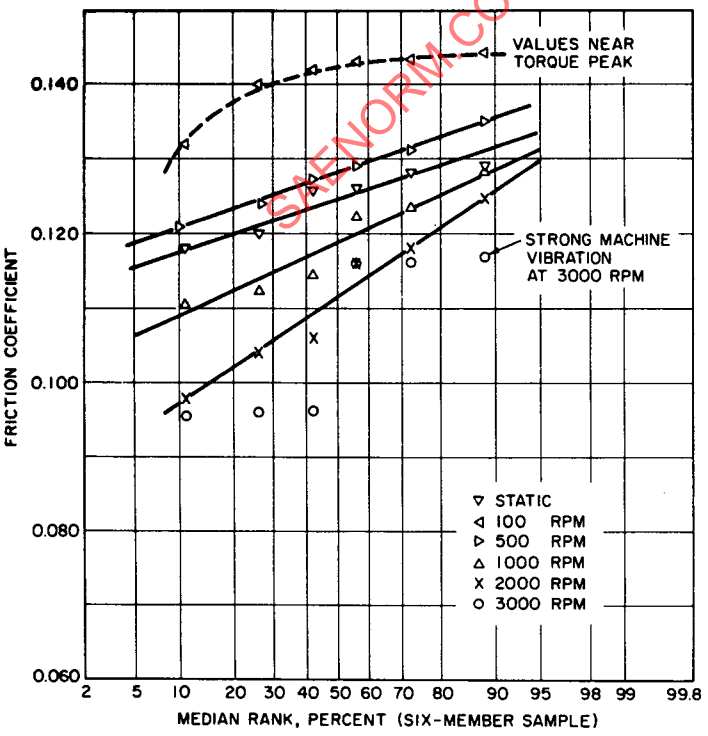
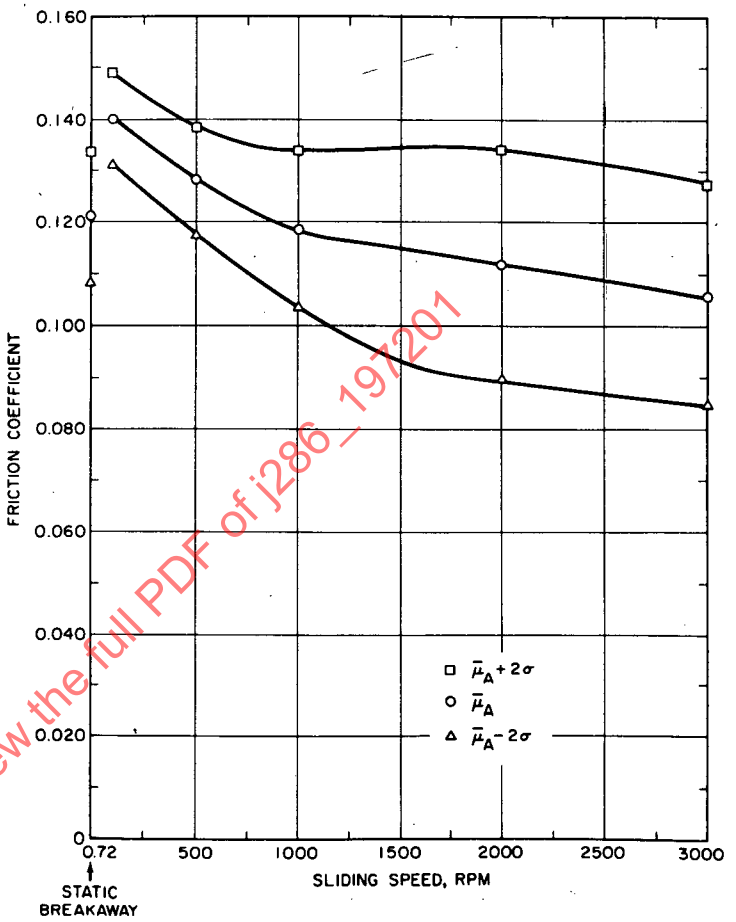


FIG. 1—TEST FOR NORMAL PROBABILITY DISTRIBUTION

6.1.7 On linear paper plot $\bar{\mu} + 2\sigma$ and $\bar{\mu}_A - 2\sigma$ at each speed point. The mean coefficient $\bar{\mu}_A$ is defined as

$$\bar{\mu}_A = \frac{1}{N}\sum_{i=1}^{N} \mu_{Ai}$$



MASTER CURVE 101 CALCULATIONS

Test Number	μA at Selected Sliding Speeds, rpm[a]						Stop Time, s
	100	500	1000	2000	3000	Static	
7	0.132	0.121	0.112	0.104	0.096	0.128	2.10
8	0.143	0.124	0.110	0.098	0.096	0.126	2.17
9	0.144	0.127	0.114	0.106	0.096	0.126	2.10
10	0.143	0.131	0.123	0.118	0.116	0.120	1.90
11	0.140	0.135	0.128	0.125	0.116	0.118	1.81
12	0.139	0.130	0.125	0.123	0.114	0.112	1.91
$\sum_{i=1}^{6} \mu_{Ai}$	0.8410	0.768	0.712	0.674	0.636	0.730	11.99
$\bar{\mu}_A$	0.1402	0.1280	0.1187	0.1123	0.1057	0.1217	2.00
$\sum_{i=1}^{6} \mu^2_{Ai}$	0.117980	0.100432	0.084738	0.076334	0.068016	0.088804	24.063
$\frac{1}{6}\left(\sum_{i=1}^{6} \mu_{Ai}\right)^2$	0.117880	0.098303	0.084490	0.075713	0.007493	0.088483	23.960
σ[b]	0.00444	0.00506	0.00758	0.01115	0.01061	0.00612	0.144
$\bar{\mu}_A + 2\sigma$	0.1491	0.1381	0.1337	0.1346	0.1269	0.1339	2.288
$\bar{\mu}_A - 2\sigma$	0.1313	0.1179	0.1035	0.0900	0.0845	0.1095	1.172

[a] Average of five recordings.
[b] The standard deviation, σ, is defined as follows:

$$\sigma = \left[\frac{\sum_{i=1}^{N} \mu^2_{Ai} - \frac{1}{N}\left(\sum_{i=1}^{N} \mu_{Ai}\right)^2}{N-1}\right]^{1/2}$$

FIG. 2—MASTER CURVE 101