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Clutch Application Powertrain Startability Rating Requirements for Truck and Bus Applications

Foreword—This SAE Recommended Practice is presented in response to a need to standardize startability calculation methods and requirements. Powertrain startability is a key factor in establishing a vehicle powertrain specification that will operate efficiently and give long service life. The four primary factors which affect how long a clutch will last in a given truck are:

- a. Powertrain specification (engine, clutch, transmission, axle, and tires)
- b. Control of drivetrain torsional activity
- c. Driver technique (starting gear selection, engagement technique, driving habits)
- d. Clutch maintenance (adjustment, lubrication, protection from rust and contamination)

The powertrain specification is not only one of these primary factors, but it also can have a major effect on another factor, driver technique. The final indicator of powertrain acceptability is the Startability Rating defined in this document.

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1. **Scope**—Although not limited to, these installations are normally used on trucks considered as Medium Duty (Class 6 and 7), as well as Heavy Duty (Class 8).

1.1 **Purpose**—This SAE Recommended Practice defines powertrain application startability rating requirements for pull type single and twin plate truck clutches.

2. **References**

2.1 **Related Publications**—The following publications are provided for information purposes only and are not a required part of this document. The following publications define the existing clutch system design configuration used in trucks and buses.

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J373—Housing Internal Dimensions for Single and Two Plate Spring Loaded Clutches

SAE J617—Engine Flywheel Housings

SAE J1463—Pull Type Clutch—Transmission Installation Dimensions

SAE J1479—Automotive Pull Type Clutch Terminology

SAE J1731—Pilot Bearings for Truck and Bus Applications

SAE J1806—Clutch Dimensions for Truck and Bus Applications

SAE J1857—Flywheel Dimensions for Truck and Bus Applications

2.1.2 TMC PUBLICATIONS—Available from The Maintenance Council, American Trucking Associations, 2200 Mill Road, Alexandria, VA 22314.

TMC RP 633 (T)—Effects of Drivetrain Torsionals

3. **Definitions**—The following specific terms as used in the document are defined as follows:

- a. Heavy-Duty (Class 8) Trucks—A truck or tractor rated by the manufacturer and certified to the US federal government to be for operation at a gross vehicle weight or a gross combination weight of 14 969 kg (33 001 lb) and over.
- b. Medium-Duty (Class 6 and 7) Trucks—A truck or tractor rated by the manufacturer and certified to the US federal government to be for operation at a gross vehicle weight or a gross combination weight of 8846 kg (19 501 lb) to 14 969 kg (33 000 lb).
- c. OEM—Original Equipment Manufacturer—The term used to identify a vehicle's manufacturer.

4. **Technical Requirements**

4.1 **Powertrain Specification**—The powertrain specification includes engine performance parameters, clutch size, transmission gear ratios, axle ratio, tire size, powertrain configuration, and vehicle weight. The interaction between these factors can be characterized by a Startability Rating which will be defined in the next section. A brief discussion of the powertrain specification factors follows:

- a. Engine—Correctly selecting and matching an engine for a given application requires the consideration of many complex requirements and is beyond the scope of this document.
- b. Clutch—Clutches are primarily selected based on rated clutch torque capacity, which must be equal to or greater than the peak torque of the engine selected. In those cases where different sized clutches are available for a given engine and torque rating, the larger clutch with more heat capacity will provide longer life. The clutch disc damper specification should be based on the need for torsional resonance vibration control.

- c. Transmission—As with engine selection, transmission selection is based on many complex factors such as torque capacity, number of gears, gear ratio steps, low gear ratios (forward and reverse), final drive ratio, shift pattern, weight, and startability (discussed later). The number of gears and gear ratio steps are important for clutch life. It is essential that a comfortable start-up gear with acceptable startability be available for any normally encountered vehicle operating weight and application condition (see Startability). The correct start-up gear may vary with vehicle weight, starting grade, and road surface conditions. Selecting a higher gear for start-up will increase clutch engagement slip time and may significantly reduce clutch life.
- d. Axle—Final drive ratio is usually selected to complement the transmission and engine choice and to allow attainment of maximum cruising speed with optimized fuel economy. The ratio has a great effect on clutch life and must be used to calculate vehicle startability.
- e. Tires—Sizes range over a broad spectrum and have the effect of modifying the final drive ratio. However, tire size has a limited effect and is not a major factor in clutch life. The startability formula includes the tire size effect through inclusion of the tire's revolutions per mile rating.
- f. Powertrain Configuration—The number of total axles and the number of driving axles affect vehicle tractive effort and driveline overall efficiency. For the purpose of defining powertrain startability, powertrain configuration has a very limited effect and is not taken as a variable factor in calculations.
- g. Vehicle Loading—This factor has a direct effect on vehicle performance, clutch heat input at startup and the startability calculation.

4.2 Powertrain Startability Rating—Powertrain startability has the most significant effect on clutch life. A startability factor is calculated which is based on energy (heat) which must be absorbed by a clutch during vehicle starts. It is important that startability be determined in the normal start-up gear (which is not necessarily the lowest ratio gear of the transmission.) The normal start-up gear is one that can be used to start the vehicle comfortably without having to fuel up the engine. Driveline component suppliers have formulas for startability which are used to assess the starting capability of a given powertrain specification. Traditionally, differences have existed between the startability formulas used by the different component manufacturers, but the Equation 1 is recommended to be used as a standard calculation method. This formula is in general agreement with all manufacturers' requirements.

$$\text{Startability} = S = \frac{T_e \times R_t \times R_a \times M}{10.7 \times GW} \quad (\text{Eq. 1})$$

where:

- T_e = Gross available engine torque during clutch engagement in lb-ft
- R_t = Transmission normal starting gear ratio
- R_a = Axle final drive ratio
- M = Driving tire revolutions per mile
- GW = Total gross vehicle weight including towed trailers (if any) in pounds

Startability, S must meet the following requirements depending on type of application:

- $S = 16$ minimum for General On-Highway usage
- $S = 25$ minimum for Moderate On/Off-Highway usage
- $S = 30$ minimum for Severe On/Off-Highway usage

T_e , the clutch engagement engine torque is the torque available from the engine at idle rpm, the assumed engine speed during clutch engagement. The minimum required clutch engagement torque for any application can be computed by using the appropriate value of S from the previous requirements and substituting it into the following rearrangement of the startability formula (see Equation 2):

$$T_e = \frac{10.7 \times GW \times S}{R_t \times R_a \times M} \quad (\text{Eq. 2})$$

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A sample startability calculation for a typical Class 8 truck, is as follows:

"Clutch Engagement Torque" = $T_e = 640$ lb-ft

Transmission starting ratio = $R_t = 10.99$

Rear axle final drive ratio = $R_a = 4.10$

Driving tire revolutions per mile = $M = 500$

Gross vehicle loaded weight = $GW = 80000$ lb

$$\text{STARTABILITY} = S = \frac{640 \times 10.99 \times 4.10 \times 500}{10.7 \times 80000} = 16.84$$

Conclusion: Acceptable for General On-Highway Usage.

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