



SURFACE VEHICLE RECOMMENDED PRACTICE

J3039™

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Definition and Measurement of Power Transfer Unit Speed-Dependent Parasitic Loss

RATIONALE

New government regulations that raise automotive fuel economy requirements and change the methods by which vehicle level fuel economy is measured drive the need for improved methods to measure component level parasitic loss. The intent of this standard is to provide the means to generate consistent component level parasitic loss data in support of modeling and analysis of vehicle-level emissions and fuel economy. This document is similar to SAE J2985, focusing however on the PTU instead of the transfer case.

SAE J3039 has been reaffirmed to comply with the SAE Five-Year Review policy.

1. SCOPE

This SAE Recommended Practice covers power transfer units (PTUs) used in passenger car and sport utility vehicles to support all wheel drive (AWD) operation. PTUs are typically full-time use geared devices (see 3.1). Some PTUs have additional features such as part-time on-demand capability via electronically actuated disconnect features, and other configurations are possible.

1.1 Purpose

To provide a common means to measure and quantify the speed-dependent parasitic loss ("spin loss") characteristics of PTUs.

2. REFERENCES

2.1 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

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 J1952 All-Wheel Drive Systems Classification

SAE J2059 All-Wheel Drive Drivetrain Schematic Symbol Standards

Kirk, M., Ilyas, S., D'Anna, T., Perakes, A. et al., "Development of a Standard Spin Loss Test Procedure for 4WD Transfer Cases," SAE Technical Paper 2012-01-0306, 2012, <https://doi.org/10.4271/2012-01-0306>.

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3. DEFINITIONS

3.1 POWER TRANSFER UNIT

The power transfer unit (PTU) facilitates (in combination with other driveline components) power transmission to the rear wheels of transverse-mounted powertrains, enabling all wheel drive (AWD) functionality from a front wheel drive (FWD) based vehicle architecture. Typically, the input of the PTU is connected to the output of the transmission and the output portion of the PTU is coupled to the rear axle via a propshaft. Internally, the PTU connects the input and output with a combination of parallel and non-parallel gear sets (as shown schematically in [Figure 1](#)).

Depending on the design, the PTU-based AWD driveline may actively control the amount of power transmitted to the rear wheels or may be permanently locked into AWD mode. PTUs may have one or more axes depending on the design and application.

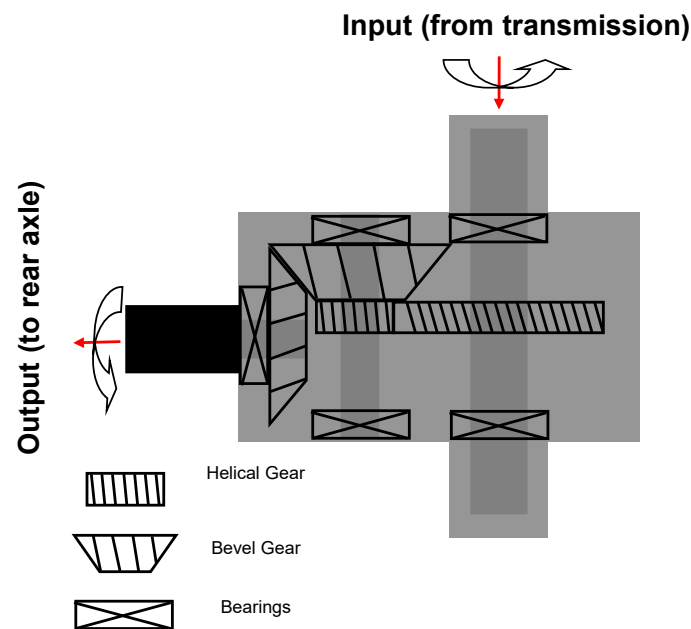


Figure 1 - Power transfer unit (PTU) schematic

3.2 UNIT UNDER TEST (UUT)

This term and its associated acronym is used to describe the test article (power transfer unit) undergoing the tests outlined herein.

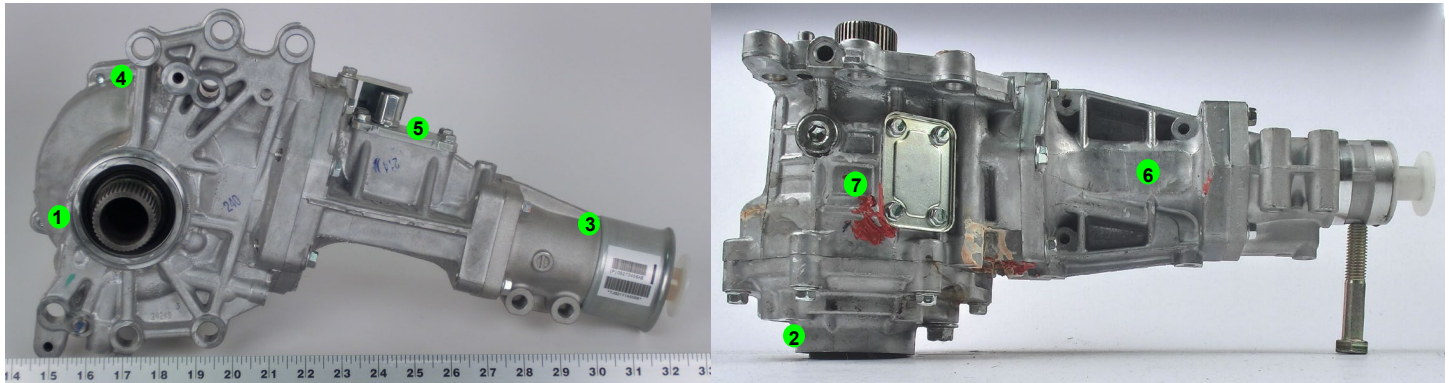
3.3 AVERAGE SKIN TEMPERATURE (AST)

To accurately represent the temperature of the unit under test (UUT), a metric has been developed using the average of multiple thermocouple readings. This method has been demonstrated to accurately represent the internal/overall (“core”) temperature of the UUT and is based on a detailed study using an array of internal and external thermocouples. The AST was developed using k-type thermocouples. The thermocouples should be soldered tip type (i.e., exposed wires/tip) and adhered to the unit using a thermally conductive adhesive to be most representative of the metal temperature. Other direct contact type transducers may be used as long as they meet the measurement requirements. It is not recommended to use non-contact temperature measurement devices. The AST is comprised of seven thermocouple readings located as follows:

1. As close to the outer race of the input (2x) and output (1x) shaft support bearings as possible.
2. As close to the outer race of the input (2x) and output (1x) shaft support bearings as possible.
3. As close to the outer race of the input (2x) and output (1x) shaft support bearings as possible.

4. Top (input section).
5. Top (output section).
6. Bottom (output section).
7. Bottom (input section).

A pictorial example of sample locations is shown in [Figure 2](#).



- | | |
|--------------------------------------|----------------------------|
| 1. Input bearing (transmission side) | 5. Top (output section) |
| 2. Input bearing (back side) | 6. Bottom (output section) |
| 3. Output bearing (12 o'clock) | 7. Bottom (input section) |
| 4. Top (input section) | |

Figure 2 - Average skin temperature sample locations

NOTE: There are many configurations of PTUs due to output torque, vehicle packaging, and feature content. Extensive testing has shown the AST methodology will predict overall temperature characteristics more accurately than a sump temperature alone. Some experimentation may be required to verify an accurate AST if the unit has unique features or content.

$$AST = \frac{\sum_{i=1}^7 \text{Thermocouple}_i}{7} \quad (\text{Eq. 1})$$

3.4 SUMP TEMPERATURE

A thermocouple is installed in the drain plug (as shown in [Figure 3](#)) of the UUT to record the temperature of the oil within the test unit. This temperature is used in conjunction with the AST to establish the temperature state of the UUT. (Note: sump temperature is not included in the AST calculation/definition in [3.3](#).)

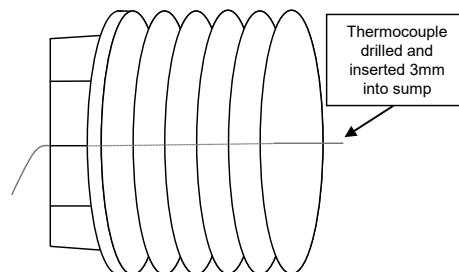


Figure 3 - Sump temperature via drain plug

3.5 TEMPERATURE-CONTROLLED CHAMBER

In order to conduct the testing outlined in Section 4, a suitable temperature-controlled chamber must be used. The chamber should be capable of controlling the PTU temperature without directly conditioning the oil inside (i.e., via convection). The chamber should be capable of achieving an average skin temperature (AST) in the range of -7 to +65 °C (20 to 150°F). Note: to achieve this range, it is likely the chamber will need to be capable of achieving temperatures slightly above and below these target temperatures. Specific design of the chamber is beyond the scope of this specification; however, during the development of this specification, liquid nitrogen (LN₂) was utilized to achieve the lower range (-7 °C) of the specification. If liquid nitrogen is used, care should be taken to ensure no liquid nitrogen is spilled or splashed directly on the UUT, as it could damage the unit. A schematic of the chamber used is shown in Figure 4.

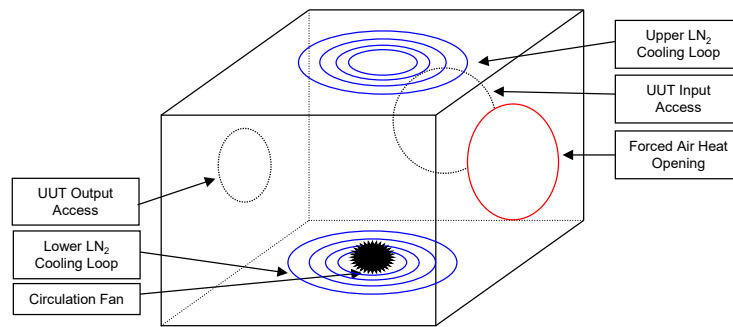


Figure 4 - Temperature-controlled chamber schematic

3.6 SOAK TIME

Minimum amount of time UUT must be maintained at target average skin temperature in order to achieve repeatable results. An example of the temperature profile for the temperatures included in the AST (defined in 3.3) is shown in Figure 5. As noted in the figure, an initial pre-soak of 4 hours was used followed by a 45-minute soak; the soak procedure as required throughout the test sequence is further outlined in 4.3.2. Should the available cooling system not be capable of reaching an AST of -7 °C within 4 hours, additional pre-soak time will be required prior to the 45-minute additional soak (at target temperature).

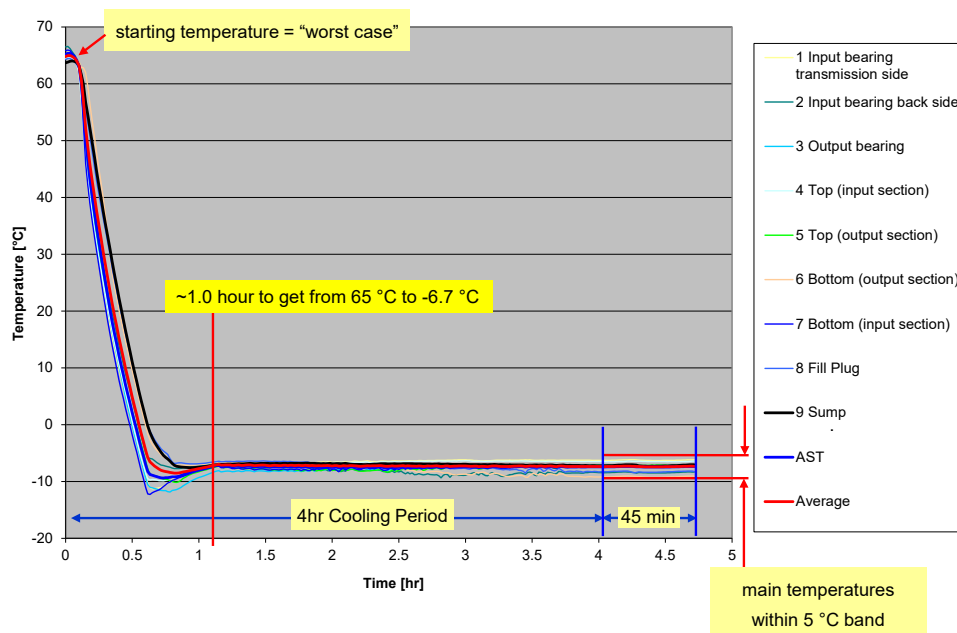


Figure 5 - Initial soak