



SURFACE VEHICLE RECOMMENDED PRACTICE

J2907™

AUG2023

Issued 2017-02
Revised 2018-02
Stabilized 2023-08

Superseding J2907 FEB2018

Performance Characterization of
Electrified Powertrain Motor-Drive Subsystem

RATIONALE

This stabilized SAE Recommended Practice documents the consensus test procedure for electric traction drive motor characterization including its mating power converter and controller. Over the past several years, the electrified transportation user community have not made requests for modification of SAE J2907. Templates for data recording remain in effect and include operating voltage and speed range as required inputs, while stall torque, peak power at manufacturer specified speed, and maximum available torque at the manufacturer specified operating voltage are validated and recorded. Common basic electric traction drive system design elements along with UN and SAE reference documents cited remain in effect allowing stabilization of this SAE Recommended Practice.

STABILIZED NOTICE

This document has been declared "STABILIZED" by SAE Hybrid - EV 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.

SAE Executive Standards Committee Rules provide that: "This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising therefrom, is the sole responsibility of the user."

SAE reviews each technical report at least every five years at which time it may be revised, reaffirmed, stabilized, or cancelled. SAE invites your written comments and suggestions.

Copyright © 2023 SAE International

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of SAE.

TO PLACE A DOCUMENT ORDER: Tel: 877-606-7323 (inside USA and Canada)
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
http://www.sae.org

SAE WEB ADDRESS:

Full document details: SAE J2907_202308

For more information on this standard, visit
https://www.sae.org/standards/content/J2907_202308/

Documents

Document Sharing Hub

TABLE OF CONTENTS

1.	SCOPE.....	3
1.1	Background and Purpose	3
1.2	Field of Application.....	4
1.3	Data Recording	4
2.	REFERENCES.....	5
2.1	Applicable Documents	5
2.1.1	SAE Publications.....	5
2.2	Related Publications	5
2.2.1	ASTM Publications.....	5
2.2.2	IEC Publications.....	5
2.2.3	IEEE Documents.....	6
2.2.4	ASME Publications.....	6
3.	DEFINITIONS	7

4.	TEST PROCEDURES.....	11
4.1	Initialization	11
4.1.1	Dynamometer Initialization.....	11
4.1.2	Power Supply Requirement	12
4.1.3	Preconditioning	12
4.1.4	Maximum Torque	12
4.1.5	Maximum Torque Determination.....	12
4.2	Maximum (Net) Power	12
4.2.1	Maximum Net Power Equipment Configuration	13
4.2.2	Maximum Net Power Preconditioning.....	13
4.2.3	Maximum Net Power Determination	14
4.3	The Maximum 30 Minute Power	14
4.3.1	Maximum 30 Minute Power Equipment Configuration.....	14
4.3.2	Maximum 30 Minute Power Preconditioning	14
4.3.3	Maximum 30 Minute Power Determination	14
5.	TEST INSTRUMENTATION	14
5.1	Instrumentation Accuracy.....	14
5.2	Additional Instrumentation	15
6.	CALCULATIONS.....	16
6.1	Instrumentation Bandwidth	16
6.2	Bandwidth of Instrumentation Cascade	16
6.3	Calculation of Mechanical Power	17
6.4	Calculation of Maximum (Net) Power	18
6.5	Calculation of Maximum 30 Minute Power.....	18
7.	TEST DATA	18
7.1	Recording Results.....	18
8.	NOTES.....	19
8.1	Revision Indicator.....	19
APPENDIX A		20
APPENDIX B		21
Figure 1	Types of electric traction motors.....	4
Figure 2	Torque-speed and power characteristics of selected traction motor types	9
Figure 3	Illustration of laboratory dynamometer test of 1600 kg BEV estimated ETDS performance for real world driving approximated by the combined drive cycle, CDC Solid traces are peak (280 N•m) and continuous torque (160 N•m) envelopes.....	11
Figure 4	Example laboratory dynamometer test of ETDS functional diagram for bench dynamometer test.....	13
Figure 5	Maximum (net) power precondition and test profile	13
Figure 6	Circuit to illustrate t_r and f_{B1}	16
Table 1	Laboratory instrumentation accuracy.....	15
Table 2	Unit conversions.....	17

1. SCOPE

This document was developed to provide a method of obtaining repeatable measurements that accurately reflects the performance of a propulsion electric drive subsystem, whose output is used in an electrified vehicle regardless of complexity or number of energy sources. The purpose is to provide a familiar and easy-to-understand performance rating. Whenever there is an opportunity for interpretation of the document, a good faith effort shall be made to obtain the typical in-service performance and characteristics and avoid finding the best possible performance under the best possible conditions. Intentional biasing of operating parameters or assembly tolerances to optimize performance for this test shall not be considered valid results in the scope of this document.

1.1 Background and Purpose

Electrified vehicles are increasing in market share, and are expected to continue to do so. These advanced vehicles are currently found on dealer lots and in marketing material. They are being compared to conventional vehicles powered by internal combustion engines; whether in light-duty, heavy-duty, or off-road applications. Additionally, these vehicles are being compared with other electrified vehicles which may operate with different voltage levels or powertrain configurations.

Currently there is no widely accepted standard for specifying the performance of a traction motor. It is our intention to be as similar in approach as possible to the existing worldwide standard UN ECE R85 (uniform provisions concerning the approval of internal combustion engines or electric drive trains intended for the propulsion of motor vehicles of categories M and N with regard to the measurement of net power and the maximum 30 minutes power of electric drive trains). In addition, a wide variety of powertrain configurations, as well as limitations arising due to the traction battery, cooling system, or vehicle controls, makes it difficult to predict the net and continuous power of the electric motor, the major component in an electric traction drive subsystem (ETDS), once installed in its application vehicle. The SAE J2907 test procedure provides an accurate assessment of the ETDS performance, under controlled laboratory conditions, using manufacturer supplied equipment settings, as the basis for in-vehicle performance as outlined in SAE J2908.

The test procedure, Section 4, is comprised of three sections:

An initialization procedure that includes specific preconditioning of the ETDS.

The maximum net power (synonymous with peak power) rating of the ETDS for manufacturer (MFG) specified power supply voltage, test speed, coolant system setpoints, and operator interface software.

The maximum 30 minute power rating, a measure of continuous power capability of the ETDS under manufacturer prescribed power supply voltage, test speed, coolant system setpoints, and operator interface software.

The tests detailed herein are application 'agnostic' and should not be interpreted as favoring any particular motor or inverter technology, powertrain architecture, or type of control employed. This recommended practice has been developed to document the consensus from industry stakeholders on acceptable motor test methods that enable a formal means of characterizing the motor as an ETDS component and communicating those characteristics. As such, the full ETDS represents the minimum hardware complement of this procedure, performed out of vehicle on a laboratory dynamometer using a regulated power supply. Use of high power industrial ac drive inverters and controls other than manufacturer supplied production algorithms (not to be modified) is outside the scope and purpose of this document.

Due to the inclusion of the inverter and associated production software, the majority of the testing results will reflect the characteristics of the motor in a specific application. The implementation of one motor design in multiple applications or with different inverters or with different algorithms and/or parameterization would require retesting to obtain the motor characteristics that represent the different motor drive systems. The procedures stated in this document apply whether the ETDS provides direct access to its motor shaft, or access via an integrated gearbox, so that test fixturing requirements are minimized.

This document should be viewed as a starting point for the standardization of electric traction motor testing. This technology will be evolving as newer and more integrated drive systems become commercially available. It is likely, therefore, that these test protocols will need to be periodically revisited and revised, as the technology matures.

1.2 Field of Application

The electric drive system in the scope of this document includes the ETDS consisting of:

- Drive motor with access to its output shaft, either directly or via a gearbox.
- Power inverter plus control electronics having MFG supplied production software.
- Cables and sensors as needed for operation, data acquisition, and operator interface software.
- Any enclosures required to support the operating system.
- Entire cooling system that mocks up vehicle usage.

This document is meant to cover electrified powertrain motor-drive subsystem regardless of end use. Typical applications include fuel cell EV (FCEV), battery electric vehicle (BEV), hybrid EV (HEV), plug-in EV (PHEV), or range extended EV (EREV), regardless of architecture.

Also included within this field of application are ETDS units as may be found in electric motorcycles, scooters, and low speed electric vehicles such as Neighborhood EVs.

Motor only characterization tests are not covered by this document. Instead, appropriate motor test procedures for the characterization of particular electric machine types, such as those illustrated in Figure 1 is described in the following IEEE Standards, and should be consulted for more in-depth testing.

- Std. 11 for rail and road vehicles
- Draft Std. P1812 for permanent magnet machines
- Std. 112 for polyphase induction motors and generators
- Std. 115 for synchronous machines

1.3 Data Recording

Appendices are provided in this recommended practice for recording pertinent information about the traction motor and its drive system undergoing test. Users are provided Appendix B as a template for recording results and Appendix A as a communications tear-off sheet that summarizes how well maximum (net) power and maximum 30 minute power match manufacturer declared values.

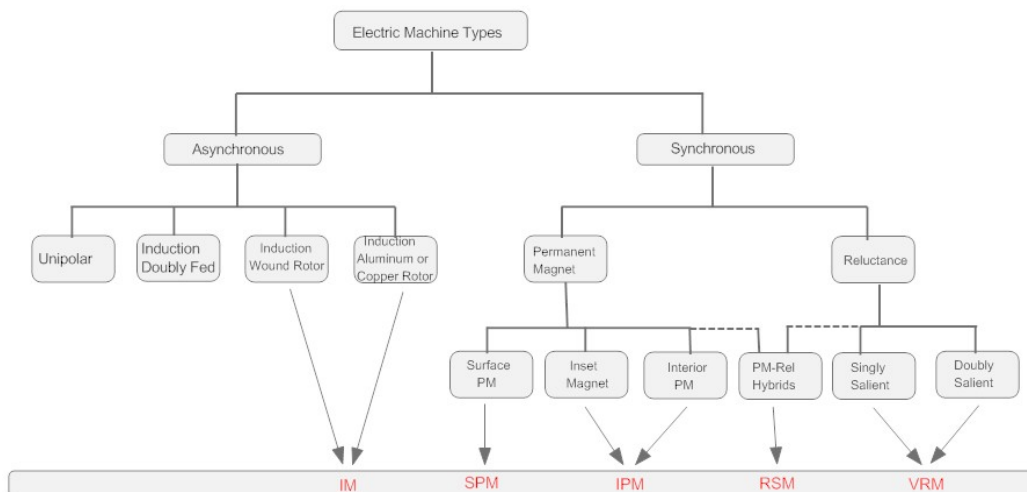


Figure 1 - Types of electric traction motors

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 J1715 Hybrid Electric Vehicle (HEV) and Electric Vehicle (EV) Terminology

SAE J2344 Guidelines for Electric Vehicle Safety

SAE J2908 Vehicle Power Test for Electrified Powertrains

2.2 Related Publications

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

2.2.1 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

UN/ECE R85 Uniform provisions concerning the approval of internal combustion engines or electric drive trains intended for the propulsion of motor vehicles of categories M and N with regard to the measurement of net power and the maximum 30 minutes power of electric drive trains

2.2.2 IEC Publications

Available from IEC Central Office, 3, rue de Varembe, P.O. Box 131, CH-1211 Geneva 20, Switzerland, Tel: +41 22 919 02 11, www.iec.ch.

IEC EIC/TR 60785 Ed. 1.0b:1984

Technical Report "Rotating Machines for Electric Road Vehicles"

IEC 60349-1 Electric Traction-Rotating Electrical Machines for Rail and Road Vehicles Part 1- "Machines Other than Electronic Converter-Fed Alternating Current Motors"

IEC 60349-2 Electric Traction-Rotating Electrical Machines for Rail and Road Vehicles-Part 2: Electronic Converter-Fed Alternating Current Motors

IEC 60349-3 Electric Traction-Rotating Electrical Machines for Rail and Road Vehicles-Part 3: Determination of the total Losses of Converter-Fed Alternating Current Motors by Summation of the Component Losses

IEC 60349-4 Electric Traction-Rotating Electrical Machines for Rail and Road Vehicles-Part 4: Permanent Magnet Synchronous Electric Machines Connected to an Electronic Converter

IEC 60077-1 Electric Equipment for Rolling Stock – Part 1: General Service Conditions and General Rules

IEC60077-2 Electric Equipment for Rolling Stock – Part 2: Electrotechnical Components – General Rules

Chinese GB/T 18488.2 Part II Testing Methods of Propulsion Electric Machine systems for Electric Vehicles

JIS (Japanese Industrial Standards) D 1302:2004 Electric vehicle –electric motors – Test method for maximum power

JASIC (Japan Automobile Standards International Center) TRIAS (Test Requirements and Instructions for Automobile Standards) 99-017

JASIC (Japan Automobile Standards International Center) TRIAS (Test Requirements and Instructions for Automobile Standards) 99-018

ISO 6469 Electrical Safety

UL 9540 Safety of Energy Storage Systems

2.2.3 IEEE Documents

Available from IEEE Operations Center, 445 and 501 Hoes Lane, Piscataway, NJ 08854-4141, Tel: 732-981-0060, www.ieee.org.

IEEE Std 11 Rotating Electric machinery for Rail and Road Vehicles

IEEE Std 1812™ Trial use Guide for Testing Permanent Magnet Machines

IEEE Std 112 Test Procedure for Polyphase Induction Motors and Generators

IEEE Std 115™ Test Procedures for Synchronous Machines

Part I – “Acceptance and Performance Testing”

Part II – “Test Procedures and Parameter Determination for Dynamic Analysis”

2.2.4 ASME Publications

Available from ASME, P.O. Box 2900, 22 Law Drive, Fairfield, NJ 07007-2900, Tel: 800-843-2763 (U.S./Canada), 001-800-843-2763 (Mexico), 973-882-1170 (outside North America), www.asme.org.

UL9540 Safety of Energy Storage Systems and Equipment

UL1741 Inverters, Converters, Controllers and Interconnection System Equipment for use with Distributed Energy Resources

UL1973 Batteries for use in Light Electric Rail and Stationary Applications

UL2200 Stationary Engine Generator Assemblies

UL810 Standard for Safety Capacitors

3. DEFINITIONS

3.1 APPROVAL

“Approval of an ETDS” means the approval of an electric drive train type with regard to its net power measured in accordance with the test procedure specified in Section 4 of this document.

3.2 ASYNCHRONOUS

An AC motor designed to deliver torque when its shaft rotates slower than synchronous with the applied line frequency, or absorb torque when super synchronous with applied line frequency.

3.3 ATF

Automatic transmission fluid used as cooling medium in some automotive electric traction motor applications.

3.4 CONTINUOUS POWER

A power level characteristic of a motor providing constant power while remaining in thermal equilibrium. Continuous power rating is an industrial motor term, often synonymous with nameplate rating, that differs from maximum 30 minute power of the ETDS used in vehicle applications. Usage in this document is for information only.

3.5 DRIVE TRAIN TYPE

“Drive train type” means a category of ETDS for installation in a motor vehicle such as its primary propulsion, or hybridized propulsion system.

3.6 DYNAMOMETER

A device which loads the motor to measure output torque and speed accurately by providing a calibrated dynamic load.

3.7 ELECTRIC VEHICLE (EV)

Defined as a vehicle that uses one or more electric motors for propulsion powered from an RESS.

3.8 ETDS

Electric Traction Drive System, terminology consistent with USCAR and the Electrical Electronic Technical Team (EETT) definitions.

3.9 FULL LOAD CURRENT

The current flowing through the line when the motor is operating at full-load torque and full-load speed with rated frequency and voltage applied to the motor terminals.

3.10 FULL LOAD SPEED

Speed at which the motor is delivering rated output with rated voltage and full load current applied to the motor terminals.

3.11 FULL LOAD TORQUE

The torque of a motor necessary to produce its rated horsepower at full-load speed, sometimes referred to as running torque.

3.12 HYBRID ELECTRIC VEHICLE (HEV)

Defined as a road vehicle that can draw its propulsion energy from a consumable fuel and a rechargeable energy storage system (RESS) that is recharged by an electric motor-generator system, an external electric energy source, or both.