SAE J2907 MOTOR POWER RATINGS STANDARDS SUPPORT

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Chair, SAE J2907 Task Force

Coordinated by:
SAE Hybrid/EV Technical Standards Committee

7 June 2016

Project ID # VS144

This presentation does not contain any proprietary, confidential, or otherwise restricted information
Overview

Timeline
Started: April 2014
Targeted end: Nov 2016
Percent complete: 70%

Budget
FY14: $25K, FY15: $50K, FY16: $50K

Need for Standard
• Currently there is no widely accepted standard for specifying the performance of a traction motor for xEV’s
• Ratings tests are needed to validate MFG claims of Net Power and Maximum 30 Minute Power
• SAE J2907 specifies procedures for tests to be done in a laboratory setting to foster a consistent and repeatable mechanism for the assessment of motor net power and maximum 30 minute power

Barriers

Barriers addressed
• J2907 is open, some Mfg. tests proprietary
• Pre-conditioning the electric traction drive system (ETDS) varies by country
• European and Korean ratings tests have established pre-conditioning requirements
• Validation of MFG claims on power testing per UN/ECE R85 must be witnessed by UN representative
• The U.S. never signed the ECE Treaty
• China has own std: GB/T 18488.1-2015

Partners
• J2907 task force members from OEM’s, Tier 1’s, industry
The need for a uniform measure of ETDS output has been pointed out for several years now, and by OEM’s M. Hoyer, “The Misconceptions of EV Motor Testing,” Machine Design, Nov. 18, 2013 noted that:  It’s time to rethink performance tests on electric motors destined for use in electric vehicles.

Motortrend news on 2016 Prius Launch puts it this way:
“Automakers haven’t collectively agreed on a single harmonized procedure to rate their hybrid powertrains. They aim to make it as similar to current engine-only ratings as possible, but hybrid configurations are highly diverse. Toyota’s change in rating technique influenced the 2016 Prius’ lower system horsepower.”

SAE 11 Jan 2016 Prius is Re-engineered on Toyota New Global Architecture
“SAE net power for the gasoline engine is 95 hp (71 kW) and 105 lb·ft (142 N·m), while the electric motor is rated at 71 hp (53 kW) and 120 lb·ft (163 N·m)”.

Relevance
Objectives: (March 2015–March 2016)
Develop consensus of opinion on an acceptable procedure for measuring the key performance parameters of the ETDS to permit component to component comparisons separate from the performance of the motor in a vehicle.

Source: http://articles.sae.org/14484
SAE J2907 – Performance Characterization of Electrified Powertrain Motor-Drive Subsystem

In J2907 we note that “Test procedures are varied among manufacturers and frequently are not explicitly defined when motor characteristics are quoted, resulting in ambiguous and vague specifications that can confuse both consumers and developers.”

**Technical Approach/Strategy:**

- Develop a uniform measure of ETDS output that can be validated by 3rd party testing facilities
- Achieve consensus on Pre-conditioning metrics
- Define procedures and conditions to validate MFG claims on Net Power and Maximum 30 Minute Power
- Develop a single J-doc for procedures and results to minimize cost to MFG
- Develop communications page in J-doc appendix for validation of MFG declared Net and Max 30 Minute Power
- Enter balloting process to Technical Information Report (TIR) readiness
Goal is an internationally accepted standard for electrified powertrain characterization to reach TIR readiness Nov 2016

<table>
<thead>
<tr>
<th>Month</th>
<th>March</th>
<th>April</th>
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- Key concerns of members have been:
  - How is pre-conditioning defined?
  - Will additional characterizations incur additional testing cost?
  - Is development of torque-speed map essential?
  - Should measurement time be specified (1s, 10s, 30s, 1min)?
  - Does J2907 focus only on BEV and FCEV traction motors?
J2907 is now structured to be similar to ECE R85 and be U.S. standard

Apply for Type-Approval
Provide Details of Motor and System

Equip engine as required by R85

“Net Power” (aka “Peak”)
Precondition as required by R85
Set operating conditions for “Net Power” as recommended by Manuf.
Set dyno to desired speed
Dyno to hold speed constant
Request 100% Torque (WOT)
Record data specified by R85
Post-process data as required by R85
Report out
Receive Type-Approval

“30 Minutes Power” (aka “continuous”)
Precondition as required by R85
Set operating conditions for “Net Power” as recommended by Manuf.
Set speed to Manuf. recommended speed for max 30 min. power
Request Manuf. Specified Torque
Record data specified by R85

Repeat over full speed range in steps as defined in R85

Source: Matt Hortop, J2907 WG1
Consumer Rating, 1 Oct 2015
J2907 Committee has reached consensus on key attributes of TIR

- Out of vehicle characterization via in-laboratory testing
- Applicable to all electrified powertrains (xEV = BEV, FCEV, HEV, PHEV)
- Using laboratory power supply set to MFG specified nominal voltage
- Using calibrated and certified equipment
J2907 is out-of-vehicle characterization. J2908 is in-vehicle testing

- Procedure focuses on net (peak) power and maximum 30min (continuous) power
- Cooling system may be 2 channel, even 3 channel, to best mock-up MFG application
- Communications interface to the ETDS requires close collaboration with MFG
- Sensors and data acquisition coordinated between J2907 and J2908
Net Power Validation

• Laboratory power supply voltage per MFG specified nominal and droop <1.25% $V_{nom}$
• Precondition with coolant 25°C +/-5°C at 80% max power for minimum 3 minutes
• Perform test runs at 5s/point at rated power inverter output
• Generate torque-speed, coolant, and motor temperature data. Compute power
• Locate speed ($n_p$) at maximum power (and torque). Validate declared power.

\[
\left| \left( \frac{P_{max}}{P_{declared}} \right) - 1 \right| \times 100 < 2\%
\]

Maximum 30 Minute Power Validation

• Same preconditioning process
• Set power inverter output to MFG specified level for continuous operation
• Perform test runs at speed $n_p$ at <5s/point for each minute of 30 minute overall run
• Validate declared 30 minutes power.

\[
< P_{30max} > = \frac{1}{N} \sum_{k=1}^{N=30} P_{30}(k) \quad \left| \left( \frac{<P_{30max}>}{P_{30\,declared}} \right) - 1 \right| \times 100 < 5\%
\]
J2907 is structured to provide SAE validation of MFG declared power

**Declared Max Power** __kW @ __rpm
**Declared Max Torque** __Nm@ __rpm
**Declared Stall Torque** __Nm
**Declared Max 30min Power** __kW
**Test dc Voltage** __V
**Cooling type** Liquid/Air____

J2907 testing to validate whether the MFG declared power values are true within prescribed tolerance

J2907 working draft V.7 under review March thru Aug 2016
Collaborations and Coordination

J2907 maintains close collaboration with J2908 for consistency in measurements, tolerances, and relevance.

If a new J-doc is initiated, there J2908 would not cover System Power, it would cover the other parameters.

Same equipment as the New J-Doc. Power measured only in EV Mode.

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### Consumer Ratings

<table>
<thead>
<tr>
<th>System</th>
<th>PHEV EV Mode Power (wheel kW)</th>
<th>Assist and Regen (battery kW)</th>
<th>Consumer-Motor-Rating</th>
<th>Consumer Engine Rating</th>
<th>Powertrain System Power Test (Wheel)</th>
<th>Motor Test</th>
<th>Engine Test</th>
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<tbody>
<tr>
<td>ICE</td>
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### Engineering Tests

<table>
<thead>
<tr>
<th>System</th>
<th>Component</th>
<th>Powertrain System Power Test (Wheel)</th>
<th>Motor Test</th>
<th>Engine Test</th>
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<tr>
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### Additional Information

- **ICE**
  - Procedure for Mapping Performance - Spark Ignition and Compression Ignition Engines

- **HEV**
  - J2907: (In Progress) Performance Characterization of Electrified Powertrain Motors and Drive Systems (outside of vehicle)
  - J2908: (In Progress) Hybrid System Power Rating - limited to ratings specific to electrified powertrains

- **New J-Doc**
  - New rating to prescribe wheel/axle power for any powertrain
  - Box with No Color = Undecided or Not Applicable

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Graphic obtained from Mike Duoba, Chair
J2908 10 Dec 2015
Proposed Future Work

April to August 2016
• Working draft revisions based on OEM and industry feedback
• Drive for consensus on preconditioning, test time/point, coolant temperature excursion, measurement tolerance, and data analysis

September to October 2016
• Prepare for circulation of ballot (J-doc still in revision stage)
• Achieve full OEM support for draft TIR

November 2016
• Official balloting process commences

Key milestones.
• J2907 committee consensus for TIR vs Guideline status by end FY16
• Publish J2907 as TIR per J-doc production process during FY17
• Advancement from TIR to Standard if no further revision
J2907 is designed to be an open document with all procedures capable of being performed by independent 3rd parties.

Goal is single J-doc at TIR status in FY17 to minimize traction motor validation costs to the manufacture and to be uniform measure of output – “A standard that provides an independently verifiable level playing field for all.”

Achieved consensus on procedure and results for Net Power and Maximum 30 Minute Power in March 2016.

J2907 standard (TIR, Guideline) will mean SAE representative witnesses validation testing instead of UN representative.

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Thank You!

Questions?