445 Maple Ave., Torrance, CA 90503
Tel: 310-212-1200, Fax: 310-212-1102
Email: abas@ushybrid.com www.ushybrid.com

# Memo

**To:** State of California AIR RESOURCES BOARD

**From:** Abas Goodarzi
President

**CC:**

**Date:** 5/25/2019

**Re: ZEV certification for Medium and Heavy-duty commercial Vehicles**

US Hybrid is pleased to provide the following recommendation/comments on the proposed ZEV certification.

The California standards and test procedures for new 2021 and subsequent model heavy-duty zero-emission powertrains requires better quantified definitions in support of test procedures, so the consumer, powertrain technology provider, OEM and the dealer have uniform understanding of the ratings.

Following is the recommendation to be included in the test procedures for the zero emission MD/HD vehicles:

Table 1. Fuel Cell Engine Energy Efficiency Determination.

| Item | Definition | Requirements |
|---|---|---|
| 1 | FC Rated Power | The FC engine must provide the manufacturer specified rated power and energy efficiency for at least 1 hour as continuous power at the vehicle or equivalent test configuration with ambient temperature of >35C and specified rated cooling system (>60C). Rated power is to be provided at rated voltage and the power rating at the end of 1 hour, and the test must meet the manufacturer specified name plate. This is the Beginning-Of-Life (BOL) test power rating. |
| 2 | FC Maximum Power | The FC engine must provide the manufacturer specified max power for at least 5 minutes (after being subjected to 15 minutes of continuous rated power) at the vehicle, or equivalent test configuration with ambient temperature of >35C and specified rated cooling system (>60C). |
| 3 | FC End-of-Life | FC engine manufacturer must specify the End-of-Life (EOL) definition for the fuel cell engine as % of rated power and maximum power at the end of 1 hour of testing/operation for continuous power and 5 minutes for max power. Typically 70%. |
| 4 | FC Run Decay | FC engine manufacturer must specify the End-of-Day (EOD) power rating decay based on 8 hours of operation. |
| 5 | FC Engine Rated Energy Efficiency | FC engine manufacturer must specify the FC engine energy efficiency kWhr/kg-H2, NET after the FC engine with all BOP included and NET after the dc-dc converter output to the vehicle HV system, at the end of 1 hour of operation at rated power and end of the 5 minute operation at the maximum power. |
| 6 | FC Engine Energy Efficiency Map | FC engine manufacturer must provide the FC engine energy efficiency over the FC engine operation from 10% to 100% of power rating at rated voltage (kWhr/kg-H2 NET) after the FC engine with all BOP included and kWhr/kg-H2 NET after the dc-dc converter output to the vehicle HV system. FC engine shall operate for >30 minutes at rated power before reducing power at 10% step and taking energy efficiency measurement at the end of this test to measure energy efficiency after 2 minutes of operation with the maximum power. |

Table 2. Energy Storage System Rated and Peak Power Testing.

| Item | Definition | Requirements |
|---|---|---|
| 1 | Battery Energy Storage Rated Power | The battery energy storage system must provide the rated power for at least 1 hour as continuous power at the vehicle or equivalent test configuration with ambient temperature of >35C and specified rated cooling system (>60C). |
| 2 | Battery Energy Storage Max Power | The battery energy storage system must provide the manufacturer specified max power for at least 5 minutes (after being subjected to 15 minutes of continuous rated power) at the vehicle or equivalent test configuration with ambient temperature of >35C and specified rated cooling system (>60C). |
| 3 | Battery Energy Storage End-of-Life | Battery system manufacturer must specify the End-of-Life (EOL) definition for the battery as % of rated power and energy at the end of 1 hour of testing/operation for continuous power as well as after 5 minutes at maximum power at EOL. |
| 4 | Battery System Energy Efficiency Map | Battery manufacturer must provide the battery system round trip energy efficiency over the FC engine operation from 10% to 100% of power rating. |

Table 3. Powertrain System Rated and Peak Power Testing.

| Item | Definition | Requirements |
|---|---|---|
| 1 | Powertrain Rated Power | Powertrain system must provide the rated power for at least 1 hour as continuous power at the vehicle or equivalent test configuration with ambient temperature of >35C and specified rated cooling system (>60C). |
| 2 | Powertrain Max Power | Powertrain system must provide the manufacturer specified max power for at least 5 minutes (after being subjected to 15 minutes of continuous rated power) at the vehicle, or equivalent test configuration with ambient temperature of >35C and specified rated cooling system (>60C). |
| 3 | Powertrain Energy-Eff Map | Powertrain manufacturer must provide the powertrain system energy efficiency over the operation from 10% to 100% of power rating at 25%, 50%, 75% and max speed. |

Table 4. Charger System Rated and Peak Power Testing.

| Item | Definition | Requirements |
|---|---|---|
| 1 | Charger Rated Power | Charger system must provide the rated power for at least 1 hour as continuous power at the vehicle or equivalent test configuration with ambient temperature of >35C and specified rated cooling system (>60C). |
| 2 | Charger Max Power | Charger system must provide the manufacturer specified max power for at least 30 minutes (after being subjected to 15 minutes of continuous rated power) at the vehicle, or equivalent test configuration with ambient temperature of >35C and specified rated cooling system (>60C). |
| 3 | Charger Energy Efficiency Map | Charger manufacturer must provide the charger system energy efficiency (AC-in/DC-out to battery) over the operation at 10%, 25%, 50%, 75% and 100% of max power rating at base voltage +/-20%. |