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## Vehicle Electrification System Standards

### V. Phase Drive Motors and Generators

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## V.c Induction Electric Machines

### Description:

3-Phase electric machines are the central component of an electric powertrain system and it provides propulsion and generated electrical power to HEV, PHEV, and BEV architectures. Understanding the construction, operation, failure modes, and diagnostic processes for Induction Machines is foundational in preparing students for a service career in the electrification service space.

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### Outcome (Goal):

Students will be able to describe and illustrate how Induction Machines operate in all modes of vehicle operation; describe how IM electric machines are constructed; analyze and evaluate the condition of IM electric machine technology by using various diagnostic techniques and tools.

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### Objective:

Students shall be able to:

1. Identify and Define IM electric machine internal components
  2. Describe how IM are constructed
  3. Explain the concepts of how IM Positive, Negative, and Zero Slip% is produced
  4. Compare and contrast Constant Torque and Constant Power
  5. Demonstrate how to analyze and evaluate the condition of IM using a serial data (scan) tool, oscilloscope, milliohm meter, insulation tester, and specialized analysis testers.
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**Task:**

Students will be able to describe how vehicle IM propulsion, regenerative braking, and coasting modes; identify powertrain architectures and powertrain components; perform testing and analysis using live vehicles or test stands; and define the term power density in the provided pictures or diagrams, using OEM vehicle service, component supplier information, and DOE/NREL/INL/ANL vehicle electrification website information while using proper technical terminology, acronyms, and definitions.

Construction and Manufacturing	
Housing	
Stator Core	<ul style="list-style-type: none"> <li>Laminations</li> <li>Lamination Slot Configurations</li> <li>Slot Fill</li> <li>Random Distributed Windings</li> <li>Series and Parallel Winding Configurations</li> <li>Number of Poles vs. Torque &amp; Speed</li> <li>Stator End Turn Cooling</li> <li>Stator Temp Sensor</li> </ul>
Rotor	<ul style="list-style-type: none"> <li>Copper</li> <li>Aluminum</li> <li>Rotor Diameter - as it relates to Torque</li> <li>Rotor Length - as it relates to Torque</li> <li>Rotor Bar Count</li> <li>Rotor Bar Shapes</li> <li>Rotor Shorting Rings</li> <li>Rotor Shaft Bearings</li> <li>Rotor Shaft Currents</li> <li>Induction Machine Spin Loss</li> </ul>
Electric Machine Operating Regions	
Constant Torque	
Constant Power	



<b>Induction Machine Torque &amp; Speed Control Operation</b>	
Speed (rpm)	Base Speed How Max rpm is Determined
Torque (Slip%)	Positive Zero Negative
Software Control Slip Tables	Slip Table Control Strategy Slip% Control vs. Stator Current Control
<b>Induction Machine Failure Modes</b>	
Stator	
Rotor	
Bearings	
<b>Diagnostics &amp; DTCs</b>	
<b>Servicing Induction Electric Machines</b>	

To comment or offer suggestions on this standard, contact Ken Mays:

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