



Powering Business Worldwide

Vehicle Group

Boosting Division

Revision: A

ECO: CO-0218972

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Electric Motor for Next Gen Fuel Cell Air compressor R900 with range 650V DC to 950V DC

Engineering Specification

Engine Air management, Boosting Division
Eaton India Innovation Centre, Pune 411028

Description: This document defines the Specification of performance and durability requirements for a High voltage DC Electric Motor Assembly to run Fuel Cell Air Compressor. The motor will be used to run the roots type air compressor which will have a suction and delivery port with a Shaft to couple to electric motor. The compressor will further deliver the compressor air to Fuel cell stack in either stationery application or Automotive application for power generation.



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1. General Information

Supplier's Proposal – Required Engineering Documents

- Electric Motor drawing (editable DXF)
- Electric Motor step model (or compatible with Pro-E 3.0)
- Electric Motor simulation data (Speed, Torque, Voltage, Current Characteristics, Thermal Map, Coolant flow, connector specs etc)
- Electric Motor sample tests results (Speed at required Torque, Voltage, Current Characteristics, Back EMF, Hipot, Winding resistance, No load speed, No load current, DOR, Thermal Map, Coolant flow, connector specs etc)
- Electric Motor Electrical Command Characterization Datasheet (Speed, Torque, up time, down time, recuperation, faults detection etc)
- **Design validation plan:** Supplier to propose DVP&R, DFA of the Electric Motor testing to meet Eaton application requirement for functionality, durability, reliability, safety requirement, environment requirement. Ease of Assembly with Eaton air compressor and at Customer end platform. Eaton will review and approve the proposal.

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2. Functional Performance Requirements

S.N.	Description of requirement	Value	Remarks
1.	Idle Motor Torque, Nm @speed, rpm	5 Nm @ 2000 RPM	Minor Changes anticipated based on air temp and altitude variation
2.	Half Load Motor Torque, Nm @ speed, rpm	14 Nm @ 6500 RPM	Minor Changes anticipated
3.	Rated Motor Torque, Nm @ speed, rpm	23 Nm @ 9800 RPM	Minor Changes anticipated
4.	Peak Motor Torque, Nm @ speed, rpm	25 Nm @ 12000 RPM	Minor Changes anticipated
5.	Duty cycle at above points 1,2,3 & 4 of Speed and Torque Vs Time	See Duty Cycle attached (fig-1)	Attached duty cycle chart is preliminary and for reference only
6.	Dynamic Rate upward (response time 10-90%: T90)	< 5 sec~(<10 sec)	Motor must be capable to move from 10% of the peak load to 90% of peak load within 5 to 10 seconds
7.	Dynamic Rate downwards (response time 90-10%: T90)	2 Sec	Motor must be able to recuperate the energy back to battery during braking operation
8.	Mechanical System peak Efficiency % (at Operating Point, Torque/Speed)	Peak efficiency not less than TBD%	Supplier to provide proposal
9.	Method of Calculation of efficiency	Shaft power / DC bus power	
10.	Direction of Rotation	Looking shaft side of motor , shaft must rotate CCW	



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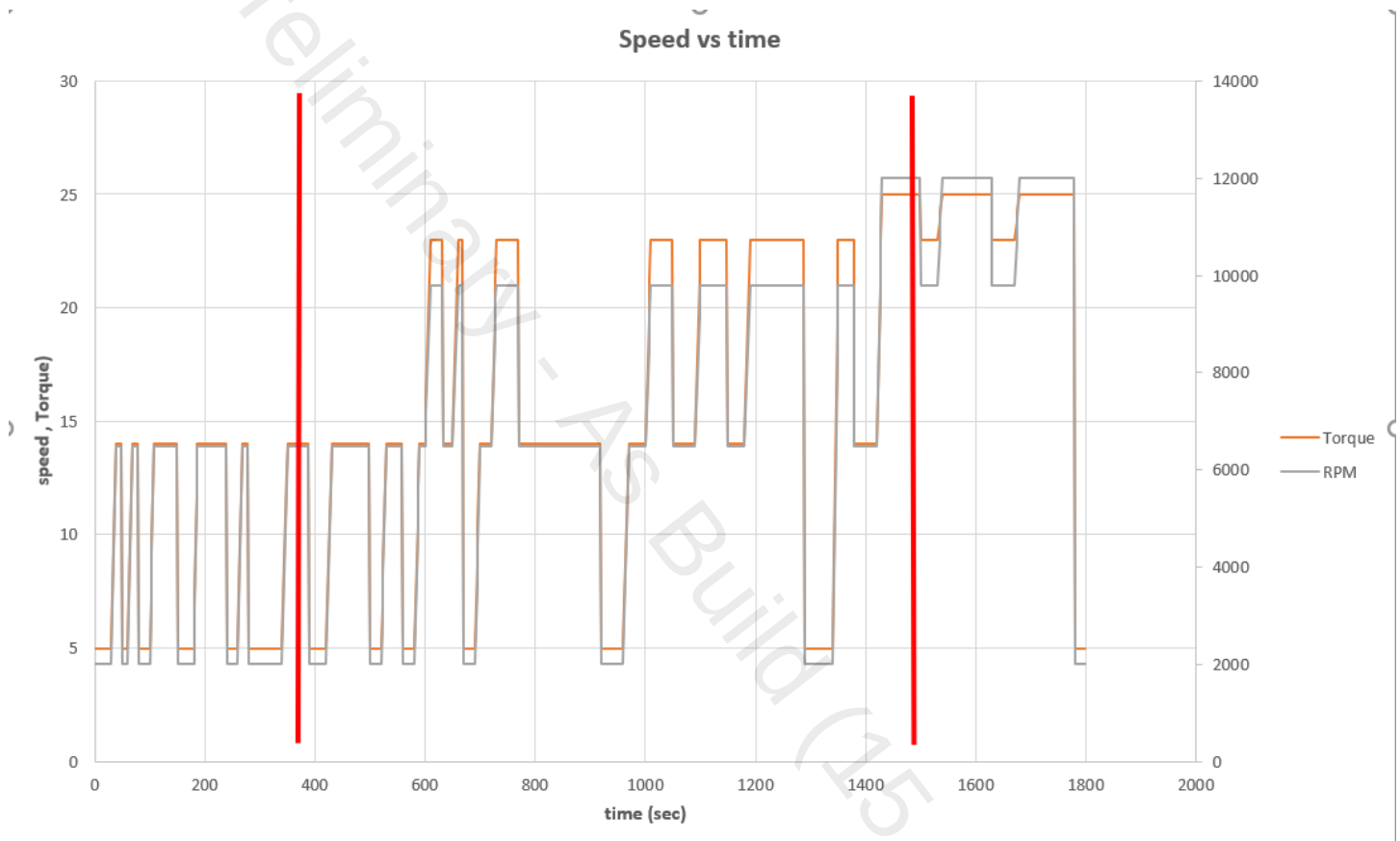


Figure 1: Duty Cycle



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3. Electrical Specifications Requirements

S.N.	Description of Requirement	Value	Remarks
1.	DC Continuous Power at Input to Controller	24 kW	
2.	DC Peak Power at Input to Controller	30 kW	
3.	Supply Voltage	800 VDC	Nominal Voltage at which OEM will generally operate the system
4.	Minimum Supply Voltage	650 VDC	Motor must meet all performance requirements at this min voltage without derating
5.	Maximum Supply Voltage	900 VDC	
6.	Max allowable motor continuous current, (Amps)	TBD	Supplier feedback requested for this value (to accomplish continuous torque/power requirements)
7.	Max allowable motor peak current, Amps	TBD	Supplier feedback requested for this value (to accomplish peak torque/power requirements)

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4. Size and Packaging Requirements

S.N.	Description of Requirement	Value	Remarks
1.	Max allowable motor diameter, OD	< 170mm	These OD and L limits are for appropriate
2.	Max allowable motor length, L	<200 mm	
3.	Max Motor + Controller weight	<10 kg	
4.	Motor Shaft Configuration	TBD	Motor shaft spline details to be shared separately to allow interface with pump shaft. Shaft seals may be required. Details TBD.
5.	Motor front mounting configuration	TBD	Eaton is open to standard/off the shelf motor housing configuration that will most likely be accommodated by using an adapter plate as an interface between the motor and pump.
6.	Motor controller mechanical configuration: Integrated or separate (with cable & connector)	TBD	Supplier's standard solution will be preferred with regards to either a separately housed controller (with appropriately rated connectors and cables attached) or an integrated controller mounted within motor housing.
7.	Motor Shaft seal requirement		
8.	Volume	TBD	Supplier to provide proposal
9.	Angles of vehicle inclination:	± 30% (17°) in all directions (also combined)	

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5. Motor Environment

S.N.	Description of Requirement	Value	Remarks
1.	Ambient temp range for this application around motor	Installation/Storage (-40 to +45 Deg C) Operation (-40 to +85~100 Deg C, TBD)	
2.	Peak Motor / Controller Skin Temp permissible	TBD	
3.	Motor thermal requirements (max allowable temp rise above max ambient)	TBD	
4.	Max Motor operating Temperature Rating		Supplier to provide
5.	Freeze start up temperature	-32°C	

6. Cooling Requirement

S.N.	Description	Value	Remarks
1.	Coolant Flow Rate / Peak Inlet Temp	6 - 12 LPM / 70 Deg C	
2.	Coolant Pressure / Max Pressure Drop allowed in motor + Controller cooling circuit	1 Bar / 0.1Bar	

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7. Reliability

S.N.	Description of Requirement	Value	Remarks
1.	Total System Life	30,000 operating hours or 1.2 million kilometers or 12 years	
2.	Reliability Target	TBD	
3.	Number of Starts	100,000	
4.	Number of cold starts	5000	
5.	Number of frosts starts	1900*	
6.	Design Validation Plan (DVP)	TBD	Detailed System Level DVP Plan at EATON with Motor +Compressor will be shared during more detailed discussion on the Motor Specs. Supplier's standard DVP&R, ATP or other test plan can be reviewed to meet this requirement for supplier level validation.

8. Standards

S.N.	Description of Requirement	Value	Remarks
1.	Safety Standard Requirement	ISO 26262 (ASIL-B or better)	Supplier's experience and/or supporting documents for compliance to these safety standards will be preferred
2.	IP Standard	IP67 or IP65 (IP67 Preferred)	Supplier's experience and/or supporting documents for compliance to the standards will be preferred
3.	Other Standards	AUTO SAR, TBD	Supplier's experience and/or supporting documents for compliance to these standards will be preferred

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9. Others

S.N.	Description of Requirement	Value	Remarks
1.	NVH	< 65 dB at Distance of 1 m in 5 different Directions inside semi Anechoic chamber	Eaton is flexible on this requirement provided supplier can demonstrate necessary noise reduction design features are incorporated in the motor design or the proposed motor noise levels are typical for the proposed motor size and type.
2.	Speed Sensor type	Hall Effect/Magnetic encoder	Other sensor types can be considered for motor commutation as recommended by motor supplier that do not compromise on cost, reliability and motor performance requirements.
3.	Motor Topology	Brushless DC (SPM or IPM)	
4.	Connector Type	CAN specifics	
5.	Inverter Topology	TBD (2 Quadrant or 4 Quadrant)	
6.	Isolation	CAN specifics	

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10. Controller Requirements

S.N.	Description	Value	Remarks
1	Dynamic Rate upward (response time 10-90%: T90):	5~10 sec	Motor must be capable to move from 10% of the peak load to 90% of peak load within 5 to 10 seconds
2	Dynamic Rate downwards (response time 90-10%: T90):	2 sec	Motor must be able to reccuperate the energy back to battery during braking operation
3	Input Low Voltage for Controller / CAN Functionality	12-24 V DC	
4	Motor controller mechanical configuration: Integrated or separate (with cable & connector)	TBD	
5	Control Type	To be decided by supplier based functional use. Eaton Approve	
6	Recommended Control Needs	Speed and Torque	
7	Speed Control Command Range	-100% to 100%	
8	Torque Control Command Range	-100% to 100%	
9	Speed Accuracy	+/-1% of command speed	
10	Torque Accuracy	TBD	
11	Controllability: Overshoot	TBD	
12	Controllability: Settling Time	TBD	
13	Controllability: Response Time	TBD	
14	Wake up Time / Time to power up [ms]	400	
15	Signal connector type		
16	Application layer	Supplier to own with input from Eaton	



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17	Controller CAN Communication	SAE J1939	
18	Protocol	CAN 2.0B	
19	Number of CAN buses	TBD	
20	Bus management required	TBD	
21	CAN pinout	Daisy chain pinout	
22	Isolation	CAN Specifics	
23	OBD	Yes	
24	System Feedback	Actual Speed Inverter Temperature Calculated Torque Bus Voltage Motor Temperature Inverter Output Power Fault Code Control Effort Target Speed Target Torque Rated Torque Rated Power FOC Iq Current FOC Id Current FOC Iq Current Cmd FOC Id Current Cmd	
25	CAN Database	Eaton to Provide, Supplier to implement	
26	Baud rate [kbps]	TBD	



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27	Fault Detection	Self-diagnose faults Supply Voltage Failure Over Temp Over Speed Over Voltage Control Error Over Current CAN Comm. Failure Current Sensor Failure* Position Sensor Failure Initialization Failure Gate Drive Fault Mismatch Speed	
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