WHITE PAPER

Designs and construction features of marine motors

BALDOR · RELIANCE

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Commercial marine motors
Meeting regulatory requirements

Commercial marine motors in general are high-grade motors treated for corrosion resistance and designed for use on shipboard applications. These motors meet the regulatory requirements governed by three major specifications: the American Bureau of Shipping (ABS) Rules for Building and Classing Marine Vessels[1], the United States Coast Guard (USCG) Electrical Engineering Regulations[2] and the Institute of Electrical and Electronics Engineers (IEEE) Standard 45, Recommended Practice for Electric Installations on Shipboard[3]. Marine motors are also used for other-than-shipboard service in functions on offshore drilling rigs, shipyard applications and port equipment. Marine motors are usually mounted to steel structures, which are subject to vibration and shock or pitch and roll movement, and typical marine application settings are very humid and salt-laden harsh environments. Therefore, the environments in which shipboard motors operate and the functions they perform require unique design and construction considerations above those of standard industrial motors.

There are many factors to consider when specifying a motor for shipboard service. Ambient temperature, motor size, inclination, materials, accessibility and enclosure are some important considerations. Although the above-mentioned features are important, there is none more crucial than the corrosion resistance of the motor itself; from the protection of the frame (paint system) to the internal protection (insulation) of the rotor assembly and stator coil windings.

Standard design

Most general purpose industrial electric motors are designed for an ambient operating temperature range of -20 to 40 degrees Celsius, unless specified otherwise in customer or industry specifications. Some applications require a higher ambient range, which can be 65 degrees or higher. The service factor (the percentage of overload the motor can handle for short periods when operating normally within the correct voltage tolerances) is either 1.15 as standard or 1.0, depending on temperature rise and rating. As a standard, ABB motors use a Class F insulation system, which is rated for 155 degrees Celsius, and Class B or Class H insulation is also available for specific customer requests (Table 1). Most motors are designed for continuous-duty applications, but some applications require short-time duty cycles of 30 minutes or 60 minutes. Heating of the motor is a consideration and must be evaluated by engineering to make sure the cooling is sufficient per the short time duty cycle.

Other motor features and designs are determined by application on a case-by-case basis. Voltage is standard as 460 volts, but other voltages are available, as high as 1,000V for certain shipboard applications. The National Electrical Manufacturers Association (NEMA) has established class designations for motors based on the motors' starting torque and accelerating loads. Design B is the typical NEMA torque design for shipboard motors, but characteristics are available for Design A, B, C or D (Table 2). Single-speed and multi-speed motors are the two main speed requirements, and again this consideration is driven by the application. Multiple enclosures are available, such as totally enclosed fan-cooled (TEFC), totally enclosed water cooled (TEWC), totally enclosed air-over (TEAO), totally enclosed non-ventilated (TENV) and drip-proof protected (DPP). Explosion-proof ratings are available if required based on the ship’s application and location of the motor. All motors are designed to meet a temperature rise of 80 degrees Celsius. This is known as a B rise. The temperature rise limit when tested at full load rating is 95 degrees Celsius by resistance at 50 degrees ambient. Non-explosion-proof marine motors are labeled and certified to be UL component recognized and included on the nameplate.

ABB Baldor-Reliance marine duty motor

NEMA motor insulation temperature ratings					Temperature rises
Class	Temp.			1.0 SF* motors	1.15 SF* motors
		Ambient	Hotspots	Rise @ 1.0	Rise @ 1.15
A	105°	+40°	+5°	60°	70°
B	130°	+40°	+10°	80°	90°
F	155°	+40°	+10°	105°	115°
H	180°	+40°	+10°	125°	Not defined

* Service factor
Note: all temperatures in degrees Celsius

Design class	Starting current	Locked rotor current	Breakdown torque	Slip	Suitable applications
A	High	Medium	High	5% max	Fans, blowers, rotary, pumps unloaded compressors, machine tools, misc. constant-speed loads
B	Medium	Medium	High	5% max	Fans, blowers, rotary, pumps unloaded compressors, machine tools, misc. constant-speed loads
C	Medium	High	Medium	5% max	High-inertia starting (e.g. - centrifugal blowers, flywheels, crushers), loaded starts (e.g. - piston pumps, compressors, conveyors), constant-speed loads
D	Medium	Extra high	Low	5 - 13%	Very high-inertia, loaded starting, considerable variation in load speed (e.g.- punch presses, shears, forming machine tools, cranes, hoists, elevators, oil pump jacks)

Marine specifications
Matching features to operating environments

Environment
Marine motor features are based on the applications' operating environment. Marine motors are found in two main environments: dry environment (below deck) or wet environment (above deck). These markings will be labeled on the nameplate of the motor.

Mechanical and electrical requirements
For shipboard marine motors, the mechanical and electrical requirements will depend on the specification, environment and enclosure. Typically, motors meeting IEEE 45 specifications for use in a dry environment will include XEX features.

The list of standard XEX (IP55) features are as follows:

- Cast iron construction: frame, conduit box, end shields, fan cover
- Oversized cast iron conduit box
- Diagonally split, neoprene-gasketed rotatable conduit box with Nation Pipe tapered thread (NPT) lead hole (1)
- UL listed clamp type grounding lug mounted in conduit box (3)
- Permanently numbered non-wicking leads
- Non-metallic V-ring shaft slinger on both ends (2)(3)
- Grease fittings
- Stinless-steel nameplate
- Sealed fits (1)
- Stator and rotor completely coated for corrosion protection

Notes:
(1) This feature is not available on fan-cooled explosion-proof (FCXP)/XEX motors.
(2) This feature is not available on TEFC-XP for Class II any or all groups. A labyrinth (Group E) slinger will be provided instead of the V-ring slinger.
(3) 180T-210T non-XP motors are provided with a green ground lead.

Motors used in IEEE 45 and ABS dry environments will include all the extra tough features, and all internal surfaces will be treated with a corrosion-resistant treatment. Crimp-type lead lugs are also standard for this design.

Motors used in IEEE 45 and ABS wet environments will include the features of XEX and dry environment as well as additional features, including a more robust insulation system specifically designed for these types of environments. All casting fits are sealed to keep contamination and water from intruding inside the motor, and drains are used on each bracket at the lowest location acceptable per the mounting of the motor. Inner caps sandwich the bearings or contain the bearings within the bearing bore of the bracket, in some cases, completing the grease cavity of the bearing; in other cases, providing the flame path – such as in explosion-proof motors. They do reduce contamination, but more importantly they are used to capture the bearing to the bracket. Usually, one cap locks the bearing, and the other bearing includes the wave spring, which preloads the bearing and allows for thermal expansion. An additional seal called the V-ring slinger provides additional sealing protection and prevents contamination from reaching the bearing cavity and the inside components of the motor. Grade 5 carbon-steel hardware is also included to resist the conditions of the environment in which the motor operates.

		Severe Duty XT	Severe Duty XEX/ECP	IEEE-841 XL
			Frame sizes from stock	
		143T-449T	143T-558	143T-449
Electrical features				
Efficiency	Baldor-Reliance motors meet or exceed all efficiency requirements for US, Canada and Mexico requirements	•	•	•
	Efficiency two to four levels above NEMA premium, up to IE5 efficiency when run across the line			
Torque	NEMA Design B torques as a minimum	•	•	•
	NEMA Design A: High torque design exceed Design C			
Voltage	230/460v thru 100 hp, 460v 125hp and up	•	•	
	460 volts	•	•	•
	575 volts	•	•	•
Service factor and temp. rise	1.15 service factor continuous	•	•	•
	1.25 service factor up to 100 Hp, 1.15 service factor over 100 Hp - continuous			
	Class F insulation with Class B rise @1.0 service factor	•	•	•
Inverter	Suitable on drive/NEMA MG 1 Part 31.4.4.2	•	•	•
Mechanical features				
IP enclosure		**IP54**	**IP55/66**	**IP56**
Construction	Cast iron frame	•	•	•
	All cast iron construction including endplates, conduit box and fan cover (586/7 frames have fabricated steel fan covers)		•	•
	All hardware is SAE zinc plated	•	•	•
Conduit box	Diagonally split, oversized rotatable conduit box (ease of connection and room for space heater leads)	•	•	•
Leads	Color leads	•	•	•
	Lead separating gasket – nipple design		•	•
Extended durability	T-drains to remove condensation	•	•	•
	Zerk fittings on all sizes		•	•
	Protective coating on rotor and stator		•	•
	Phase paper & coil head lacing	•	•	•
Berings and lubrication	Regreaseable bearings – PLS system			•
	Ball bearing designs – same size bearings on both ends		•	•
	Oversized ball bearings up to 50 Hp, ball and roller bearing designs 60 Hp and up. 5 6/7/8 frames include oversized roller bearings on DE.			
Paint	Corrosion resistant 2 part epoxy paint system, exceeding 300 hrs. salt fog test per ASTM B 117w	•	•	•
Other key features				
Certifications and tests	Vibration testing as standard			•
	Corona inception testing	•	•	•
	Documented final motor test – ships with motor			•
	UL® recognized, CSA certified markings	•	•	•
	Meets and exceeds IEEE 841 and IEEE 45			•
Safety	Heavy duty grounding lugs on frame		•	•
	Vertical lifting provisions for ease of installation			
Nameplate information	Class I, Division 2 (Group A, B, C, D) on standard NEMA frames	•	•	•
	Stainless steel embossed raised lettering		•	•
	Stainless steel laser etched lettering	•		
	Turn-down ratios on nameplate	•	•	•
Reliability	ABB Ability Smart Sensor ready	•	•	•
	Designed and built in the USA	•	•	•
	Warranty - in years from date of manufacture	3	3	5

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01 VPI chamber at an ABB motor manufacturing facility

Optional construction features

Spraytight and watertight enclosure enhancements are also available. A spraytight enclosure includes seals, a marine paint system and additional features. These features provide an ingress protection capability of IP55. A watertight enclosure is just that, suitable for watertight applications. This is a significant feature for aboard-ship applications. Watertight enclosures use special seals and bracket designs to meet this requirement. The use of O-ring washers is used under all hardware heads including the inner cap screws. These enclosures also use a vacuum pressure impregnation (VPI) insulation system and additional motor features to make them watertight (Figure 2). Watertight motors meet IP56 ingress protection.

The option of ductile iron - a type of cast iron known for its impact, fatigue and wear resistance - is also available where required. The frame, brackets, inner caps and conduit box of these motors are of ductile iron construction, and are primarily used in high-vibration applications.

A weather deck paint system option is also available. This system is an epoxy-encapsulated, VPI system, which starts with a coated magnet wire with improved insulation capabilities. The entire wound stator is then VPI insulated with a multiple resin compound. The epoxy resin material and the VPI process provide a virtually void-free winding. The resins are thick and provide superior electrical resistance properties, greater mechanical strength and better heat dissipation. Each conductor is surrounded by cured resin and locked into position. Winding end-turns are completely covered and filled with resin to withstand vibration and movement without cracking. They are effectively sealed against contamination, and better heat dissipation throughout means the elimination of air gaps. The net result is a superior insulation system that provides longer motor life. Motors utilizing this system include a certificate of compliance. ABS, IEEE45 or USCG-259 is documented on the manufacturer's certificate of compliance with the manufacturer's serial number assigned, and the motor nameplate is stamped with the appropriate governing authority.

References

1. Rules for Building and Classing Marine Vessels (MVR), 2022, American Bureau of Shipping
2. USCG-259 Code of Federal Regulations/ Electrical Engineering Regulations CG-259, Title 46, Chapter 1, Subchapter J, Part 111, Subpart 111.25 - Motors
3. IEEE 45-2002, Recommended Practice for Electric Installations on Shipboard, October 9, 2002, Institute of Electrical and Electronics Engineers Standards Association
4. Commercial marine product design standard manual (RSP-3-0070-14-751-9/RSP-03231-06-751-0), ABB

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