



EM-PMI375-T1100

Electric machine, permanent magnet internal

FEATURES

- Synchronous Reluctance assisted Permanent Magnet (SRPM) technology
- Extremely compact and robust aluminum frame structure
- Highest efficiency throughout the operation range on the market (~96 %)
- Liquid cooled with plain water or water/glycol mixture
- Low coolant flow required
- Allowed coolant temperature up to +65°C
- IP65 enclosure class to maximize reliability, IP67 available as option
- Multiple mounting possibilities

GENERATOR SPECIFIC FEATURES

- Standard SAE flange mounting to match the diesel engine connection
- Wide selection of speed ratings allowing the generator to be selected to customer specific applications with various voltage requirements
- Can be also used as starter motor for the ICE

MOTOR SPECIFIC FEATURES

- Extended speed and torque capabilities compared to standard PM motors from Danfoss reluctance assisted permanent magnet motor technology
- Motor structure is designed to be able to produce high starting torque: EM-PMI motor can produce instantly full torque to a non-rotating shaft
- Optimized speed range to meet the most common gear ratios used in heavy mobile machinery



GENERAL

The machine is developed especially for demanding applications. It is smaller, lighter and more efficient than conventional products on the market.

TYPICAL APPLICATIONS

- Generator for diesel-electric/serial hybrid applications
- Traction/propulsion motor
- Generator/Motor for parallel hybrid applications

SPECIFICATIONS

General electrical properties

| | |
|--------------------------------------|--|
| Nominal voltage (line to line) | 500 V _{AC} |
| Voltage stress | IEC 60034-25, Curve A: Without filters for motors up to 500 V _{AC} |
| Nominal efficiency | 96 % |
| Pole pair number | 6 |
| Power supply | Inverter fed. |
| Nominal inverter switching frequency | 8 kHz |
| Minimum inverter switching frequency | 4 kHz (with limited speed 1.4 times nominal speed) |
| Basic information | |
| Machine type | Synchronous reluctance assisted permanent magnet |
| Frame material | Aluminum |
| Mounting direction | Horizontal assembly. (see user guide and bearing documentation for details and possible limitations) |
| Mounting (IEC 60034-7) | IM 3009-B5 (Flange horizontal), IM 3019-V1 (Flange and D-end down) |
| Standard Flange D-end (SAE J617) | SAE 3 mating transmission housing |
| Bearing type | Standard: 6214/C3 (with LGHP2 grease) +BIN option: D-end: 6214/C3 (with LGHP2 grease), N-end: 6214/HC5C3 (with LGHP2 grease) +BIA option: 6214/HC5C3 (with LGHP2 grease) |
| Standard axle spline D-end | DIN5480 W55x2x26x8a |
| Standard Flange N-end (SAE J617) | SAE 4, flywheel housing |
| Standard rotation direction | Clockwise (both directions possible) |
| Protection class | IP65 IP67 available as option +IP67 Tests: 0.3 bar under pressure held for 120 seconds. Pressure not allowed to drop under 0.1 bar (IP65) Pressure not allowed to drop under 0.25 bar (IP67) |
| Duty type (IEC 60034-1) | S1/S9 |
| Standard color | Dark grey RAL7024 powder coating |

Mechanical

| | |
|--|--|
| Total weight | 295 kg (no options) |
| Moment of inertia | 0.99 kgm ² |
| Torsional stiffness of shaft drive end | 7 Nm/rad (from middle of the d-end spline to rotor air gap) |
| Rotating mass | 111 kg |
| Maximum static torque range on the shaft, max. 25000 cycles, R=0 (*) | 6800 |
| Maximum dynamic torque range on the shaft, max. 1e6 cycles, R=0 (*) | 4000 |
| Maximum allowed vibratory torque range, 1e9...1e10 cycles (*) | 0,3 x Nominal torque of machine |
| Maximum deceleration (fault stop) | 2000 rad/s ² |
| Dimensions | |
| Length (frame) | 548 mm |
| Diameter (frame) | 450 mm |
| Cooling | |
| Cooling liquid | Plain water with appropriate corrosive inhibitor (max. 50 % corrosive inhibitor) |
| Cooling liquid corrosive inhibitor type | Ethylene glycol Glysantin G48 recommended |
| Cooling method (IEC 60034-6) | IC 71 W |
| Minimum cooling liquid flow | 20 l/min |
| Coolant circuit capacity | 2.8 l |
| Maximum operating pressure | 3 bar |
| Pressure loss | 0.4 bar with 20l/min (+25°C coolant) |
| Nominal cooling liquid temperature | +65°C (derating required if exceeded) |
| Minimum cooling liquid temperature | -20°C |
| Maximum cooling liquid temperature | +70°C |
| Condensation dew point | Please use anti-condensation heaters |

| | | | |
|--------------------------------|--|---|--|
| Temperature rating | | | 70 mm ² : Druseidt with narrow flange 03906 |
| Insulation class (IEC 60034-1) | H (180°C) | HV connection boxes | - 1 x 3 phase box (SINGLE winding model) - 2 x 3 phase box (DUAL winding model) - 1x connection box with one 3 phase system and 1x connection box with two 3 phase systems (TRI winding model) |
| Temperature rise (IEC 60034-1) | 85°C (F) / 110°C (H) | LV connector | 47 pin DEUTSCH HD34-24-47PE for resolver and temperature measurement. |
| Maximum winding temperature | 175°C | LV connector type | DEUTSCH HD34-24-47PE |
| Nominal ambient temperature | +65°C / +45°C with +CL option | LV connector pin type | Gold plated |
| Min. ambient temperature | -40°C | LV mating connector type | DEUTSCH HD36-24-47SE or DEUTSCH HD36-24-47SE-059 |
| Nominal altitude (IEC 60034-1) | 1000 m | LV mating connector pin type | DEUTSCH 0462-201-1631 DEUTSCH 0462-005-2031 Plug: DEUTSCH 0413-204-2005 (size 20) Plug: DEUTSCH 0413-003-1605 (size 16) |
| Vibration & Shock tolerance | | LV connector pin configuration | See Table below |
| Mechanical vibration | 5.9 G _{RMS} ISO 16750-3 Test VII – Commercial vehicle, sprung masses – Table 12 Notes: test duration 8h axis (two axes tested; radial and axial) total spectral acceleration 5,91 grms Test done with EM-PMI375-T800 (with flange mounting) | LV connections (+LVB1 option) | Connection box with 2x M25 cable glands (reserve 2x plugged M16 threads available) and terminal block for LV connections. See Table below |
| Mechanical shock | 50 G ISO 16750-3 4.2.2 Test for devices on rigid points on the body and on the frame Notes: –acceleration: 500 m/s ² ; –duration: 6 ms; –number of shocks: 10 per test direction. Test done with EM-PMI375-T800 (with flange mounting) | Anti-condensation heater (+HEAT1 option) | 130 W 230 V _{AC} single phase heater resistor |
| Connections | | Heater connector (+HEAT1 option) | Hummel art. no. 7651 0 51 01 D |
| Coolant connection | 2 x G3/4 bore | Heater mating connector | Hummel art. no. 7550 6 51 02 D |
| Cable direction | Standard cable direction towards D-end | Heater connector pin type | Hummel 7010 9 42 01 1 |
| HV cables | 3 x 70 mm ² max. (SINGLE winding model) 2 x 3 x 70 mm ² max. (DUAL winding model) 3 x 3 x 70 mm ² max. (TRI winding model) | Heater connector pin configuration | See Table below |
| HV cable glands | Pflitsch blueglobe TRI bg 225ms tri | Bearing temp. measurement connector type | 4-pin M12 A coded male |
| HV cable | Recommended H+S Radox screened cable | Bearing temp. measurement mating type | 4-pin M12 A coded female |
| HV cable lug size | 35-8, 50-8, 70-8 | Bearing temp. measurement connector pin configuration | See Table below |
| Recommended cable lug | 35 mm ² : Druseidt with narrow flange 03901 50 mm ² : Druseidt with narrow flange 03903 | | (* The values are based on structural analysis and they are not applicable to any marine class rules or requirements. |

| PIN | Description |
|-----|--|
| 47 | Temperature 1, PT100 (P), windings |
| 46 | Temperature 1, PT100 (N), windings |
| 33 | Temperature 2, PT100 (P), windings |
| 32 | Temperature 2, PT100 (N), windings |
| 45 | Temperature 3, PT100 (P), windings |
| 31 | Temperature 3, PT100 (N), windings |
| 30 | Temperature 4, PT100 (P), windings (+TEMP4 option) |
| 29 | Temperature 4, PT100 (N), windings (+TEMP4 option) |
| 44 | Temperature 5, PT100 (P), windings (+TEMP4 option) |
| 43 | Temperature 5, PT100 (N), windings (+TEMP4 option) |
| 28 | Temperature 6, PT100 (P), windings (+TEMP4 option) |
| 16 | Temperature 6, PT100 (N), windings (+TEMP4 option) |
| 35 | Resolver, RES_COS_N, in-built non-contacting |
| 20 | Resolver, RES_COS_P, in-built non-contacting |
| 36 | Resolver, RES_SIN_N, in-built non-contacting |
| 21 | Resolver, RES_SIN_P, in-built non-contacting |
| 22 | Resolver, EXCN, in-built non-contacting |
| 10 | Resolver, EXCP, in-built non-contacting |
| 34 | Resolver, SHIELD/GROUND, in-built non-contacting |
| 37 | Resolver, RES_COS_N, in-built non-contacting (additional resolver with +RES2 option) |
| 24 | Resolver, RES_COS_P, in-built non-contacting (additional resolver with +RES2 option) |
| 23 | Resolver, RES_SIN_N, in-built non-contacting (additional resolver with +RES2 option) |
| 11 | Resolver, RES_SIN_P, in-built non-contacting (additional resolver with +RES2 option) |
| 9 | Resolver, EXCN, in-built non-contacting (additional resolver with +RES2 option) |
| 8 | Resolver, EXCP, in-built non-contacting (additional resolver with +RES2 option) |
| 4 | Resolver, SHIELD/GROUND, in-built non-contacting (additional resolver with +RES2 option) |

Table 1 Pin configuration of LV-connector

| PIN | Description |
|-----|--|
| 1 | Temperature 1, PT100 (P), windings |
| 2 | Temperature 1, PT100 (N), windings |
| 3 | Temperature 2, PT100 (P), windings |
| 4 | Temperature 2, PT100 (N), windings |
| 5 | Temperature 3, PT100 (P), windings |
| 6 | Temperature 3, PT100 (N), windings |
| 7 | Temperature 4, PT100 (P), windings (+TEMP4 option) |
| 8 | Temperature 4, PT100 (N), windings (+TEMP4 option) |
| 9 | Temperature 5, PT100 (P), windings (+TEMP4 option) |
| 10 | Temperature 5, PT100 (N), windings (+TEMP4 option) |
| 11 | Temperature 6, PT100 (P), windings (+TEMP4 option) |
| 12 | Temperature 6, PT100 (N), windings (+TEMP4 option) |
| 16 | Heater, phase, 230 V _{AC} |
| 17 | Heater, neutral |
| ⊥ | Heater, ground / protective earth, M4 screw inside connection box |
| ⊥ | General shielding, ground / protective earth, M4 screw inside connection box |
| 18 | Resolver, RES_COS_N, in-built non-contacting |
| 19 | Resolver, RES_COS_P, in-built non-contacting |
| 20 | Resolver, RES_SIN_N, in-built non-contacting |
| 21 | Resolver, RES_SIN_P, in-built non-contacting |
| 22 | Resolver, EXCN, in-built non-contacting |
| 23 | Resolver, EXCP, in-built non-contacting |
| 24 | Temperature, PT100 (P), bearings N-end (+BTMP1 option) |
| 25 | Temperature, PT100 (N), bearings N-end (+BTMP1 option) |

Table 2 Pin configuration of LV connections (+LVB1 option)

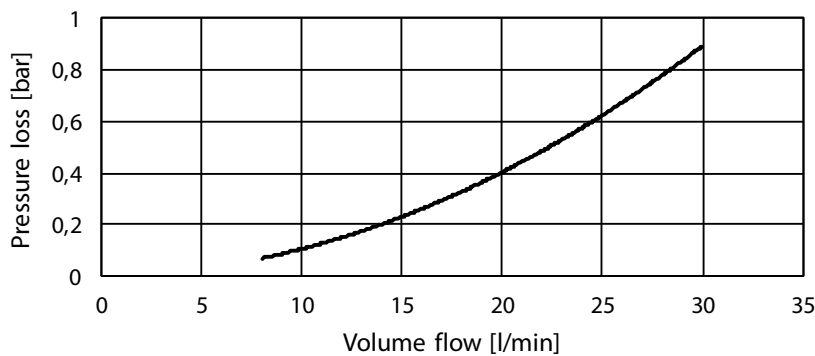
| PIN | Description |
|-----|----------------------------|
| 1 | Phase, 230 V _{AC} |
| 2 | Neutral |
| ⊥ | Ground / protective earth |
| 4 | Reserve |
| 5 | Reserve |

Table 3 Pin configuration of heater with connector

| PIN | Description |
|-----|-------------|
| 1 | PT100 |
| 2 | |
| 3 | PT100_GND |
| 4 | |

Table 4 Pin configuration of bearing temperature sensor connector (one sensor)

PRESSURE LOSS VS COOLANT FLOW



Picture 1 Pressure loss vs coolant flow

MOTORS (temperature class F, maximum winding temperature 150 °C, with +CL option)

| Type | Coolant temperature +65°C | | | Coolant temperature +40°C | | | Coolant temperature +40 / +65°C | | | | |
|----------------------|---------------------------|------------------|------------------|---------------------------|------------------|------------------|---------------------------------|------------------|------------------------|-----------------------|-----------------------|
| | Cont. Torque [Nm] | Cont. Power [kW] | Nom. Current [A] | Cont. Torque [Nm] | Cont. Power [kW] | Nom. Current [A] | Nom. speed [rpm] | Max. speed [rpm] | Peak torque SINGLE (*) | Peak torque DUAL (**) | Peak torque TRI (***) |
| EM-PMI375-T1100-1200 | 1306 | 164 | 207 | 1399 | 176 | 221 | 1200 | 2400 | 2100 | 3270 | 4100 |
| EM-PMI375-T1100-1500 | 1175 | 185 | 261 | 1310 | 206 | 292 | 1500 | 3000 | 1550 | 2500 | 3850 |
| EM-PMI375-T1100-1800 | 1077 | 203 | 271 | 1225 | 231 | 310 | 1800 | 3600 | 1380 | 2500 | 2750 |
| EM-PMI375-T1100-2100 | 995 | 219 | 288 | 1178 | 259 | 343 | 2100 | 4000 | 1100 | 2170 | 2400 |
| EM-PMI375-T1100-2400 | 952 | 239 | 323 | 1060 | 266 | 358 | 2400 | 4000 | 1040 | 2000 | 2050 |
| EM-PMI375-T1100-2900 | 896 | 272 | 367 | 998 | 303 | 409 | 2900 | 4000 | 800 | 1500 | 1750 |

(* Peak torque achieved with one 350A inverter

(** Peak torque achieved with two 350A inverters

(***Peak torque achieved with three 350A inverters

GENERATORS (temperature class F, maximum winding temperature 150 °C, with +CL option)

| Type | Coolant temperature +65°C | | | | Coolant temperature +40°C | | | | Coolant temperature +40 / +65°C | | |
|----------------------|---------------------------|------------------|------------------|--------------|---------------------------|------------------|------------------|--------------|---------------------------------|-----------------|---------------------------------|
| | Apparent power [kVA] | Cont. power [kW] | Nom. Current [A] | Power factor | Apparent power [kVA] | Cont. Power [kW] | Nom. Current [A] | Power factor | Nom. speed [rpm] | Nom. Freq. [Hz] | Volt/ speed ratio [V/rpm] (***) |
| EM-PMI375-T1100-1200 | 179 | 175 | 205 | 0.98 | 193 | 188 | 219 | 0.97 | 1300 | 130 | 0.41 |
| EM-PMI375-T1100-1500 | 222 | 205 | 257 | 0.92 | 251 | 229 | 288 | 0.92 | 1700 | 170 | 0.33 |
| EM-PMI375-T1100-1800 | 232 | 214 | 267 | 0.92 | 266 | 243 | 305 | 0.92 | 1900 | 190 | 0.278 |
| EM-PMI375-T1100-2100 | 245 | 230 | 283 | 0.94 | 293 | 271 | 338 | 0.93 | 2200 | 220 | 0.238 |
| EM-PMI375-T1100-2400 | 270 | 248 | 314 | 0.92 | 302 | 277 | 351 | 0.92 | 2500 | 250 | 0.208 |
| EM-PMI375-T1100-2900 | 308 | 281 | 358 | 0.91 | 344 | 312 | 401 | 0.91 | 3000 | 300 | 0.172 |

(*** Back EMF for cold (20°C) generator

MOTORS (temperature class H, maximum winding temperature 175 °C)

| Type | Coolant temperature +65°C | | | Coolant temperature +40°C | | | Coolant temperature +40 / +65°C | | | | |
|----------------------|---------------------------|------------------|------------------|---------------------------|------------------|------------------|---------------------------------|------------------|------------------------|-----------------------|-----------------------|
| | Cont. Torque [Nm] | Cont. Power [kW] | Nom. Current [A] | Cont. Torque [Nm] | Cont. Power [kW] | Nom. Current [A] | Nom. speed [rpm] | Max. speed [rpm] | Peak torque SINGLE (*) | Peak torque DUAL (**) | Peak torque TRI (***) |
| EM-PMI375-T1100-1200 | 1410 | 177 | 242 | 1515 | 190 | 263 | 1200 | 2400 | 2100 | 3270 | 4100 |
| EM-PMI375-T1100-1500 | 1310 | 206 | 292 | 1455 | 228 | 294 | 1500 | 3000 | 1550 | 2500 | 3850 |
| EM-PMI375-T1100-1800 | 1187 | 224 | 298 | 1338 | 252 | 338 | 1800 | 3600 | 1380 | 2500 | 2750 |
| EM-PMI375-T1100-2100 | 1070 | 235 | 310 | 1300 | 286 | 380 | 2100 | 4000 | 1100 | 2170 | 2400 |
| EM-PMI375-T1100-2400 | 1036 | 260 | 350 | 1155 | 290 | 386 | 2400 | 4000 | 1040 | 2000 | 2050 |
| EM-PMI375-T1100-2900 | 976 | 296 | 398 | 1098 | 333 | 456 | 2900 | 4000 | 800 | 1500 | 1750 |

(* Peak torque achieved with one 350A inverter

(** Peak torque achieved with two 350A inverters

(*** Peak torque achieved with three 350A inverters

The maximum allowed peak torque duration at stator winding starting temperature +90°C is 2 minutes. The given values indicate typical duration and are not verified. In case more accurate values are required, cyclic dimensions are needed.

GENERATORS (temperature class H, maximum winding temperature 175 °C)

| Type | Coolant temperature +65°C | | | | Coolant temperature +40°C | | | | Coolant temperature +40 / +65°C | | |
|----------------------|---------------------------|------------------|------------------|--------------|---------------------------|------------------|------------------|--------------|---------------------------------|-----------------|---------------------------------|
| | Apparent power [kVA] | Cont. power [kW] | Nom. Current [A] | Power factor | Apparent power [kVA] | Cont. Power [kW] | Nom. Current [A] | Power factor | Nom. speed [rpm] | Nom. Freq. [Hz] | Volt/ speed ratio [V/rpm] (***) |
| EM-PMI375-T1100-1200 | 211 | 199 | 239 | 0.94 | 229 | 213 | 260 | 0.93 | 1400 | 140 | 0.41 |
| EM-PMI375-T1100-1500 | 251 | 230 | 288 | 0.92 | 279 | 253 | 288 | 0.91 | 1700 | 170 | 0.33 |
| EM-PMI375-T1100-1800 | 252 | 239 | 292 | 0.95 | 287 | 269 | 332 | 0.94 | 2000 | 200 | 0.278 |
| EM-PMI375-T1100-2100 | 264 | 246 | 305 | 0.93 | 325 | 306 | 373 | 0.94 | 2200 | 220 | 0.238 |
| EM-PMI375-T1100-2400 | 293 | 269 | 343 | 0.92 | 328 | 300 | 379 | 0.92 | 2500 | 250 | 0.208 |
| EM-PMI375-T1100-2900 | 332 | 307 | 385 | 0.93 | 384 | 349 | 443 | 0.91 | 3100 | 310 | 0.172 |

(***) Back EMF for cold (20°C) generator

PRODUCT CODE AND OPTIONS

Use product code including all needed options for ordering. Standard options are not given with the code as they are selected by default if a non-standard option is not selected. Standard options are indicated by a star (*).

| Product code | Description |
|-------------------------------|--|
| EM-PMI375-T1100-1800 | Standard 1800 rpm unit with standard options |
| EM-PMI375-T1100-1800+BIN+RES1 | Standard unit with insulated bearing in N-end and resolver |

Table 5 Product code examples

| Variant | Code | Description | Additional information |
|----------------------------------|--------|---|--|
| High voltage connections | * | One 3 phase system | One connection box containing one 3 phase system with one M25 cable gland per phase |
| | -DUAL | Two galvanically isolated 3 phase systems | Two connection boxes each containing one 3 phase system with one M25 cable gland per phase |
| | -TRI | Three galvanically isolated 3 phase systems | Two connection boxes one containing one 3 phase system and another one containing two 3 phase systems with one M25 cable gland per phase |
| Low voltage connections | * | Low voltage connections done with connector | DEUTSCH HD34-24-47PE connector for LV connections |
| | +LVB1 | Low voltage connections done with connection box and terminal strip | Connection box with 2x M25 cable glands (reserve 2x plugged M16 threads available) and terminal block for LV connections |
| N-end attachment | * | Flange | SAE 4 flywheel housing |
| | +NE2 | Male shaft + Flange | DIN5480 W55x2x26x8a + SAE 4 flywheel housing |
| Bearing insulation | * | Non-insulated bearings | Non-insulated bearings |
| | +BIN | Insulated bearing in N-end | Insulated bearing in N-end |
| | +BIA | Insulated bearing in both ends | Insulated bearing in both ends |
| Shaft grounding | * | None | |
| | +SG1 | D-end shaft grounding | In-built grounding ring |
| Cable direction | * | Cable direction fixed | Cable direction towards D-end |
| | +CNE | Cable direction towards N-end | Cable direction towards N-end |
| Rotation sensor | * | None | No resolver |
| | +RES1 | Resolver | In-built non contacting resolver, 6-pole pair |
| | +RES2 | Double resolver | 2 x In-built non contacting resolver, 6-pole pair |
| Winding temperature sensors (**) | * | Temperature surveillance | 3 x PT100 (two wire) in windings |
| | +TEMP4 | Redundant temperature surveillance | 6 x PT100 (two wire) in windings |
| Bearing temperature sensors | * | None | |

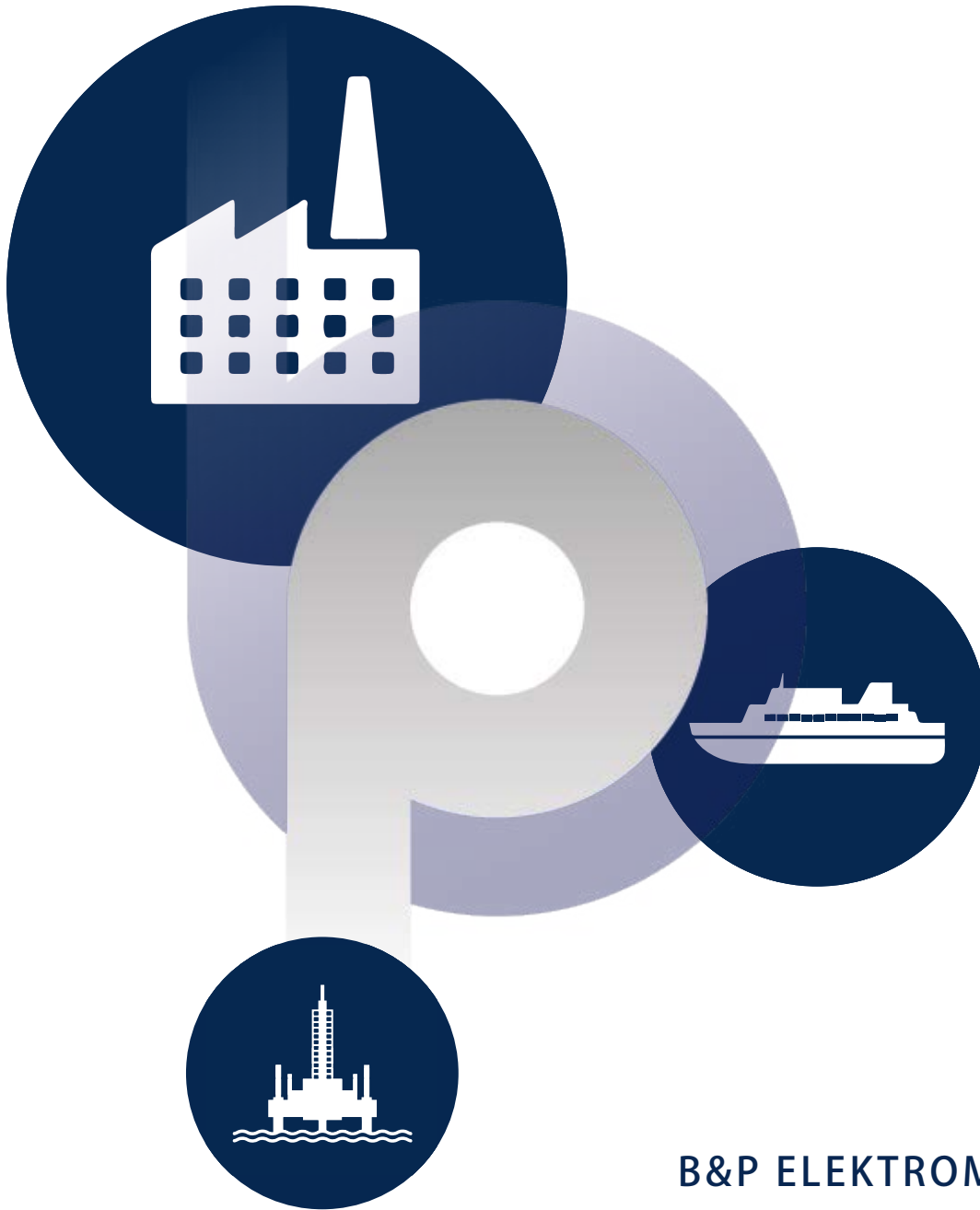
| | | | |
|---------------------------|--------|------------------------------|---------------------------------|
| | +BTMP1 | PT100 in bearings | Plug-in connector |
| Anti-condensation heaters | * | None | |
| | +HEAT1 | One anti-condensation heater | 230 V _{AC} / 130 W |
| Marine classification | * | No marine classification | |
| | +CL1 | | ABS American Bureau of Shipping |
| | +CL2 | | BV Bureau Veritas |
| | +CL3 | | DNV GL DNV GL AS |
| | +CL4 | | LR Lloyd's Register |
| | +CL5 | | RINA |

(* Standard option

(** Winding temperature sensors are for stator winding. The selection of high voltage connections does not have an influence on the quantity of PT100 elements.

Table 6 Option list

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