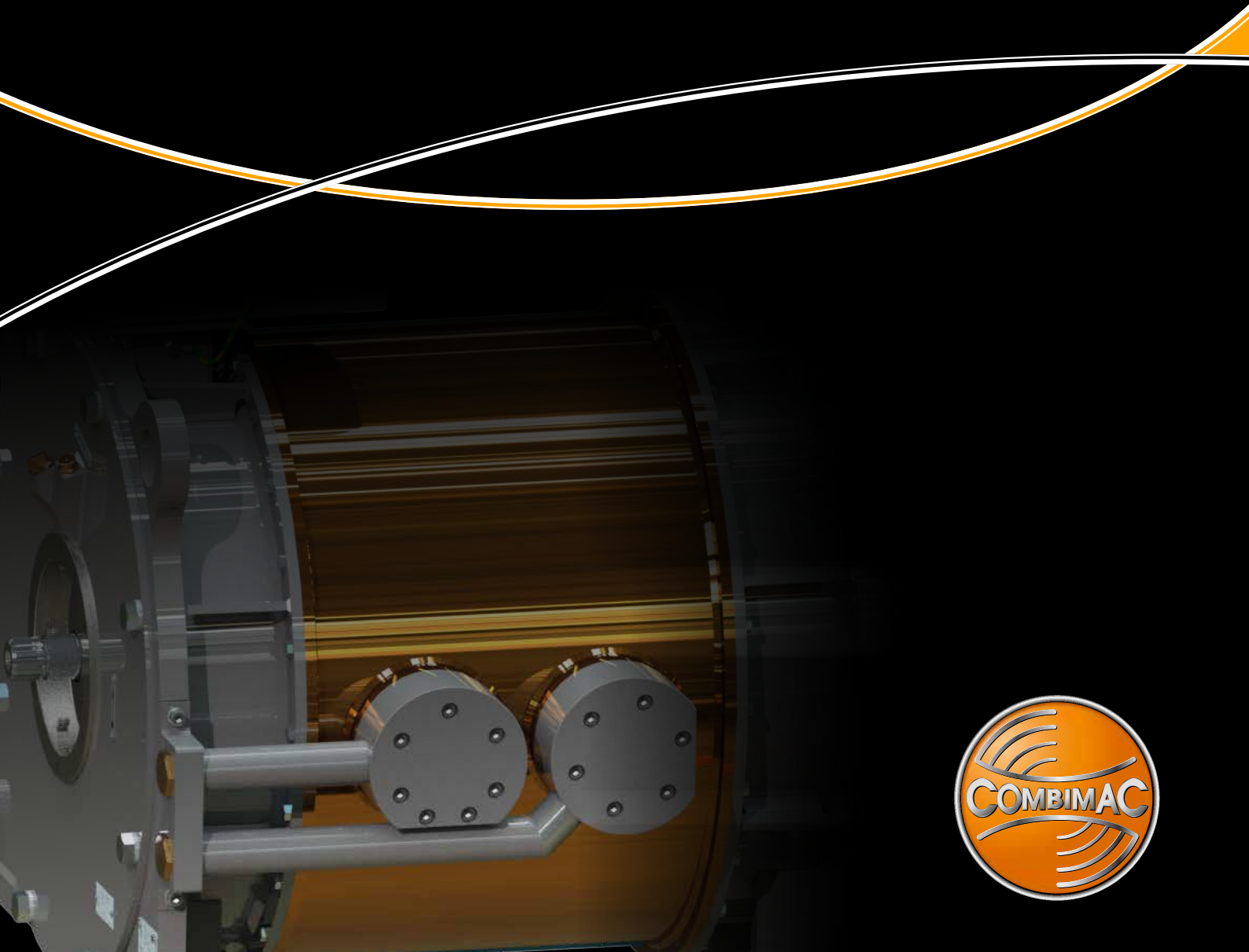
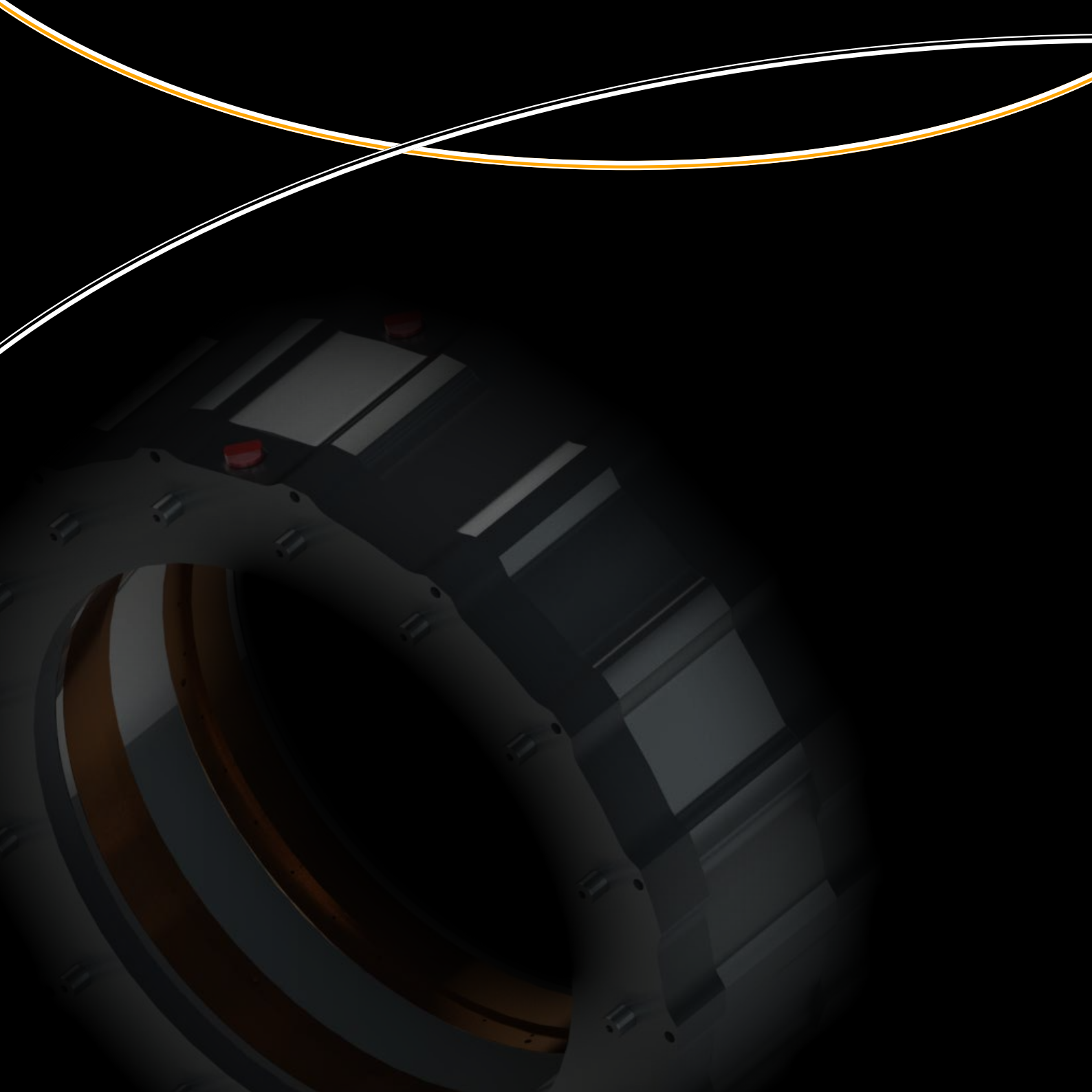


# Special Electric Motors





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# Introduction

## Combimac

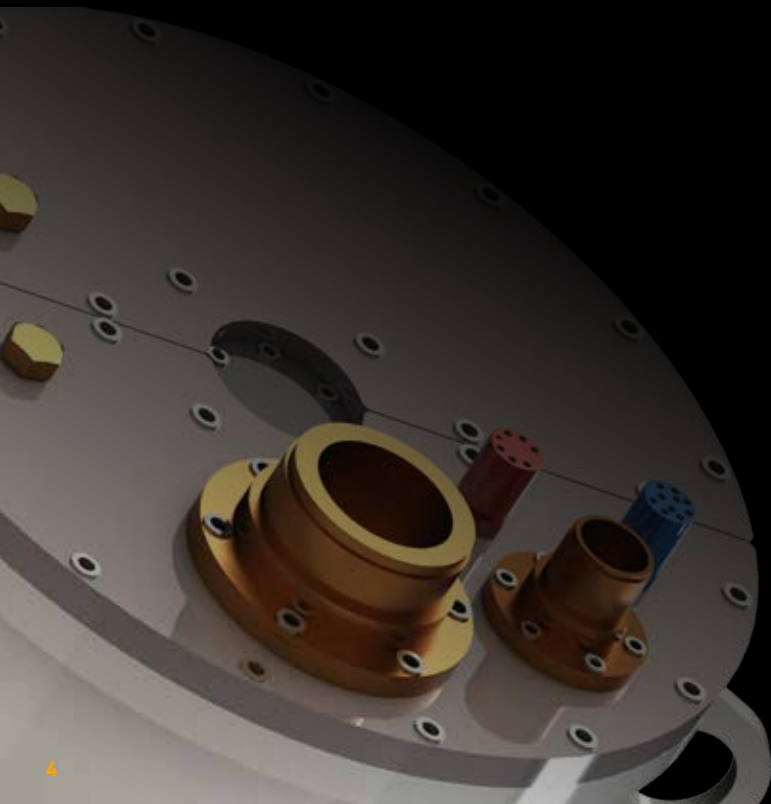
Combimac is a wholly independent, middle size company, established in the north east part of the Netherlands, in the town of Emmen. As a supplier of electrical prime movers, Combimac has for many years been a prominent market leader, deriving its leading position from the following product groups:

- Special electric motors
- Industrial and special fans

Combimac's keyword is knowledge and quality control. Indeed it is quality that dominates the company's entire production process, from design up to delivery and beyond in after sales. All necessary monitoring is carried out by Combimac in the company's own laboratory, this being the only way of achieving absolute accuracy. All work is carried out to established quality procedures and standards. In short, Combimac aims for perfection striving to attain continuous quality.

Thanks to the high quality standards, proven over many years, Combimac has become an established subcontractor for many companies.

Combimac's electric motors, installed in vessels of many Navies and various industrial installations world wide, live up to the highest reputation.



# Special electric motors

## Features

As previously mentioned one of Combimac's main products is a range of special electric motors. The following types of electric motors can be manufactured:

- A-synchronous and synchronous AC-motors
- Single-phase AC-motors
- Direct current motors
- Low magnetic motors
- Strayfield compensated motors
- Immersible and submersible motors
- (Sea) water cooled motors
- Permanent magnet motors

The following features can also be incorporated into this range:

- Shock protected up to 300g
- Flameproof (ATEX)
- Increased safety (ATEX)
- Non sparking (ATEX)
- Low noise and vibration
- Up to IEC frame size 450



Low magnetic oil cooled motor



Sea water cooled motor

# Submersible electric motors

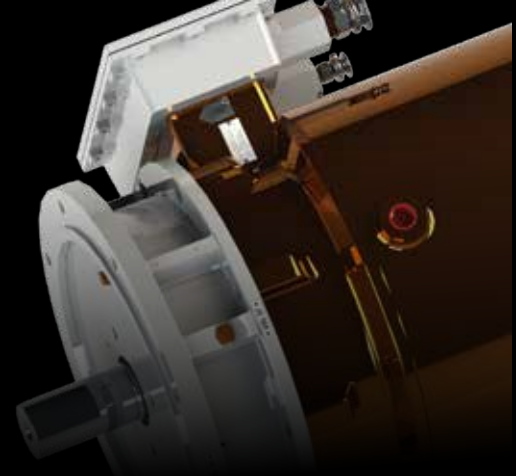
Being a supplier of custom made electric motors for many years, Combimac is able to offer several particular electric motor ranges for various specific demands. Parts of the scope of delivery are submersible electric motors for various applications. Combimac supplies two main types of submersible electric motors:

- Surface cooled electric motor
- Forced cooled electric motor

## Surface cooled electric motor

For continuous submersible operation or operation only when submerged, Combimac provides a wide range of surface cooled electric motors. Typical applications for these electric motors are dredging-, deep well-, and sewage pumps. The surface cooled electric motors provide the following features:

- Dimensions in acc. with IEC72
- Frame sizes up to IEC 450
- Method of cooling = IC4A1W0
- Minimum protection class IP67 or IP68
- Insulation class F and H
- Power rating up to 500 kW
- Mechanical seals, lipseals, airbell construction



## Forced cooled electric motor

Combimac has developed various varieties of forced cooled electric motors to suit immersible or submersible applications. Often electric motors have to perform their nominal power rating when running both dry or wet. As these electric motors are continuously cooled by means of a forced liquid flow, either water, oil or any other available cooling liquid, they can provide maximum power both in submerged and dry conditions.

Other features of this design are the very low airborne noise levels produced by these types of electric motors and the lack of heat dissipation to its environment that, in some instances, can be of vital importance. Also because of their more efficient cooling compared with air-cooled electric motors a high output in small frame sizes is possible. These types of electric motors, normally provided with IEC standard flanges and shaft extensions, can be fully manufactured in accordance with the customer's requirements. Furthermore the forced cooled electric motors provide the following features:

- Cooling jacket available in different materials
- Dimensions in acc. with IEC72
- Method of cooling = IC7A1W7
- Frame sizes up to IEC 450
- Minimum protection class IP55 or IP68
- Insulation class F and H
- Power rating up to 500 kW
- Mechanical seals, lipseals and airbell construction

# Permanent magnet motors

The use of permanent magnets to create a constant flux in the air gap, results in synchronous performance with the robust design of an asynchronous induction motor. The permanent magnets are made from neodymium iron boron (NdFeB) or samarium cobalt (SmCo). Both materials provide the powerful magnetic material at room temperature, with high flux density at high magnetization. Based on these design features Combimac are able to offer AC permanent magnet motors.

Applications that require high torque at low speeds often use synchronous motors with reducers, as standard induction motors generate plenty of torque, but unfortunately not at low speeds. Therefore they are not particularly suited for low-speed operation because their efficiency drops with reduced speed.

However, gearboxes take up space, reduce efficiency and need both maintenance and constant lubrication. Eliminating the gearbox saves space and installation costs, energy and maintenance, and provides more flexibility in production line and facility design.



Water cooled high speed PM motor



PM motor/generator

Synchronous motor designs using permanent magnets make it possible to have low speed and high torque in one package, eliminating gearboxes and other mechanical components. Also for high speed applications permanent magnet motors provide improved properties.

Because of its nature, PM machines can be used both as motor and as generator. As generator these are often used in (super) yachts, where its compactness and very low heat emission are well valued.

Furthermore, the generator does not have to run at fixed speeds of 1500 rpm or 1800 rpm; the speed is best chosen to suit the diesel engine or gas turbine.

Main features provided by the synchronous motor design:

- Automotive liquid cooled or sea water cooled
- Very high efficiency, even at 25% load
- Very high power-to-weight and power-to-volume ratio
- Up to more than 4 times more than conventional motors
- High torque at low speed
- Smaller sized high speed motor

# Direct current motors

Besides alternating current (AC) electric motors Combimac, is able to supply a wide range of:

- Conventional direct current (DC) electric motors
- Special DC-motors

## Conventional DC-motors

The Combimac conventional standard range of DC-electric motors is totally adapted to the latest modern design standards. Incorporated in the specific DC-motor design are parts, which have been derived directly from the Combimac squirrel cage electric motors range. Together with a modern stator core with laminated design, they provide the following features:

- Dimensions in acc. with IEC72
- Minimum protection grade IP44 up to IP68
- Method of cooling = IC4A1A1
- Excellent commutation properties, also at thyristor duty
- Low noise & vibration levels
- Voltage range

## Special DC-motors

Various applications, for example submersible battery driven drives on board silent running leisure crafts in pollution restricted areas, have special demands. Durability, easy maintenance and high efficiency require special solutions. Combimac is able to provide these solutions with DC-motors designed specifically for this purpose and requirements.




Axial fan motor



DC fan motor unit





DC-motors used on board submarines, which should be able to run from the batteries in the event of a power failure on board the submarines, is a totally different application demanding a different spectrum of requirements and limiting operating conditions. Again Combimac is able to design, engineer and manufacture suitable motors for these purposes.



## High-speed electric motors

Various high-speed electric motors, up to 50.000 rpm and 150 kW power rating, have been designed and manufactured to meet our customers' high-speed requirements. Combimac high-speed motors are often used to drive test equipment connected with bearings, seals and transmissions. Furthermore, most of the high-speed motors have been designed to meet the customers' individual interface and motor performance requirements.

# Brake motors

Combimac is able to offer a wide range of electric brake motors for several applications and in a wide variety of designs and models. Brake motors can both be provided with stopping as well as holding brakes. Stopping brakes are being used for braking the rotary movements, whilst holding brakes are being used when a fully locked motor is required when the electric motor is not being operated.



Water cooled PM brake motor

For various applications and to cover the special demands for electric motors provided with brakes, Combimac has supplied electric brake motors for:

- Radar equipment
- Bow thrusters
- Winches
- Elevators
- Hangar doors
- Sonar systems

Combimac can provide the majority of its different electric motor ranges with electric brakes.

Electric brakes can be fitted to shock resistant motors, as well as to the low magnetic range of electric motors. Special attention in this case is being given to the magnetic signature.

Electric brakes can be supplied for both AC or DC operation and also with an additional manual release facility, to enable the release of the brake in the event of a power failure or an emergency. A variety of manual release can be offered, as can be seen on the different examples shown.

# Oil cooled electric motors

## Method of cooling

Combimac designs and manufactures oil cooled electric motors with three different types of cooling methods. One version provides surface oil cooling and the other versions have internal oil cooling.

### Surface cooled

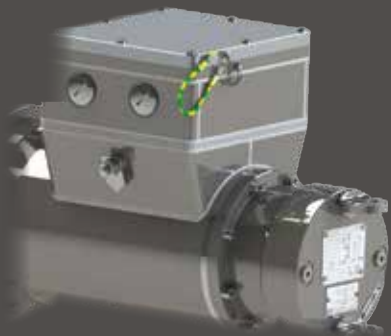
Surface oil cooled electric motors are provide with a separate cooling jacket. The cooling oil is cooling the outside of the motor stator, whereas the motor internal parts are dry running. To guarantee a sufficient amount of cooling, the cooling mantles are manufactured from bronze alloy or aluminium.

### Internally cooled

Unlike surface cooled electric motors, the cooling oil is running through the motor, providing an optimum cooling. The cooling oil at the same time is used to lubricate the motor bearings, often leading to a simplified electric motor design.

### Canned motors

Another option for an internally cooled electric motor is to have internally oil cooled motors, providing the use of a can, the so called canned motors. This method is used to prevent the stator winding getting in contact with a possibly aggressive cooling medium to avoid any risk of deterioration of the windings.



# Water cooled electric motors

## Method of cooling

Combimac designs and manufactures water cooled electric motors with two different types of cooling methods. One version provides surface water cooling and the other version provides internal water cooling.

### Surface cooled

Surface water cooled electric motors are provide with a separate cooling jacket on the outside of the motor. The cooling water is cooling the outside of the motor stator, whereas the motor internal parts remain dry running. The cooling mantles depending on the type of water, for example fresh or sea water, can be manufactured from a variety of materials. Other features of this design are the very low airborne noise levels produced by these types of electric motors and the lack of heat dissipation to its environment that, in some instances, can be of vital importance. Also because of their more efficient cooling compared with air-cooled electric motors a high output in small frame sizes is possible.

### Canned motors

The same principle used in oil cooled motors can be used in water cooled motors. Using a can prevents the stator winding getting in contact with a possibly aggressive cooling medium to avoid any risk of deterioration of the windings.



Surface cooled motor



# ATEX

## Electric motors in accordance with ATEX 2014/34/EU

For the application of electric motors in hazardous environments Combimac is able to design and manufacture electric motors in accordance with the ATEX 2014/34/EU directive. Explosion protection for electric motors to IEC 60079 are classified in accordance with the following categories protection types.

### Flameproof enclosure “d”

Electric motor apparatus destined for Zones 1 and 2 (IEC 60079-14), Electrical Equipment for Hazardous Areas (except for mines).

The constructional requirements are in accordance with IEC 60079-1. The protection concept is defined so that all potential ignition sources are housed inside a flameproof enclosure. Unavoidable sealing surfaces are therefore designed as flameproof joints, so that, in case of ignition of an explosive atmosphere inside the enclosure, the explosive atmosphere is not transferred to the potentially explosive atmosphere surrounding the enclosure. The application is for all type of motors, such as squirrel cage, commutator, permanent magnet and all modes of operations (S1 to S9). Suitable also for severe starting conditions and variable speed drives.

### Increased safety “eb”

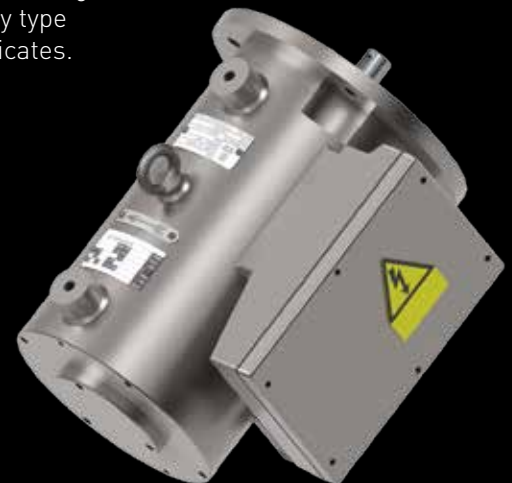
Electric motor apparatus destined for Zones 1 and 2. The constructional requirements are in accordance with IEC 60079-7. The protection concept defines, steps must be taken to ensure that the creation of sparks, electric arcs and inadmissible heating processes is prevented during proper operation of the apparatus.

The application is only for squirrel cage motors with adapted motor protection switches.

### Increased safety “ec”

Electric motor apparatus destined for Zone 2. The constructional requirements are in accordance with IEC 60079-7. The protection concept is defined as, under normal operation conditions, no sparks, electric arcs or inadmissible temperatures may occur. The application is for all types of electric motors with motor protection switches and overpressure monitoring. Prevention of sparks created under normal operating conditions should be implemented and Manufacturers' information about these measures is provided.

Both the flameproof and increased safety require an EU type testing certificate from an accredited Notified Body. This is not required for the non-sparking versions. Combimac is able to offer all 3 types, including the necessary type testing certificates.



# Naval motors

## Shockproof electric motors

For various naval applications, for example pumps, compressors, fans or winches, Combimac supplies the following type of asynchronous AC, shock resistant, electric motors in accordance with the following classifications:

- Mild shock - General Ruggedness
- Medium shock
- High shock

Every electric motor range provides its own features to suit the requirements such as shock, low noise & vibration and performance for each type of application.

### Mild shock

Combimac electric motors which are designed to meet mild shock or general ruggedness requirements for standard applications are totally enclosed fan cooled motors. Designed to meet naval requirements on shock and low noise & vibration.

### Medium shock

Combimac electric motors, which are designed to meet higher shock demands, such as for example, the Combimac type 50 meet the British MOD standard NSSII. As a result of this higher shock resistance all IEC frame sizes up to 400L are manufactured from nodular cast iron. For more stringent weight requirements Combimac is able to build motors meeting the same shock levels. The Combimac aluminium type 60 motors are derived from the type 50 motors meeting relatively high shock levels, however aiming for a lower mass and therefore providing a low weight, high shock resistant motor.



Closed coupled high shock batwing motor

This low weight advantage can be exploited even more by designing it close coupled to the equipment which has to be driven, as done on many occasions for several pump manufacturers.

### **High shock**

Combimac electric motors have been developed and designed over the years to meet the most stringent shock levels and, if required, combined with ultra low noise & vibration levels. The motors often consist out of a completely steel welded construction that makes them suitable for meeting shock figures up to 340g. These motors are therefore often used onboard submarines. Furthermore this particular design can easily be adapted to meet operation in hazardous environments by developing it into a flame proof, increased safety or non-sparking design.



# Naval motors

## Low magnetic electric motors

For use onboard MCMV's (Mine Counter Measure Vessel) such as minehunters and -sweepers, which require electric motors with a low magnetic and acoustic signature Combimac has developed two main ranges of low magnetic electric motors:

- Low magnetic AC-motor
- Low magnetic strayfield compensated AC-motor

### Low magnetic electric motor design

Combimac low magnetic electric motors are manufactured, as far as technically possible, from low magnetic materials. Also the design and the electrical configuration is set up in such a way that the strayfield and acoustic signature is kept to a minimum. The Combimac low magnetic electric motors provide the following features:

- Shock protected standard up to 30g
- Dimensions in acc. with IEC72
- Method of cooling = IC4A1A1
- Minimum protection class = IP55 up to IP68
- Insulation class F and H

### Low magnetic and strayfield compensated electric motor design

Combimac low magnetic strayfield compensated electric motors represent the latest development to minimize the emanating magnetic strayfields of electric motors. The Combimac low magnetic strayfield compensated electric motors provide a significant reduction in the strayfield levels without the use of sophisticated electronics or additional ferro magnetic materials. Furthermore it does not require any additional space or larger frame sizes.



Low magnetic strayfield compensated brake motor



As the compensation is an integrated part of the motor, the magnitude of compensation follows automatically the load of the electric motor without the use of sophisticated and vulnerable electronics. So providing an optimal protection against the threat of strayfield sensitive mines. Furthermore Combimac low magnetic and strayfield compensated electric motors provide the same features as the low magnetic motors.

The general design of the developed Combimac low magnetic strayfield compensated electric motor is in accordance with the latest requirements and technical standards. The following types of motors have been developed out of the basic design: totally enclosed motors, sea water cooled motors, submersible and immersible motors.



# Reference list

## Naval motors

Due to their proven reliability Combimac equipment is in use for the following applications on naval ships.

## Surface ships

- S, L, GW, M and LCF-frigates (Netherlands)
- Halifax class patrol frigates (Canada)
- F123, F124, F125 -frigates (Germany)
- K130 corvettes (Germany)
- T21, T22 and T23-frigates (UK)
- Invincible class aircraft carrier (UK)
- T42, T45-destroyers (UK)
- Fort George class AOR (UK)
- LPD (UK)
- ANZAC - frigates (Australia and New Zealand)
- MEKO@ 100 corvettes (Malaysia)
- F100 frigates (Spain)
- Visby class corvettes (Sweden)
- KDX-II, KDX-III destroyers (Korea)
- MEKO@ 200 frigates (South Africa, Algeria)
- MEKO@ A200 corvettes (South Africa)
- CVF Aircraft carrier (UK)
- Type 26 frigates (UK)

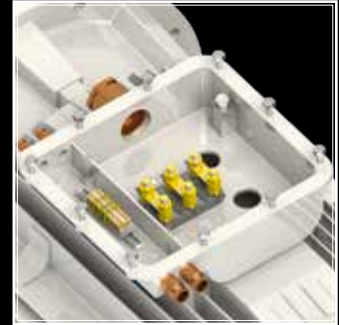
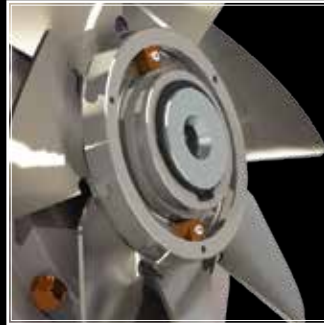
## Minehunter and -sweepers

- Tripartite minehunters (Netherlands, Belgium and France)
- Single Role minehunters (UK and Saudi Arabia)
- Oksoy / Alta class minehunters and -sweepers (Norway)
- Tripartite minehunters (Indonesia and Pakistan)
- Osprey class minehunters (USA)
- Styrsö class minehunters (Sweden)
- Bedok class minehunters (Singapore)
- Sugashima class minehunters (Japan)
- Type 331 minehunters (Germany)
- Huon class minehunters (Australia)
- Segura class minehunters (Spain)
- Lat Ya class minehunters (Thailand)
- Mahamiru class minehunters (Malaysia)
- KUHA class minehunters (Finland)
- Swallow class minehunters (Korea)
- Alanya class minehunters (Turkey)
- Katanpää class minehunters (Finland)
- Kormoran II minehunter (Poland)

## Submarines

- Walrus class submarines (Netherlands)
- Trafalgar class submarines (UK)
- Vanguard class submarines (UK)
- Astute class submarines (UK)
- Type 209 submarines (Chile, Argentina)
- Type 212 submarines (Germany, Italy)
- Type 214 submarines (Greece, Korea)
- Victoria class submarines (Canada)
- Seadragon class submarines (Taiwan)
- Sauro class submarines (Italy)
- Scorpène submarines (Chile & Malaysia)
- Barracuda class submarines (France)
- S80 submarines (Spain)
- Jangbogo submarines (Korea)
- A26 submarines (Sweden)
- Dreadnought class submarines (UK)





## Quality Assurance and Control

At Combimac, we operate strictly in accordance with the procedures laid down in our quality manual.

This ensures that we achieve constant and guaranteed high quality levels in our products, which are also extensively tested in our computerized laboratory.

The complete logistics within the factory are computer supported, providing an efficient production flow and an optimised use of existing labour and machining capacities. The majority of the testing and measuring equipment is fully computer controlled, thereby providing easily accessible test data. All these factors contribute towards full product traceability at competitive prices and advantageous delivery times.





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