Cooling – November 2020

Guide

Cooling systems for electric motors

HOYER

MOTORS

Contents

Why proper cooling is important

Like in many other situations in life, the right level of cool can mean the difference between keeping things running smoothly and suffering a heat-induced breakdown.

When an electric motor is in operation, the rotor and stator losses generate heat which must be managed through an appropriate cooling method.

Efficient cooling – or the lack thereof – has a significant impact on the lifetime of your motor. This is especially the case for the bearings and the insulation system, which are the components most vulnerable to overheating. In addition, long-term overheating can cause metal fatigue.

This basic rule of thumb illustrates the relationship between heat and lifetime:

- The lifetime of your motor's **isolation system** is divided by two for every 10°C over the rated temperature and multiplied by two for every 10°C below.
- The lifetime of your motor's **bearing grease** is divided by two for every 15°C over the rated temperature and multiplied by two for every 15°C below.

In addition to ensuring the health of the motor, maintaining optimal temperature levels are important to avoid efficiency reduction in general.

In short, ensuring proper heat management results in **a more reliable and robust motor with a longer lifetime**. And with an effective cooling system, it is often possible to use a smaller motor, which carries significant size-, weight- and cost reductions.

There are many cooling options available for electric motors. The optimal choice depends on your application, where the motor is mounted, the operating environment and several other factors. In this guide, we give you what you need to know to make an informed choice.

Reading an IC code

In the IEC 60034-6 standard, several suitable methods for efficient cooling of electric motors are defined. Each method is designated with an IC code which breaks down the individual elements of the cooling method.

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The IC code can be expressed with either a long or short designation (e.g. IC 4A1A1/ IC 411), which is broken down as follows:

IC	4	A	1	A	1
Code letters	**Circuit arrangement** 0: Free circulation 4: Frame surface cooled	**Primary coolant** A: Air (long designation only)	**Method of movement of primary coolant** 0: Free convection 1: Self circulation	**Secondary coolant** A: Air W: Water (long designation only)	**Method of movement of secondary coolant** 0: Free convection 1: Self circulation 6: Machine mounted independent component 8: Relative displacement

IC code vs NEMA designation

In some cases, letter acronyms based on the NEMA (National Electrical Manufacturers Association) definitions are used as an alternative or supplement to the IC code. The IC codes and corresponding NEMA acronyms for the most common methods of cooling are:

IC code	NEMA designation
IC411	Totally Enclosed Fan Cooled (TEFC)
IC410	Totally Enclosed Non-Ventilated (TENV)
IC416	Totally Enclosed Force Ventilated (TEFV)
IC418	Totally Enclosed Air Over (TEAO)

The most common cooling methods

While there are many different methods for cooling of electric motors, the methods described in this section cover the majority of use cases.

Hoyer Motors produce many different types of motors, but the majority are frame surface cooled (signified by the “4” in the IC code). The frames are with cooling ribs to create a greater surface area allowing the heat to dissipate faster. Hollow fins or ducts of a surface-cooled motor enables the creation of an internal cooling circuit which transports a large part of the heat directly to the cooling ribs of the housing. Here, the heat is dissipated by the external cooling circuit, which is where we find the main variation between the cooling methods.

The four most frequently used cooling methods for electric motors are:

IC411 – Totally Enclosed Fan Cooled (TEFC)

Description

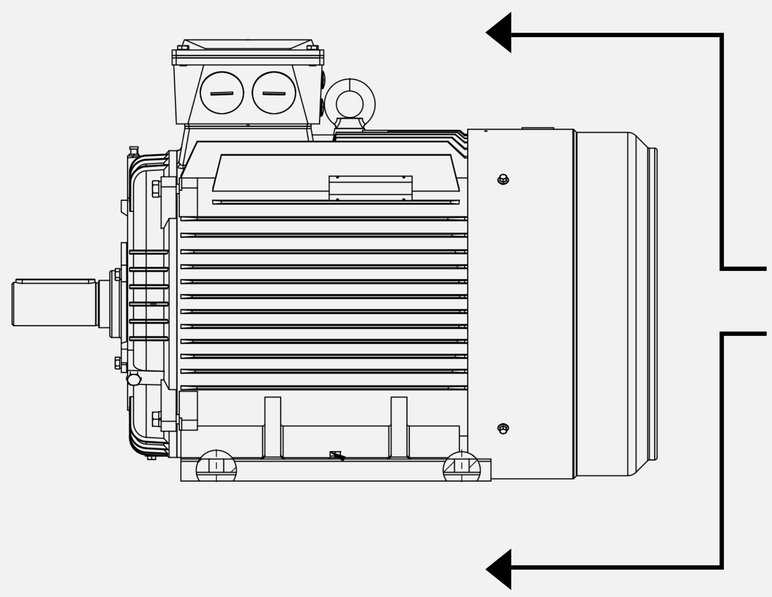
The motor is totally enclosed in a smooth or finned casing and cooled by an external fan mounted on the motor shaft.

Applications

This is by far the most common of all cooling methods and is used as standard for a wide range of different applications, including pumps, fans and hydraulics.

Pros and cons

Since the cooling fan is mounted on the motor shaft, the motor cools itself whenever it is running. The cooling provided by the fan is directly correlated to the speed of the motor.



IC410 – Totally Enclosed Non-Ventilated (TENV)

Description

The motor is totally enclosed in a smooth or finned casing, without any external fan.

Applications

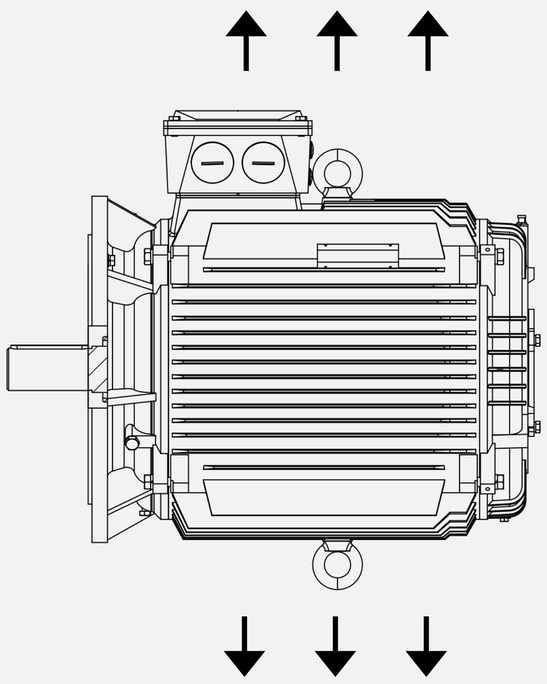
This cooling method is especially suitable for winches, cranes and other applications which only operates at constant load for a brief period of time. Also known as duty type S2. A typical anchor handling winch is usually rated S2-30 minutes and a lifeboat davit S2-10 minutes.

Pros and cons

If an application is rated for short time duty and is allowed to de-energize so the motor temperature reaches ambient temperature between uses, cooling is not required.

It is possible to use the motor at an even higher power than at S1 duty with TEFC/IC411 cooling, or to use a smaller motor size for the application which can offer cost and/or space saving for compact applications.

By removing the fan, fan cover and fan shaft you increase reliability and durability and lower maintenance costs.



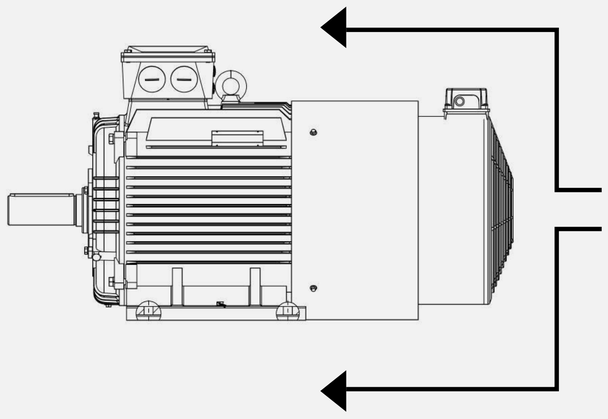
IC416 – Totally Enclosed Force Ventilated (TEFV)

Description

The motor is totally enclosed in a smooth or finned casing and cooled by an externally mounted motorized axial fan supplied with the motor.

Applications

This method is usually used for applications with VFD controlled motors, which operate at varying speeds or at low speed with constant torque.



Pros and cons

Since the cooling fan is mounted and operated separately from the motor, it is possible to provide constant cooling even if the motor's speed is adjusted, such as through frequency converter control. This often makes it possible to reduce the size of the motor, which can make a difference in both cost and space requirements.

This method can also be used as an alternative to IC411/ TEFC cooling to reduce the noise level at high speeds.

IC418 – Totally Enclosed Air Over (TEAO)

Description

The motor is totally enclosed in a smooth or finned casing, without any external fan. Instead, the motor is placed in an airstream generated by the application it powers.

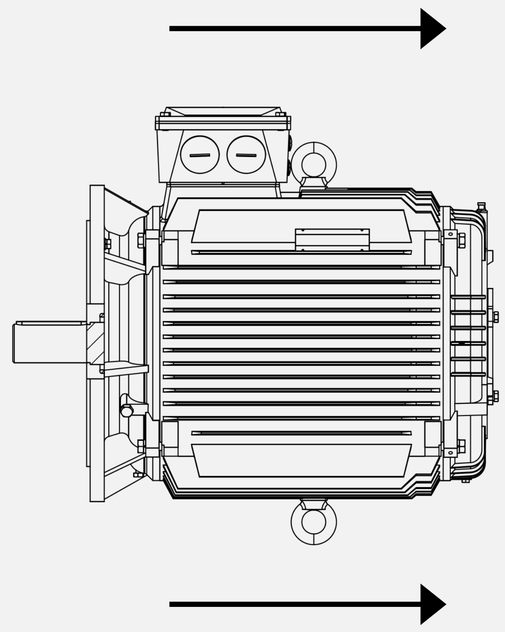
Applications

This method is often used for fans and especially axial fans or other HVAC applications including cooling towers.

Pros and cons

For motors mounted on fans, further cooling would be redundant, since the application already generates far more cooling than the motor fan would do. On the contrary, the extra cooling capacity provided by the application airstream makes it possible to reduce the motor size, since it can run at increased capacity.

On cooling towers, eliminating the motor mounted cooling fan makes it possible to install drain holes in V6 mounting without the motor fan "splashing" the water around.

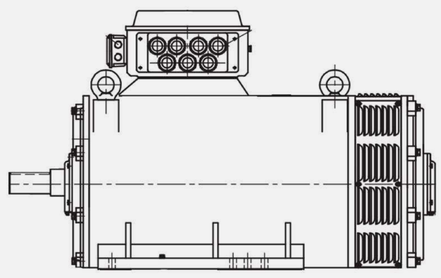


Alternative cooling methods

In some cases, special applications or environmental considerations may call for a different approach to cooling the motor than the typical methods. These usually require a high degree of customisation.

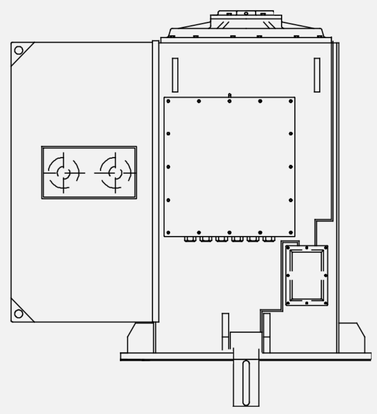
IC01 Open Drip Proof

Motors with vents in the casing (IP23) can be cooled by an internal fan. This method is only suitable for indoor use in carefully controlled environments, for applications such as bow thrusters, compressors, pumps, or high-power applications. The cooling air absorbs the heat at the source and transports hot air to the outside. The cooling effect is more intensive than in case of surface cooling such as IEC411. Compared to IC4XX less material is need for the active parts and the motor size can be reduced with same output. Using the motor in a highly polluted environment will shorten its lifespan.



IC8, 5, 6 Water-cooled

In general, water-cooled motors can be divided by two types of cooling – jacket cooling and cooling by heat exchanger (air/water). When using a heat exchanger the airflow is either arranged by a fan on the motor shaft or by an independent motor. The cooling medium has to be controlled on temperature, pressure and availability. Water-cooling it typically used for high powered medium and high voltage motors.



C01 Hydraulic Oil Submerged

Under the right conditions, it may be possible to submerge the motor in oil. This is especially used for hydraulic applications installed on deck or offshore applications. The advantages are more efficient cooling, lowered noise, and reduced sensitivity to harsh environments. However, the oil temperature must be carefully monitored and contamination from water or metal particles should be avoided.

Selecting the right cooling

When designing new applications, selecting the right cooling method can provide significant benefits. Optimal cooling of an electric motor boosts its performance, allowing for a smaller motor to be used and increasing energy efficiency while reducing cost.

As shown, many cooling methods are especially well suited for specific types of applications. But there are many important elements to consider when choosing how to cool your motor. The optimal cooling strategy depends on your application, the operating environment, lifetime requirements and more. And with insufficient cooling, you could risk burning out the motor windings after only a few minutes of operation in the wrong conditions.

To make the right decision, you can rely on Hoyer to provide advise and support. The technical team has extensive experience and a fully updated overview of the available alternatives and the pros and cons of the individual options.

Contact us today and let us help you keep your motor cool.

About Hoyer Motors

Hoyer Motors is an international supplier of high-end electric motors, drives and controls. Headquartered in Denmark and China, we are represented through sales offices and distributors worldwide.

We pride ourselves on being an elite manufacturing enterprise with the highest attention to service and flexibility – a company where dedication, competitiveness and reliability are second to none.

We have a focus on selected industrial markets including Marine, HVAC, Industrial Pumps, Oil & Gas, Wind and HPU. Through strong partnerships with leading OEMs within these markets, we offer a unique set-up and industrial insight. We add supply chain value by understanding the business and markets of our customers.

Together with our business partners, we strive to improve industrial energy efficiency and thereby reduce emissions.

Contact us

We are ready to support you with more insight on cooling. Please contact us if you have further questions.

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