

# AoFrio

WHITE PAPER

## IP protection: solving the problem of motor protection from moisture, water and dust in commercial refrigerators



## Overview

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Moisture, water and dust are common causes of motor failure in commercial refrigeration applications like refrigerated display cases, beverage merchandisers and vending machines. IP ratings are often used by motor manufacturers to indicate how tolerant their products are to these conditions.

This white paper discusses the meaning and effectiveness of different motor IP ratings in commercial refrigeration applications, and compares moisture, water and dust protection for AoFrio's Wellington™ ECR motors to the ratings of other common types of refrigeration motors.

## 1. IP ratings

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Ingress Protection (IP) ratings are a standardized method established by the International Electrotechnical Commission (IEC) to describe the ability of enclosures of electrical devices to withstand exposure to dust particles and water. IP ratings are defined by IEC standard 60529.

These ratings consist of the letters "IP" followed by two numbers. The first number denotes the degree of protection against foreign objects and dust's access to sensitive parts of the motor, ranging from 0 (not protected) to 6 (dust tight). The second number indicates the degree of protection against water, which ranges from 0 (not protected) to 8 (suitable for continuous immersion).

Tables describing the meaning of individual IP ratings are found at the end of this white paper.

## 2. The problem

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Electric motors used in refrigeration applications require protection against moisture, water and dust due to the environment found in refrigerated display cases, beverage merchandisers and vending machine condensers and evaporators. Motors are typically exposed to the following elements:



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- **Water from condensation forming on cooled parts**

Condensation is common in the cold space of all types of commercial refrigerators.

- **Melting of built-up ice**

Ice on evaporators is melted during defrost cycles and water from this often drips onto motors. In low temperature applications, it is also not uncommon to find built-up ice melting over the motors because of the heat radiated by the motors themselves. This problem is less significant in the case of ECM motors because they generate less heat than shaded pole and PSC induction products.

- **Water jet spraying**

In applications containing food, like refrigerated display cases, the lower portion of display cases are periodically cleaned with water sprayed by a hose in order to meet sanitation and cleanliness standards. Motors are also sprayed during this process.

- **Spillage**

Liquid products stored in the refrigerator can be spilled, and where evaporators are mounted below the product, this spillage often finds its way onto evaporator fan motors.

- **Dust**

In self-contained refrigerators, condenser fans are often mounted low in the refrigerator and suck air in from the outside. This leaves them highly exposed to a build-up of dust from the external environment. In open-front coolers, dust is often introduced through the air curtain and recirculated by the fan blades.

Dust ingress is hazardous to motors because it contaminates bearing grease leading to rapid failure, blocks air circulation leading to motor overheating, and increases the risk of electrical short circuits.

Water ingress is hazardous because it causes electrical short circuits, corrosion and can contaminate bearing grease.

### 3. Refrigeration motors IP ratings

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Shaded pole motors are commonly used in commercial refrigeration applications and are typically rated IP42 or IP44. These motors often suffer from water ingress, especially if not mounted horizontally. Also, because of their low efficiency, these motors generate a lot of heat that makes water evaporate more quickly when water droplets do enter the motor. Water and dust ingress will shorten a shaded pole motors' life, but water ingress is less likely to cause rapid failures in shaded pole motors than in ECMs. Shaded pole motors also tend to have a shorter life than ECMs due to their greater self-heating and poor starting torque, which reduces the effective bearing life. Lower IP rating is therefore more likely to be tolerable in shaded pole motors, particularly if long life is not a concern.

ECM motors for commercial refrigeration applications are offered with varying IP ratings ranging from IP42 to IP67. Electronically commutated (ECM) motors require higher degrees of protection to avoid getting the electronic control wet, as electronics do not mix well with water. An IP42 rating leaves the ECM motor open to the ingress of dust and indicates very limited protection against moisture and none against water jet spraying.



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Because ECM motors typically have ball bearings, they can be mounted at any angle so water resistance from all directions is required. Further, short-term water ingress is hazardous to electronic controls so protection from hose down washings is necessary. AoFrio therefore recommends that *all refrigeration fan ECMs be rated at IP55 as a bare minimum.*

However, it is important to understand that, apart from the IPx8 rating test, IP certification tests are all of short duration. Over their lifetime, refrigeration motors are subject to many effects that reduce their water and dust tolerance: these include wear on seals and other moving parts, vibration, and thermal cycling. There are also water ingress mechanisms, such as capillary action, and “pumping” past seals due to expansion and contraction of trapped air inside the motor. In particular, pumping causes water ingress at a rate too slow to be detected in the IP certification test. To give peace of mind, especially for long life applications or where the design exposes motors to continual dripping, *AoFrio recommends the use of ECMs with the highest IP rating available.*

#### **4. AoFrio’s Wellington™ ECR solution**

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Wellington ECR motors are specifically designed for commercial refrigeration applications. This makes them highly resistant to all environments typically found in refrigerated display cases, beverage merchandisers and vending machines, including low temperature applications and those with defrost cycles.

Our ECR 01 and ECR 82/92 motors have been independently tested to IP55 standard according to IEC60529. They are suitable for everyday refrigeration applications where purchase cost is the major driver.

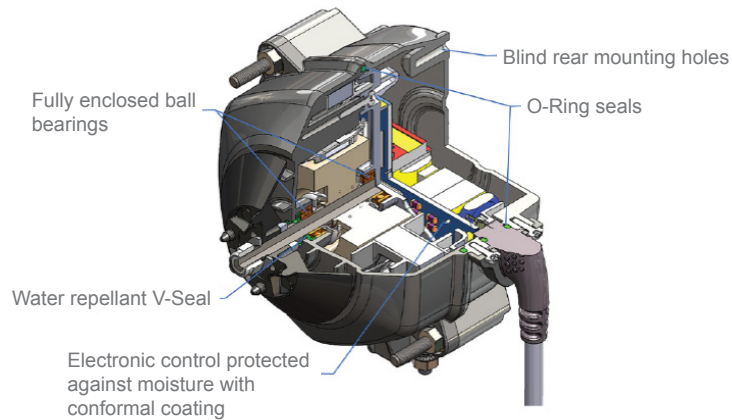
Our **Wellington ECR 2** motor has been designed to be the most reliable and flexible ECM in the market. This includes having best in class ingress protection to minimize the chance of water or dust ingress shortening its life. The ECR 2 motor has been independently tested to IP67 standard, proving that it is even capable of running underwater in the test’s conditions. This provides a comfortable buffer against the circumstances likely to be encountered in a refrigeration application over time. Note however that as AoFrio provides customerspecific connectors on ECR motors, to get the full benefit of the IP67 rating either the connectors must also be IP67 or IP68 rated, or the cable end must be located in a position protected from moisture.

As well as the IP rating test, AoFrio tests all ECR motor designs using a 2,500 hour water spray test per MIL-810G part 506.5. During this test, the motor duty cycle is one hour on, five minutes off while under continuous water spray to allow thermal cycling of the air volume inside the motors to maximize the chance of leakage.



Wellington ECR 2 motors achieve a degree of protection that allows them to solve all the moisture, water and dust problems typical of commercial refrigeration applications with the design features illustrated in Figure 1 below.

**Figure 1. ECR 2 motors moisture, water and dust resistance features**



In the IP rating system, each digit and value corresponds to a specific level of protection that the motor provides. The first digit relates to protections for humans and motor components (Table 1) and protections against solid foreign objects (Table 2). The second digit shows protections against water (Table 3).

**Table 1 - Protections provided to humans as well as components in the motor**

First characteristic digit	Degree of protection	
	Brief description	Definition
0	Non-protected	-
1	Protected against access to hazardous parts with the back of a hand	The access probe, sphere of 50 mm , shall have adequate clearance from hazardous parts
2	Protected against access to hazardous parts with a finger	The jointed test finger of 12 mm , 80 mm length, shall have adequate clearance form hazardous parts
3	Protected against access to hazardous parts with a tool	The access probe of 2,5 mm shall not penetrate
4	Protected against access to hazardous parts with a wire	The access probe of 1,0 mm shall not penetrate
5	Protected against access to hazardous parts with a wire	The access probe of 1,0 mm shall not penetrate
6	Protected against access to hazardous parts with a wire	The access probe of 1,0 mm shall not penetrate

**Table 1 - Protections provided to humans as well as components in the motor (continued)**

NOTE: In the case of the first digit being 3, 4, 5 or 6, protection against access to hazardous parts is satisfied if adequate clearance is kept. The adequate clearance should be specified by the relevant product committee in accordance with 12.3.

Due to the simultaneous requirement specified in Table 2, the definition “shall not penetrate” is given in Table 1.

From: International Electrotechnical Commission Central Office Switzerland. International Standard IEC 60529 Edition 2.1. 2001-02

**Table 2 - Protections provided against solid foreign object penetration**

First characteristic digit	Degree of protection	
	Brief description	Definition
0	Non-protected	-
1	Protected against solid foreign objects of 50 mm and greater	The object probe, sphere of 50 mm , shall not fully penetrate <sup>1)</sup>
2	Protected against solid foreign objects of 12,5 mm and greater	The object probe, sphere of 12,5 mm , shall not fully penetrate <sup>1)</sup>
3	Protected against solid foreign objects of 2,5 mm and greater	The object probe, sphere of 2,5 mm , shall not penetrate at all <sup>1)</sup>
4	Protected against solid foreign objects of 1,0 mm and greater	The object probe, sphere of 1,0 mm , shall not penetrate at all <sup>1)</sup>
5	Dust-protected	Ingress of dust is not totally prevented, but dust shall not penetrate in a quantity to interfere with satisfactory operation of the apparatus or to impair safety
6	Dust-tight	No ingress of dust

1) The full diameter of the object probe shall not pass through an opening of the enclosure.

From: International Electrotechnical Commission Central Office Switzerland. International Standard IEC 60529 Edition 2.1. 2001-02

**Table 3 - Protections against water penetration**

First characteristic digit	Degree of protection	
	Brief description	Definition
0	Non-protected	-
1	Protected against condensation and vertically falling water drops	Vertically falling drops shall have no harmful effects
2	Protected against vertically falling water drops when enclosure tilted up to 15°	Vertically falling drops shall have no harmful effects when the enclosure is tilted at any angle up to 15° on either side of the vertical
3	Protected against spraying water drops	Water sprayed at an angle up to 60° on either side of the vertical shall have no harmful effects



**Table 3 - Protections against water penetration (continued)**

First characteristic digit	Degree of protection	
	Brief description	Definition
4	Protected against splashing water drops	Water splashed against the enclosure from any direction shall have no harmful
5	Protected against water jets	Water projected in jets against the enclosure from any direction shall have no harmful effects
6	Protected against powerful water jets	Water projected in powerful jets against the enclosure from any direction shall have no harmful effects
7	Protected against immersion in up to 1 meter of water for up to 30 minutes	Ingress of water in quantities causing harmful effects shall not be possible when the enclosure is temporarily immersed in water under standardized conditions of pressure and time
8	Protected against the effects of continuous immersion in water	Ingress of water in quantities causing harmful effects shall not be possible when the enclosure is continuously immersed in water under conditions which shall be agreed between manufacturer and user but which are more severe than for numeral 7

*From: International Electrotechnical Commission Central Office Switzerland. International Standard IEC 60529 Edition 2.1. 2001-02*

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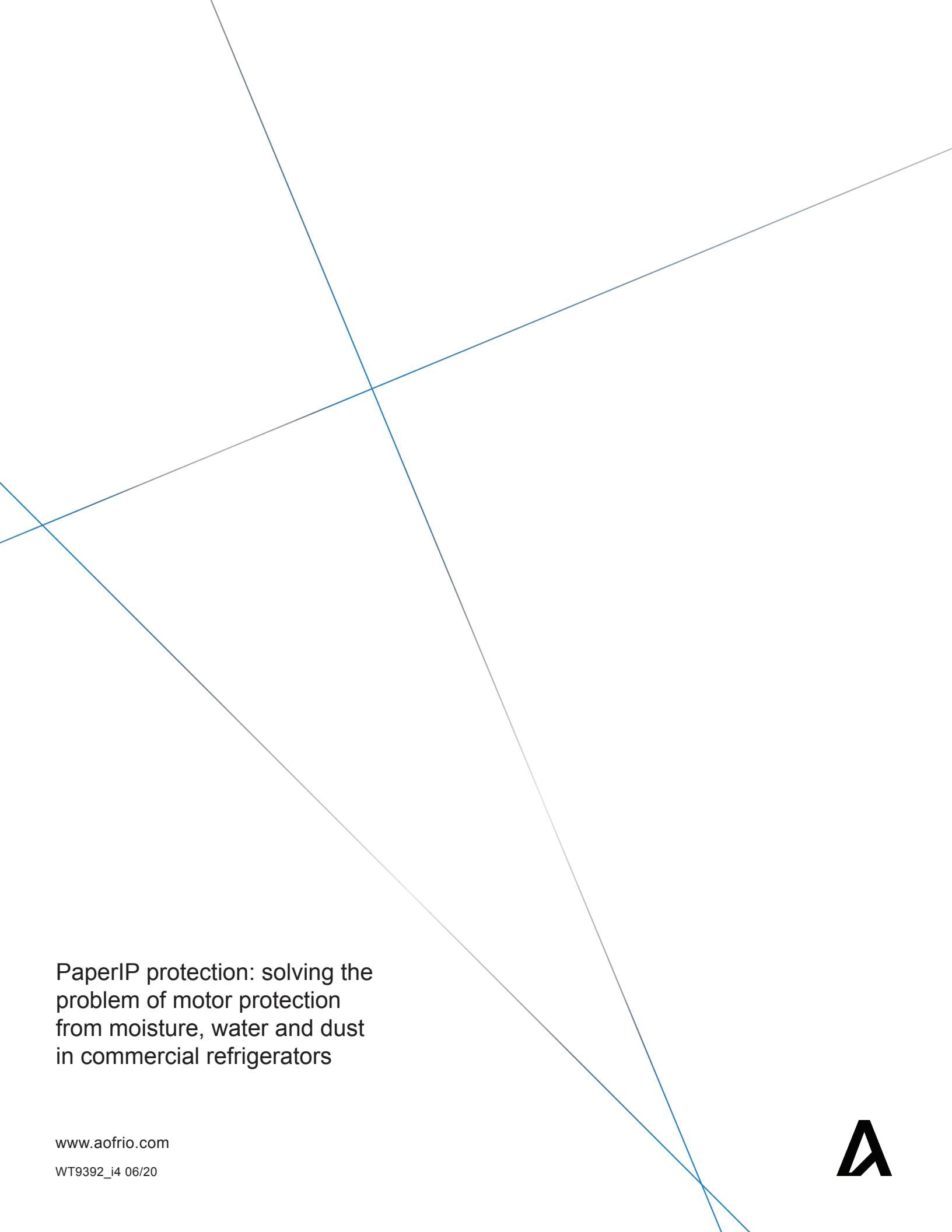
**About AoFrio Limited:**

AoFrio is a leading provider of IoT solutions, cloud-based fleet management platforms, energy-efficient electronic motors and connected refrigeration control solutions. It serves some of the world's leading food and beverage brands and refrigerator manufacturers and offers proximity-based marketing for Smart Cities to the Australian market. AoFrio's services and products improve sales, decrease costs and reduce energy consumption. Headquartered in Auckland with a global reach, AoFrio is listed on the New Zealand stock exchange under the ticker symbol NZ: AOF

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