CROP-PROTECTOR® Chiller


# CROP-PROTECTOR®
# Chiller

## Superior chilling

**Based on**

- ✓ Hi-Tec components
- ✓ iGRAIN sensors
- ✓ iGRAIN control technology

# Grain Chilling Theory

## Why grain chilling?

Grain is the foundation of our culture, and grain is at the root of almost all food and feed supply chains. The worldwide total harvest of grains is in excess of 2.200 million tonnes per year.

A lot of grain is stored and consumed locally, but an increasing part of the total grain harvest is distributed around the world and undergo long and complex transport routes. The grain may go through several intermittent stages, before it is permanently stored in a silo prior to consumption in a food or feed processing plant.

According to FAO (Food and Agriculture Organization of the United Nations) the annual losses of grain harvested worldwide is over 20%. These losses are primarily caused by poor storage and inefficient monitoring and control. The total losses would feed more than all starving people on the planet!

During storage many factors have an impact on the losses, one of the most important is infestation by insects and fungi along with other micro-organisms, if the grain is not stored at a safe temperature and humidity. In many cases grain cooling is the best solution to cope with infestation problems and secure safe storage.

Grain cooling has become an important tool for many grain storagers to keep their stored grain free from infestation and the grain safe for a long period of time.

**There are many reasons to use grain chilling - here are some of the most important:**

- Ambient temperature is increasing in many parts of the world due to climate changes. Chilling keeps the grain cool
- Infestation has become an increasing problem. Cooling keeps insects etc. dormant
- Fumigation with toxic gases is less and less effective because of increased immunity (Grain Weevil, Lesser Grain Borer and Indian Meal Moth)
- Increased consumer demand for organic grain that has not been treated with pesticides

## Grain temperature

Each grain is a living organism, and its biological respiration is low when stored in safe conditions. The grain is waiting for an opportunity to sprout, and will sprout when the right biologic environment is present.

The respiration and the associated energy (heat) generation is often shown as:

$$C_6H_{12}O_6 + 6\,O_2 \longrightarrow 6\,CO_2 + 6\,H_2O + 677\ \text{kcal/mole}$$

Carbonhydrates + Oxygen → Carbon dioxide + Water + Heat

The grain respiration is low during safe storage. With chilling the grain can be put to “sleep”.

If grain is stored at a high temperature for longer periods, it may affect other parameters in the grain negatively and can lead to spoilage and losses.

The key to safe grain storage is controlling the temperature and humidity to have a low respiration and prevent infestation from insects and fungi to develop. For long time storage a temperature of 10 - 15 degrees Celsius and a grain moisture concentration of 12 – 14% (depending on commodity type) is an optimal condition to keep the grain safe.

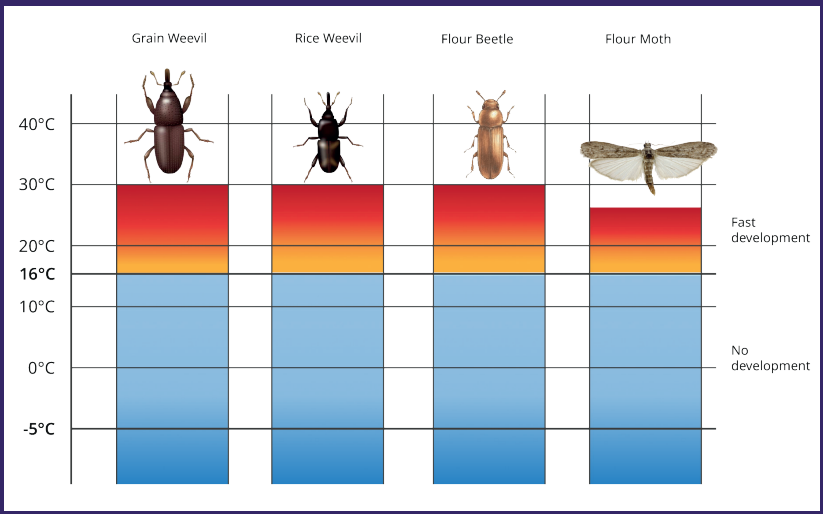
Most infestation starts with insect infestation which leads to fungus infestation because of the insect respiration wetting the grain.

Insects

Time with increased moisture

Fungi & Aflatoxin

With the grain Chiller the temperature can be controlled to prevent insect growth, as illustrated.



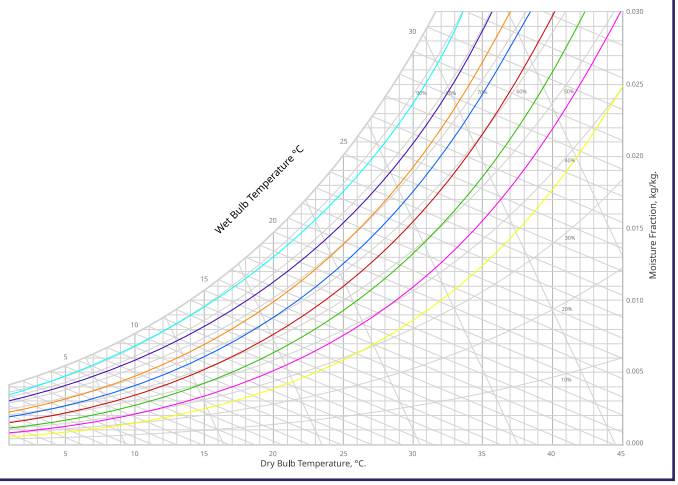

## Grain moisture

The grain moisture (absolute moisture %) can be controlled by controlling the relative humidity in the air surrounding the grain. This is possible because the grain cell membrane passively regulates the diffusion of moisture through the cell membrane. This is called Equilibrium Moisture Concentration (EMC). Figure A shows different EMCs in % values for wheat, and corresponding ambient temperature and relative humidity values.

Figure A - EMC values concerning wheat

| Temperature | Relative humidity in % | | | | |
|---|---|---|---|---|---|
| °C | 40 | 50 | 60 | 70 | 80 |
| 5 | 11,7 | 13,1 | 14,6 | 16,1 | 17,9 |
| 10 | 11,3 | 12,7 | 14,2 | 15,7 | 17,4 |
| 15 | 11,0 | 12,4 | 13,8 | 15,2 | 17,0 |
| 22 | 10,6 | 11,9 | 13,3 | 14,7 | 16,4 |
| 26 | 10,4 | 11,7 | 13,0 | 14,4 | 16,1 |
| 28 | 10,3 | 11,6 | 12,9 | 14,3 | 15,9 |

Figure B - Psychometric diagram




If one of the three parameters: temperature, relative humidity or absolute grain moisture are changed then the other parameters will change correspondingly. If temperature is kept constant, any change in humidity in the air will directly affect the grain moisture and vise-versa.

The psychometric diagram equations as shown in figure B, are used to calculate such changes. By changing the relative humidity of the air directed into the silo, EMC of the stored grain can be increased or decreased.

# The Chilling Process

## Humidity and grain temperature

In the process of chilling the grain, the chilled air flows through the grain in the silo. When cold air is moving up through the silo, the grain is cooled down. This shifts the equilibrium between relative humidity in the cooling air, and the grain moisture inside the grain.

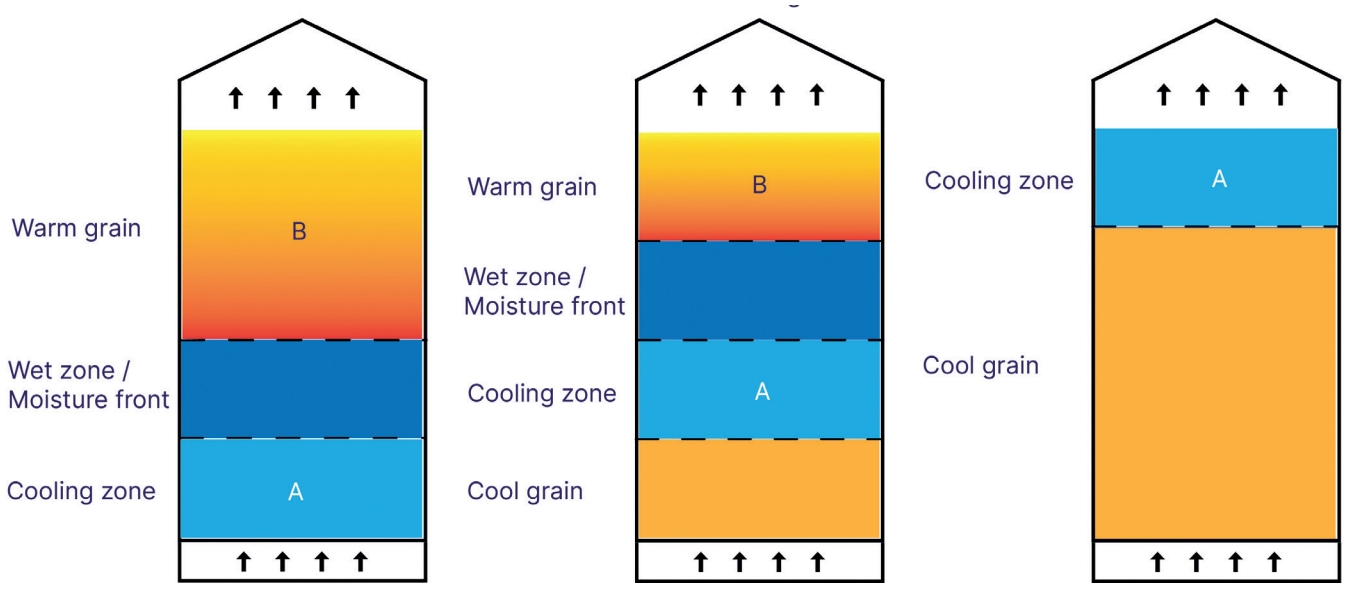
The EMC concentration is now shifting, and the grain is subject to diffusion of moisture out of the grain kernels and thereby raising the relative humidity in the flowing air. This moisture is then flowing upwards through the grain.

Eventually the air will reach a relative humidity close to the dew point, and the grain will start to become wet on the surface.

## Progression of the chilling process

- Initially the lowest grain is cooled first in the cooling Zone A (See illustration below)
- The grain above the cooling zone is getting wetted, called the wet zone. A moisture front starts to move up the silo
- Above the wet zone, the relative humidity goes down again because the flowing air is now heated to the grain temperature, and the grain is hardly influenced by the grain cooling below (Zone B)
- Over the course of time, the cooling zone moves up the silo until all the grain has been cooled
- Chilling grain will always be at the “cost” of some moisture loss from the grain

**Representation of the progression of the chilling process**




## Advantages of the chilling technology with CROP-PROTECTOR Chiller

- Allows the grain to be stored safely in any climatic zone
- Reduces the risk for infestation with insects and fungi significantly
- Keeps the stored grain at a high quality for a long time
- The automatic control system with feedback from the sensor lance in the silo is a game changer in chilling performance

# CROP-PROTECTOR Chiller

## A unique way to preserve your stored crop, avoid infestation and increase profit

When crops are chilled to a temperature below 16 degrees Celsius, unwanted biological activity, such as insects, mites and fungus growth is interrupted and insect procreation will cease. Any type of grain, seed, oilseed, bean, nut, meal etc. can be chilled by the CROP-PROTECTOR Chiller.

The Chiller is designed, based on extensive knowledge of safe and efficient crop storage. The Chiller is unique, high-quality and durable. We utilise an air flow capacity much higher than the competition. The Chiller is easy to operate via the touch screen computer and it is equipped with all necessary safety precaution devices and switches.

**The Chiller has proven cost effective, with a normal payback period of 8-24 months depending on use.**

## Working principle

The Chiller can adapt to any temperature and humidity conditions. It works in any climatic zone and ensures that the grain is chilled gently, with reduced risk of condensation issues. It is designed to cool the grain with minimum loss of moisture, thus avoiding shrinkage and increasing profit. This process requires consideration of the EMC so that the cooling occurs at the correct relative humidity in the chilled air. The Chiller control system is designed in a special way to reduce this risk and make the chilling safe with little power consumption. The target temperature can be set in the start menu irrespective of commodity type and climatic zone.

## High volume chilling

The Chiller is equipped with a very strong fan. This allows the chilled air to pass through the grain mass at a high speed, cooling the grain uniformly and minimising large temperature differences between different grain layers in the storage silo. The Chiller has a very strong fan and an exceptional cooling capacity. The Chiller is connected to the silo with a flexible air duct. The cooled and dehumidified air is blown via the hose into the silo plenum and blown up into the grain.

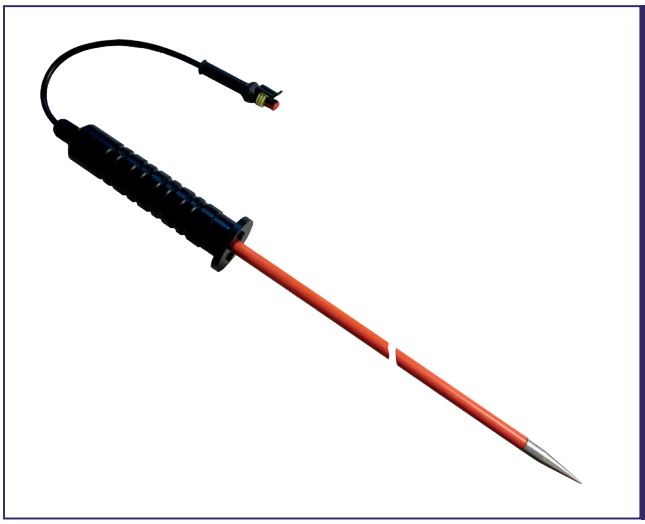
The high volume pressure fan is of great advantage because a successful chilling process is in most cases dependant on a high flow rate. This stretches out the wet zone and reduces the wetting of the grain, if the control system is designed for that. However, when chilling grain there is always a risk of wetting the grain too much and for too long. This increases the risk of fungus growth and consequent Mycotoxins.

CROP-PROTECTOR Chiller: Chilling two silos at a time

## Chiller applications

The Chillers can be adapted to almost all types of silos and bulk storage warehouses. Normally the existing aeration system is used for the chilled air injection, so it is normally easy to connect the Chiller. In warehouses the air is distributed via a duct system that can be designed and installed to obtain the highest chilling efficiency for your needs.

Each Chiller comes with a 4m iGRAIN Sensor Lance with two grain temperature and two grain moisture sensors. These enable a control loop to optimise the chilling efficiently with reduced risk of wetting the grain during the chilling process.



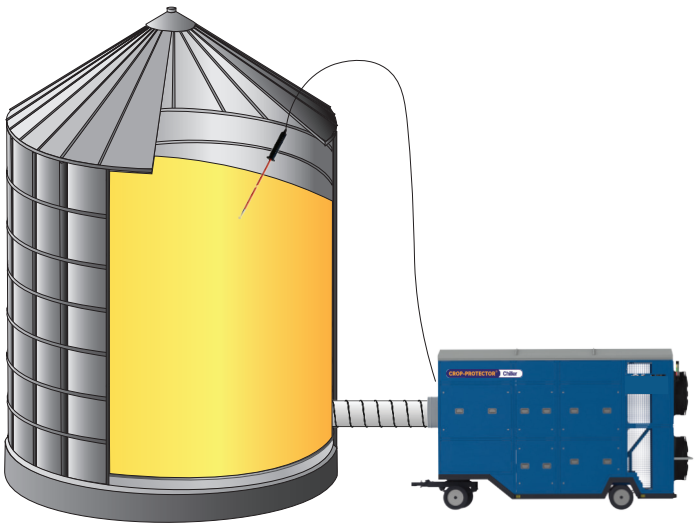
### Key component: iGRAIN Sensor Lance

The key component in the chilling process is the iGRAIN Sensor Lance giving unique feedback from the commodity sensor measuring grain temperature and humidity. This feedback is essential to optimum chilling results.
A 4m sensor lance placed into the top of the grain is measuring temperature and moisture concentration in the grain. The lance is connected to the Chiller and alerts the grain manager when the chilling process has reached its target. Data are shown directly in the iGRAIN Smart App.

### Optimum results through:

- Very high flow through the grain
- A speed control of the fan to adapt to varying conditions in the grain condition in the silo and varying ambient conditions
- Variably cooling depending on the grain condition
- To have the key parameters under control it is important to have a sensor lance that provides feedback to the control system. See Figure C where the iGRAIN Sensor Lance is providing vital information about the progress of the chilling process
- Fully automated chilling process.
- Remote control on the iGRAIN Smart App

**Figure C - iGRAIN Temperature Lance feedback to Chiller**



### Chilling advantages

- Slows the respiration of the grain
- Stop emerging infestations at an early stage
- Store the grain freshly for a longer period
- Secure the quality of the stored crop
- Optimise the use of your grain
- Avoid use of toxic fumigation
- Avoid losses caused by unwanted biological activity
- Air cooled

## Advanced and simple to use control system (HMI)

The control system is centered around the 7” HMI touch panel PLC. It has a user friendly software and makes it esay to operate the Chiller. The user can select the operating mode from a menu with a few programs to match the need.

## Modes of operation

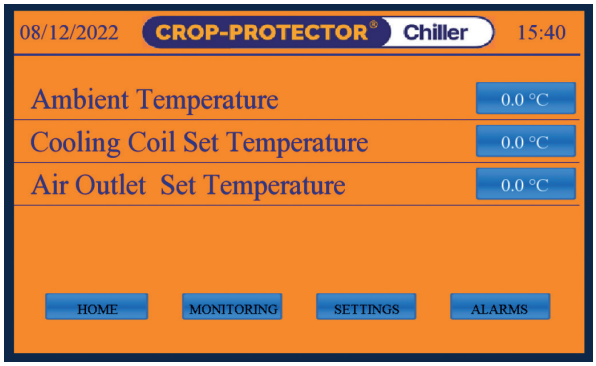
**Normal Cooling Mode:** It automatically works toward the set target temperature. All control processes are adjusted by the PLC. The system capacity is regulated according to the required cooling. The evaporator fan and air flow rate automatically increase or decrease to achieve the desired condition of the grain. Likewise, compressor and condenser fans work as required.

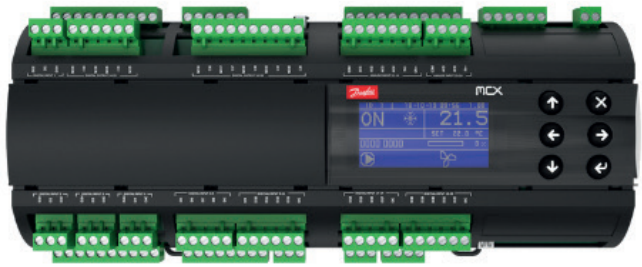
**Super Cooling Mode:** In Super Cooling Mode, compressors and evaporator fan operate at maximum cooling power. In this mode, the Chiller operates for 30 minutes or longer regardless of the outdoor temperature. This may be required in some emergency situations.

**Cascade Cooling:** In this mode the grain is cooled down stepwise to avoid wetting the grain. This mode facilitates the safest cooliing process, and takes longer time than the other cooling modes.

**Aeration Only Mode:** In this mode the Chiller is used to take advantage of favourable ambient condition and cool the grain based on low ambient temperature or air at a desired humidity level.

**Silent Cooling Mode:** In this mode the noise level in the Chiller is reduced. The cooling power decreases depending on the ambient temperature. This mode is often used at night, if the Chiller is operating near inhabited areas.

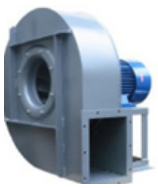



## Key components in the Chiller

### High pressure centrifugal fans

Provide sufficient air volume and pressure to assure high air volume chilling. Up to 6.000 Pascals.
The air flow can be regulated between 35% and 100% via the inverter.



### Two high quality compressors

Used for the cooling cycle in the operation and cooling control.
The control system will automatically use one or both compressors for most efficient operation.

### Remote control and monitoring

The Chiller connects to LAN Ethernet or GSM technologies.
The operational status can be monitored remotely.

### Connection hoses

Flexible hose connection of the Chiller to the silo. The hoses can be provided at 5m, 10m or 15m.

# Technical Specifications

| CROP-PROTECTOR Chiller | CP 100A | CP 160A | CP 240A | CP 320A |
|---|---|---|---|---|
| **Performance** | | | | |
| Cooling capacity (tonnes/day) [1] | 220 - 430 | 280 - 600 | 360 - 800 | 530 - 1500 |
| Compressor cooling capacity (kW) [2] | 100 | 160 | 235 | 320 |
| Re-heating capacity (kW), optional | 24 | 30 | 30 | 45 |
| Air flow rate (m3/h) @1000Pa | 13.000 | 18.000 | 27.000 | 35.000 |
| Max. external static pressure (Pa) | 6.000 | 6.000 | 6.000 | 6.000 |
| Refrigerant | R407C | R407C | R407C | R407C |
| Max. ambient operating temperature | 45°C | 45°C | 45°C | 45°C |
| Cooling capacity control | 0-50-100 | 0-50-100 | 0-50-100 | 0-50-100 |
| **Structural Features** | | | | |
| Compressor | Optional: Hermetic scroll or semi-hermetic reciprocating | | | Semi-hermetic reciprocating |
| Number of refrigerant circuits | 1 | 1 | 1 | 1 |
| Number of compressors | 1 or 2 [3] | 1 or 2 [3] | 2 | 2 |
| Condenser cooling | Axial air fan | | | |
| Number of condenser fans | 2 | 4 | 4 | 4 |
| Cold air blower fan type | High pressure centrifugal fan | | | |
| Blower fan motor (frequency controlled) | Direct drive | | | |
| Drain pan | Stainless steel | | | |
| Heater (optional) | Electric heater | | | |
| Air hose diameter / quantity (Ø mm) | 1 x Ø 356 | 1 x Ø 600 | 1 x Ø 600 | 1 x Ø 800 |
| Drain connection size (inch) / quantity | 2 × 1" | 2 × 1" | 2 × 1" | 2 × 1" |
| **Electrical Features** | | | | |
| Compressor power input (kW) | 2×12 | 2×16 | 2×23 | 2×30 |
| Blower fan max. power input (kW) | 30 | 30 | 37 | 55 |
| Condenser fan max. power input (kW) | 2 × 2,3 | 2 × 1,9 | 4 × 1,9 | 4 × 2 |
| Total power input (kW) [4] | 83 | 100 | 124 | 168 |
| Total max. current (A) | 175 | 210 | 300 | 340 |
| Circuit breaker (A) | 140 - 200 | 175 - 250 | 220 - 320 | 280 - 400 |
| Power supply (standard) | 400VAC/3Ph/50Hz | 400VAC/3Ph/50Hz | 400VAC/3Ph/50Hz | 400VAC/3Ph/50Hz |
| **Weight & Dimensions** | | | | |
| Dimensions (LxWxH - cm) | 460×155×250 | 470×215×250 | 565×215×250 | 595×225×290 |
| Net weight (kg) [5] | 2650 | 3000 | 3950 | 5100 |

1. Grain cooling capacity estimated at outdoor temperature 20° C and 52% relative humidity. Daily grain cooling capacity may vary depending on the climatic conditions, the type of grain in the silo or other conditions.
2. Compressor cooling capacity values calculated for 10° C evaporation and 45° C condensation temperatures.
3. The values given are in case of two compressors. Determined in the purchase process.
4. Power consumption estimated at nominal operating conditions. It may vary at different temperatures etc.
5. Weight may vary depending on options selected.

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