
Turbocor Compressor Technology for liquid chiller applications



Danfoss Turbocor Compressors Inc.

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Introduction

Danfoss Turbocor Compressors

- The world's first totally oil-free compressor
- Specifically designed for the Heating, Ventilation, Air Conditioning and Refrigeration (HVAC-R) industry
- The convergence of proven aerospace and industrial technologies which include magnetic bearings, variable-speed centrifugal compression and digital electronic controls
- ➔ Enable the Turbocor family of compressors to achieve the highest overall efficiencies for middle-market, water-cooled, evaporative cooled and air-cooled HVAC-R applications

Facts about Danfoss Turbocor

A short history

Turbocor started as an R&D company in Australia with an international team of designers and engineers

1993



First Turbocor compressors in the field get installed in California

2000



Danfoss Turbocor completes its move to Tallahassee, Florida to a new, larger, and state-of-the-art facility creating new production standards, and expanding its product line

2007



1999



Turbocor moves to Montreal
Stage-one manufacturing plant, testing and engineering labs, and training facility were established

2004



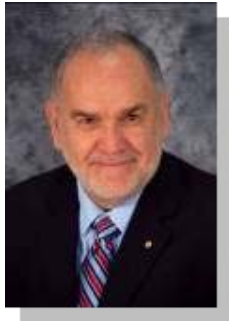
Danfoss and Turbocor form a 50/50 joint venture called Danfoss Turbocor

2009



Serious scale reached

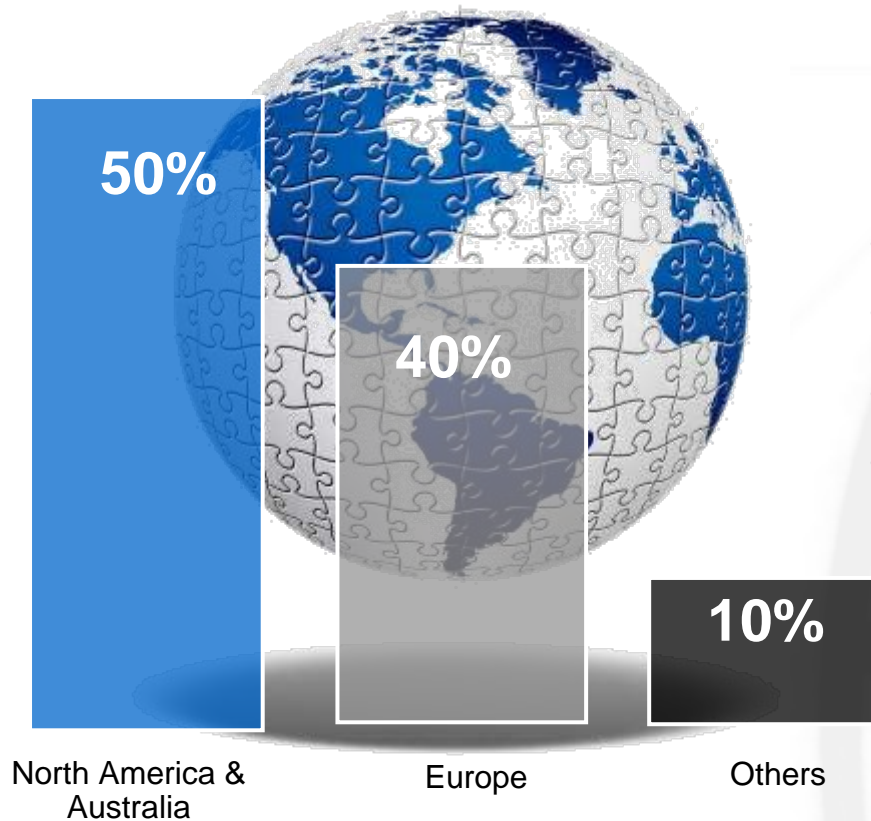
- >15,000 compressors running in the field
- ~40 million operating hours



Ron Conry
Founder

Facts about Danfoss Turbocor

Sales split



- **Sales:**

30% growth 2007 - 2008
25% growth 2008 - 2009
expansion 2009 - 2010

- **Plant:** 65,000 square feet
- **Location:** Tallahassee, Florida
- **Employees:** ~180
- **Markets:**
 - USA
 - Canada
 - Europe
 - China
 - Australia

Facts about Danfoss Turbocor Recognition



2003 (Ashrae) AHR - USA
Energy Innovation Award



2008 Institute of Refrigeration – England
J&E Hall Gold Medal



2005 Natural Resource Canada – Canada
Energy Innovation Award



2004 Environmental Protection Agency – USA
Climate Protection Award



Danfoss Turbocor is certified
ISO 9001:2000



2006 Frost & Sullivan - USA
Technology Leadership of the Year
Award



Making a world of difference.

What are the current drivers for building owners & consultants today?

A hand is shown with the index finger pointing towards a power button icon. The background is a blurred image of a person in a white lab coat.

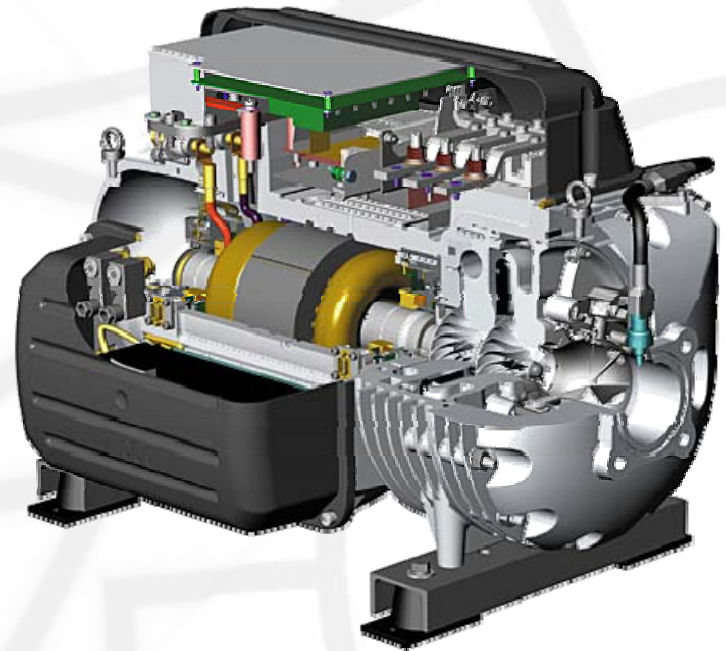
Capital costs
Reliability
Floor space
Comfort / Noise
Life cycle costs
Return on investment

However, a wave is now heading for high efficiency and green!

The advantages of the Turbocor technology

Many people see its advantages in different ways, some of these include:

- HFC refrigerant for optimum environmental position
- Outstanding part load efficiency
- High full load efficiency
- Intelligent, self-contained control
- Light weight
- Low vibration
- **Oil free operation** reduces complexity and cost, improves heat exchange efficiency and eliminates disposal issues
- Very low sound
- Soft Starting
- Small footprint



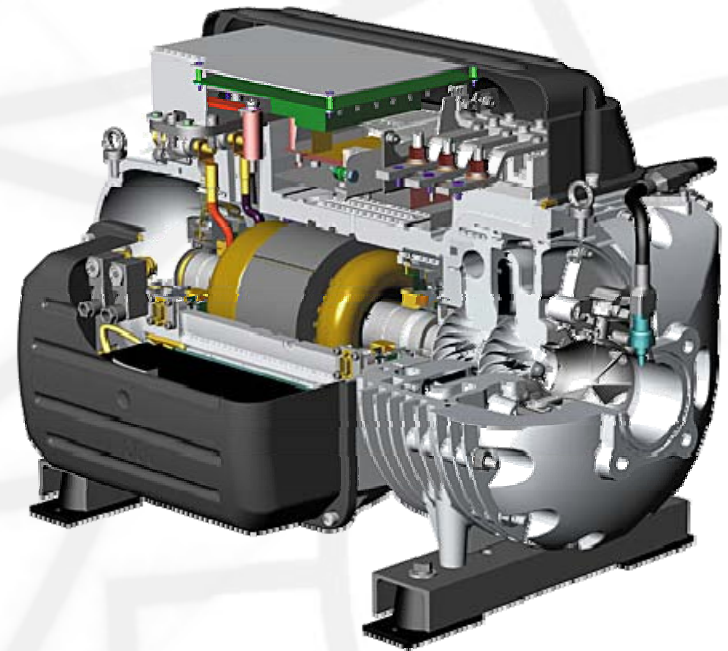
The advantages of the Turbocor technology

The energy efficiency

Turbocor is one of the most efficient compressors in the world

This achievement comes from several factors among these are:

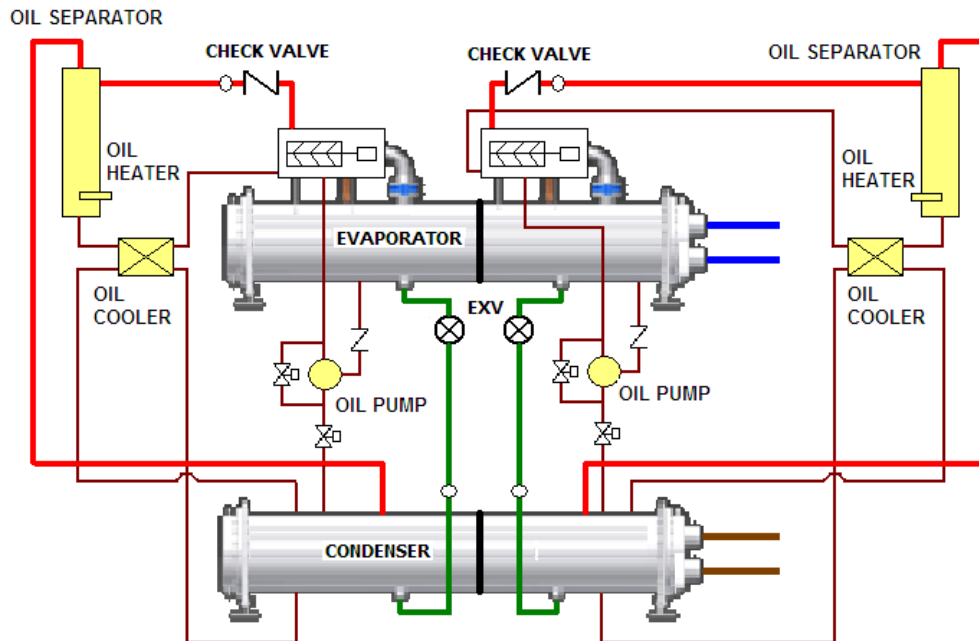
- The bearing technology
- The motor technology
- The power electronics technology
- The compression technology and
- The combination of all of these features into one product



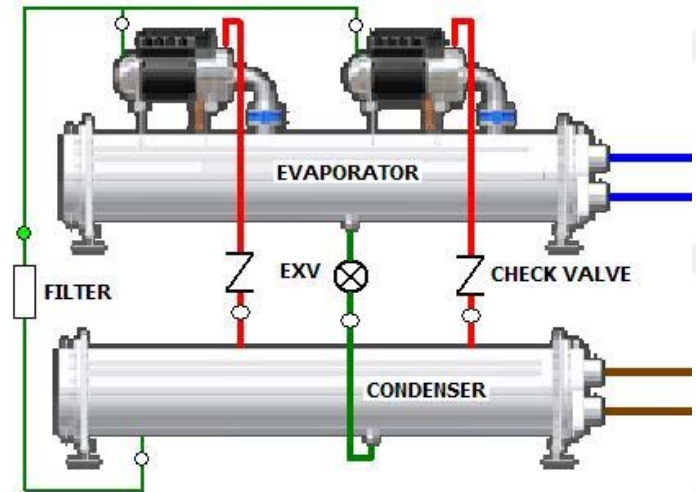
The advantages of the Turbocor technology

Oil free technology

Typical screw water-cooled chiller



Oil-free water-cooled chiller

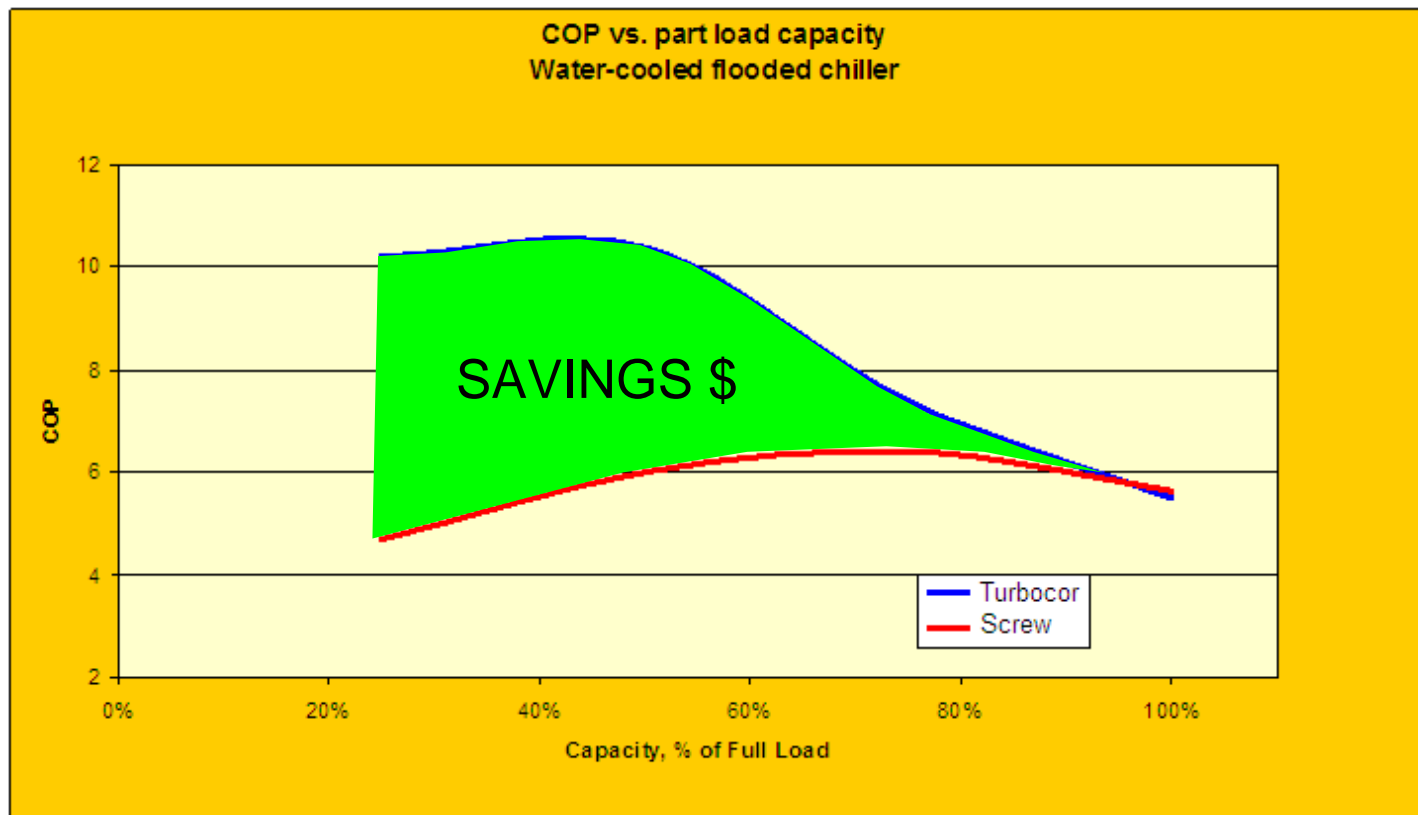


- Eliminate oil film on heat transfer surfaces
 - Eliminate stacking of oil in evaporator at lower loads
 - No disposal required
 - No oil heater and cooler
 - No oil separator
 - No oil pump, oil solenoid valves, oil filter
 - No oil pressure transducer
- Simplify application and reduce cost

The advantages of the Turbocor technology

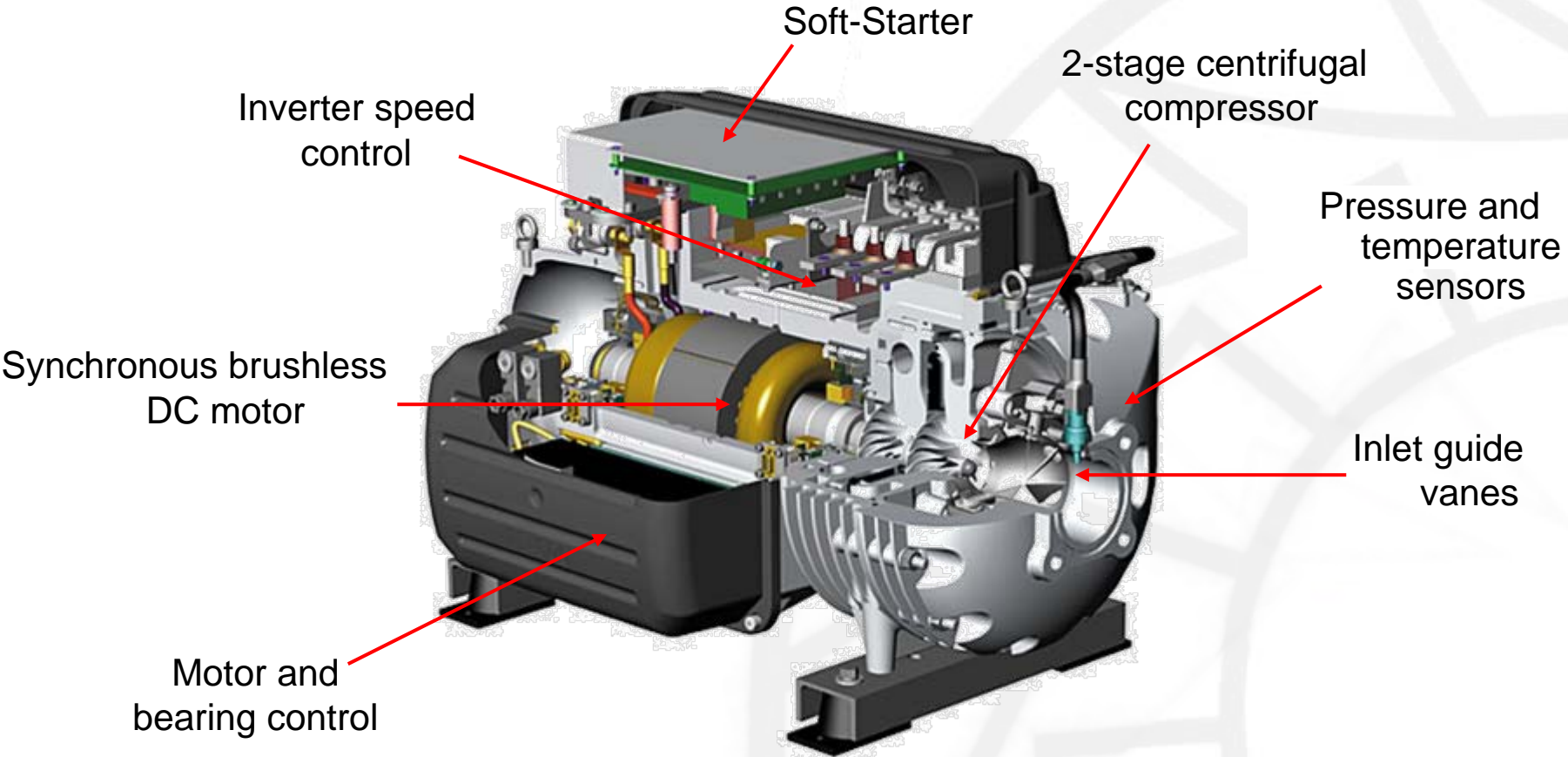
Performance comparison

The first cost component (design, equipment procurement and construction) is small compared to the total cost of ownership



Description of the Turbocor technology

It is a fully integrated system



Description of the Turbocor technology

The working end

It is a centrifugal compressor that:

- Is two stage
- Has an economizer feature
- Operates on R134a
- Has infinitely variable capacity control
- Uses guide vanes and diffusers to optimize its performance
- Does not require oil for compression sealing

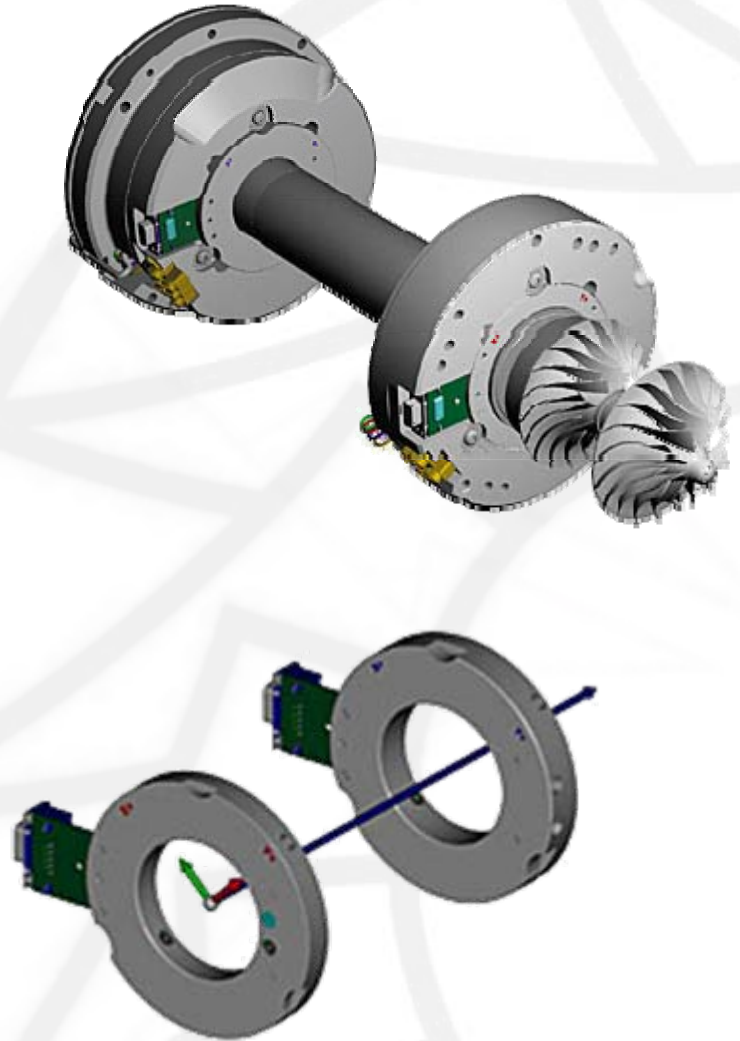


Description of the Turbocor technology

Magnetic bearings

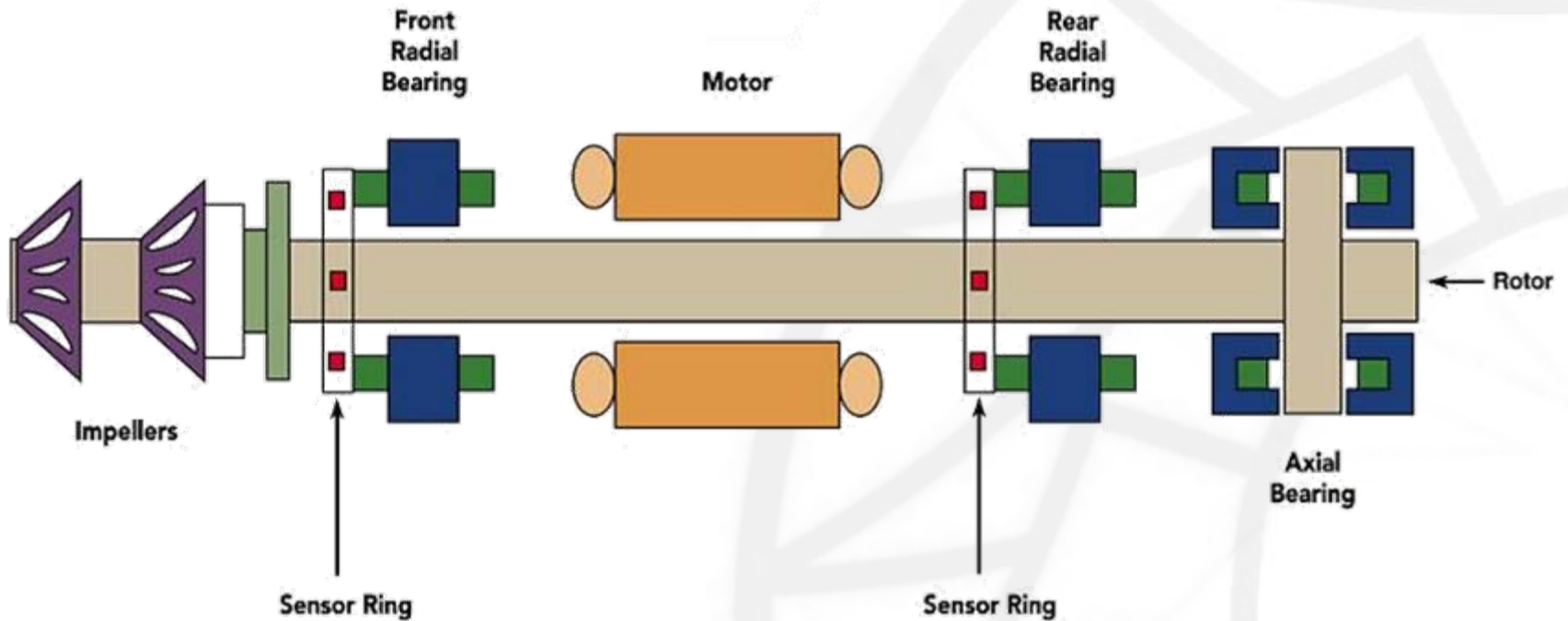
Magnetic bearings contribute to the most efficient, reliable, quiet, and low maintenance centrifugal compressors available:

- Radially and axially located magnetic bearings prevent contact between rotor and other metallic surfaces
- Touchdown bearings support the rotor when the compressor is not energized



Description of the Turbocor technology

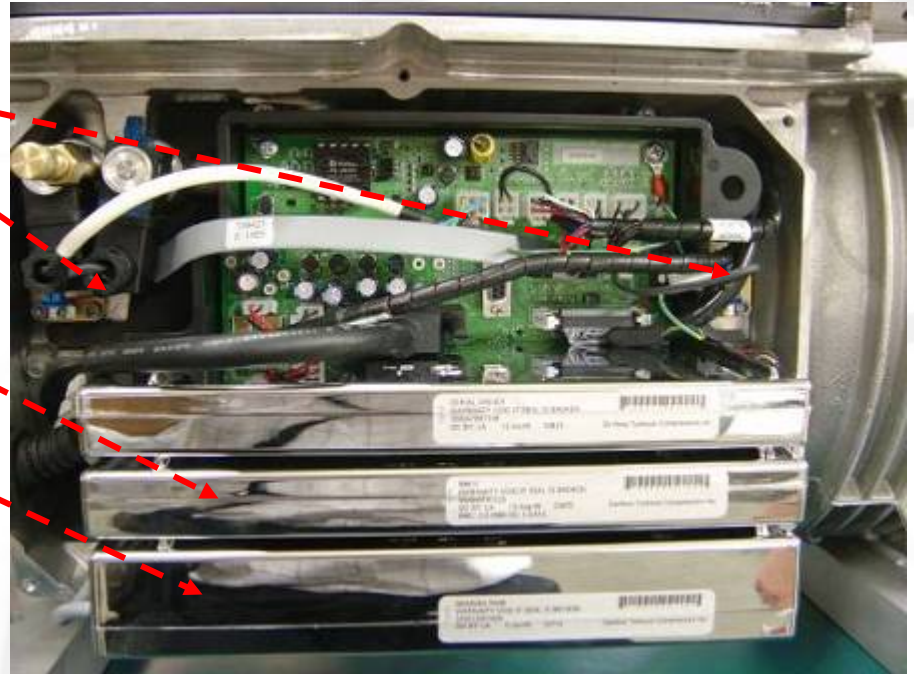
Magnetic bearing system



Description of the Turbocor technology

Magnetic bearing system

- 5 axis proximity sensors
- Digital controller
- 5 separate pulse width modulators (PWM)
- Movements of less than 0.00002" are sensed and adjustments are made accordingly 100,000 times per second



Description of the Turbocor technology

The motor

The motor is a synchronous permanent magnet brushless DC design, this enables the compressor to have:

- Low starting current (2 amps compared to 500 amps)
- High reliability – minimal stress on the stator windings
- High efficiency throughout its operating range
- Lower cost – Size greatly reduced because of high operating speed
- High efficiency and compactness



120kW motor the same size as a 0.75kW motor

Description of the Turbocor technology

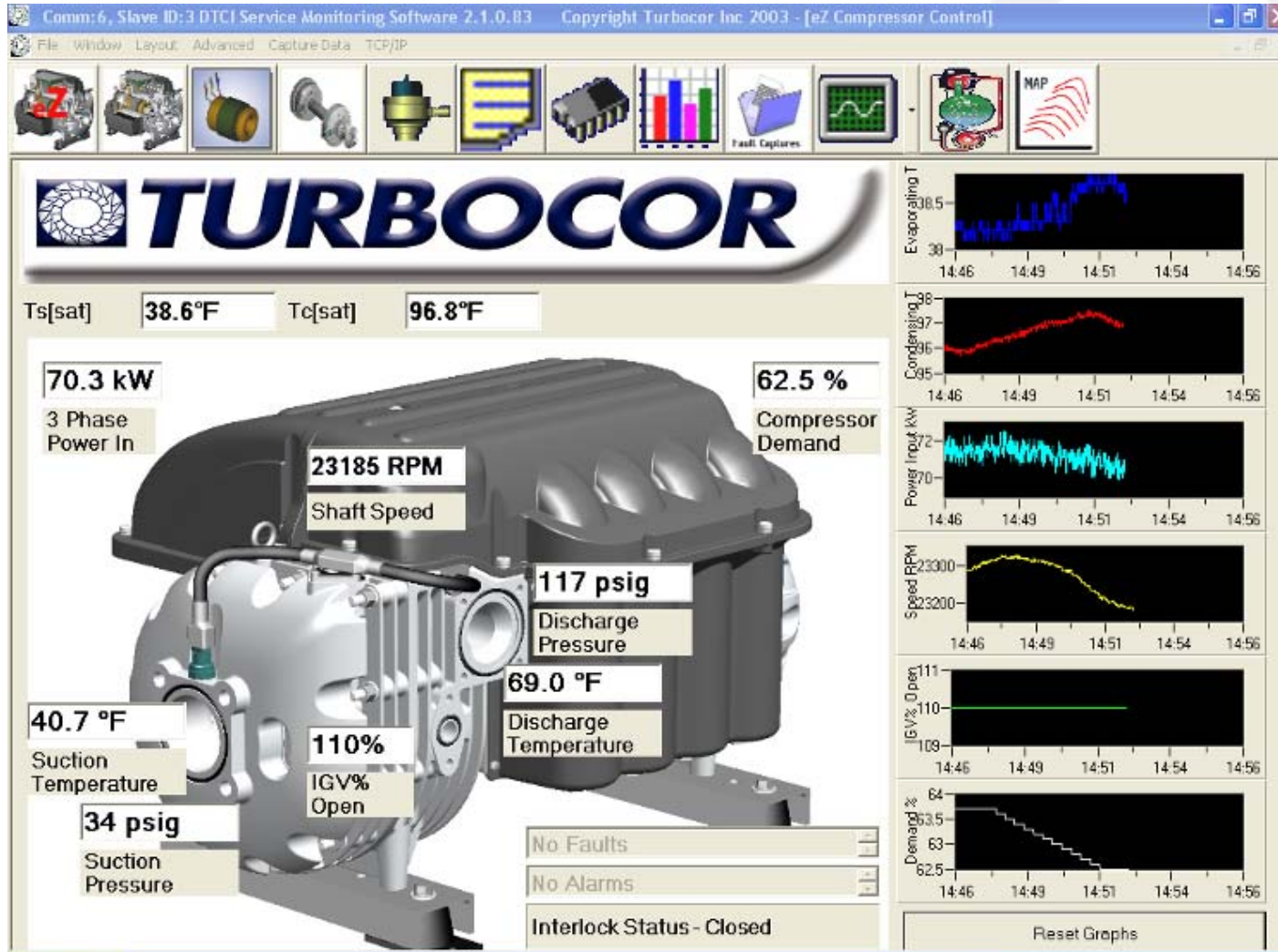
Safeties with no added costs

- Inbuilt diagnostics
- Modbus communication
- 216 Modbus registries
- Diagnostics on:
 - Motor
 - Bearings
 - Compressor
 - Expansion valves
 - Events
 - Faults
 - Trends
 - Chiller
 - And more ...

COMPRESSOR PROTECTION	Extra cost	Turbocor
Bearing Oil High Temperature		Not Required
Motor High Temperature		Built In
Refrigerant (Condenser) High Pressure		Built In
Refrigerant (Cooler) Low pressure		Built In
Lube Oil Low Pressure		Not Required
Compressor (Refrigerant) Discharge Temperature		Built In
Under Voltage		Built In
Over Voltage		Built In
Oil Pump Motor Overload		Not Required
Cooler and Condenser Water Flow		N/A
Motor Overload		Built In
Motor Acceleration Time		Built In
Intermittent Power Loss Protection		Built In
Compressor Starter Fault		Built In
Compressor Surge Protection		Built In
Low Level Ground Fault		Built In
Low Level - Phase to Phase and Phase to Ground Protection		Built In

Description of the Turbocor technology

The controls

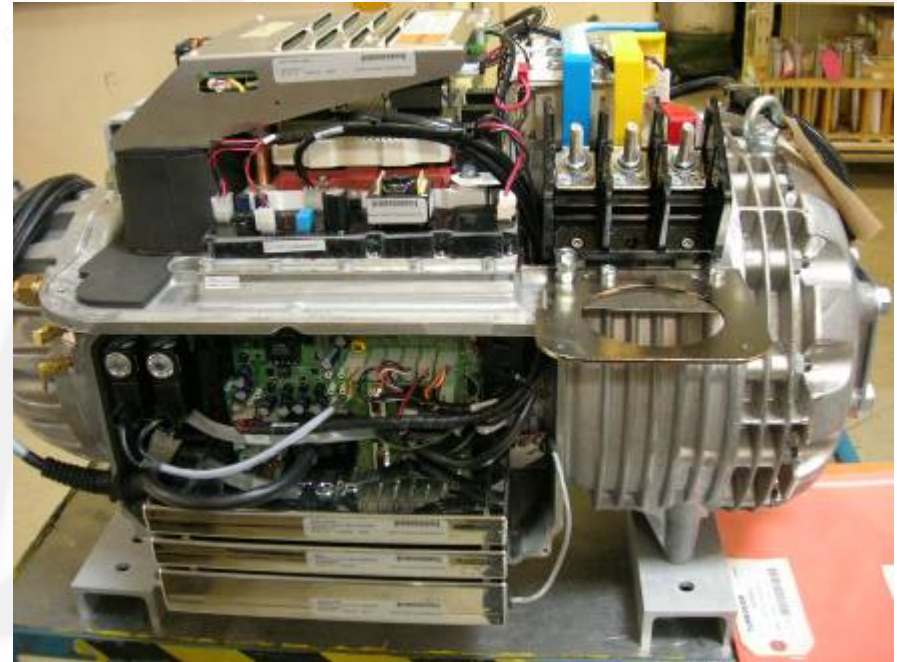


Description of the Turbocor technology

The electronics

The electronics have been designed specifically to maximize the potential of all the technologies within the compressor, this means:

- Maximum energy efficiency
- Low vibration miniaturized design
- Optimized product costs
- Higher reliability
- More efficient component cooling

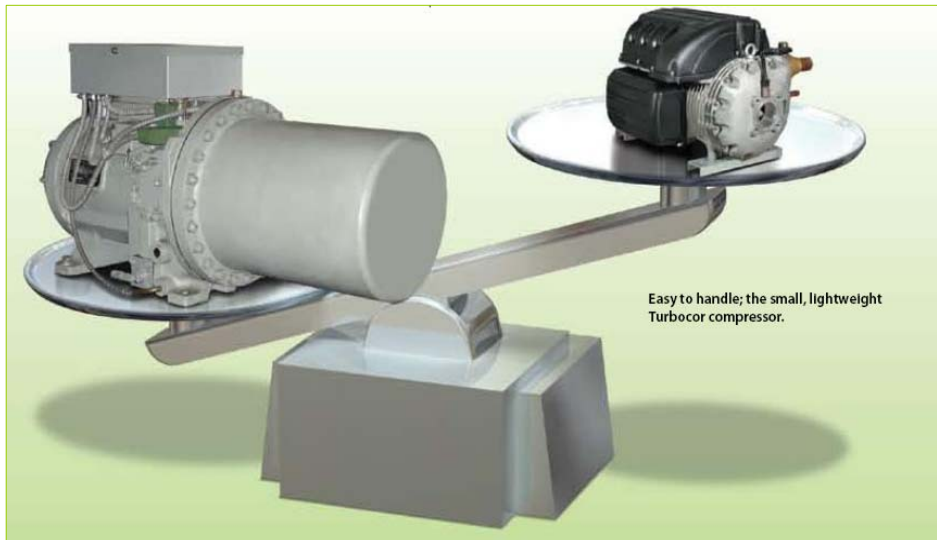


IGBT's, BMCC's, Soft Starters, DC/DC Converters, Bearing PWM's, EXV Drivers, Feed Through's, Buss Bars and I/O cards are all specifically designed for the compressor

Description of the Turbocor technology

Small footprint

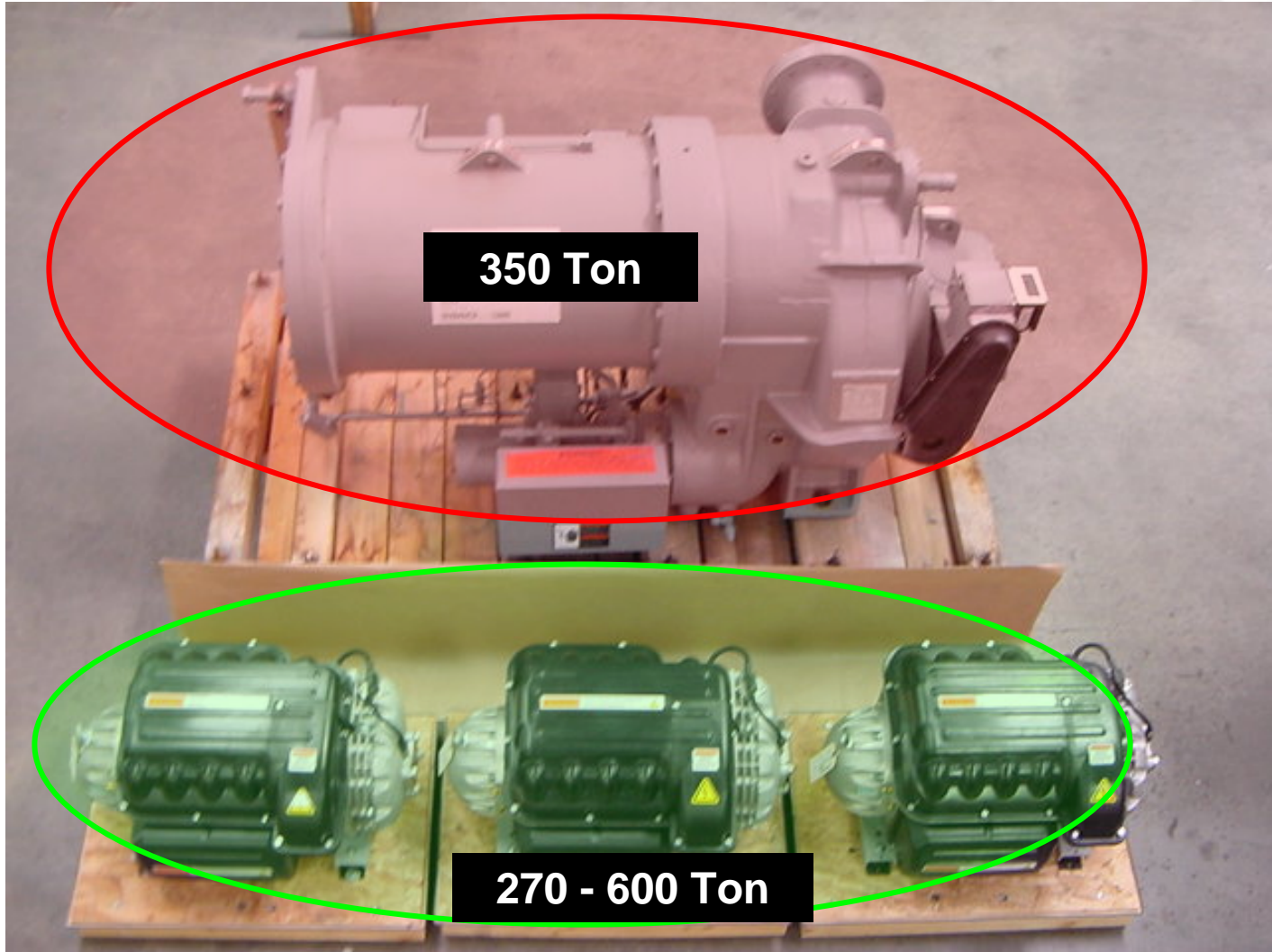
→ Size & weight does matter, valuable plant room space can be reduced



Under 300 lbs is a fraction of the weight of conventional compressors with an approximate 50% smaller footprint

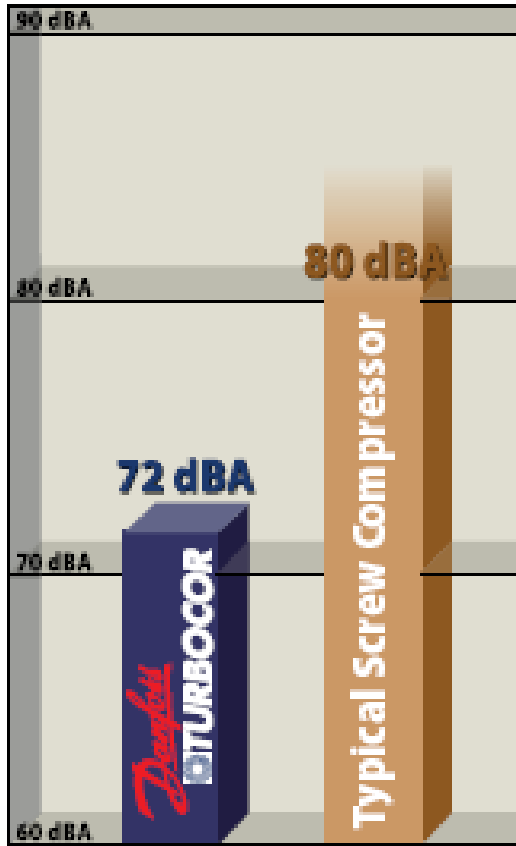
Description of the Turbocor technology

Small footprint



Description of the Turboacor technology

Noise sensitive applications



		Operational Mode of Compressor (Capacity)			
		TT300		TT400	
Distance		250 kW (70 Ton)	315 kW (90 Ton)	422 kW (120 Ton)	522 kW (150 Ton)
Meters	Feet				
1	3	72.5 dBA	78 dBA	81 dBA	82 dBA
5	16	59.5 dBA	64 dBA	68 dBA	69 dBA

Description of the Turbocor technology

Refrigerant

- Current used refrigerant R134a

Future refrigerants

- Danfoss Turbocor are currently investigating other refrigerants



The TT series of compressors

Product portfolio

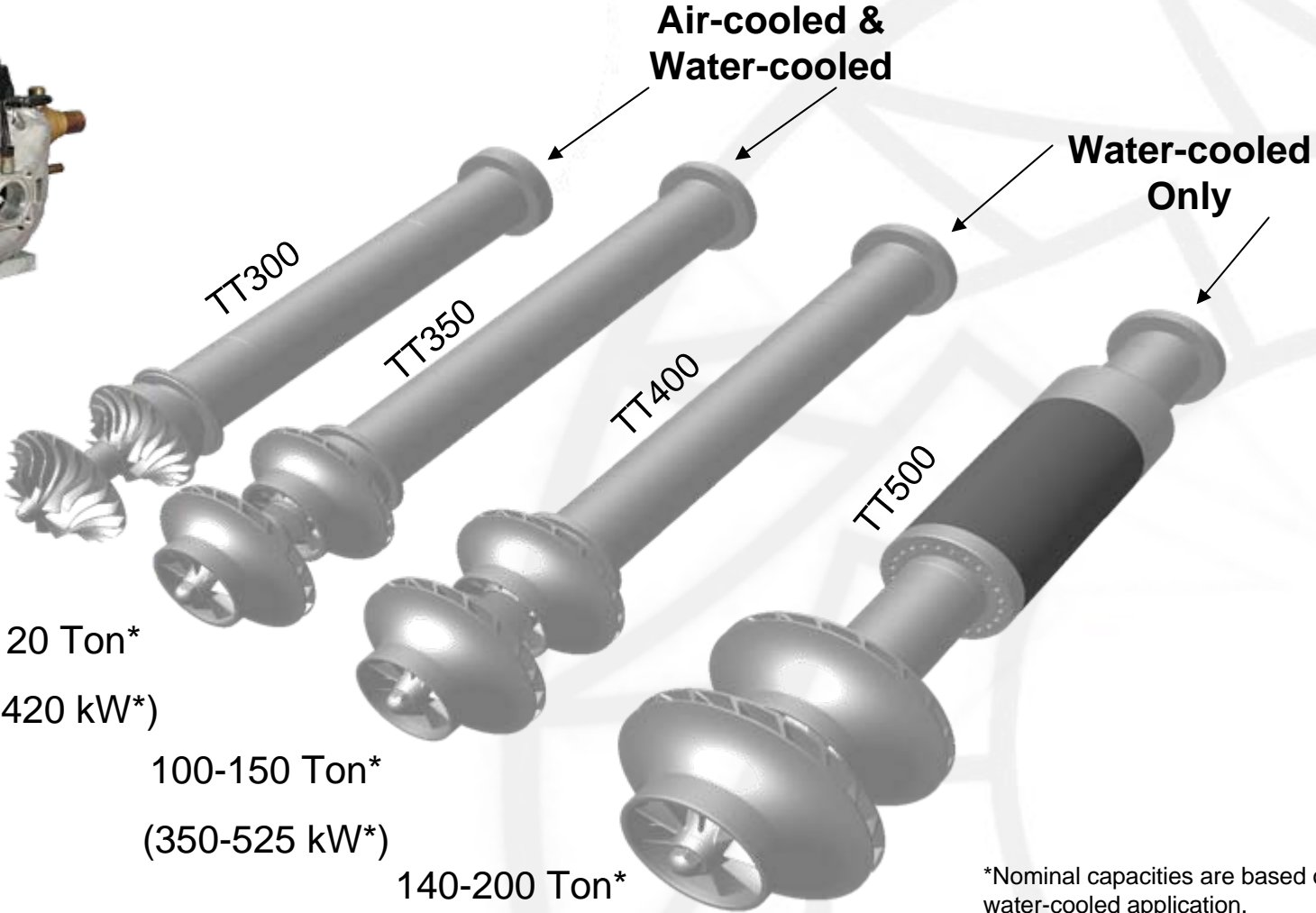


60-90 Ton*
(200-315 kW*)

90-120 Ton*
(315-420 kW*)

100-150 Ton*
(350-525 kW*)

140-200 Ton*
(500-700 kW*)



*Nominal capacities are based on water-cooled application.

Capacity will vary depending on actual running conditions.



Making a world of difference.

Applications





Danfoss Turbocor Compressors

Making a world of difference