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

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

1999

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

2004

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

Ron Conry
Founder

2009

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

Making a world of difference.
Facts about Danfoss Turbocor

Sales split

• **Facts about Danfoss Turbocor**

Sales split

• **Sales:**
  - 30% growth
  - 25% growth
  - expansion
  - 2007 - 2008 - 2009 - 2010

• **Plant:**
  - 65,000 square feet

• **Location:**
  - Tallahassee, Florida

• **Employees:**
  - ~180

• **Markets:**
  - USA
  - Canada
  - Europe
  - China
  - Australia

Making a world of difference.
Facts about Danfoss Turbocor

Recognition

Danfoss Turbocor is certified
ISO 9001:2000

Making a world of difference.
What are the current drivers for building owners & consultants today?

- 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

- Inverter speed control
- Synchronous brushless DC motor
- Motor and bearing control
- Soft-Starter
- 2-stage centrifugal compressor
- Pressure and temperature sensors
- Inlet guide vanes
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
Making a world of difference.

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 …

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<tr>
<th>COMPRESSOR PROTECTION</th>
<th>Extra cost</th>
<th>Turbocor</th>
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<tbody>
<tr>
<td>Bearing Oil High Temperature</td>
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<tr>
<td>Motor High Temperature</td>
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<tr>
<td>Refrigerant (Condenser) High Pressure</td>
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<td>Built In</td>
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<tr>
<td>Refrigerant (Cooler) Low pressure</td>
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<td>Built In</td>
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<tr>
<td>Lube Oil Low Pressure</td>
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<tr>
<td>Compressor (Refrigerant) Discharge Temperature</td>
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<td>Under Voltage</td>
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<tr>
<td>Over Voltage</td>
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<td>Oil Pump Motor Overload</td>
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<tr>
<td>Motor Overload</td>
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<tr>
<td>Motor Acceleration Time</td>
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<tr>
<td>Intermittent Power Loss Protection</td>
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<td>Compressor Starter Fault</td>
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<td>Compressor Surge Protection</td>
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<td>Low Level Ground Fault</td>
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<td>Low Level - Phase to Phase and Phase to Ground Protection</td>
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<td>Built In</td>
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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

The first intelligent compressor

The Turbocor compressor was the world’s first digital compressor, with:

- Digitally controlled bearings
- Digitally controlled power electronics
- Digitally controlled compressor control
- Digitally controlled chiller control
- Digitally controlled expansion valve control
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 Turbocor technology
Noise sensitive applications

<table>
<thead>
<tr>
<th>Distance</th>
<th>TT300</th>
<th>TT400</th>
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<tr>
<td>Meters</td>
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<td>1</td>
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<td>78 dBA</td>
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<td>5</td>
<td>59.5 dBA</td>
<td>64 dBA</td>
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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

- TT300
  - 60-90 Ton*
  - (200-315 kW*)
- TT350
  - 90-120 Ton*
  - (315-420 kW*)
- TT400
  - 100-150 Ton*
  - (350-525 kW*)
- TT500
  - 140-200 Ton*
  - (500-700 kW*)

Air-cooled & Water-cooled
Water-cooled Only

*Nominal capacities are based on water-cooled application.
Capacity will vary depending on actual running conditions.
Applications

Making a world of difference.
Danfoss Turbocor Compressors
Making a world of difference