Smardt Oil-Free Chillers

SMARDT

SMARDT

Danfoss

TURBOCOR

Company History in Brief

- Turbocor compressor invented in Australia in 1993
- Turbocor was relocated to Montreal in 1999
- Danfoss forms 50/50 partnership in 2004
- Smardt was founded in 2004 to manufacture chillers
- Product range grows from 60 to over 800 tons in 2005
- Air cooled models extend from 60-250 tons
- ARI Certifications were completed in 2007
- Over 7,000 compressors, 1,000 chillers installed
- NEW 220 ton compressor. 1,320 ton chiller slated for 2008

The Quantum Group – World Leaders

SMARDT

SMARDT

clever cooling powerpax

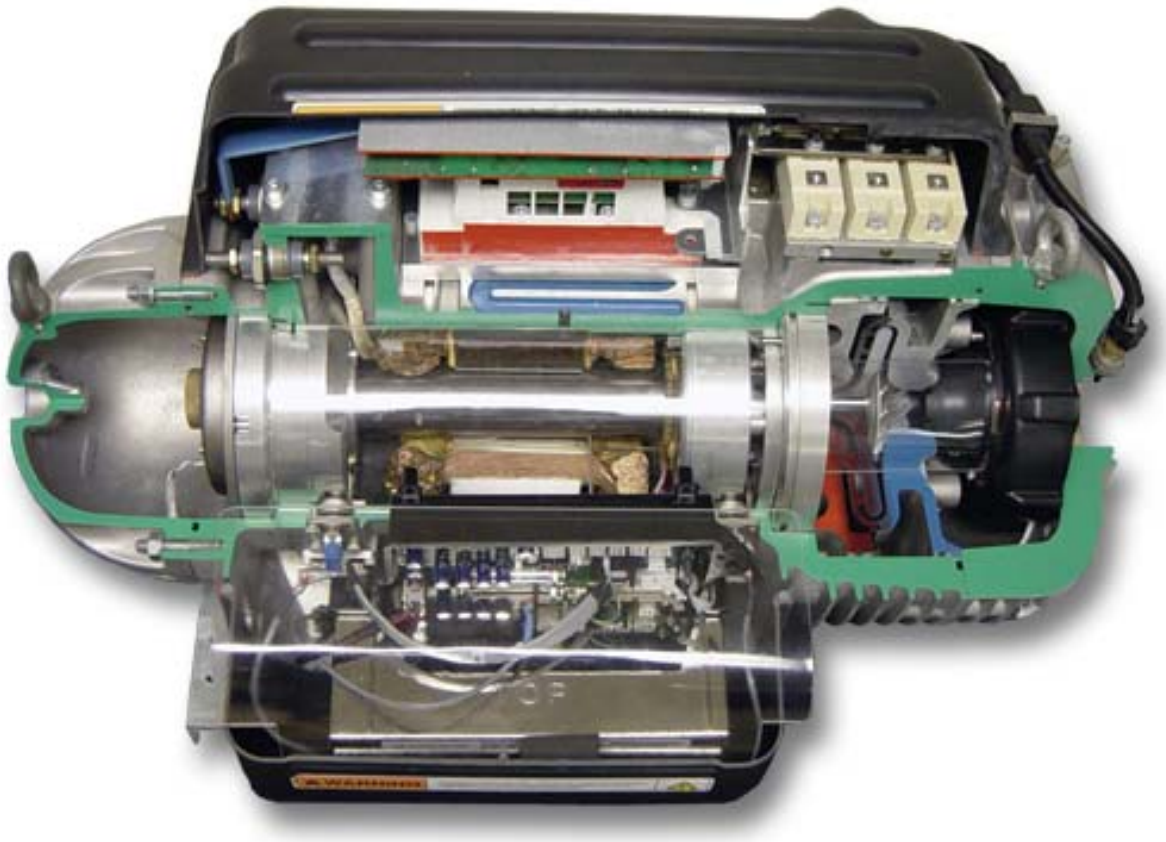
AXIMA Refrigeration

suez

Worlds largest chiller group specializing in Turbocor oil-free centrifugal technology, heat exchanger innovation and Kiltech Control Systems.

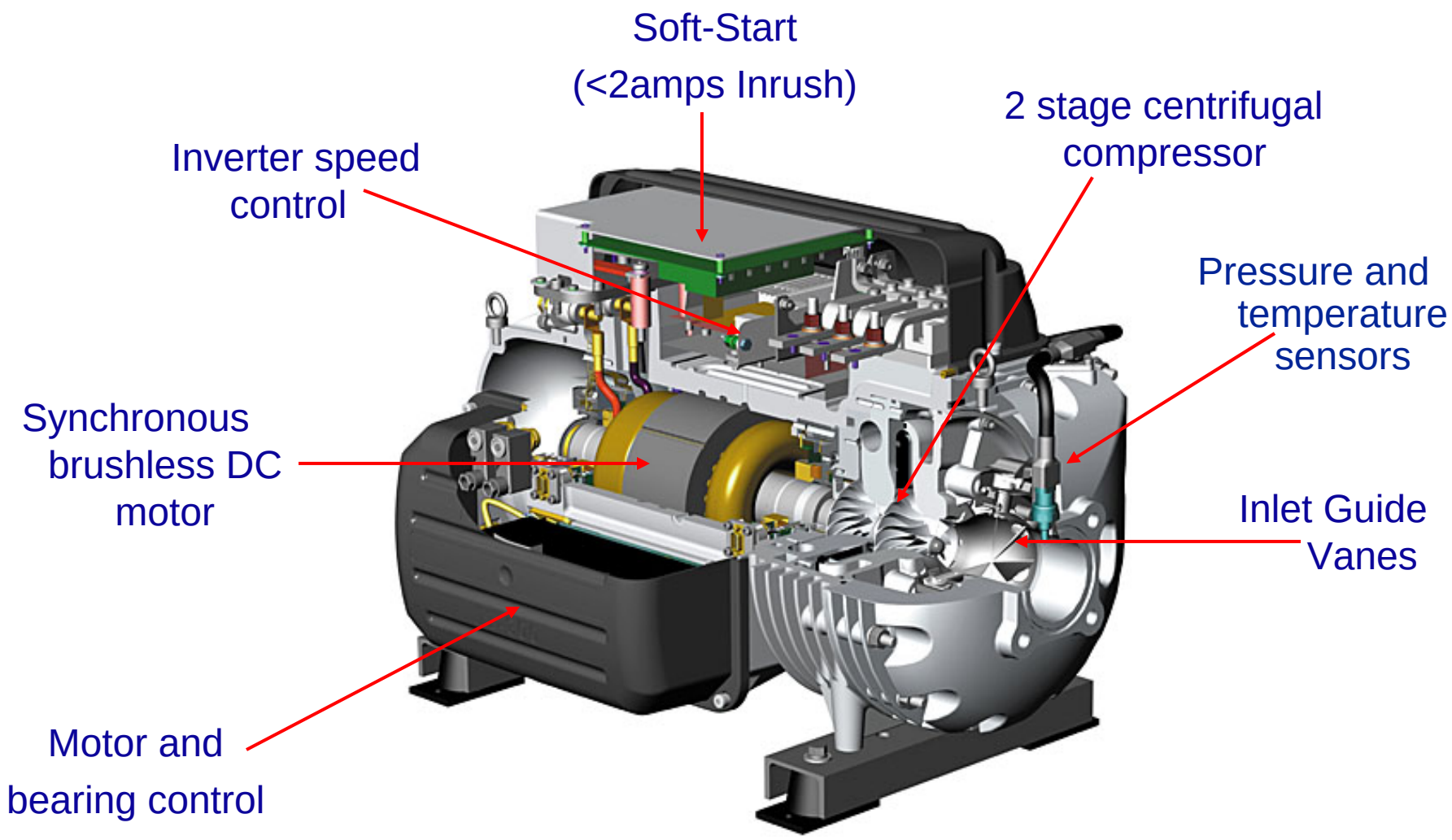
The Remarkable Turbocor Compressor

SMARDT



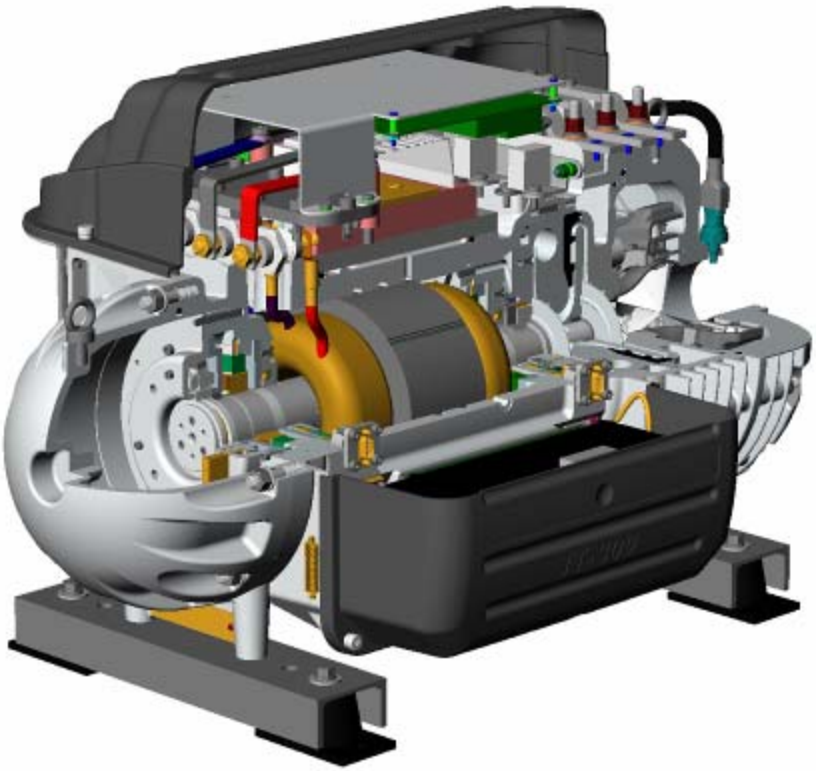
- **100% Oil Free** eliminates oil system maintenance costs.
- **R134a Refrigerant** meets Montreal protocol and is not subject to phase-out.
- **Magnetic Bearings** eliminate frictional losses.
- **One moving part** assures long service life.
- **Unmatched Efficiency** as low as .31 kw/ton IPLV.
- **Low In-Rush Current** reduces installed cost and peak load.
- **Lowest Noise** - Only 72 dBa.

The Turbocor Compressor

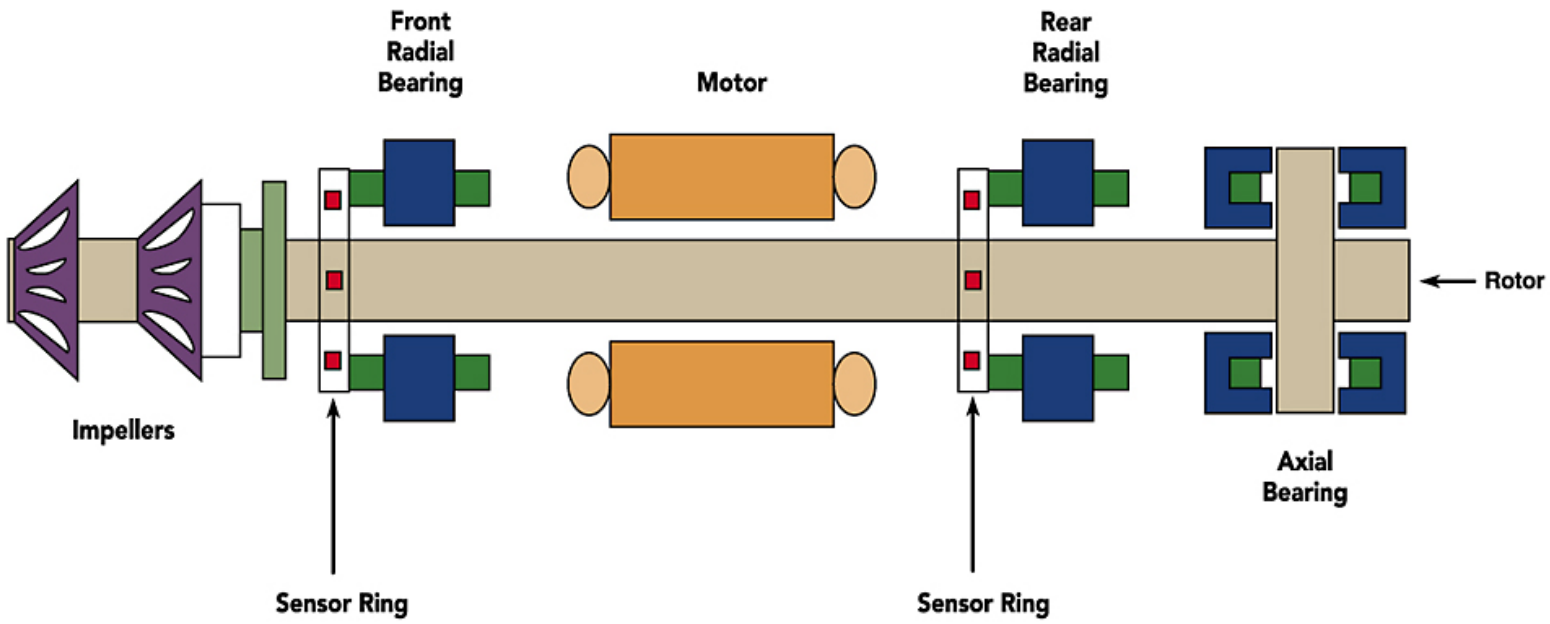


VFD and Inlet Guide Vane Operation

- The Compressors speed adjusts automatically to match the load and current operating conditions so that optimum efficiency is gained.
- Primary capacity control is done using the onboard VFD and only use the Inlet Guide Vanes to supplement VFD controls. IGVs prevent surge conditions at low turndown. IGVs normally operate at the 110% position.
- The slower the compressors, the greater the efficiency. As speeds is reduced, energy consumption is reduced by the cube.
  - Speed $\propto$ Energy^3



The Magnetic Direct-Drive System



Magnetic bearings and sensors keep the shaft properly centered and positioned at all times. The rotor shaft is held in position with ten separately controlled electro magnetic cushions which continually changes in strength to keep the shaft centrally positioned. The shafts position is monitored with 10 sensor coils who's signal is fed back to a digital controller. Movements of less than .00002" are sensed and adjustments are made accordingly. Back up carbon or roller bearings are fitted to catch the shaft and prevent damage should a control or bearing failure occur.

Shaft is monitored and positioned 100,000 / sec.

What Happens with a Power Outage?

- **In the case of a power outage, the compressor is fully protected.**

- Within 0.5 of a micro-second, the motor becomes a generator which then feeds power to the various controls and bearing actuators during a controlled coast-down. The onboard capacitors have adequate power to fully support the bearing system during the switch from motor to generator mode. Capacitors are replaced every five years.

- After the compressor comes to a complete stop, the rotor de-levitates normally onto touchdown bearings. Carbon or roller touchdown bearings are also used as a back up bearing system to act as a cradle for the rotor during the off-mode.

- The system then determines if normal power is restored, if YES, the shaft levitates. If there is a call for cooling, the rotor will then begin to rotate. The entire cycle from loss of power to normal operation takes about 3-5 minutes.

Compressor Sizes and Uses

Model	*Capacity*	*IPLV*	*Turndown*
TT300	90 tons	.38	12 tons
TT400	140 tons	.33	65 tons
TT500	220 tons	.31	TBD

Chilled Water Range – 25F to 60F – 134a limited

Condenser Water Range – 50F to 90F

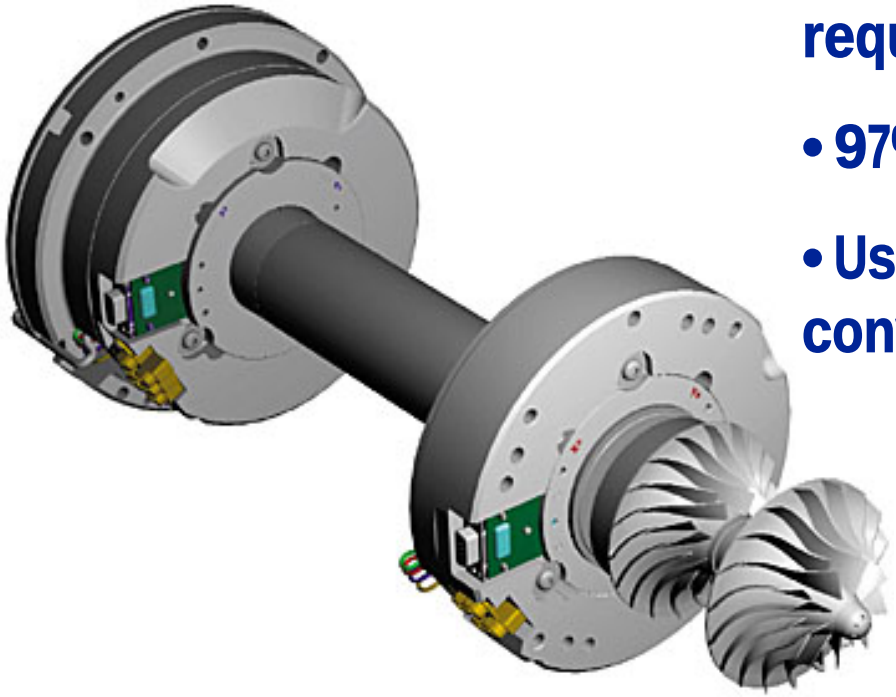
Ambient Range – 10F to 108F

Heat recovery to 120F

Rule of thumb – 12 degrees between LWT and ECT

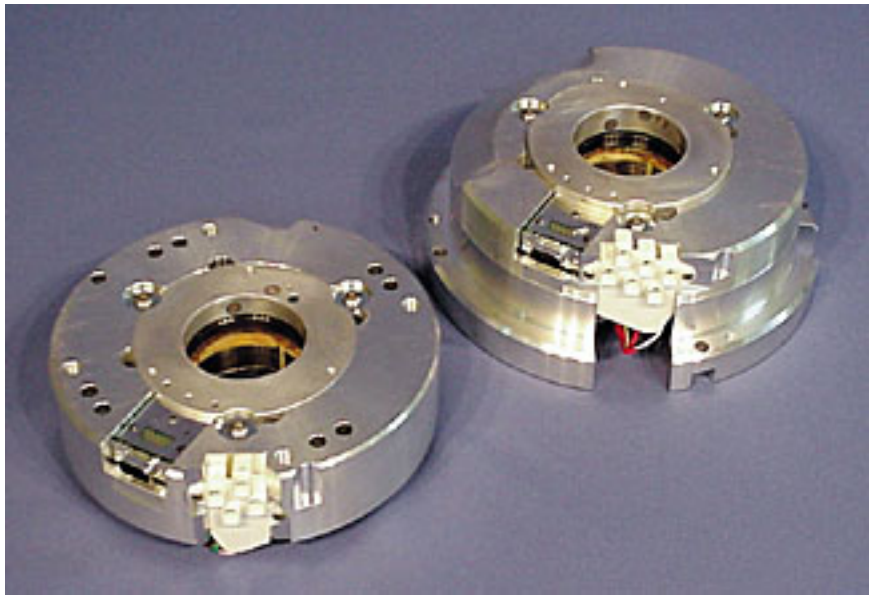
The Magnetic Bearing System

SMARDT



- Permanently magnetized shaft does not require electrical power for operation.
- 97% energy efficient
- Uses 0.5% of the energy required for conventional bearings for same service

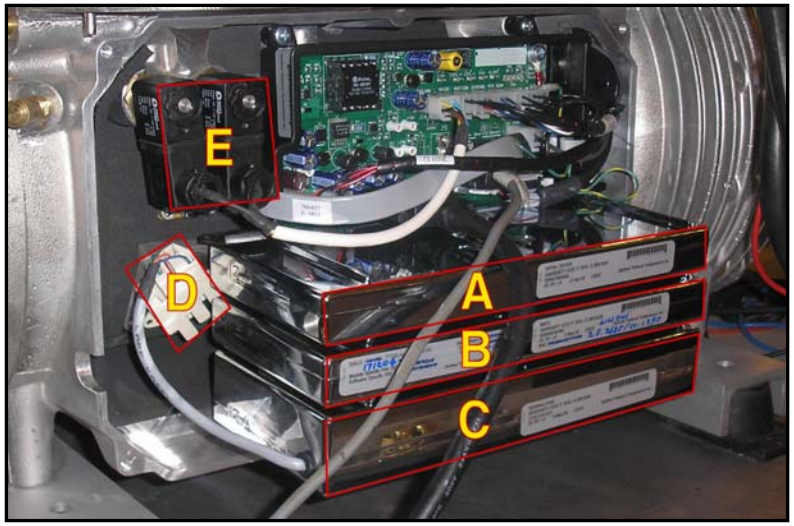
- Eliminate high mechanical friction losses
- Eliminate oil-related heat transfer losses
- Eliminate cost of oil management systems (controls and hardware)
- Increase equipment life through elimination of wear surfaces



Compact Size - Easy to Service

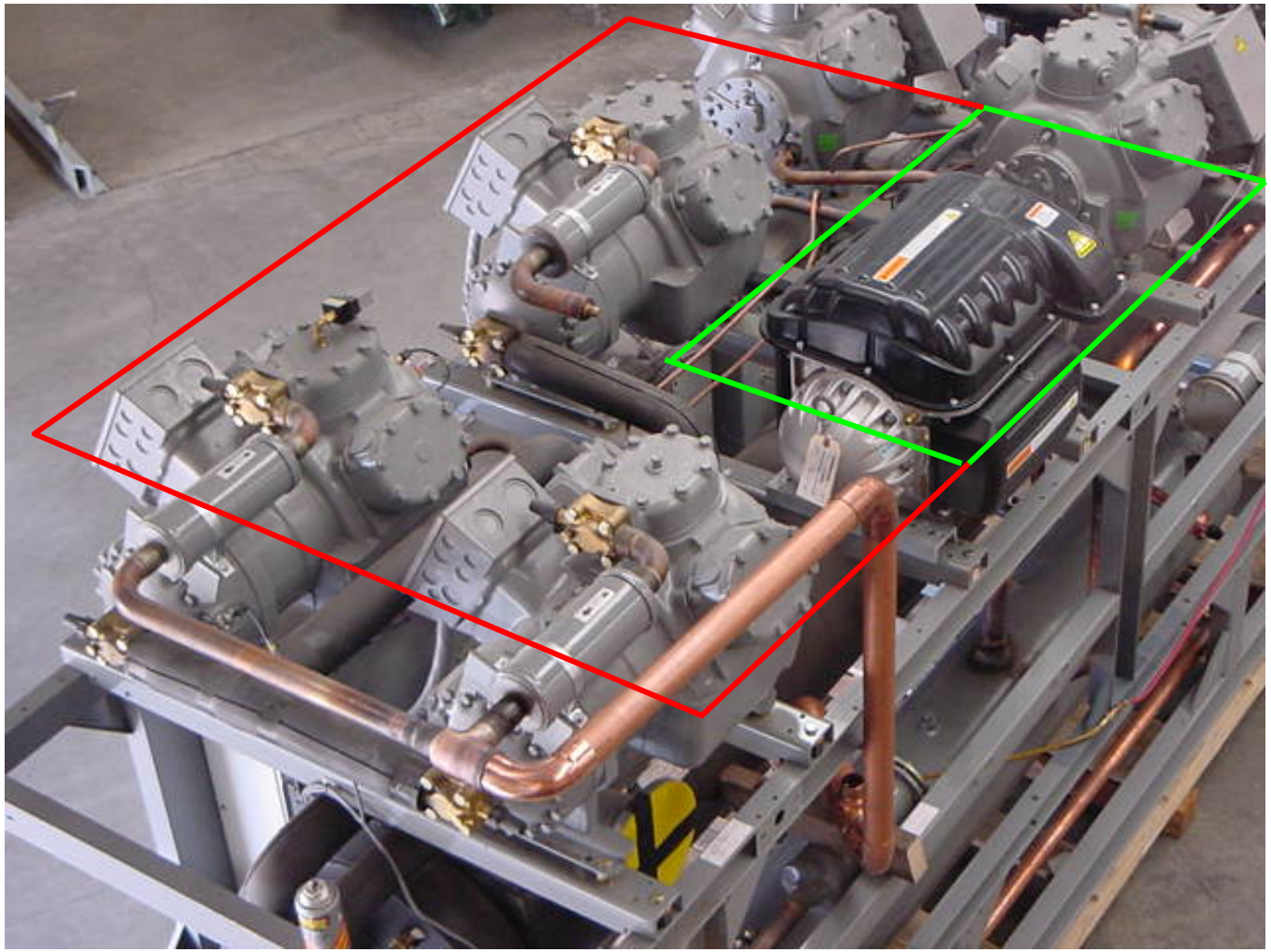
125 HP motor is in the foreground.

150 HP Turbocor permanent magnet motor behind.



Variable-speed, magnetic bearing and cooling controls.

High Capacity – Smaller Size



Oil-Free Eliminates Piping Complexity

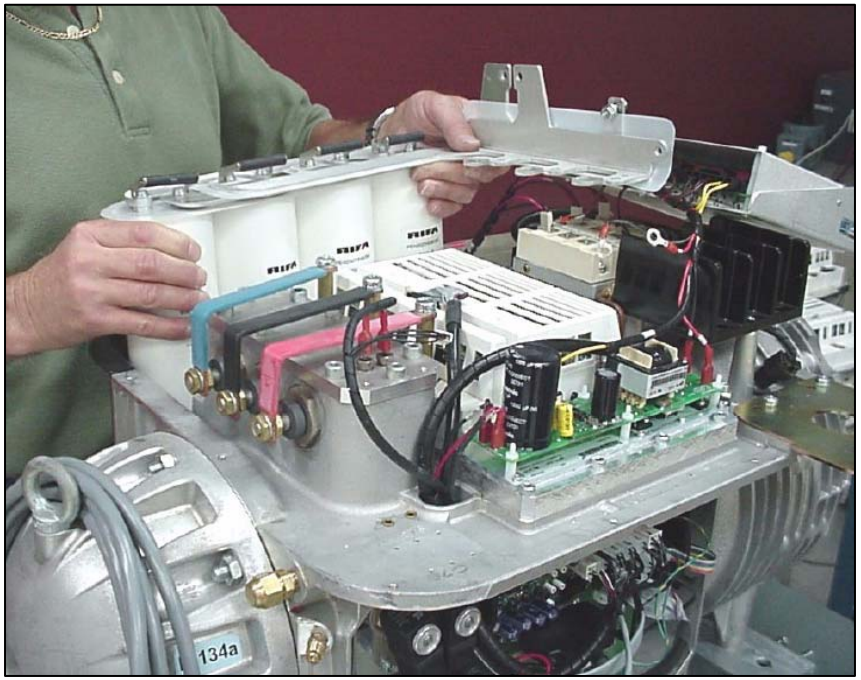
No need for elaborate piping designs compared with oil management systems.

- **No traps and risers**
- **Lower installed costs**
- **Eliminates leak sources**

- **Enables centrifugal chiller with remote condenser to be placed at distance.**

Lowest Cost of Service

- Annually check electronics for tight connections
- No oil service or oil disposal - EVER.



- Replace capacitors every five years

Automatic Bearing Compensation

SMARDT

This compressor continued to operate even though this hole saw slug was embedded in the 1st stage impeller.

The compressor is not designed to pump hole saw slugs, however when faced with this problem, the auto-balance feature was robust enough to handle the challenge.

The compressor continued to operate at 35,000 rpm with this imbalance.

Lowest Noise and Vibration Levels

SMARDT

- "Best in Class" low sound levels. No moving mechanical part touches any part of the housing or frame to transmit acoustic energy.

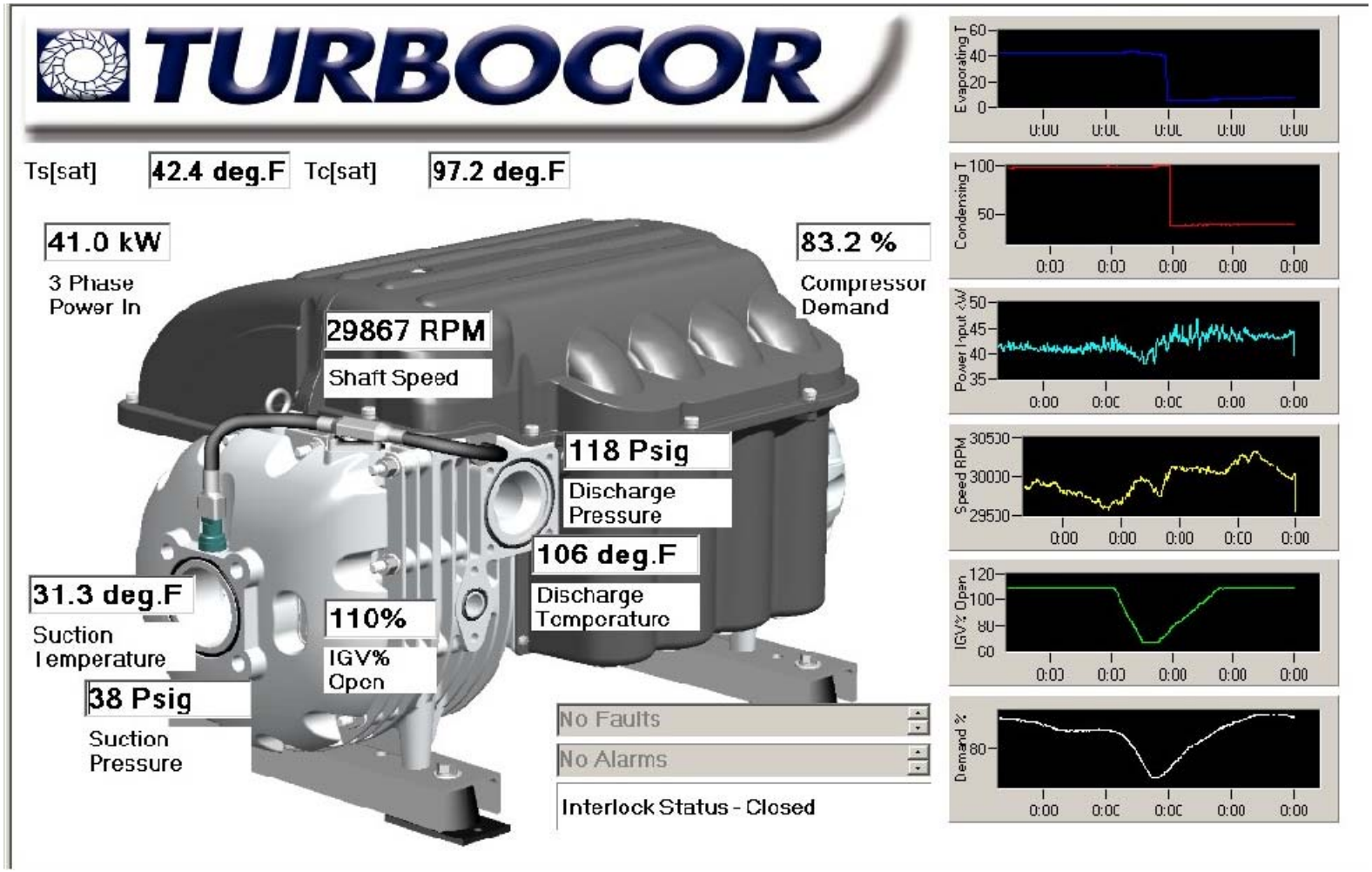
- Tested at 72 dBa at 1 meter with no sound attenuation. Screw compressors, by comparison, are approximately 80 dBa or higher.

- Vibration is essentially non-existent.

- The chiller with 5 compressors operating at full speed only produces 75 DB of sound at 10 feet., about the sound level of your television.

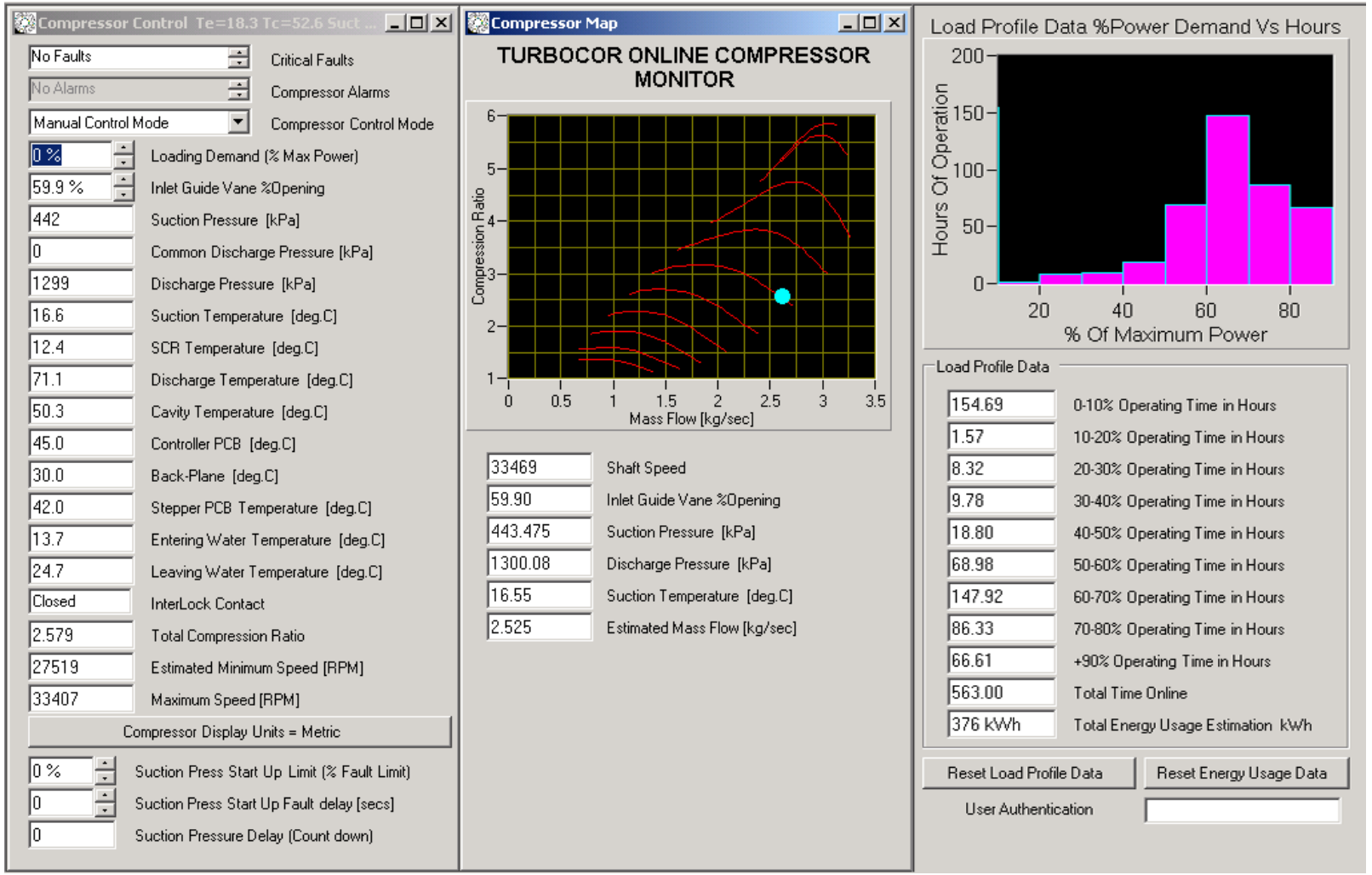
Turbocor Monitoring Software

SMARDT

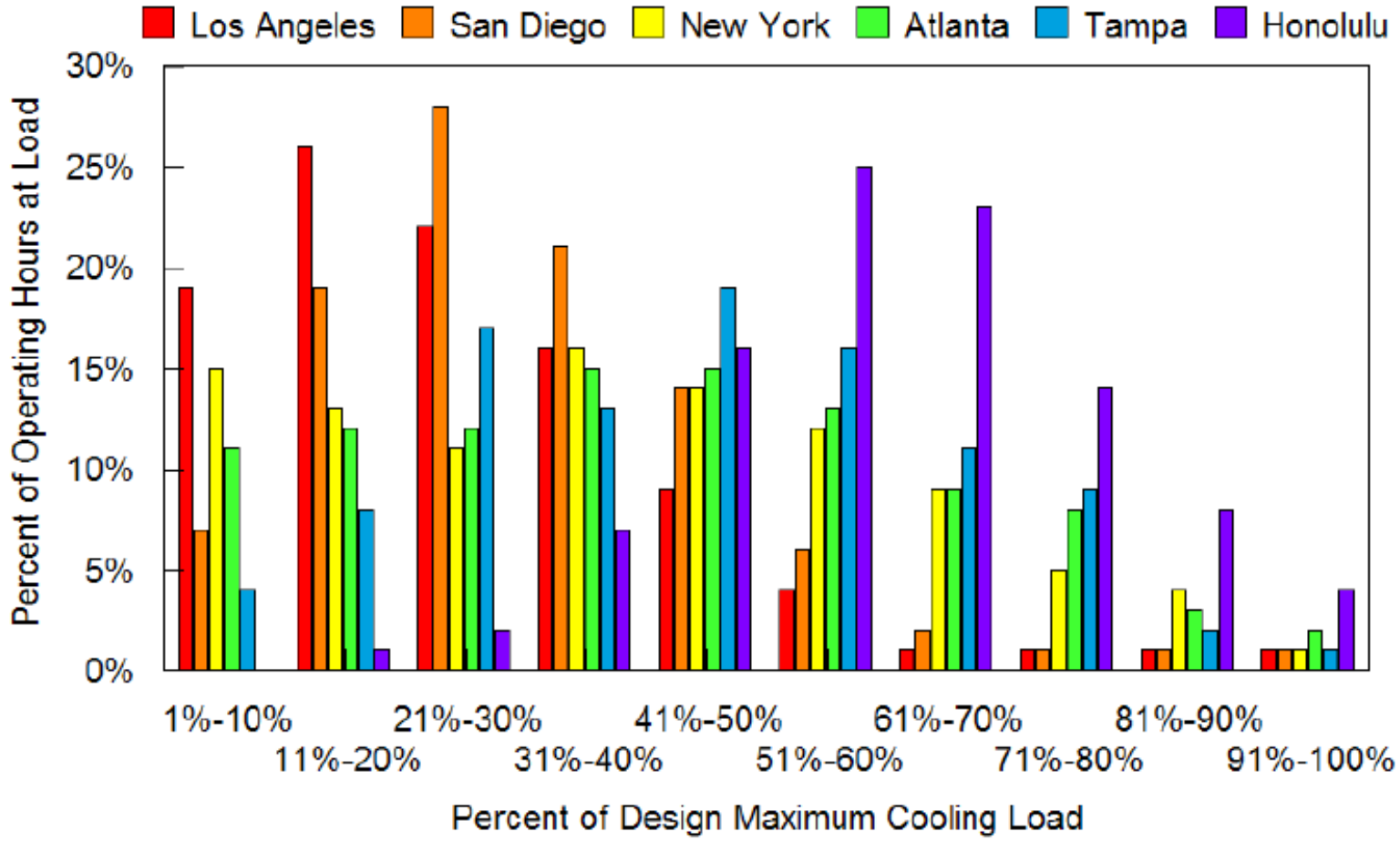


Turbocor Monitoring Software

SMARDT



Why Is Smardt So Compelling?



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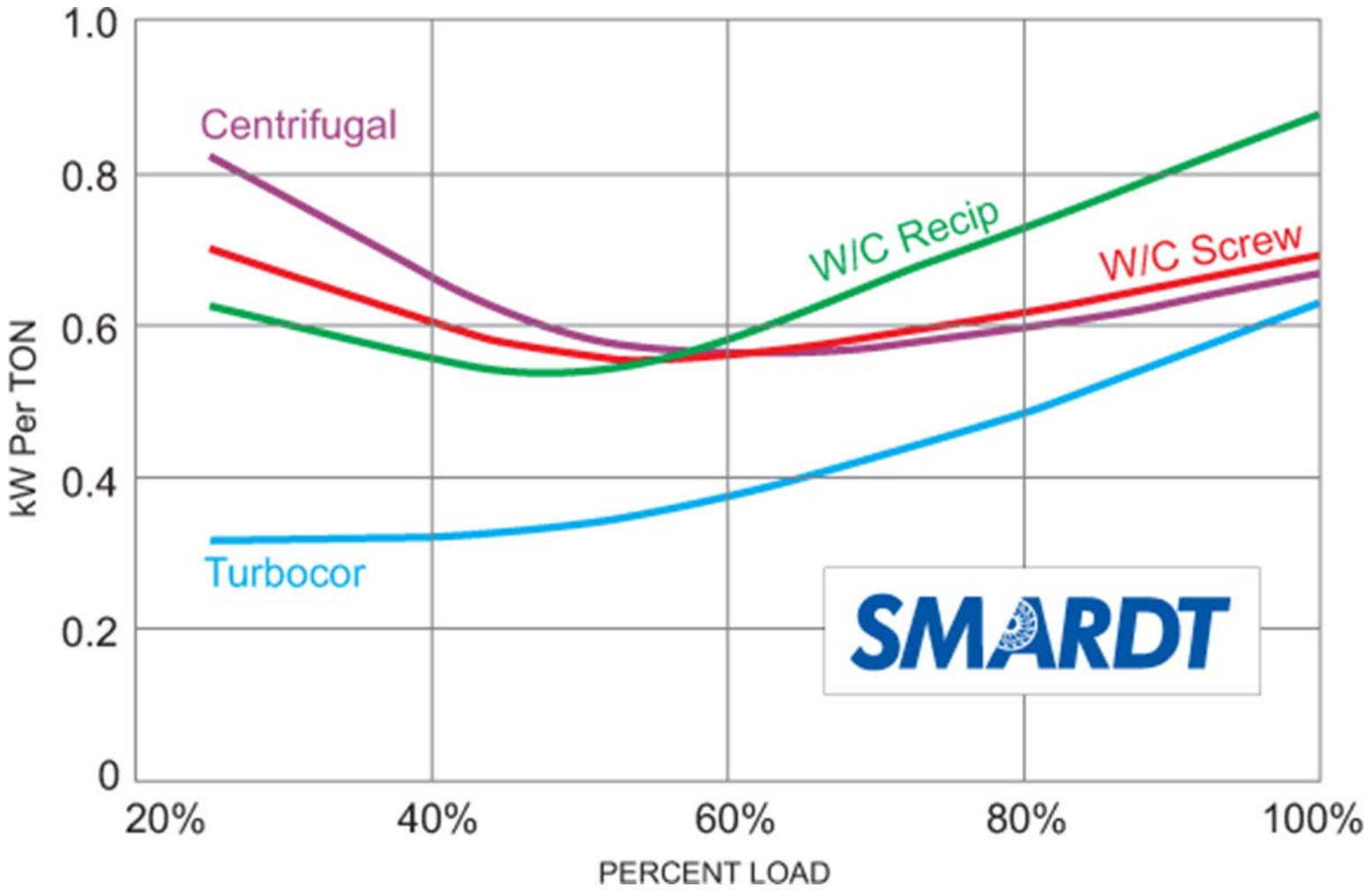
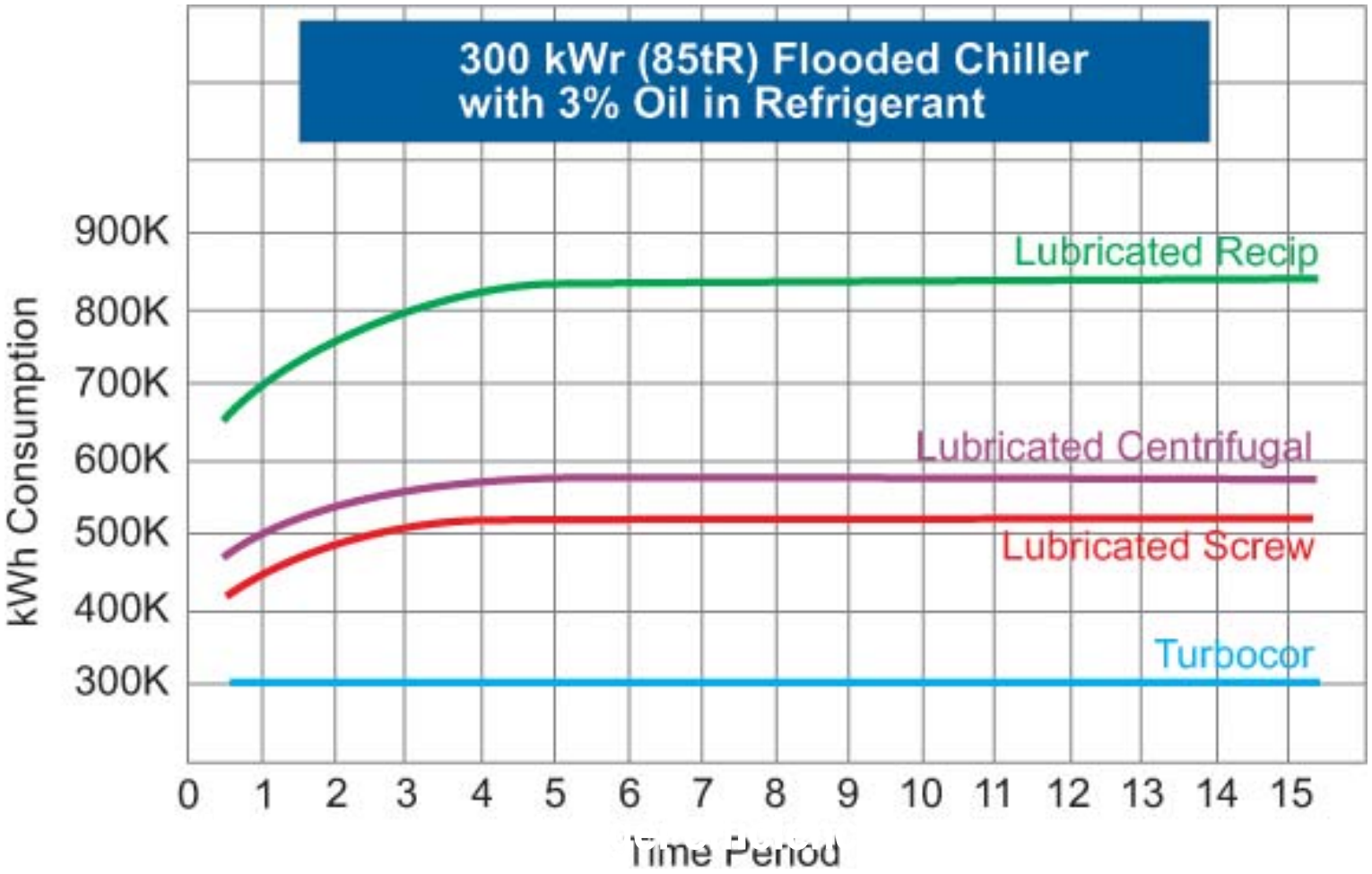


The Dramatic Effects of Oil



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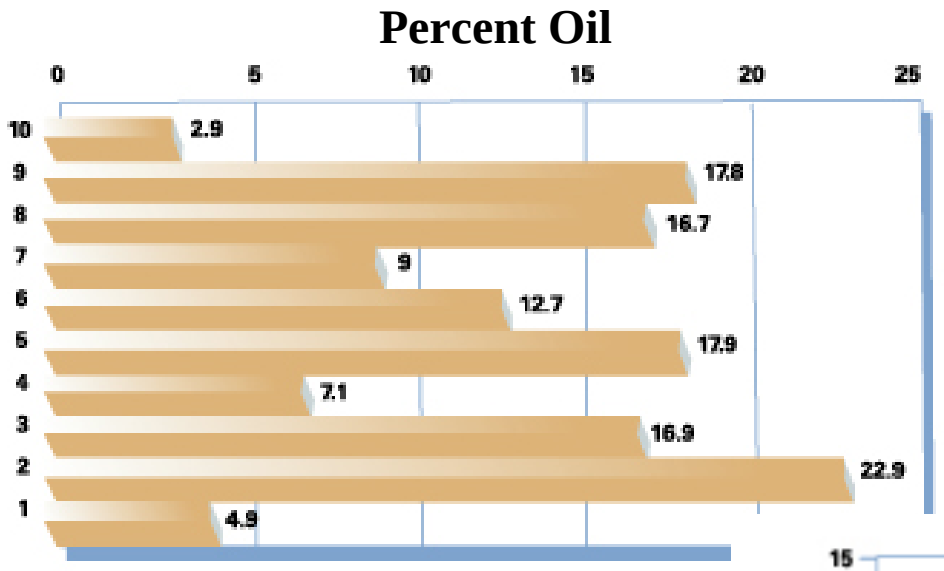
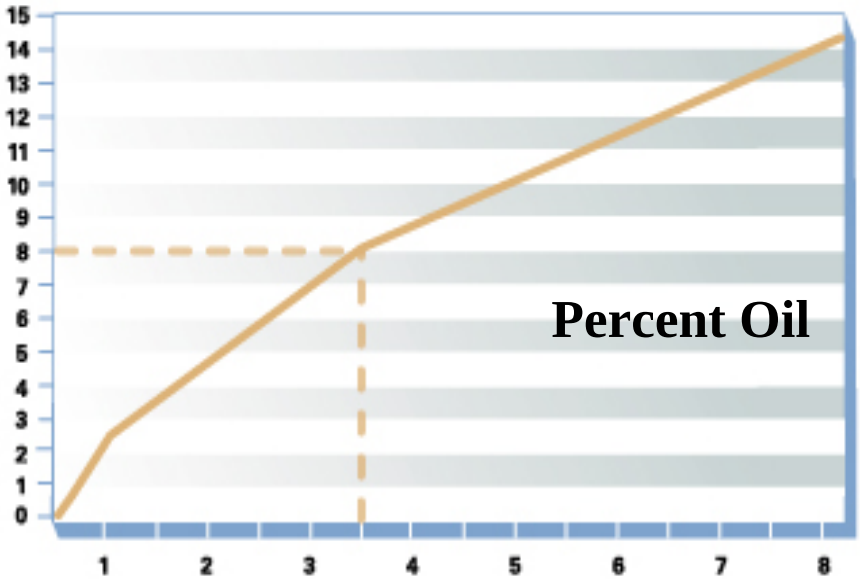


ASHRAE 601 sampling shows average percentages of oil present in chillers

Efficiency loss in heat exchangers account for substantial operation costs



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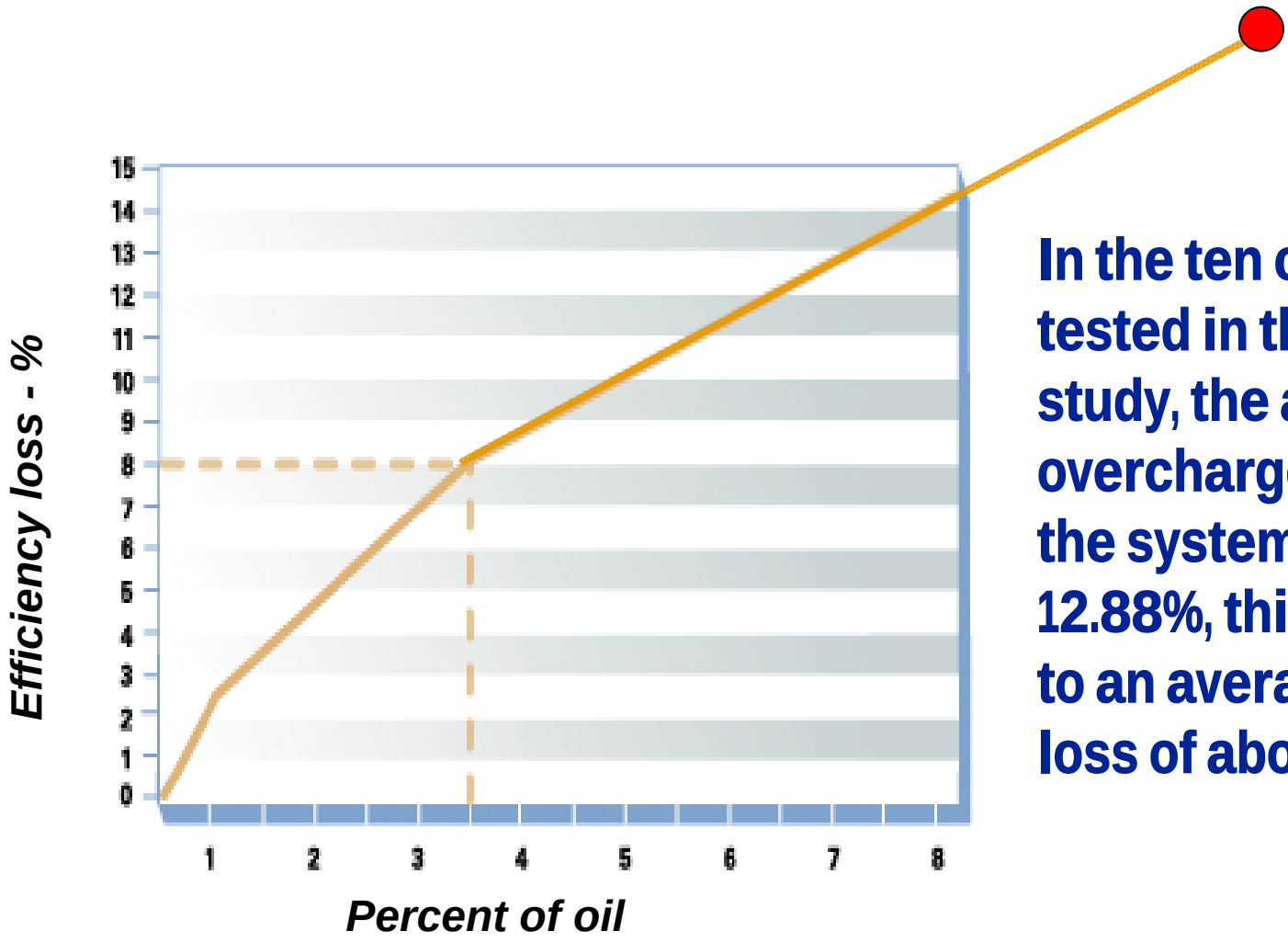


In the ten chillers tested in the ASHRAE study, the average overcharge of oil in the system was 12.88%, this equated to an average energy loss of about 21%

Smardt Chillers Compared with Screws

ARI 550/590-1998 Conditions			Leading Screw WATER COOLED				Smardt Chiller with TT300 WATER COOLED			
Load	ECW F/C	LCHW F/C	SST F/C	SCT F/C	COP	kW/Ton	SST F/C	SCT F/C	COP	kW/Ton
100%	85/29.5	44/6.7	42/5.6	98/36.7	5.33	0.64	42/5.6	98/36.7	5.56	0.63
75%	75/23.9	44/6.7	42.3/5.8	89.6/32	5. 73	0.6	42.3/5.8	85/29.5	7.31	0.48
50%	65/18.3	44/6.7	42.5/5.9	89.6/32 *	5.49	0.64	42.5/5.9	72.2/2.2	11.38	0.30
25%	65/18.3	44/6.7	42.8/6.	89.6/32 *	4.11	0.845	42.8/6	70/21.1	10.86	0.32
IPLV	*COP*	kW/Ton			5.4	.65			9.55	0.36

Conclusion – The Smardt Chiller using the Turbocor TT300 compressor is 45% more efficient than the leading screw compressor

Smardt Chillers Compared with Screws

ARI 550/590-1998 Conditions			Leading Screw AIR COOLED				Smardt with TT300 AIR COOLED			
Load	Air F/C	LCHW F/C	SST F/C	SCT F/C	COP	kW/Ton	SST F/C	SCT F/C	COP	kW/Ton
100%	95/35	44/6.7	35.5/2	122/50	3.19	1.10	35.5/2	122/50	3.08	1.13
75%	80/26.7	44/6.7	36.5/2.5	104/40	4.20	0. 83	36.5/2.5	104/40	4.44	0.79
50%	65/18.3	44/6.7	37.5/3	86/30	5.26	0.69	37.5/3	82.5/28	7.23	0. 48
25%	55/12.8	44/6.7	38/3.5	86/30	3.98	0.88	38/3.5	66.2/19	9.77	0.35
IPLV	*COP*	kW/Ton			4.6	0.76			6.32	0. 55

Conclusion – The Smardt Air Cooled Chiller using the Turbocor TT300 compressor is 29% more efficient than the leading screw compressor

Standard 90 Ton Compact Chiller

SMARDT

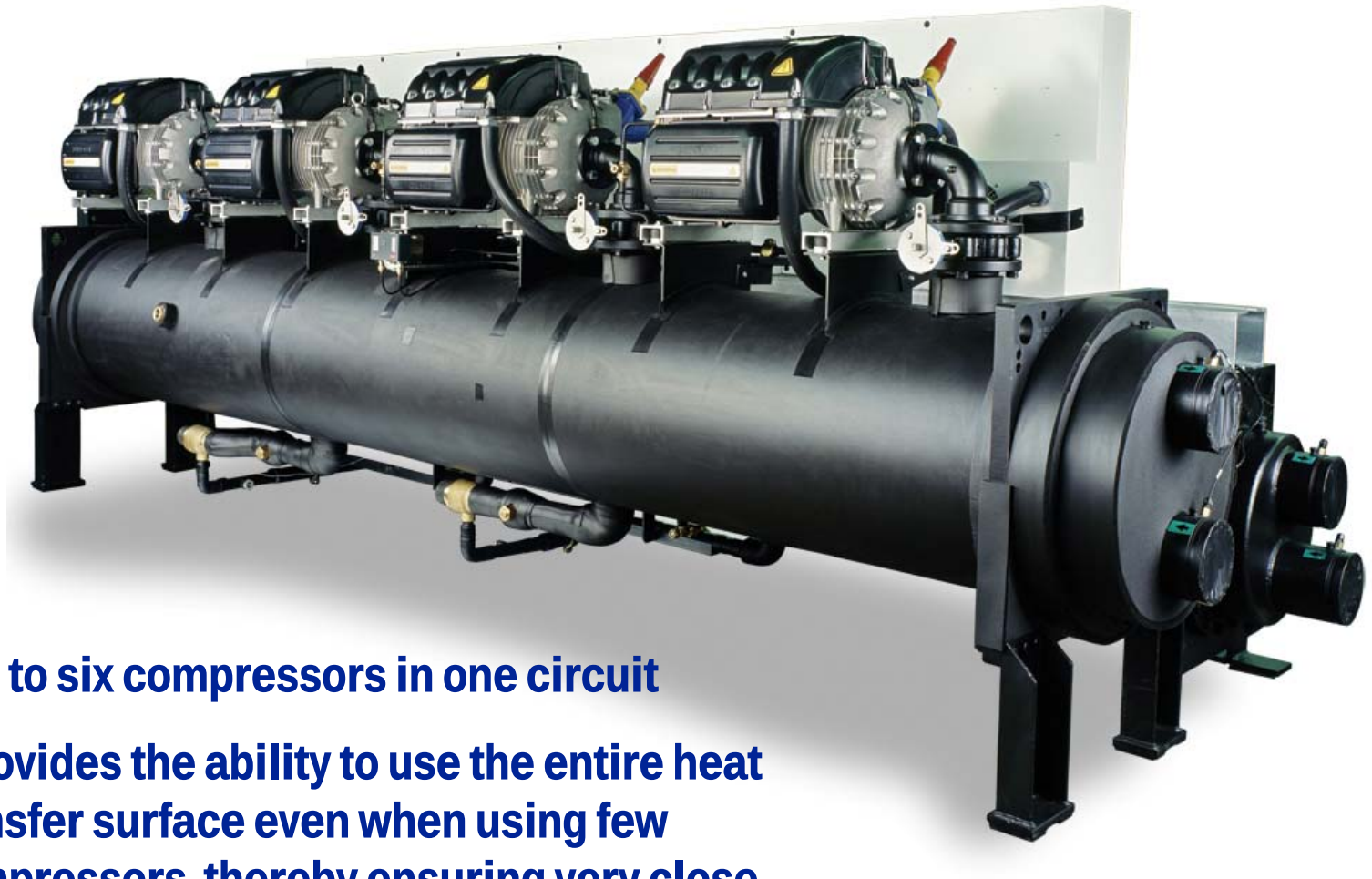
- Oil-Free design eliminates frictional losses and high cost.
- Lowest IPLV in the industry.
- Variable-speed Drive.
- Flooded evaporator for thermal buffer and close approach.
- Cleanable condensers.
- NEMA 1 Panels Standard.
- Kiltech Controls Standard
- Marine Water Box Option.
- “FATMAX” Option.
- Ashrae 90.1 thoughts

Standard Design 350 Ton Chiller

SMARDT

- Standard design uses stacked heat exchangers
- Split systems are available.
- Multiple Circuits available.
- NEW Condenser-less and Condensing Units available SOON.
- NO Oil acid burnout.

Multiple Compressor Chillers



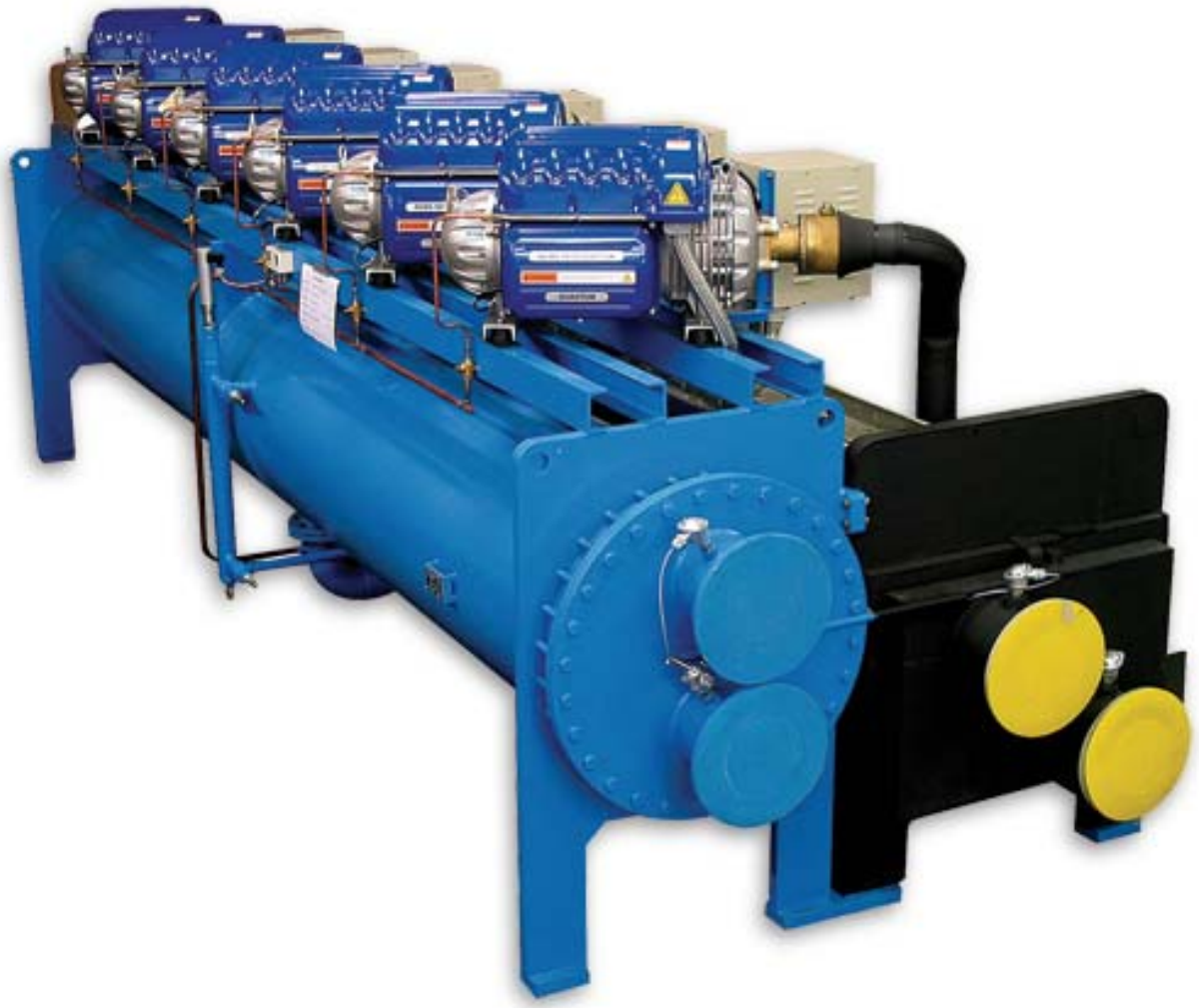
- Up to six compressors in one circuit
- Provides the ability to use the entire heat transfer surface even when using few compressors, thereby ensuring very close approach temperatures.

NEW Split-able Shell Chiller

SMARDT

- Shell can be split to transport short sections into equipment rooms.
- Enables the efficiency and lower cost of single-circuit while enabling transport through doors, elevators and around corners
- Results in Dual-Circuits
- Components can be Shipped-Loose

High-Efficiency - Multiple Compressors

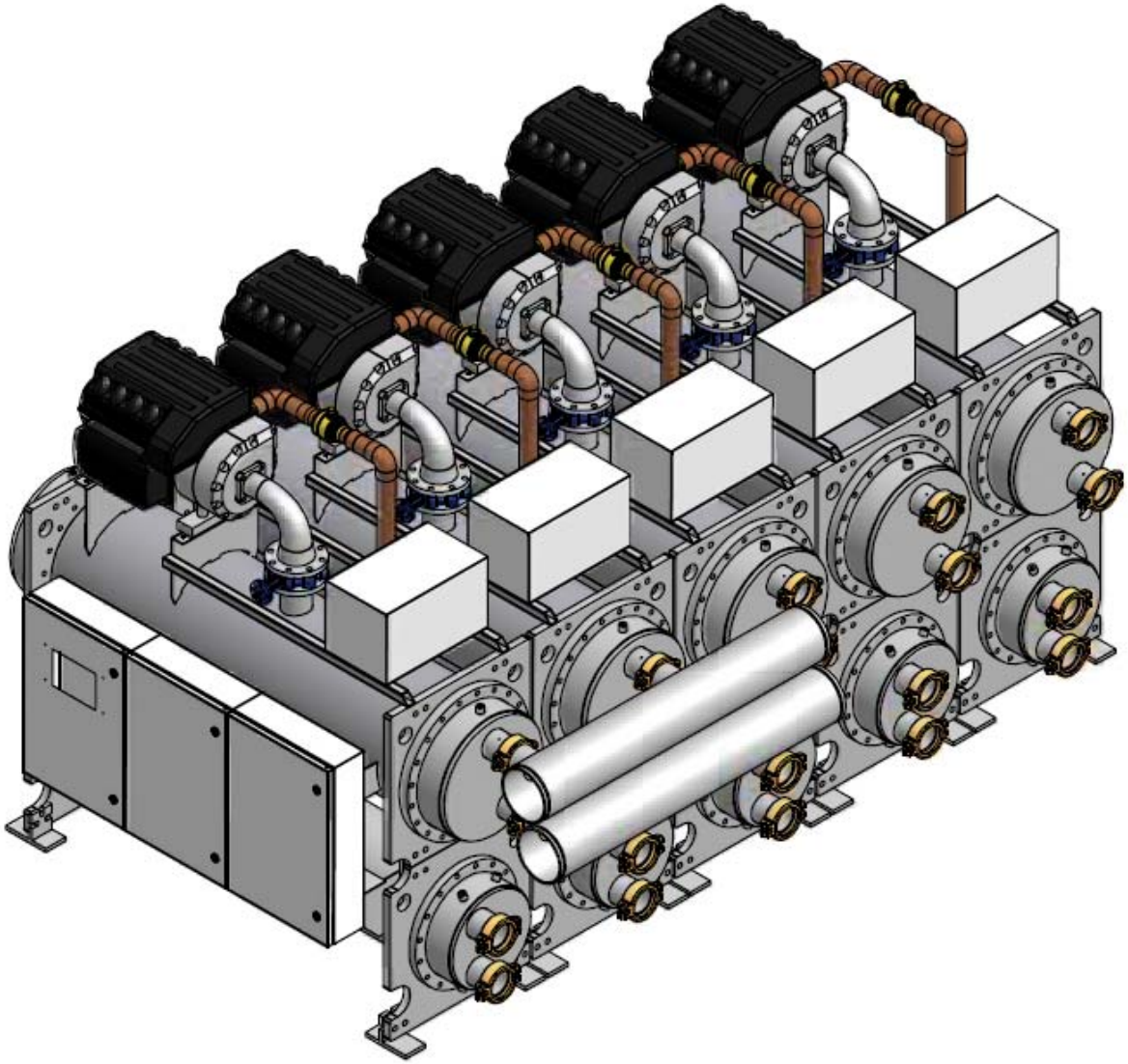


Staging compressors – must reduce head pressure to add compressors. Can affect set point temporarily. More noticeable with more compressors.

Process applications may require hot gas bypass at each compressor to assure steady set point.

Thermal mass tanks can be helpful for data-centers, museums, critical temp applications.

Compact Parallel Modular Approach



- Enables transport of compact , low capacity modules and assemble high capacity systems in the equipment room.
- Common headers can allow optional variable flow systems while ensuring correct fluid velocities.
- Isolation valves required for stepped flow
- Set Point Reset required for constant flow because of effect of mixing.

Air Cooled Chillers – 90 to 250 Tons

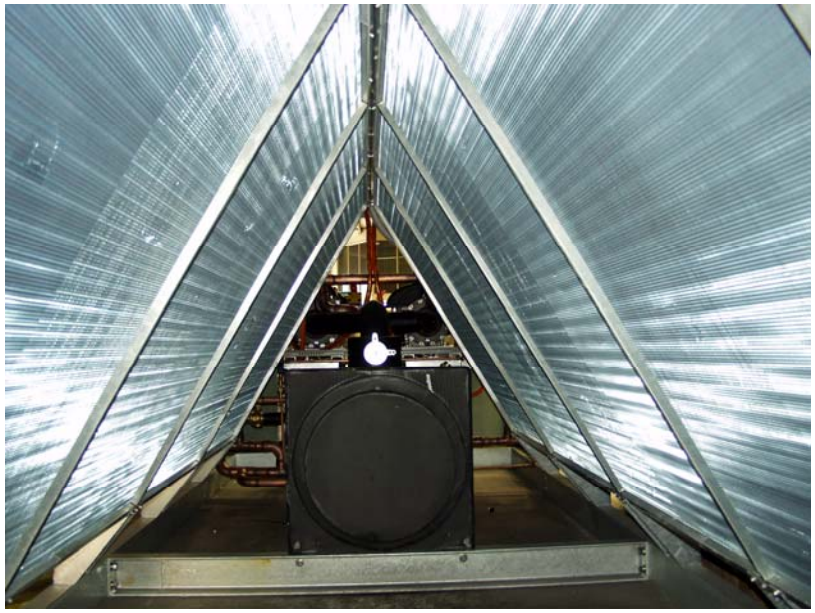
SMARDT

Up to three compressors and 12 fans – 250 tons now. 350 tons 2008.

Minimum compressor starting temp 32 degrees. Maximum 108 ambient.

Air Cooled Chillers – 90 to 270 Tons

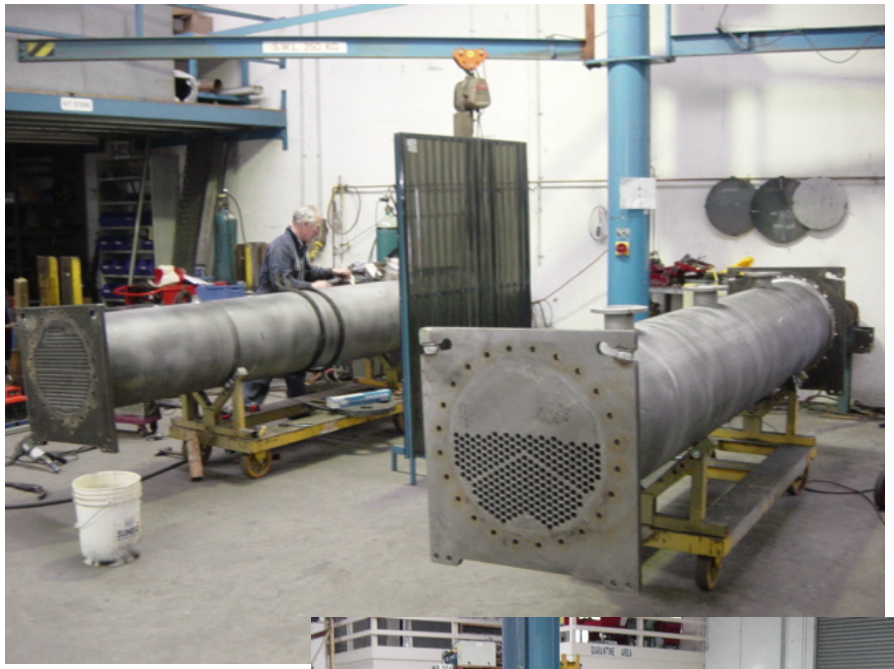
SMARDT



- Standard two-speed fans.
- Optional variable-speed fans with low-noise and self-contained VFD. Can significantly reduce overall energy usage.
- All condenser coils are coated. Options Thermoguard and ElectroFin.
- Evaporative pre-cooling systems show savings of 30% compared with normal air-cooled operation. To 125 degrees F.

ASME Heat Exchanger Manufacturing

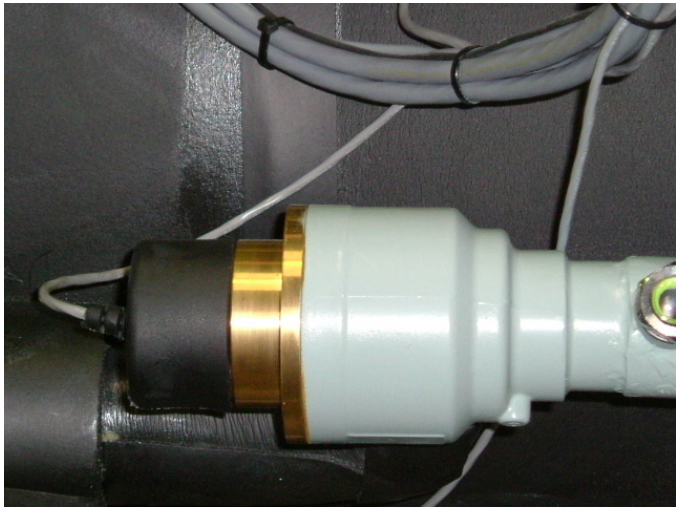
SMARDT



- Smardt makes its own heat exchangers
- Group buying power, proven designs
- Superior, reliable performance
- Precise liquid controls.

Advanced Engineered Components

SMARDT



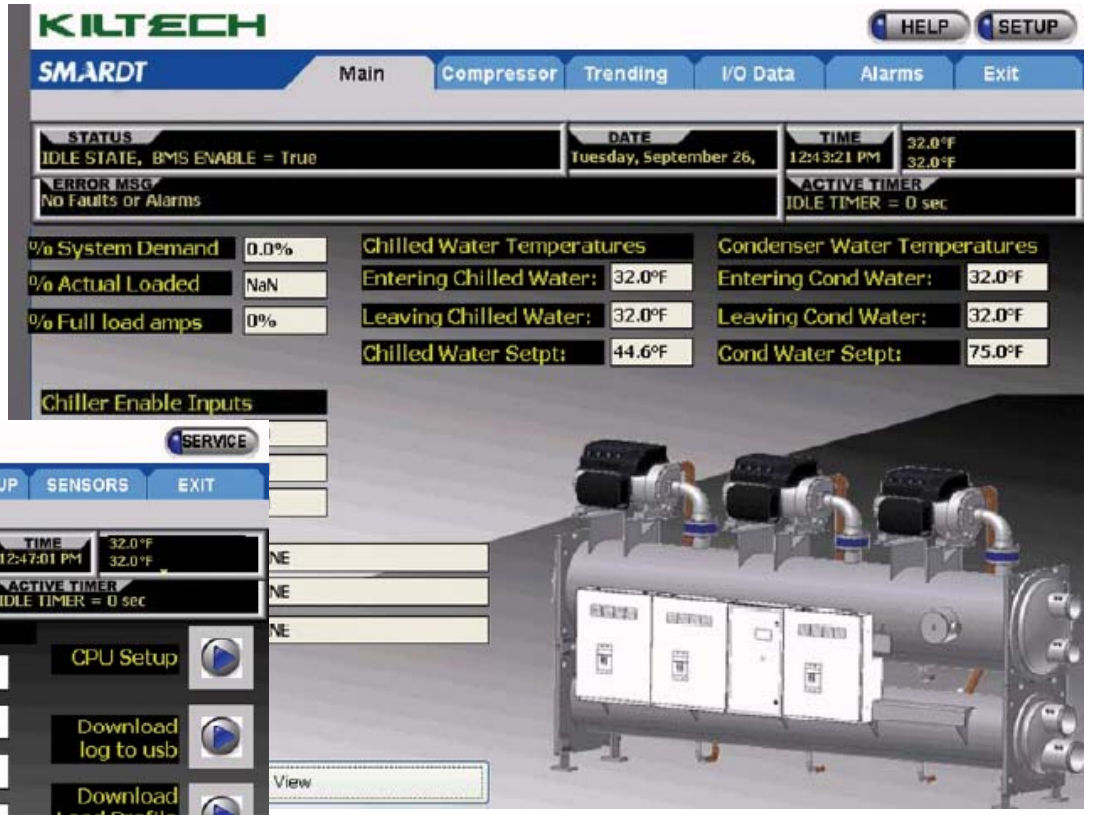
- Smardt makes its own heat EXV. 6,000 Step design assures correct refrigerant metering under every condition. Used for expansion and load-balancing requirements. Precisely controls liquid level for increased system stability. NOT a fixed orifice design.

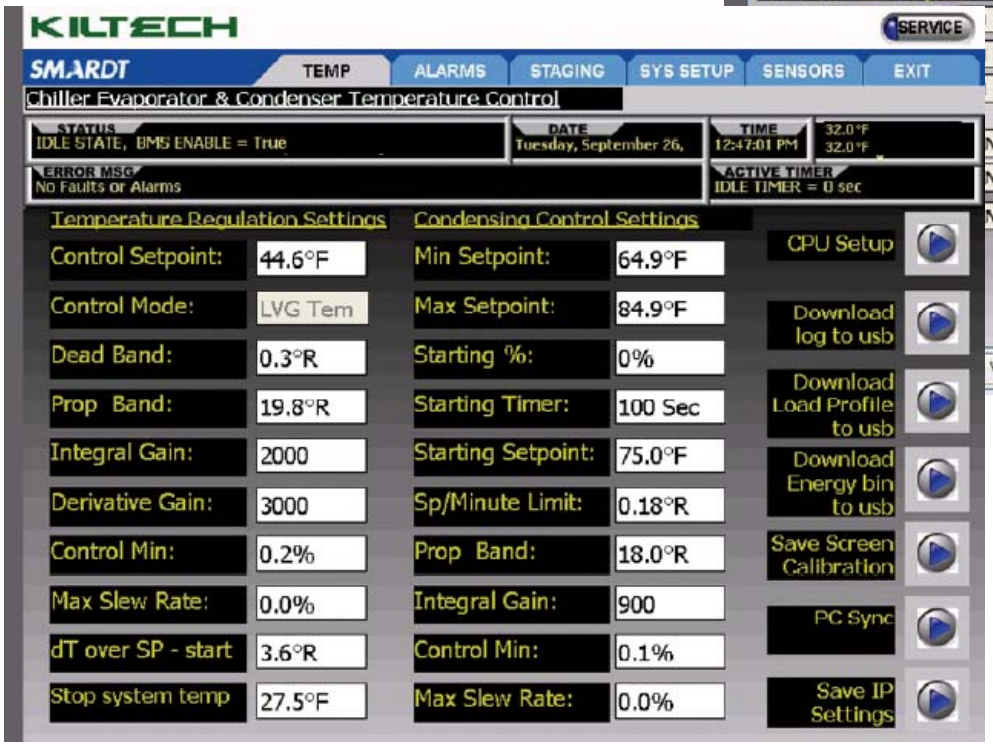
- Smardt makes its own Discharge Check Valve. Industrial design provides highly reliable seating and lower pressure drop. Solves refrigerant reverse direction issues.

- SUPERIOR & RELIABLE OPERATION

Advanced, Easy to Use Chiller Controls

SMARDT

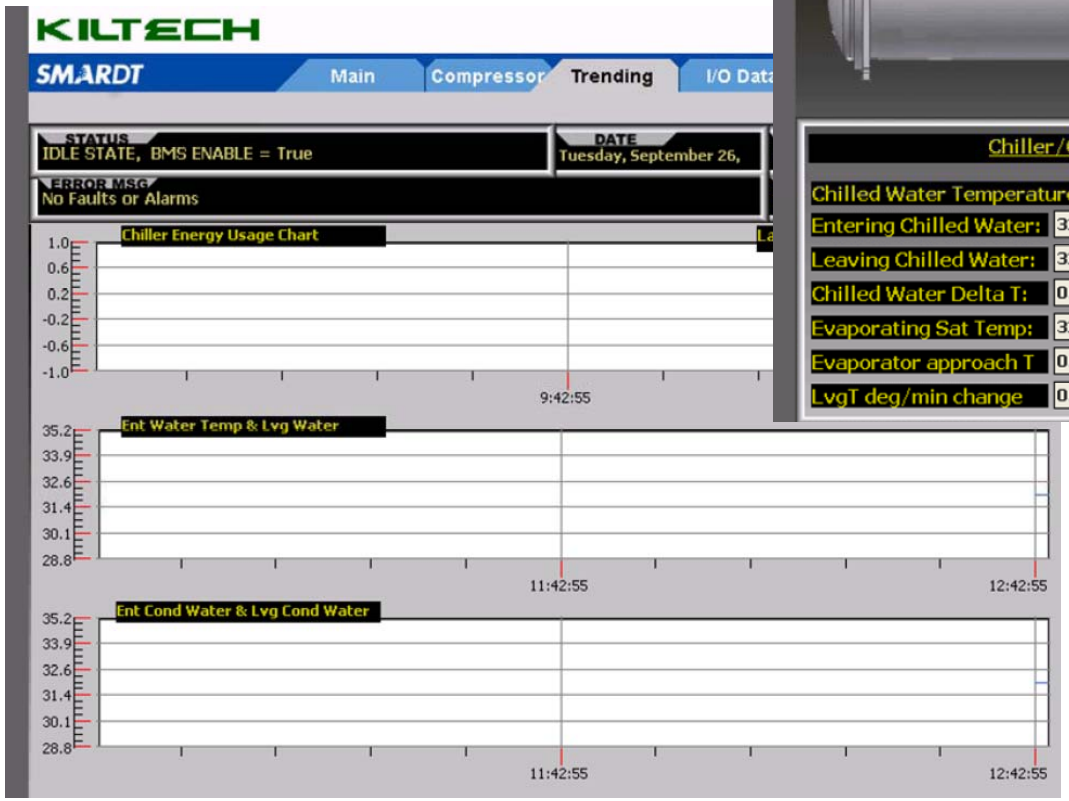




Advanced, Easy to Use Chiller Controls

SMARDT

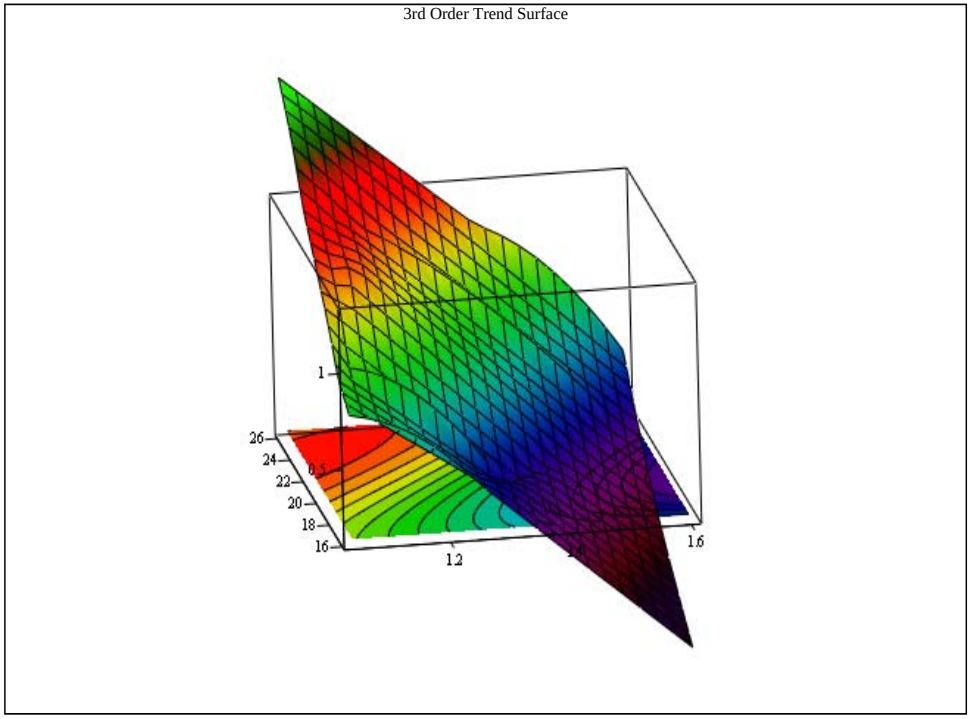
- Real-Time Trending
- Most Comprehensive



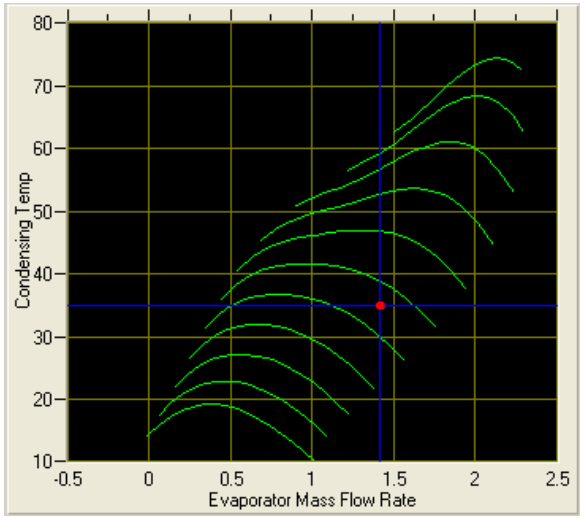
Compressors and Heat Exchangers

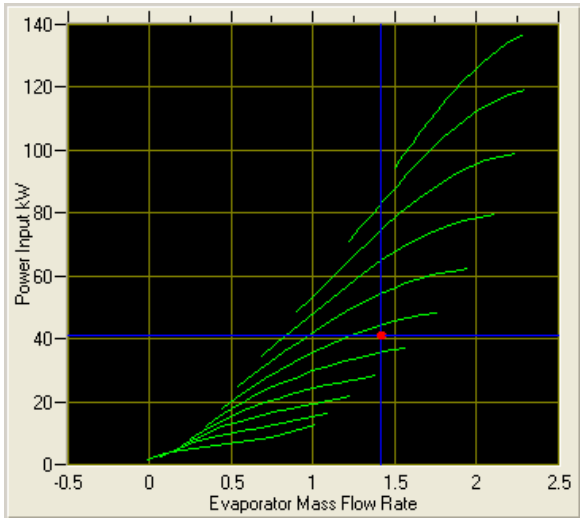
SMARDT

Developed from the ground up using Turbocor performance maps and optimized with proprietary heat transfer technologies.



(zp), (x1, x2, Y)





Control System Highlights

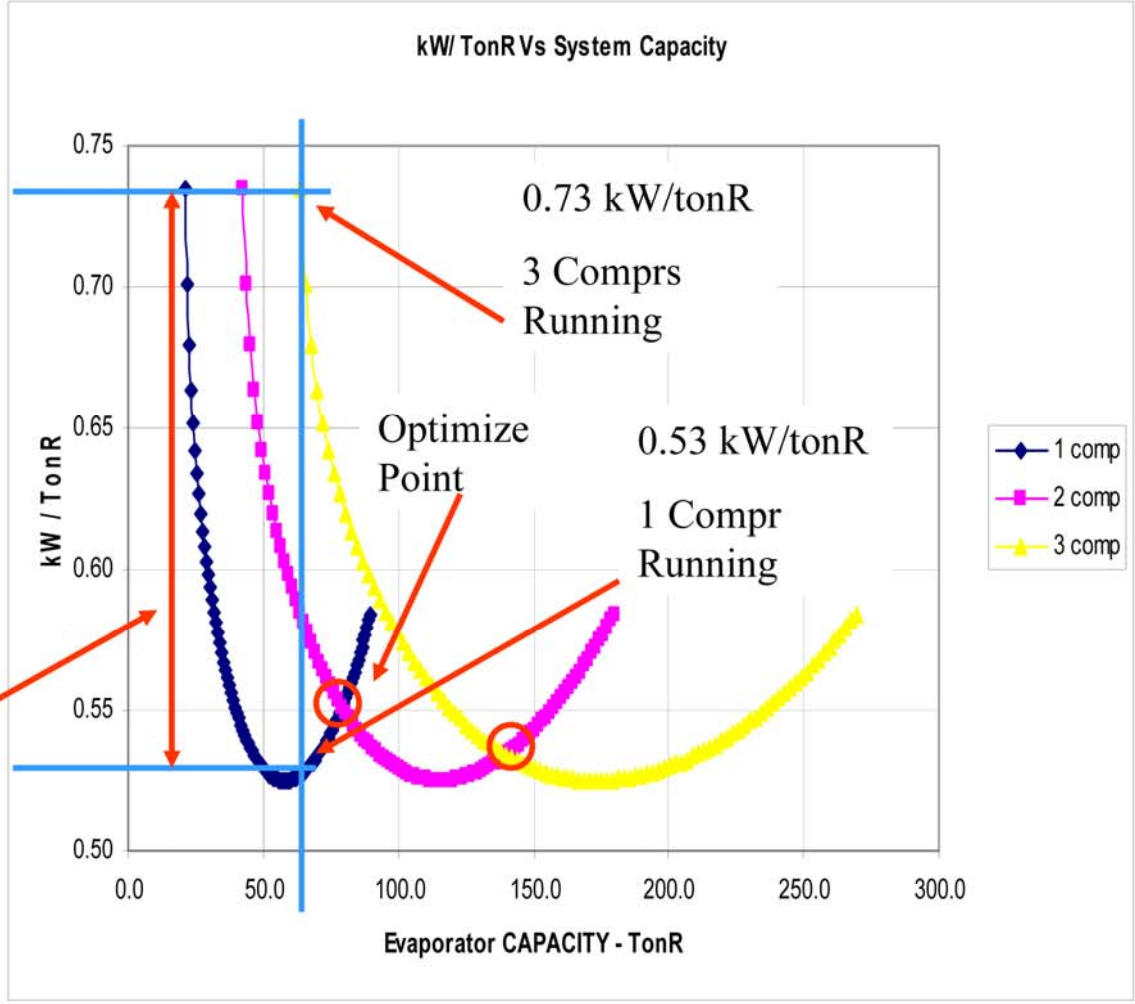
- Easy to use graphical touch-screen interface.
- Proven compressor performance maps are self-contained.
- Monitors 150 compressor and flow control parameters.
- Adjusts compressor speed and Inlet Guide Vane position in real-time to precisely match system output to demand input.
- Multiple layers of operational safety protect compressor.
- Embedded Web & FTP Servers for remote access, diagnostics & control.
- System uses advanced algorithm that can adjust evaporator flow rate, condenser flow rate and remote tower fan speed .
- Provide a complete, zero-loss heat transfer system from cooling demand to heat rejection - at the lowest possible kW consumption.

Control System kW Optimization

SMARDT

- Calculation of optimum points to stage on and off.
- With compressor, pump and fan optimization employed controller payback of less than *1 year.

38% Energy Saving from compressors alone. Even more savings when cooling tower energy and pumping energy is reduced as well due to lower rejection heat load. Up to 50% total plant energy reduction possible.



* 1 Year payback based on 6 compressor system with 2800hrs run time.

Smardt Control System Advantages

- Up to 18% better performance at part load
- Real time cooling capacity estimation
- Real time efficiency estimation
- Real time power analysis
- Increased load stability
- Predictable / repeatable performance
- Real-time compressor staging optimization
- Variable-speed plant integration

Features of Smardt Controls

- Utilizes internal compressor staging optimization algorithms to precisely match total system output from demand to final heat rejection.

- Uses the DDC network to coordinate the operation of multiple system components to optimize overall system operation. Many can be performed right on the chiller.

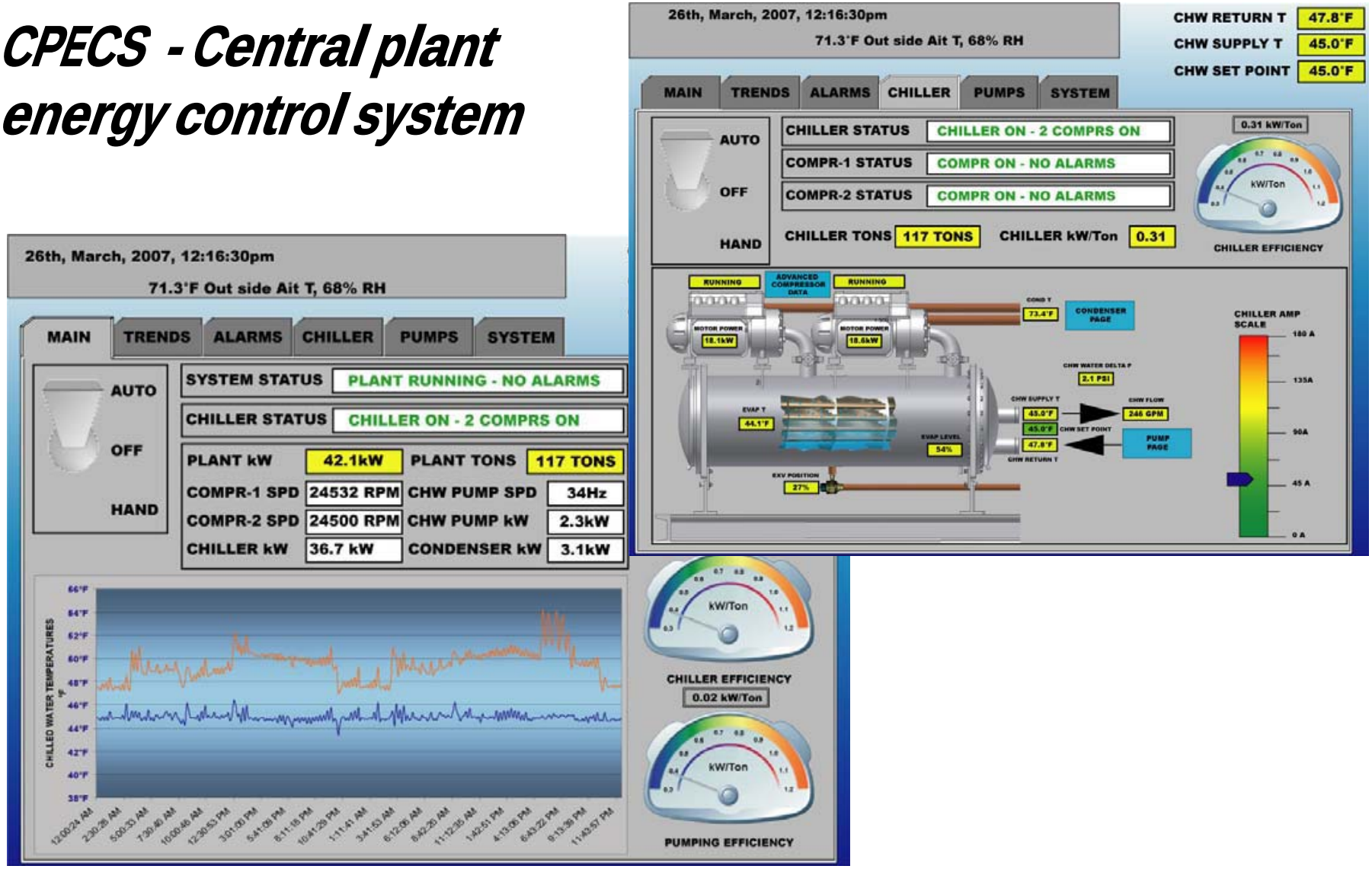
- Provides control based on adaptive methods rather than static temperature & pressure set-points.

- Permits equipment to operate as close as possible to its natural curve at part loads.

NEW CPECS Plant Control System

SMARDT

CPECS - Central plant energy control system



CPECS - Features

SMARDT

- Complete packaged central plant variable speed system.
- Optimized control specifically designed for SMARDT/Powerpax chillers
- Chilled water pump duty standby capability
- Condenser water pump duty standby capability
- Tower fan duty standby capability.
- Web monitoring
- Plant kW/Ton (COP) monitoring
- Chiller kW/Ton (COP) monitoring
- Battery backed up redundant controller
- BAS communication protocols easily handled – Lon, BacNet and Modbus
- Rapid payback on investment – typically under 3 years for new or existing chiller.
- One year data logging of all major variables.
- Multiple chiller optimized sequencing
- Chiller isolation valve control
- Chilled water decoupling valve control
- Multiple cooling tower isolation valve and sequencing control
- Monitoring of up to 4 critical zones (temperature and differential coil pressure)
- Complete override capability
- Plant error condition monitoring
- Choice of variable speed drives – Yaskawa or ABB
- Direct communications to all drives

Smardt Training and Certification

- Conducted by those most knowledgeable in Turbocor technologies and application nuances.
- Classes in Montreal, Florida and California
- Includes Compressor, Controls and Chillers

Smardt Variable Speed Factors

- **Power is proportional to the speed *cubed***

- **To achieve power reduction, the speed of fans, pumps and compressors should be reduced at lower loads.**

- **Emerging VFD plant controllers optimize the technology.**

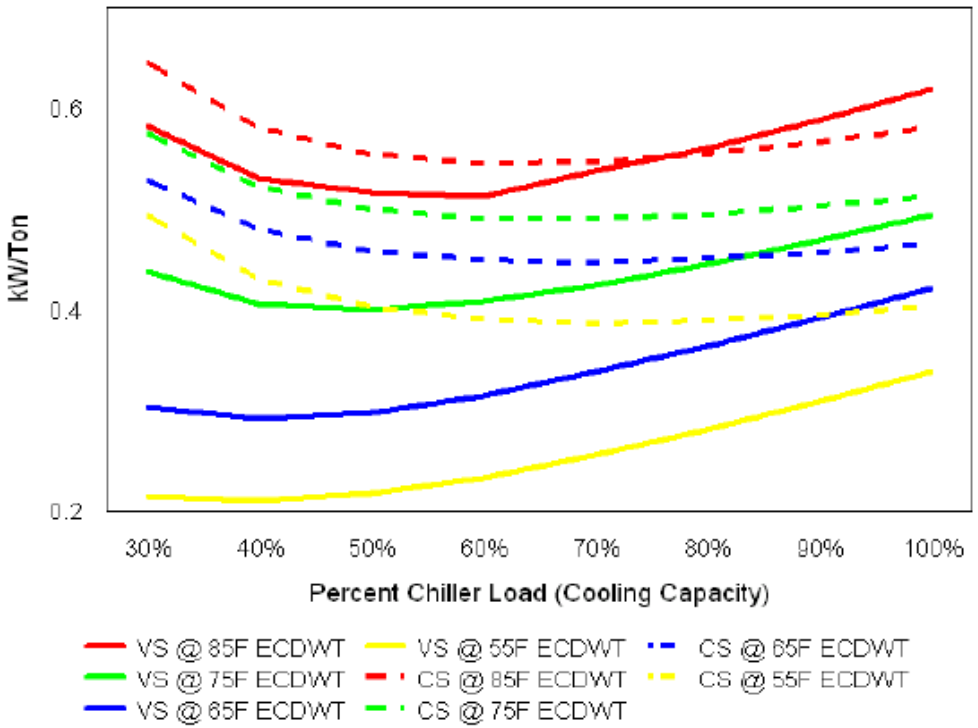
- **Flooded designs with water in tubes can limit flow range due to velocity and laminar flow issues. DX can be better solution in some applications, but with efficiency loss.**

- **Cooling tower selections optimized for lower temp and flow. Can increase installed cost yet reduce operational costs.**

Variable – vs – Constant Speed

SMARDT

- While Constant Speed Chiller Efficiency is nearly constant between 60% & 100% loading, the Efficiency of Variable Speed Centrifugal Chillers increases dramatically as load falls in that range.



- The Efficiency of Variable Speed Centrifugal Chillers is more significantly improved by the Reduction in Condensing Water Temperature – down to 50F.

- Ideally provide condenser water relief and set point reset in real time by controlling tower fan and condenser pumps.

Recent Application Notes

- Heat Recovery – 118 °F maximum. Special high-lift compressor required. Only works with TT300, no TT400s.

- New 120 ton TT350 high-lift compressor to be introduced soon

- Controller has settable minimum flows to avoid laminar conditions.

- New Danfoss Operating Envelope. 25°F min at 25% max glycol.

- Staging relief valves required for process applications to increase temperature stability. Also needed for most glycol and low unloading.

- Surging can cause extremely high temps at impeller. Caused by pressure ratio too high, low charge, miss-set EXV, low suction.

Recent Application Notes

- NEW Johnson controls N2 interface.

- Factory run tests now available to 270 tons for water cooled and air cooled to 150 tons.

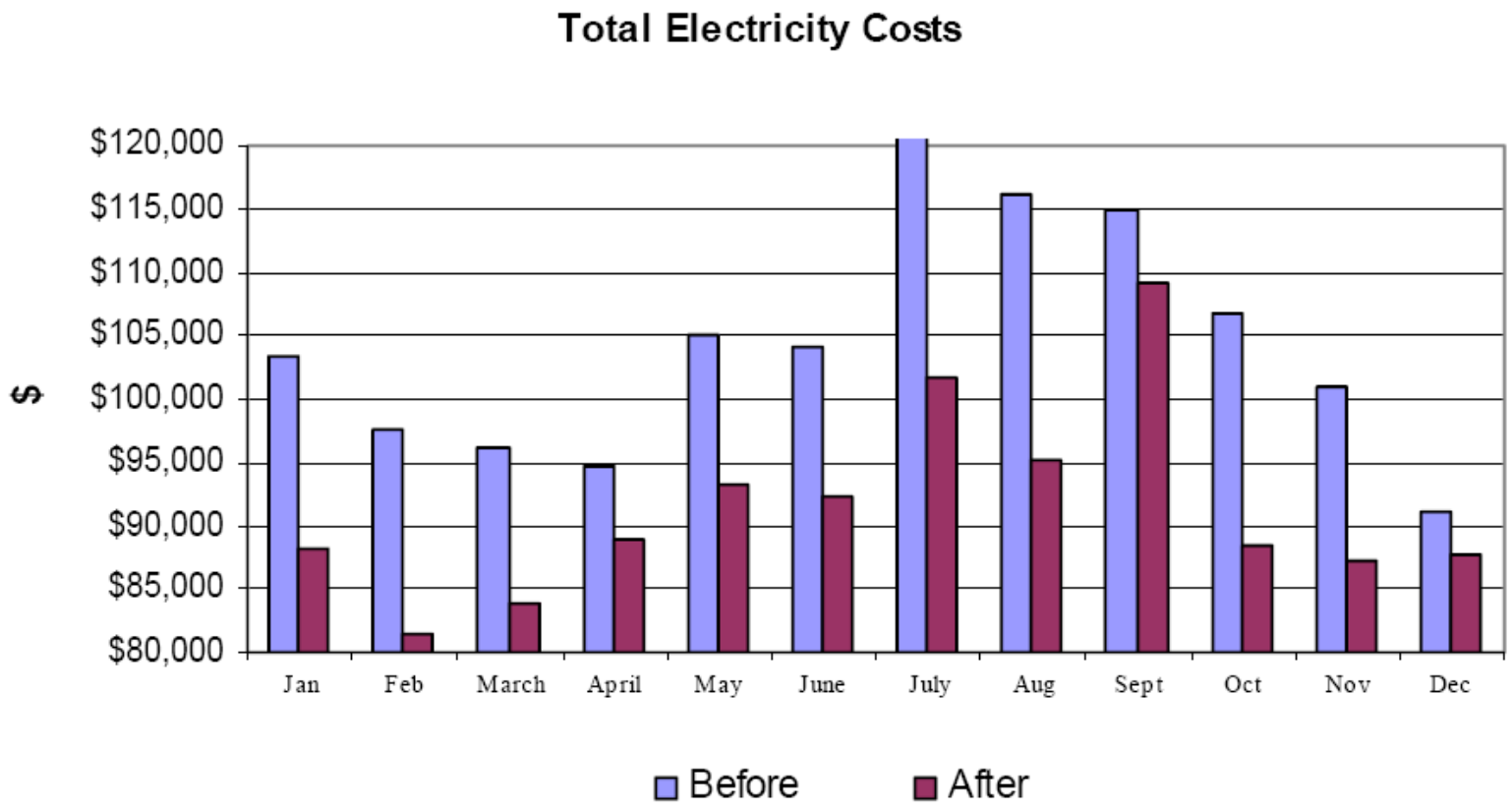
- Glycol applications above 25% may require DX, not flooded design.

- Differential temp for TT300 is @ 7-8 °F. 10-12°F for TT400. This is the difference between the entering condenser and leaving chilled water.

- NEW product range to be released this month, wider range. No 5-6 compressor TT400s until June – 1" tube exchangers in R&D.

- NEW web-based software BETA now in testing. Field use Q2.

San Diego Case Study Before and After



- **$175,000 annual energy savings**
- **$423,000 implementation cost**
- **$205,000 Utility Rebate**

Example – Multiple Compressor System

- Lowest kW per ton in energy usage.
- Single flooded evaporator circuit assures lowest approach temperature.
- Provides compressor redundancy.

HVAC vs Process applications

- R134a limits use in process. Can provide chilled water temps to about 25 degrees F.
- No Ice-Rinks – YET.
- High reliability and compressor redundancy.
- Data Centers can take advantage of condenser water relief – not reduced load.
- R&D data center modules, DX racks, refrigerant distribution

Example – Air-Cooled Chiller Systems

- Models from 90 to 250 tons
- Operates well in medium-hot ambient

NEW 38,000 Square Foot Factory

- Heat exchanger manufacturing
- Air-cooled chiller manufacturing
- Room to expand with rapid growth

Why Chose Smardt and Turbocor?

SMARDT

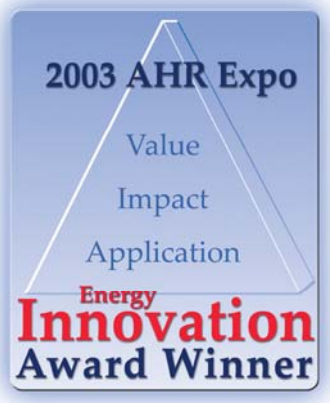
- More Experience than Anyone
- Widest Product Range to Meet Needs
- Lowest Energy Consumption
- Reliable - Lowest Maintenance Cost
- Easily Serviced with Advanced Controls
- Interfaces with Most BMS Systems

Why Chose Smardt and Turbocor?

- International Service & Support
- Global business functions & documents
- Always One-Step-Ahead
- Superior Custom Engineered Components
- Advanced Web Based Tools
- Lowest Total Cost of Ownership

Why Chose Smardt and Turbocor?

ASHRAE Expo
Energy Innovation
Award



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