



REVOLUTIONARY ENERGY SAVINGS

Air-cooled oil-free centrifugal chillers from Smardt Chiller Group

SMARTD

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INTRODUCTION AND OVERVIEW

SMARTD CHILLER GROUP - WORLD LEADER IN OIL-FREE CHILLER EFFICIENCY

The PowerPax and SMARTD companies joined forces in 2005 to merge their global operations in engineering, development, testing and certification, supply chain, technical services and customer support.

PowerPax, based in Melbourne, Australia, was founded in 2000 by a team of HVAC industry experts, to specialize in high-efficiency shell-and-tube heat exchangers and their optimization in oil-free centrifugal chillers.

SMARTD, based in Montreal, Quebec, was founded in 2005 by a team of Turbocor veterans, to produce chillers which optimized the energy efficiency potential of the Turbocor compressor technology.

The SMARTD Chiller Group now has well over 2000 operating chiller installations across the world, all delivering high reliability, outstanding part-load efficiencies, and the overall lowest cost of ownership in the market today. Achieving these goals consistently remains the Group's core purpose, and clearly differentiates it from competitors with conventional machines.

CERTIFICATION

All SMARTD chillers are ETL listed, have lifetime electrical safety coverage, and incorporate evaporators and condensers that fully comply with ASME pressure vessel codes.

SMARTD chiller energy efficiency performance is certified according to AHRI standard 500/590 (ref: www.ahrinet.org). IPLV performance always far exceeds the minimum levels set out by ASHRAE standard 90.1, CSA 743, Eurovent, Australia's MEPS, and other governing bodies.

STRONG LEED CONTRIBUTION

Use of SMARTD chiller technology can significantly contribute to achieving Leadership in Energy & Environmental Design (LEED™) certification for a building, be it in existing buildings, core and shell constructions, or new construction, because it can help win critical points in the Energy & Atmosphere category. Market research by the U.S. Green Building Council (USGBC) finds that the streamlined LEED process is second only to rising energy costs as a driver for stronger adoption of green building practices and the transformation of the built environment to sustainability. SMARTD is a member of the USGBC.

STRONG SUPPORT FOR THE EPA RESPONSIBLE USE VISION

The EPA's Responsible Use vision, encourages manufacturers, system designers, and owners, to invest in products and technologies which document sustainability of the highest efficiencies, in tandem with the lowest emissions. SMARTD is a strong supporter of the vision and of the EPA.

SMARTD PRODUCT BENEFITS

SMARTD AIR COOLED CHILLER RANGE

60 TR to 300 TR

Lowest Lifetime Operating Costs

SMARTD works hard to minimize complexity in chiller design and operation, and SMARTD simplicity is reflected in low product operating costs. The thinking makes simple sense: no oil, flooded shell-and-tube evaporation, soft start, low power consumption, low maintenance costs and high reliability, with only one main moving part.

SMARTD field reliability has been outstanding, and not surprising when one considers that some 80% of all chiller problems in the field are due to failures in compressor oil return. And SMARTD chillers use no oil.

The growing fraternity of turbocor-trained engineers and technicians often suggests that total maintenance costs for oil-free chillers run at well under half the costs of traditional lubricated chillers.

Serviceability

Always important in minimizing operating costs, is ease of serviceability. Service access is swift and simple with SMARTD chillers, as is access to operating history through remote monitoring. Operating history and compressor and chiller set points are all accessible remotely by trained and authorized service personnel.

Simple BAS Integration

Integration with Modbus, Bacnet and LONworks building management systems is standard, as is connectivity with most industry-standard protocols.

Custom Design and Problem Solving

SMARTD design engineers are always ready and willing to resolve particular equipment design challenges. For example, high-efficiency heat recovery and free-cooling applications can all be custom designed and supplied competitively, and corrosion protection and other options are also available.

Redundancy

The use of multiple compressors allows for built-in redundancy safeguards. SMARTD's redundancy potential can offer system designers unique opportunities to eliminate multiple chillers, multiple controls, and multiple pumps, thus bringing further savings for owners.

Multiple compressors also allow system designers to save on low-load or pony chillers, because with a VFD integrated into each compressor control, a chiller which uses multiple compressors can be efficiently driven right down below 10% or even 5% load.

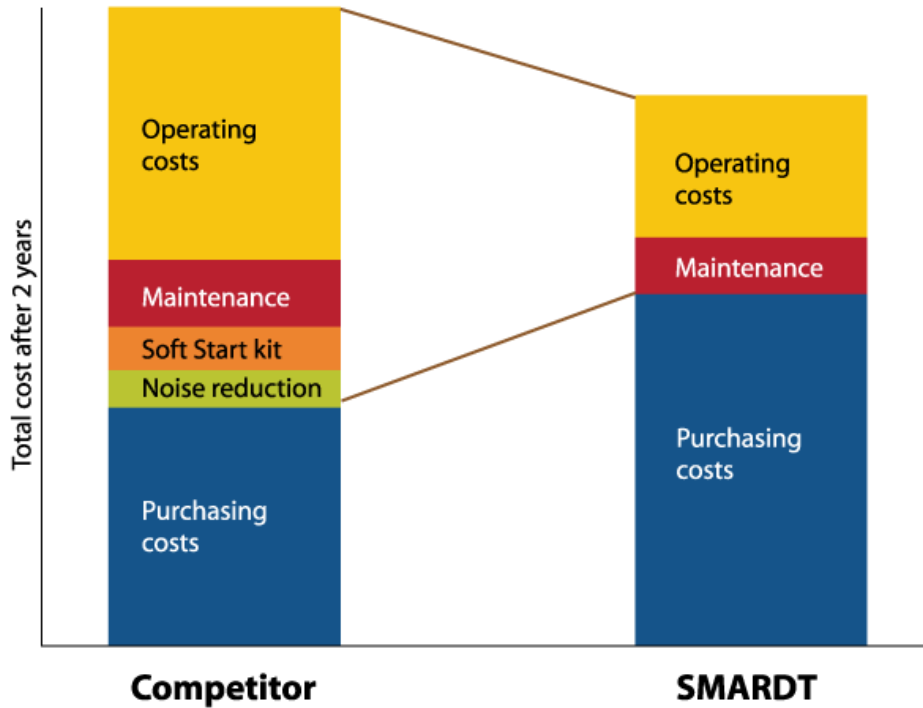
Optimization in Design

Condenser coils use a W configuration to optimize heat rejection and footprint. Coils are baked and double-coated and with sealed edges as standard, so as to extend the coil's physical protection from environmental corrosion.

Remote Air-Cooled Condensing

Remote location of the condenser can be a preferred option in some applications. SMARTD can supply either a full package as desired, or, on a condenser-less basis.

CHILLER COST COMPARISON



The above diagram shows a 2 year total chiller cost comparison, for a hotel in San Diego, CA. The left-hand option is a competitor low-cost lubricated screw chiller. The right-hand option is an oil-free 300TR SMARTD air-cooled chiller.

A QUANTUM LEAP IN ENERGY EFFICIENCY

All SMARTD chillers, whether air-cooled or water-cooled, are designed to optimize the performance of the highly efficient Danfoss Turbocor oil-free centrifugal compressor. Oil-free magnetic bearing technology and variable-speed drives deliver better IPLV efficiencies than conventional oil-lubricated centrifugal, reciprocating, scroll, and screw compressors. They are also high-speed - up to 48,000 rpm, very compact, very quiet, rugged, and reliable. The Power Factor is a high .92.

Proprietary magnetic bearings replace conventional oil lubricated bearings, which eliminate high friction losses, mechanical wear, and high-maintenance oil management systems, to deliver chiller energy savings of 35 percent and more over conventional chillers, while ensuring long-term reliability. Over 75,000 magnetic bearing machines are operating in the field, mainly in high-end vacuum pumps and CNC spindles - any innovation risk having been long overcome.

Turbocor's one main moving part (rotor shaft and impellers) is levitated during rotation by a digitally-controlled magnetic bearing system. Position sensors at each magnetic bearing, provide real-time feedback to the bearing control system at 120 times each revolution, thus ensuring constantly centered rotation.

Key benefits of SMARTD chillers can be summarized as:

- Heat transfer optimization through oil-free design
- Extraordinary soft-start efficiency
- Rugged & built-in defense against power failure
- HFC-134a ozone friendly refrigerant
- Significant noise reduction
- Spectacular energy cost savings
- Improved part load efficiencies

Heat Transfer Optimization Through Oil-Free Design

The well-known ASHRAE study (research Project 361) concluded that typical lubricated chiller circuits show reductions in design heat transfer efficiency of 15-25%, as lubricant accumulates on heat transfer surfaces, denatures and blocks normal thermodynamic transfer processes. Logically, no oil in your chiller means no oil contamination over time, so design efficiency is maintained effortlessly.

Extraordinary Soft-Start Efficiency

The compressor's power electronics, further enhanced by SMARTD's chiller controllers, require only 2 amps for start-up, compared with 500-600 amps for conventional machines. This means further savings for owners, who can reduce maximum power loads and reduce backup generator size, cost and capacity.

Rugged & Built-in Defense Against Power Failure

Each compressor has a bank of capacitors for energy storage and to filter DC voltage fluctuations. In case of a power failure, the capacitors provide continuity power to the bearings to keep the shaft levitated, allowing the motor to turn into a generator and to power itself down to a stop. Extended life testing confirms the system's remarkable durability.

HFC-134a Ozone Friendly Refrigerant

R134a has no ozone depletion potential and no phase-out schedule under the Montreal Protocol; it has an A1 rating under ASHRAE standard 34 (no flame propagation, lower toxicity). Positive pressure chiller designs (compared with negative pressure designs

using R123, for example) enhance sustainable performance, as neither air or moisture can leak into the chiller. No purge unit is required - a further saving. Liquid R134a refrigerant is used in SMARTD chillers to cool critical electronic and electromechanical components, to assure maximum efficiency and safe operation.

Significant Noise Reduction

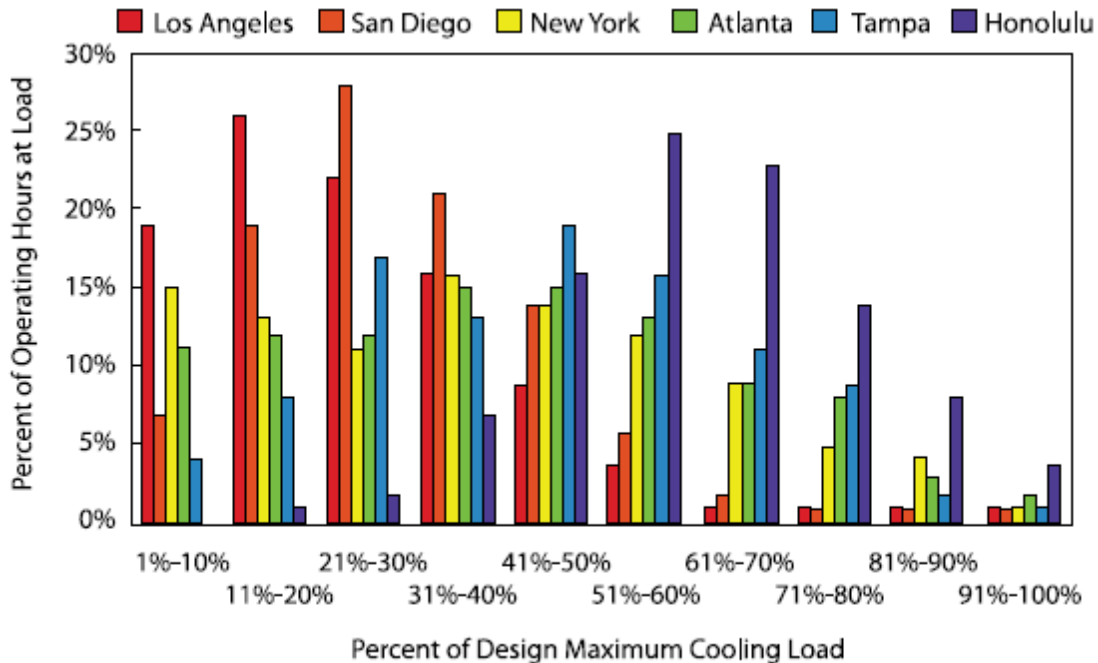
Very low sound and vibration levels are achieved, because there is no physical contact between moving metal parts, eliminating the need for expensive attenuation. Testing of SMARTD air cooled chillers, with reference to AHRI standard 575, yields readings as low as 77dBA at 1 meter.

Spectacular Energy Cost Savings

Compared with a new screw chiller, SMARTD IPLV energy efficiency is routinely more than 32% better. Compared with older lubricated reciprocating, screw, scroll, or centrifugal chillers, year round energy savings with SMARTD chillers can be a spectacular 50% and more. Under AHRI conditions, SMARTD IPLV performance can be as low as .33 kW/TR while part-load efficiency can be under .30 kW/TR.

Improved Part Load Efficiencies

The graph below (data source: AHRI 2005) shows very simply that a wide range of large US cities all demand the vast bulk of their chiller operations at part load - enabling much lower operating costs with a SMARTD oil free chiller, compared with a lubricated alternative.



PRODUCT DESCRIPTION

GENERAL DESCRIPTION

The SMARTD range of chillers offer the smallest footprint, the quietest operation, and some of the highest operating efficiencies on the market.

SMARTD's Air-Cooled centrifugal chiller consists of a shell & tube evaporator, twin-turbine centrifugal compressor(s), compressor controller(s), hot gas bypass valves, air cooled condenser coils, condenser fans, refrigerant level sensor(s), electronic expansion valve(s), interconnecting refrigerant piping, and safety features such as triple freeze protection. Condenser coils use a W configuration to optimize heat rejection and footprint, sealed edge coils are baked and double-coated as standard to extend the coil's protection from environmental corrosion, and all SMARTD chillers are designed to optimize the performance of oil-

free centrifugal compressors from Danfoss Turbocor Compressors Inc.

The SMARTD chiller set is a packaged unit, requiring connection to the chilled water circuit, main electrical supply, and integration with the building automation system (BAS) if applicable.

The following protocol interfaces are available on SMARTD chillers for BAS: LON, BACNET, BACNET/IP, N2, and MODBUS/IP, and these interfaces are usually installed within the SMARTD main control panel.

SMARTD chillers deliver a high level of reliability, outstanding part-load efficiency, and the lowest overall cost of ownership on the market.



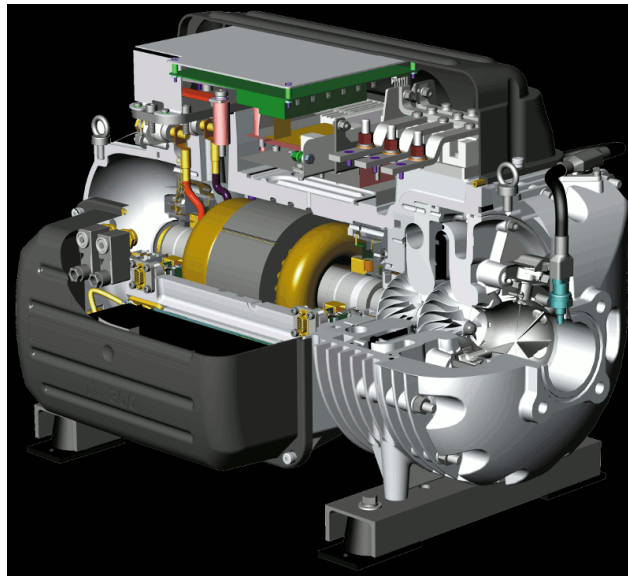
SMARTD Air-Cooled Chillers offer the smallest footprint, the quietest operation, and the highest air-cooled operating efficiencies on the market, and service access is also outstandingly simple.

COMPRESSOR TECHNOLOGY

SMARTD chillers optimize the benefits of the revolutionary Danfoss Turbocor oil-free centrifugal compressor technology. The TT300 compressor delivers 60 to 90 TR and the TT400 delivers 120 to 150 TR.

Advanced electronics mean that mechanical forces can be managed with extraordinary

tolerances and achieve a very high degree of reliability. The integral 2 stage centrifugal compressor and shaft is levitated utilizing state of the art magnetic bearing technology, which positions and adjusts the assembly automatically, 120 times per revolution.

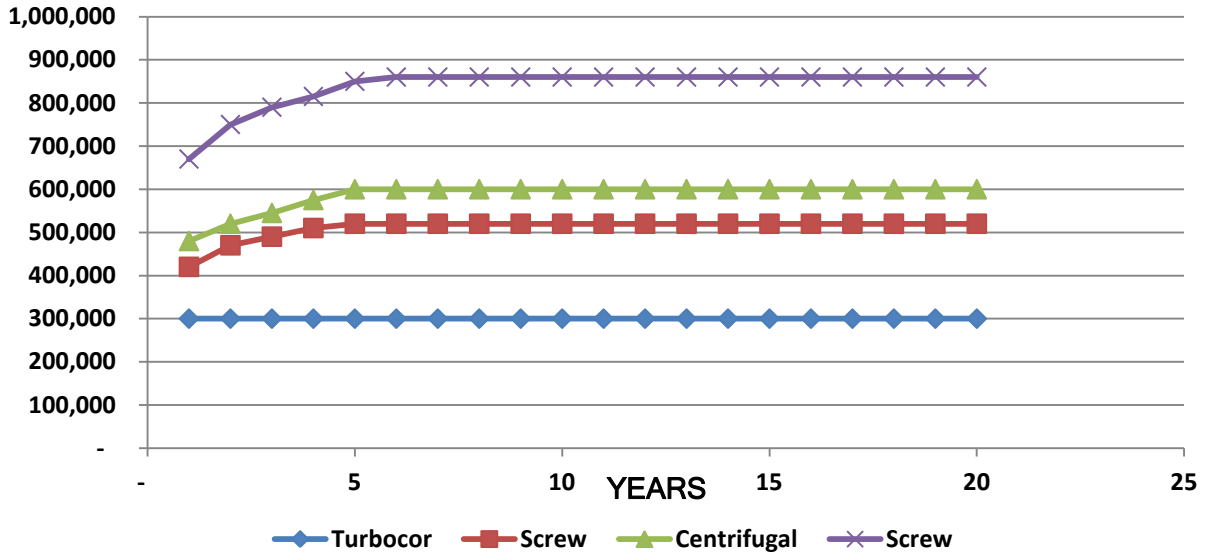


Cutaway view of the advanced oil-less magnetic bearing technology of the Danfoss Turbocor Compressor used in the SMARTD range of Chillers.



The one combined moving part in the SMARTD Chiller - the magnetically levitated 2 stage centrifugal compressor and shaft of the Turbocor Compressor.

300 kW (85tR) flooded chiller
with 3% oil in refrigerant



As this comparative AHRI study showed, over 20% of a lubricated chiller's operating efficiency is routinely lost in its early years, as a result of oil clogging of heat transfer surfaces.

USER FRIENDLY CONTROLS

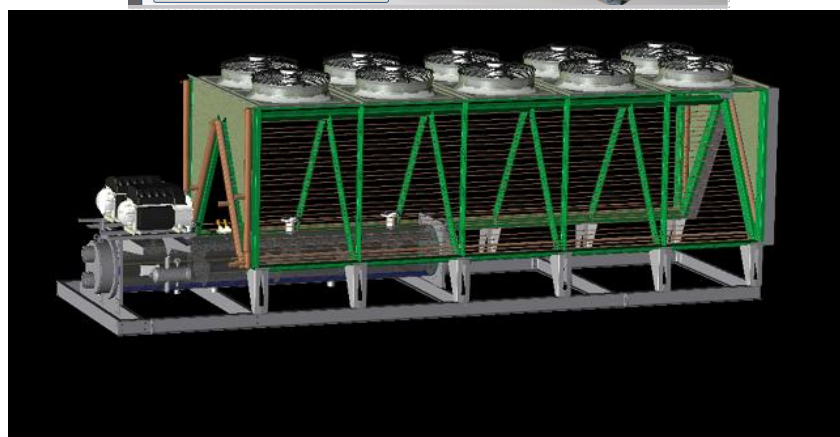
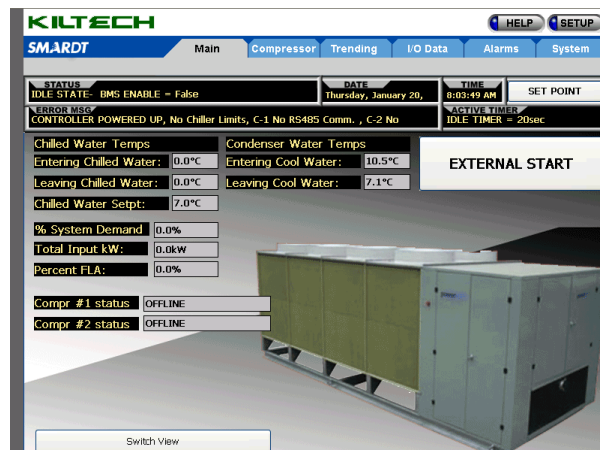
SMARTD's Kiltech controller is very user-friendly, highly intuitive, and allows optimization of both single and multiple compressor operation whilst enabling a rich array of communication options.

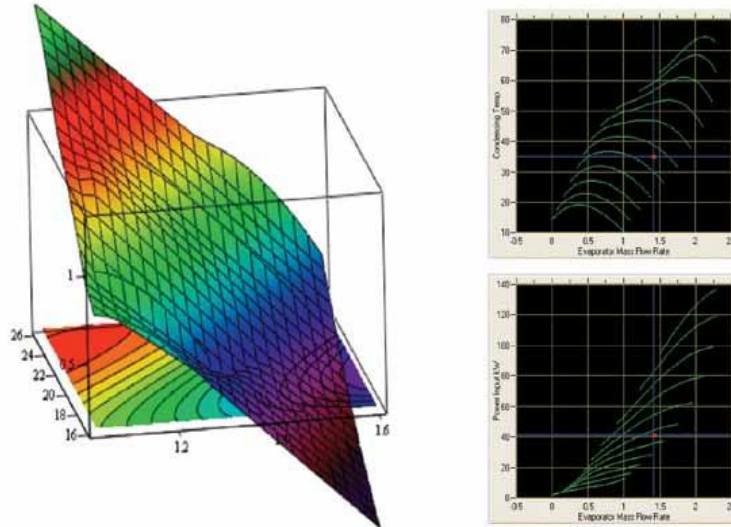
SMARTD chiller controllers have been developed from the ground up using primary compressor performance maps, maximizing the performance potential within these, then optimizing the whole chiller's operation to minimize energy consumption

The compressor's on-board digital controller proactively manages compressor operation, while allowing external control and web-enabled monitoring of performance and reliability information.

The PowerPax microprocessor system has been used on many chiller sites, and the in-field experience gained has resulted in the generation of state-of-the-art controls software that both maximizes operating efficiencies and minimizes maintenance and operating costs.

The SMARTD Kiltech controller provides for several access levels for plant operators and for commissioning, and offers a wide variety of options for flexible operation and optimization of power consumption, thereby maximizing time spent operating at compressor sweet spots.





Condensing Temp v Evaporator Mass Flow Rate
Power Input (kW) v Evaporator Mass Flow Rate

SMARTD chiller controllers have been developed from the ground up, using primary compressor performance maps, maximizing the performance potential within these maps, then optimizing the whole of the chiller's operation to minimize energy consumption.



Remote Monitoring Application - Compressor Overview Screen Capture

The SMARTD chiller remote monitoring application brings numerous additional benefits, including superior protection of HVAC assets, early diagnostics assistance, & enhanced rapid response in the detection of alarms or faults.

AIR COOLED CHILLER - PRINCIPAL COMPONENTS

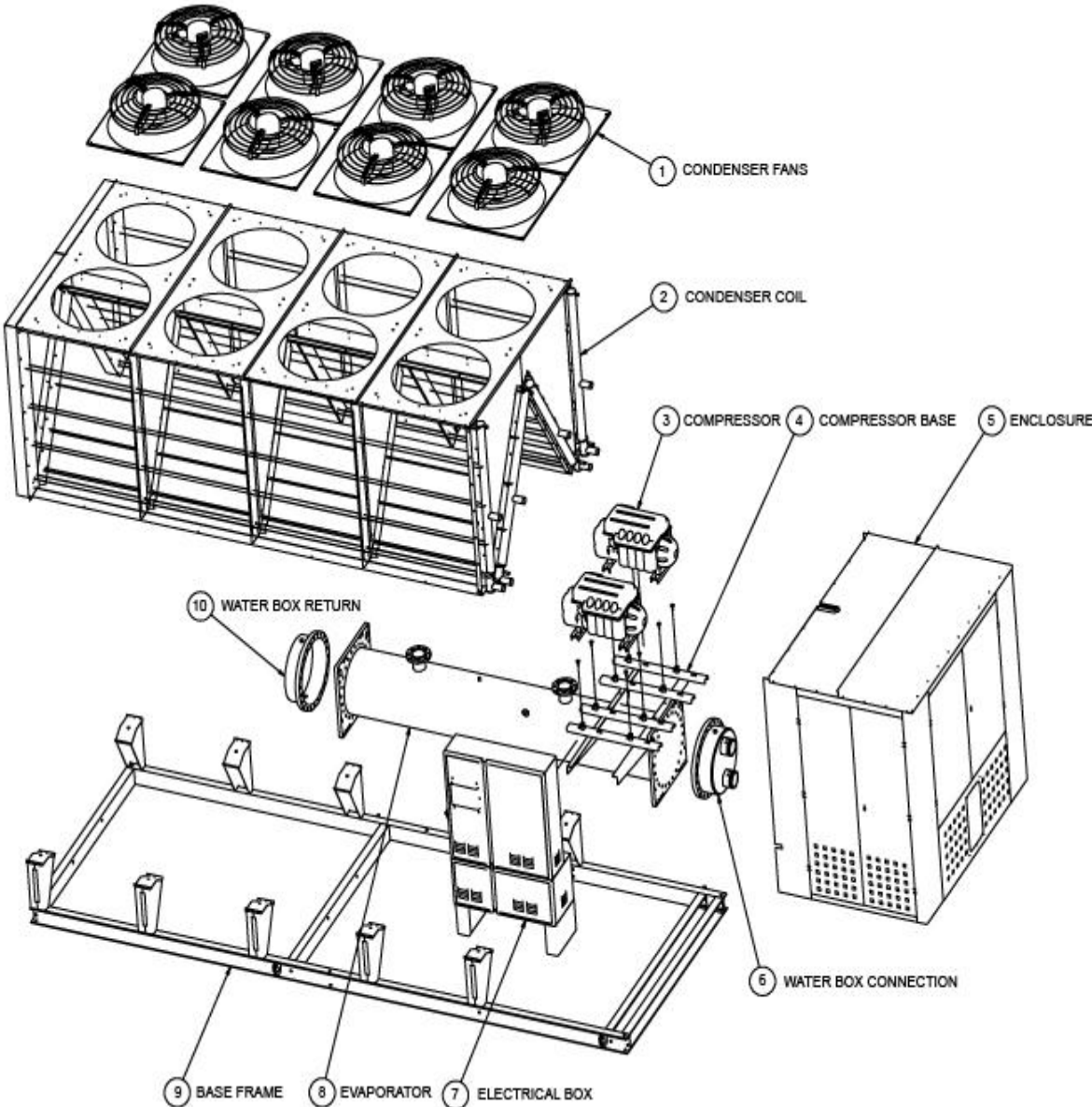


Figure 1: Exploded View - Air Cooled Chiller - Principal Components

GENERAL PIPING SCHEMATIC

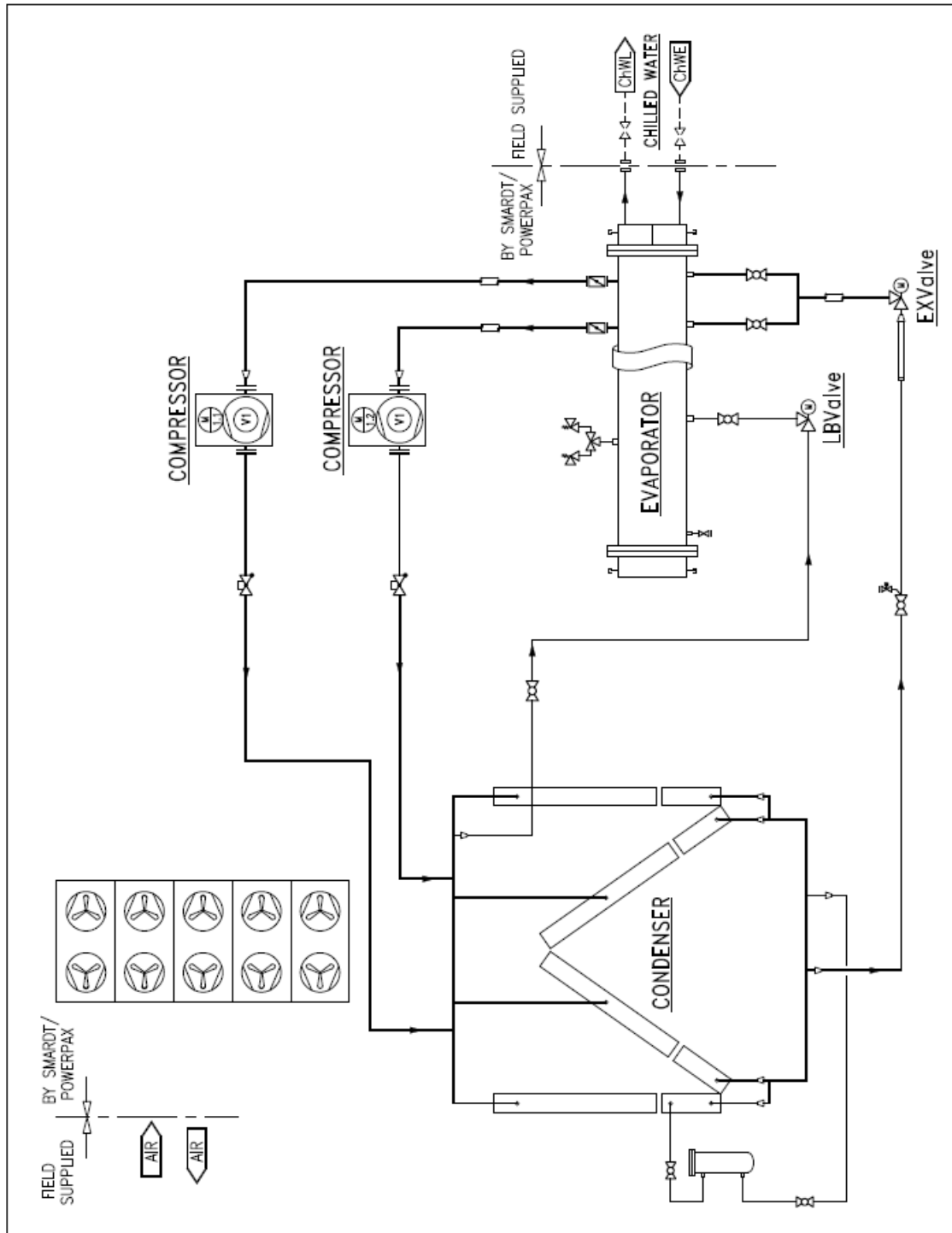


Figure 2: General Piping Schematic

CHILLER NOMENCLATURE

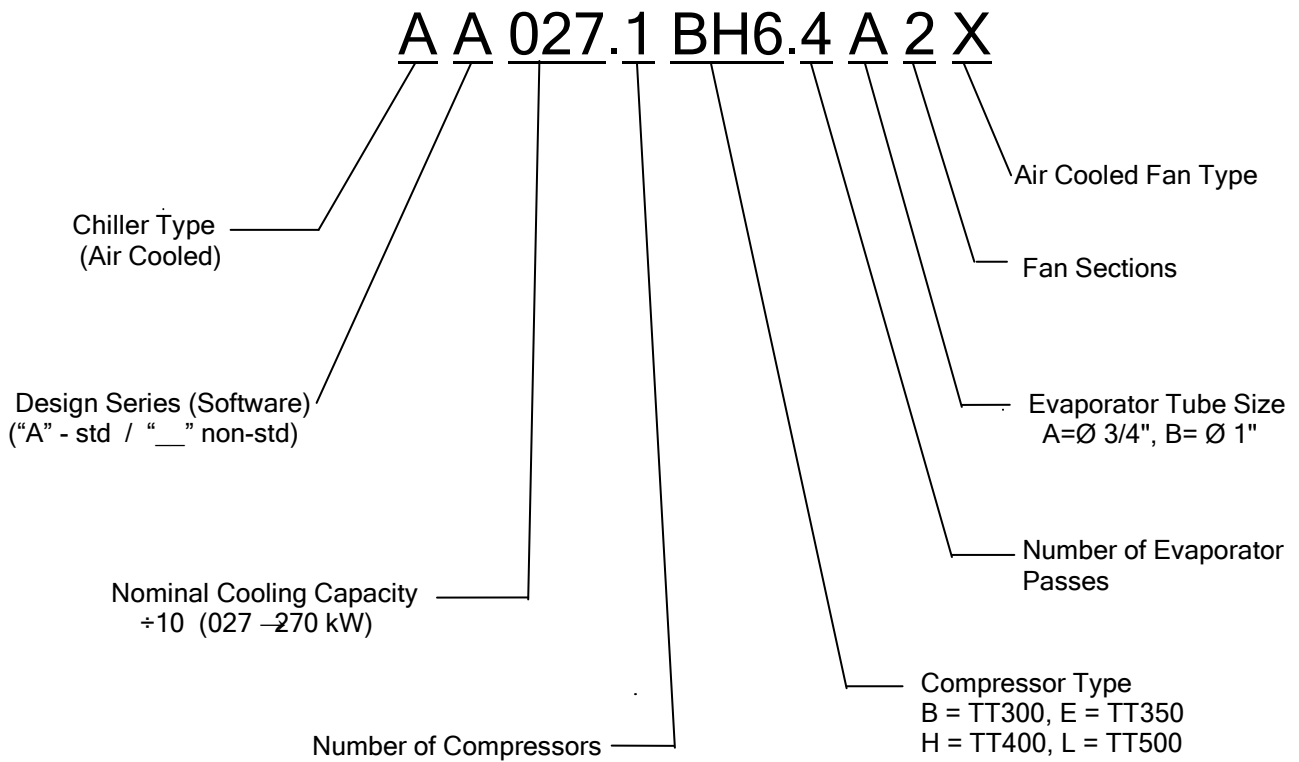


Figure 3: Chiller Nomenclature

CHILLER DIMENSIONS & CLEARANCES

Dimensions For Plant Layout Air-cooled Chiller

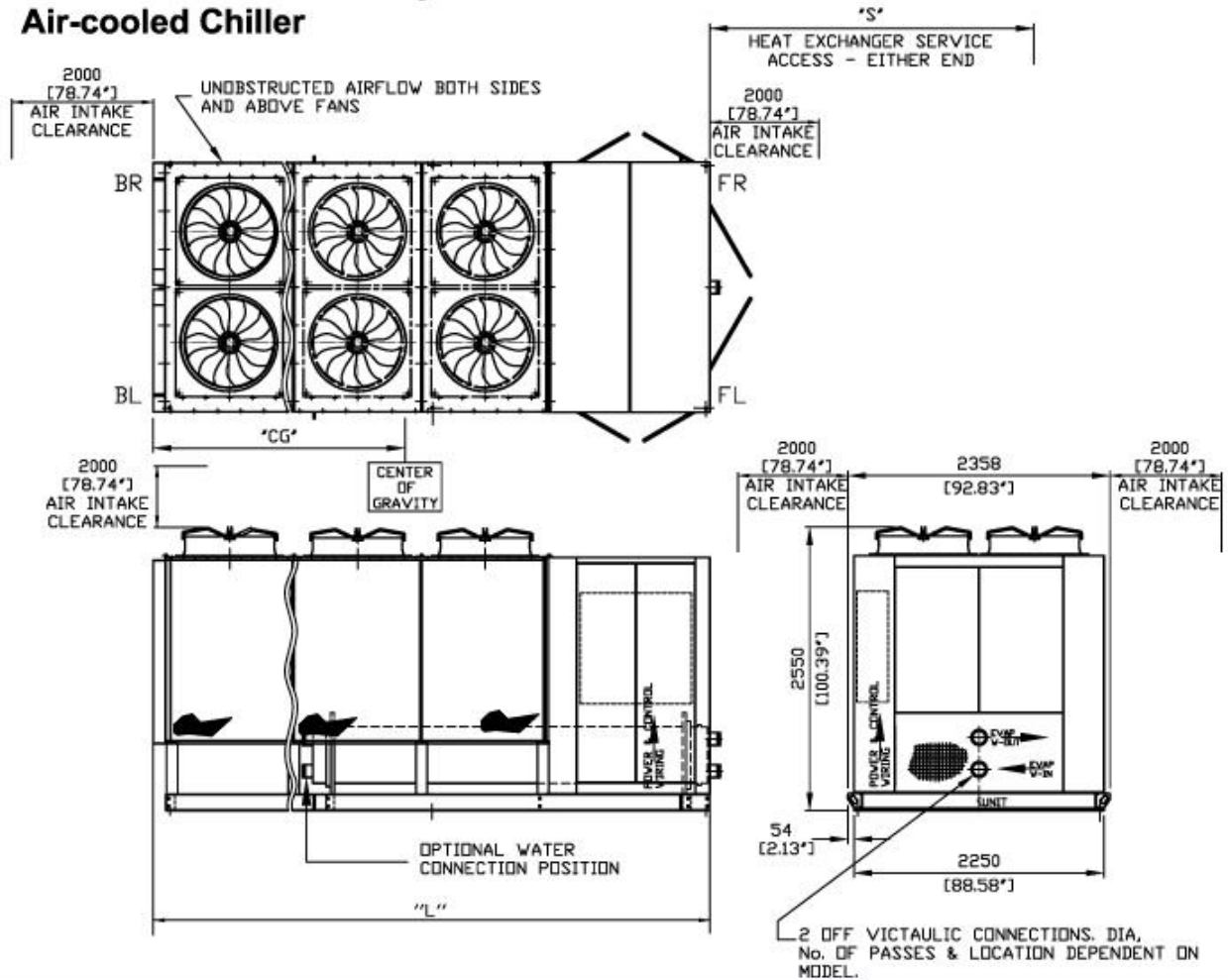


Figure 4: Chiller Dimensions & Clearances
(Ref. Table 2)

MINIMUM PLACEMENT CLEARANCES

UNIT PLACEMENT	SIDE CLEARANCE
Single unit, floor level	1830 mm (6'- 0")
Single unit, pit installation no deeper than height of unit	2440 mm (8'- 0")
Units side by side, floor level	3660 mm(12'- 0") between units, 1830 mm (6'- 0") on other sides
Units side by side, pit installation no deeper than height of unit	4880 mm (16'- 0") between units, 2440 mm (8'- 0") on other sides

Table 1: Minimum Placement Clearances

OVERALL DIMENSIONS, WEIGHTS, & PHYSICAL DATA

Model No.	No. of Comp'	No. of Fans	Length	Service Length	No. of Lifting Lugs	Empty Weight	Shipping Weight (Charged)	Operating Weight	Weight at Foot FR
			mm (ft-in)	mm (ft-in)		Kg (lbs)	Kg (lbs)	Kg (lbs)	Kg (lbs)
A027	1	4	3680 (12'-8")	8458 (27'-9")	4	3038 (6698)	3230 (7120)	3348 (7382)	899 (1983)
A030	1	6	5010 (16'-5¼")	8458 (27'-9")	4	3745 (8256)	4000 (8820)	4144 (9137)	1195 (2635)
A054	2	8	6150 (20'-21/8")	8458 (27'-9")	4	4798 (10578)	5150 (11360)	5323 (11735)	1528 (3368)
A059	2	10	7315 (24'-0")	8458 (27'-9")	6	5358 (11812)	5750 (12680)	5952 (13123)	1758 (3876)
A073	3	10	7315 (24'-0")	8458 (27'-9")	6	5846 (12888)	6250 (13780)	6467 (14258)	1903 (4195)
A082	3	12	8458 (27'-9")	8458 (27'-9")	6	6396 (14100)	6850 (15100)	7092 (15636)	2122 (4678)

Weight at Foot FL	Weight at Foot BR	Weight at Foot BL	Center of Gravity	R134a Charge	Water Content	Flow Range **	No. of Tube Passes	Water Conn. Sizes (Victualic)
Kg (lbs)	kg (lbs)	kg (lbs)	mm (ft-in)	kg (lbs)	kg (lbs)	L/s (gpm)		
943 (2079)	736 (1623)	770 (1697)	2060 (6'-9")	191 (422)	119 (262)	8-18 (127-285)	2	4
1238 (2729)	840 (1852)	871 (1921)	2870 (9'-5")	256 (564)	144 (317)	10-20 (127-285)	2	4
1570 (3461)	1099 (2422)	1127 (2484)	3505 (11'-6")	356 (782)	170 (375)	12-30 (127-285)	2	5
1800 (3969)	1224 (2698)	1211 (2670)	4300 (14'-1")	394 (868)	201 (443)	21-48 (333-713)	3	6
1945 (4289)	1295 (2856)	1324 (2918)	3680 (14'-1")	405 (892)	217 (478)	26-54 (412-856)	2	6
2169 (4782)	1387 (3057)	1415 (3119)	5260 (17'-3")	454 (1000)	243 (536)	26-54 (412-856)	2	6

The above table applies to 460 VAC - variable speed. For 575 VAC refer to SMARTD model specific equipment spec.

*Values differ by chiller model. Refer also to SMARTD model specific equipment spec for further details.

**gpm are U.S. gallons per minute

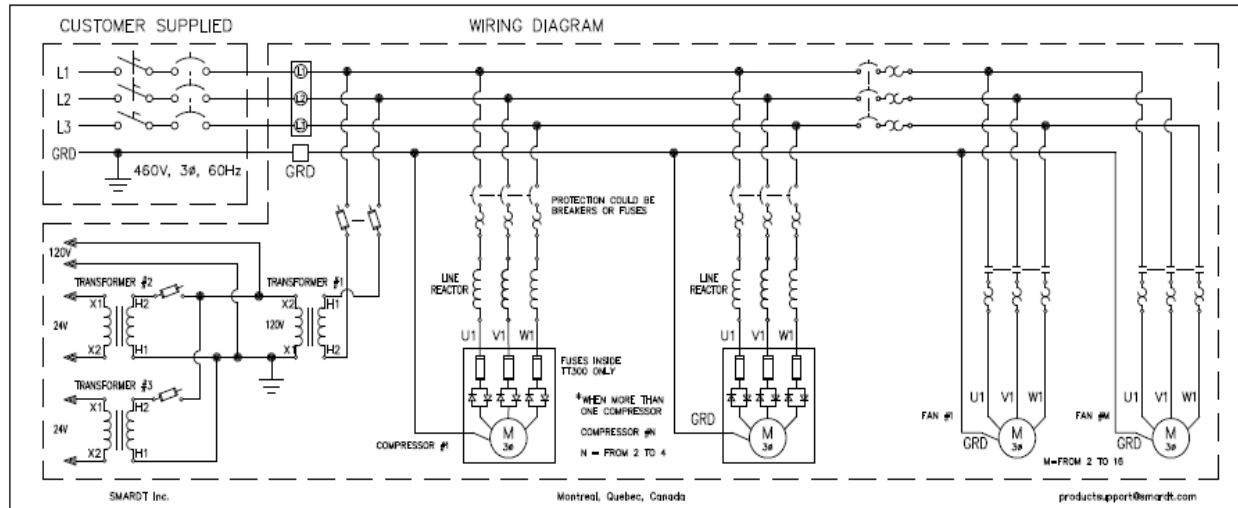
Table 2: Overall Dimensions, Weights, & Physical Data

*Includes full refrigerant charge - water circuits empty.

Weights may vary with individual tube count.

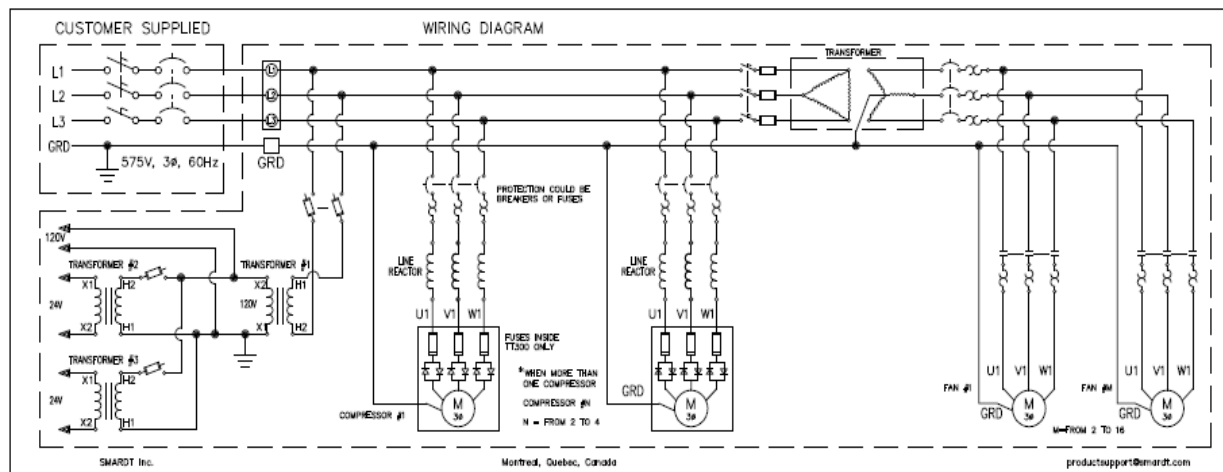
ELECTRICAL

FIELD WIRING



AIR COOLED

Figure 5: Field Wiring for 460V Air Cooled Chiller



AIR COOLED

Figure 6: Field Wiring for 575V Air Cooled Chiller

ELECTRICAL RATINGS

ELECTRICAL RATING - AIRCOOLED - TT300 460V 60Hz FOR USA									
CHILLER	COMP. - TT300		FAN		CHILLER				
	QTY	MODEL	QTY	MODEL	MCA (A)	MOP (A)	MDS (A)	MFW/9 0°C	MFW/ 75°C
A027.1BG6.X2V	1	G6	4	CI01-03	170	250	161	1/0	2/0
A027.1BG6.X2E				CH03-03	164	250	154	1/0	2/0
A027.1BG6.X2F				SDQ.6N.V7 D	167	250	157	1/0	2/0
A027.1BG6.X2S				SDQ.6N.V7 Y	159	250	148	1/0	2/0
A027.1BG7.X2V		G7		CI01-03	188	300	178	2/0	3/0
A027.1BG7.X2E				CH03-03	182	300	171	2/0	3/0
A027.1BG7.X2F				SDQ.6N.V7 D	186	300	175	2/0	3/0
A027.1BG7.X2S				SDQ.6N.V7 Y	178	300	165	2/0	3/0
A030.1BG6.X3V	1	G6	6	CI01-03	179	250	172	2/0	3/0
A030.1BG6.X3E				CH03-03	170	250	161	1/0	2/0
A030.1BG6.X3F				SDQ.6N.V7 D	175	250	167	2/0	2/0
A030.1BG6.X3S				SDQ.6N.V7 Y	163	250	153	1/0	2/0
A030.1BG7.X3V		G7		CI01-03	198	300	189	3/0	3/0
A030.1BG7.X3E				CH03-03	189	300	179	2/0	3/0
A030.1BG7.X3F				SDQ.6N.V7 D	194	300	184	2/0	3/0
A030.1BG7.X3S				SDQ.6N.V7 Y	182	300	170	2/0	3/0
A044.2BG6.X3V	2	G6	6	CI01-03	299	400	310	300	350
A044.2BG6.X3E				CH03-03	290	400	299	250	350
A044.2BG6.X3F				SDQ.6N.V7 D	295	400	305	300	350
A044.2BG6.X3S				SDQ.6N.V7 Y	283	400	291	250	300
A044.2BG7.X3V		G7		CI01-03	333	450	344	350	400
A044.2BG7.X3E				CH03-03	324	450	334	350	400
A044.2BG7.X3F				SDQ.6N.V7 D	329	450	339	350	400
A044.2BG7.X3S				SDQ.6N.V7 Y	317	450	326	300	400
A054.2BG6.X4V	2	G6	8	CI01-03	309	400	321	300	350
A054.2BG6.X4E				CH03-03	297	400	307	300	350
A054.2BG6.X4F				SDQ.6N.V7 D	304	400	315	300	350
A054.2BG6.X4S				SDQ.6N.V7 Y	288	400	296	250	350
A054.2BG7.X4V		G7		CI01-03	343	450	356	350	500
A054.2BG7.X4E				CH03-03	331	450	342	350	400
A054.2BG7.X4F				SDQ.6N.V7 D	337	450	349	350	500
A054.2BG7.X4S				SDQ.6N.V7 Y	321	450	331	350	400

Table 3: Electrical Ratings

Electrical Ratings (cont'd)

ELECTRICAL RATING - AIRCOOLED - TT300 460V 60Hz FOR USA									
CHILLER	COMP. - TT300		FAN		CHILLER				
	QTY	MODEL	QTY	MODEL	MCA (A)	MOP (A)	MDS (A)	MFW/ 90°C	MFW/ 75°C
A059.2BG6.X5V	2	G6	10	CI01-03	319	400	332	300	400
A059.2BG6.X5E				CH03-03	304	400	315	300	350
A059.2BG6.X5F				SDQ.6N.V7 D	312	400	324	300	400
A059.2BG6.X5S				SDQ.6N.V7 Y	292	400	301	300	350
A059.2BG7.X5V		G7		CI01-03	353	450	367	400	500
A059.2BG7.X5E				CH03-03	338	450	350	350	500
A059.2BG7.X5F				SDQ.6N.V7 D	346	450	359	350	500
A059.2BG7.X5S				SDQ.6N.V7 Y	326	450	336	350	400
A073.3BG6.X5V	3	G6	10	CI01-03	439	500	470	2 x 3/0	2 x 4/0
A073.3BG6.X5E				CH03-03	424	500	453	2 x 3/0	2 x 4/0
A073.3BG6.X5F				SDQ.6N.V7 D	432	500	462	2 x 3/0	2 x 4/0
A073.3BG6.X5S				SDQ.6N.V7 Y	412	500	439	2 x 3/0	2 x 4/0
A073.3BG7.X5V		G7		CI01-03	488	600	522	2 x 4/0	2 x 250
A073.3BG7.X5E				CH03-03	473	600	505	2 x 4/0	2 x 250
A073.3BG7.X5F				SDQ.6N.V7 D	481	600	514	2 x 4/0	2 x 250
A073.3BG7.X5S				SDQ.6N.V7 Y	461	500	491	2 x 4/0	2 x 250
A082.3BG6.X6V	3	G6	12	CI01-03	449	500	482	2 x 3/0	2 x 4/0
A082.3BG6.X6E				CH03-03	431	500	461	2 x 3/0	2 x 4/0
A082.3BG6.X6F				SDQ.6N.V7 D	440	500	472	2 x 3/0	2 x 4/0
A082.3BG6.X6S				SDQ.6N.V7 Y	416	500	444	2 x 3/0	2 x 4/0
A082.3BG7.X6V		G7		CI01-03	498	600	533	2 x 4/0	2 x 250
A082.3BG7.X6E				CH03-03	480	600	513	2 x 4/0	2 x 250
A082.3BG7.X6F				SDQ.6N.V7 D	489	600	524	2 x 4/0	2 x 250
A082.3BG7.X6S				SDQ.6N.V7 Y	465	600	496	2 x 4/0	2 x 250

Table 3: Electrical Ratings (cont'd)

Electrical Ratings (cont'd)

ELECTRICAL RATING - AIRCOOLED - TT300 575V 60Hz - FANS 460V FOR CANADA									
CHILLER	COMP. - TT300		FAN		CHILLER				
	QTY	MODEL	QTY	MODEL	MCA (A)	MOP (A)	MDS (A)	MFW /90°C	MFW /75°C
A027.1BF6.X2V	1	F6	4	CI01-03	146	225	139	1/0	1/0
A027.1BF6.X2E				CH03-03	139	225	132	1	1/0
A027.1BF6.X2F				SDQ.6N.V7 D	139	225	132	1	1/0
A027.1BF6.X2S				SDQ.6N.V7 Y	134	225	125	1	1/0
A027.1BF7.X2V		F7	4	CI01-03	159	250	151	2/0	2/0
A027.1BF7.X2E				CH03-03	152	250	143	1/0	2/0
A027.1BF7.X2F				SDQ.6N.V7 D	152	250	143	1/0	2/0
A027.1BF7.X2S				SDQ.6N.V7 Y	146	250	136	1/0	1/0
A030.1BF6.X3V	1	F6	6	CI01-03	154	250	148	1/0	2/0
A030.1BF6.X3E				CH03-03	146	225	139	1/0	1/0
A030.1BF6.X3F				SDQ.6N.V7 D	146	225	139	1/0	1/0
A030.1BF6.X3S				SDQ.6N.V7 Y	139	225	132	1	1/0
A030.1BF7.X3V		F7	6	CI01-03	166	250	160	2/0	2/0
A030.1BF7.X3E				CH03-03	159	250	151	2/0	2/0
A030.1BF7.X3F				SDQ.6N.V7 D	159	250	151	2/0	2/0
A030.1BF7.X3S				SDQ.6N.V7 Y	152	250	143	1/0	2/0
A044.2BF6.X3V	2	F6	6	CI01-03	254	350	263	250	250
A044.2BF6.X3E				CH03-03	246	300	254	250	250
A044.2BF6.X3F				SDQ.6N.V7 D	246	300	254	250	250
A044.2BF6.X3S				SDQ.6N.V7 Y	239	300	247	250	250
A044.2BF7.X3V		F7	6	CI01-03	276	350	286	300	300
A044.2BF7.X3E				CH03-03	269	350	277	300	300
A044.2BF7.X3F				SDQ.6N.V7 D	269	350	277	300	300
A044.2BF7.X3S				SDQ.6N.V7 Y	262	350	270	250	300
A054.2BF6.X4V	2	F6	8	CI01-03	268	350	280	300	300
A054.2BF6.X4E				CH03-03	254	350	263	250	250
A054.2BF6.X4F				SDQ.6N.V7 D	254	350	263	250	250
A054.2BF6.X4S				SDQ.6N.V7 Y	239	300	247	250	250
A054.2BF7.X4V		F7	8	CI01-03	291	400	303	300	350
A054.2BF7.X4E				CH03-03	276	350	286	300	300
A054.2BF7.X4F				SDQ.6N.V7 D	276	350	286	300	300
A054.2BF7.X4S				SDQ.6N.V7 Y	262	350	270	250	300

Table 3: Electrical Ratings (cont'd)

Electrical Ratings (cont'd)

ELECTRICAL RATING - AIRCOOLED - TT300 575V 60Hz - FANS 460V FOR CANADA									
CHILLER	COMP. - TT300		FAN		CHILLER				
	QTY	MODEL	QTY	MODEL	MCA (A)	MOP (A)	MDS (A)	MFW /90°C	MFW /75°C
A059.2BF6.X5V	2	F6	10	CI01-03	273	350	285	300	300
A059.2BF6.X5E				CH03-03	254	350	263	250	250
A059.2BF6.X5F				SDQ.6N.V7 D	268	350	280	250	250
A059.2BF6.X5S				SDQ.6N.V7 Y	246	300	254	250	250
A059.2BF7.X5V		F7	10	CI01-03	296	400	308	300	350
A059.2BF7.X5E				CH03-03	276	350	286	300	300
A059.2BF7.X5F				SDQ.6N.V7 D	291	400	303	300	300
A059.2BF7.X5S				SDQ.6N.V7 Y	269	350	277	250	300
A073.3BF6.X5V	3	F6	10	CI01-03	373	450	400	500	500
A073.3BF6.X5E				CH03-03	354	450	378	500	500
A073.3BF6.X5F				SDQ.6N.V7 D	368	450	395	500	500
A073.3BF6.X5S				SDQ.6N.V7 Y	346	400	369	500	500
A073.3BF7.X5V		F7	10	CI01-03	406	500	435	2 x 3/0	2 x 4/0
A073.3BF7.X5E				CH03-03	386	450	413	2 x 3/0	2 x 3/0
A073.3BF7.X5F				SDQ.6N.V7 D	401	500	429	2 x 3/0	2 x 4/0
A073.3BF7.X5S				SDQ.6N.V7 Y	379	450	404	500	500
A082.3BF6.X6V	3	F6	12	CI01-03	373	450	400	500	500
A082.3BF6.X6E				CH03-03	368	450	395	500	500
A082.3BF6.X6F				SDQ.6N.V7 D	373	450	400	500	500
A082.3BF6.X6S				SDQ.6N.V7 Y	346	400	369	500	500
A082.3BF7.X6V		F7	12	CI01-03	406	500	435	2 x 3/0	2 x 4/0
A082.3BF7.X6E				CH03-03	401	500	429	2 x 3/0	2 x 4/0
A082.3BF7.X6F				SDQ.6N.V7 D	406	500	435	2 x 3/0	2 x 4/0
A082.3BF7.X6S				SDQ.6N.V7 Y	379	450	404	500	500
MDS: MINIMUM DISCONNECT SIZE RATING									
MFW: MINIMUM FIELD WIRING SIZE: BASED ON COPPER (AWG / kcmil)									

Table 3: Electrical Ratings (cont'd)

ELECTRICAL, INSTALLATION

GENERAL

All applicable codes should be adhered to. The Limited Product Warranty does not cover damaged equipment caused by wiring non-compliance, an open fuse resulting from an overload, a short, or a ground. Correct the cause of the open fuse before replacing the fuse and restarting the compressor.

Compressor motors are designed to operate satisfactorily over a range of ± 10 percent of the standard design voltage.

ELECTRICAL WIRING

All electrical wiring connecting to the unit should be made of copper.

All wiring must be installed in accordance with appropriate local and national electrical codes, and will require a circuit breaker or fuses to protect the main wiring run from the final distribution sub-board to the unit.

According to specific model and/or option selected, field wiring connections will require either one or two supply conductors in parallel.

Each SMARTD Chiller is provided with a 3 pole power distribution block or busbar system, splitting field supply main power into multiple secondary circuits.

Ground lugs are located next to field wiring terminals for equipment grounding.

Minimum required bending space at terminals and means for strain relief of supply conductors, shall be provided by installation contractor to prevent leads separating from their terminations, or subjecting them to damage from sharp edges.

All electrical wiring connecting to the unit shall only be made of copper and shall be shielded and grounded. It is assumed that supply conductors rated 75°C (167°F) will be used in determining the size of terminals.

The main power input connection for the SMARTD range of chillers is a single point termination via a main termination box (supplied as standard) on each chiller unit. All power wiring from this point on, is the responsibility of the installation contractor. From the main termination box, each compressor control box (power and controls) is pre-wired to the individual compressors.

All wiring must be installed in accordance with appropriate local and national electrical codes, and will require a circuit breaker or fuses to protect the main wiring run from the final distribution sub-board to the unit.

DESCRIPTION OF OPERATION

CHILLER CYCLE

Controls - Cooling Cycle Operation:

When the SMARTD chiller control system is set to “HVAC_COOL” mode, indicating the chiller is to be used to control the leaving chilled water temperature (LCWT) to a desired value, the following description of operation is true:

EVAPORATOR DESCRIPTION

When the chiller is operated in cooling mode, the condensed liquid refrigerant exits the electronic expansion valve (4) Figure 7, and enters the bottom of the flooded evaporator, where it is evenly dispersed along the length of the evaporator by the use of a distributor plate (3). Liquid refrigerant inside the evaporator at low pressure then makes contact with the copper tubes that the building’s water runs through, exchanges heat to the refrigerant, and vaporizes it (2) at the suction pressure of the compressor (1). As a result of the lower density of the vapor and the suction of the compressor, the vaporized refrigerant gas is then drawn to the top of the evaporator through the mist eliminators (5). (Mist eliminators inhibit minute liquid particles entrained in the vaporized refrigerant, from entering the compressor). Passing through the (pre-rotation) inlet guide vanes (6), the vaporized refrigerant then enters the compressor inlet (7), where the angle of incidence of the refrigerant hitting the first stage impeller, is altered, thereby allowing a higher compression efficiency for a given compressor rotor speed.

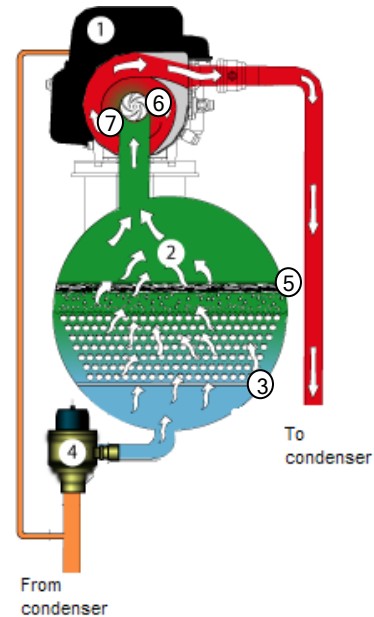


Figure 7: Evaporator Refrigerant Flow

COMPRESSOR DESCRIPTION

SMARTD oil free chillers exclusively use Turbocor variable speed magnetic bearing compressors (Figure 8) on all chillers. All of the Turbocor compressors are a two stage design, meaning the compression of the vapor refrigerant takes place through two impellers.



Figure 8: Turbocor Compressor - External View

The refrigerant enters the suction side of the compressor as a low-pressure, low-temperature, super-heated gas - ref Figure 9, (1). The refrigerant gas passes through a set of adjustable inlet guide vanes (IGV) (2) that are

used to control the compressor capacity at low load conditions.

The first compression element that the gas encounters is the first-stage impeller (3), and the centrifugal force produced by the rotating impeller results in an increase in both gas velocity and pressure. The high-velocity gas discharging from the impeller is directed to the second stage impeller (4) through de-swirl vanes (5). The gas is further compressed by the second stage impeller and then discharged through a volute (6) via a vane-less diffuser (7). (A volute is a curved funnel increasing in area to the discharge port. As the area of the cross-section increases, the volute reduces the speed of the gas and increases its pressure.) From there, the high-pressure/high temperature gas exits the compressor at the discharge port (8).

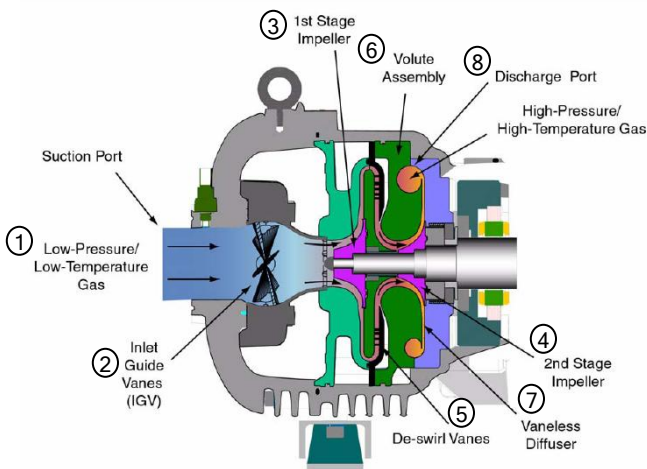
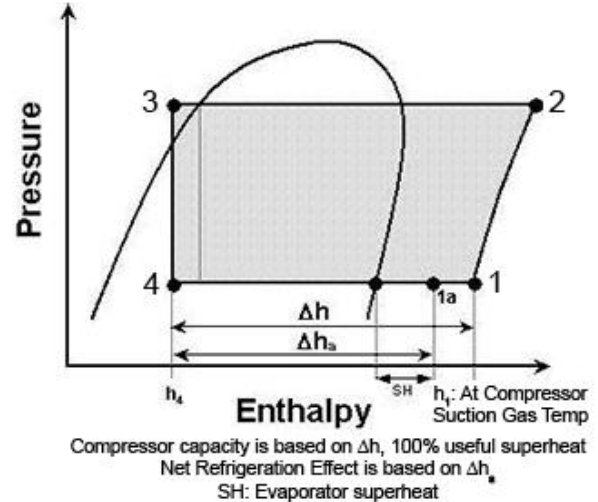


Figure 9: Turbocor Compressor Cross Section



The Pressure-Enthalpy (PH) Diagram

Figure 10: Pressure v Enthalpy

Capacity control on SMARTD chillers is achieved by varying the speed, inlet guide vane position, and number of operating compressors. Figure 11 provides a graphical representation of the centrifugal compressor's response to demand and operating conditions.

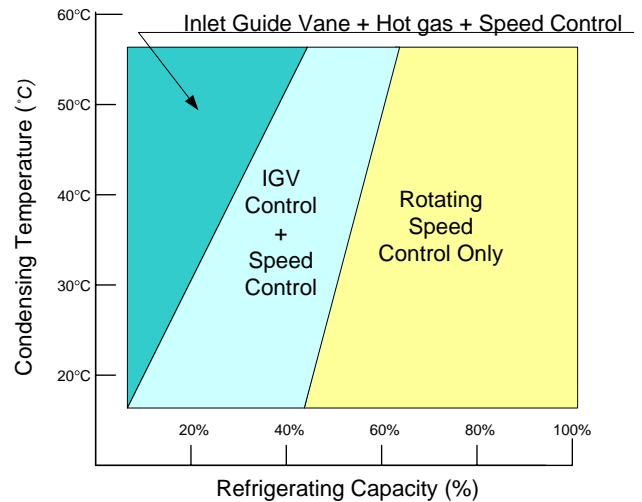


Figure 11: Graphic Representation of Capacity Control

CONDENSER DESCRIPTION

Superheated refrigerant from the compressor enters at the top of the condenser barrel where it is dispersed by a deflection plate. As the refrigerant is moving around the tubes in the condenser, heat is being constantly removed from the refrigerant and dissipated to the cooling water that is moving through the condenser tubes.

HOT GAS VALVE CONTROL

The hot gas valve provides the following functionality:

- Capacity control at low load.
- Assisted pressure ratio relief for starting new compressors.
- Head pressure relief for heat pump and air cooled chillers operating above design conditions.

Low Load Capacity Control Functionality

Hot gas control of leaving water temperature (LWT) is a last resort method of control when speed control and inlet guide vane control is no longer an option. The hot gas valve control uses the compressor's *IGV*% surge. Choke and actual rpm determine when to use the hot gas valve for capacity control.

The set point for the hot gas control is a differential temperature below the leaving temperature set point. By using a differential temperature, the hot gas control set point automatically adjusts with a change in supply temperature set point for the chiller, such that it is easy to implement alongside set point reset strategies.

As the diagram in Figure 11 shows, the hot gas valve is only used once the compressors have used up all speed and *IGV* control envelopes. If the chiller's capacity must be increased, and the hot gas valve is in the open position, the valve will close before adjustment is made for increased compressor demand.

It should be noted that the hot gas capacity control of SMARDT air cooled chillers, only takes place when the last compressor is operating. The chiller control system makes best use of compressor staging before resorting to hot gas control. Under normal air conditioning loads where the outside air temperature and the heat load applied to the chiller are closely related, it is not uncommon for the hot gas capacity control valve never to be used.

Assisted Pressure Ratio Relief

Major reasons for requiring pressure ratio relief when turning on one or more additional compressors within a refrigerant circuit where compressors are already operating, are:

- To avoid rapid rotor displacement - which is an inherent weakness of all centrifugal compressors which do not incorporate pressure ratio unloading.

To reduce the potential of rotating component damage.

High dynamic forces can impact traditional bearing technology significantly. With the incorporation of the revolutionary magnetic bearing design used in the Turbocor compressor on SMARDT chillers, the potential for rotating component damage is greatly reduced, in that shutdown can occur before any surface impact takes place.

- Instability, as the compressor overcomes the system pressure and begins to open the discharge check valve.

The danger of holding ramp up conditions without flow, for an extended period of time:

- All energy transferred to the compressor, has no outlet, and results in high internal temperatures.

- Large sudden amperage spikes on the inverter can be dangerous, due to low thermal inertia on Inert Gate By-polar Transistors (IGBT). The higher the head that must be overcome, the higher the amperage spikes.

Control Strategy

The assisted hot gas bypass start up is enabled whenever the chiller enters the “STAGE UP” mode, and the pressure ratio calculated from the highest discharge pressure and lowest suction pressure of all compressors online, is above a configured limit default pressure ratio of 2.2.

If hot gas pressure ratio assistance is required, the hot gas valve is forced open at 1% per second, until the pressure ratio is reduced below the limit at which the next compressor is start enabled. Once the new compressor has started and is running within 10% of the speed of the other compressors, the hot gas valve is closed slowly at a rate of 0.5% per second.

Return Water Control

Occasionally, instead of supplying chilled water control, SMARTD chillers are selected to provide return water temperature control in a plant. Return water temperature control allows the leaving chilled water set point to automatically float with the actual building load. Running higher leaving chilled water temperatures permits a higher chiller performance - an efficiency increase of approximately 3% per 0.5°C (1°F) increase in set point is possible.

Selecting “HVAC_RET” mode on the chiller’s graphical touch pad interface will enable control from the return water temperature. All alarm and fault trip points are active in this mode, and extra care must be taken when selecting a return water temperature to run, to avoid driving the chiller into low suction pressure or low leaving chilled water faults. SMARTD suggests a set point of 10°C (50°F) to 15.5°C (60°F).

CHILLED WATER SYSTEM

EVAPORATOR WATER CIRCUITS

Chiller performance and efficiency can be adversely affected by contaminants in the water circuits, and such contaminants could impede or block the flow of water through the circuit or reduce the performance of the heat exchanger.

Strainers should be located on the inlet side of the evaporator, return water to the chiller must be connected to the lower connection of the evaporator, and all external water piping must be cleaned or flushed before being connected to the chiller set.

Water circuits should be arranged so that pumps discharge through the evaporator and are controlled as necessary, to maintain essentially constant chiller water flows through the unit at all load conditions.

To ensure the chiller's performance and longevity, air must be purged from both water boxes on the evaporator, and from the entire water circuit.

CHILLED WATER PUMPS

Make all connections prior to filling with water. Run a preliminary leak check before insulating the pipes and filling with water. SMARTD recommends consulting authorities in order to be compliant with local building codes and safety regulations.

Additional considerations, as follows, should be made when designing the piping system:

- All piping systems should include temperature and pressure measures at the evaporator. Make these connections prior to filling with water.
- Water pressure should be maintained throughout the system. Install regulating valves or

comparable pressure maintenance devices.

- The piping system should be designed with a minimum number of elevation and directional changes in order to minimize system pressure drop.
- To prohibit debris from entering the pump, a strainer should be installed at the water supply line, and ahead of (before) the pump.
- Piping made to and from the chiller water connections and pressure relief valves, must be made in such a way that weight and strain is removed from the chiller connections. All chilled water piping attached to chiller connections, should be adequately insulated. Strainers with 20 mesh filters, should be installed upstream of the evaporator .
- Adequate valving should be supplied to permit draining of water from the evaporator.
- Install vibration eliminators to reduce vibration transmission to the building.
- Install air valves at the system high points and drain valves at the system low points. Additionally, shutoff valves should be installed for unit servicing.

- Protect water from freezing by insulating water piping. Ensure there is a vapor barrier on the outside of the insulation, in order to protect from pipe condensation within the insulation.

Note: If glycol or propylene is added for freeze protection, this will cause a pressure drop, which may then result in the loss of performance. Only use glycol with factory approval.

WATER VOLUME

When designing the chilled water system, consider:

- The minimum cooling load.
- The minimum plant capacity during a low load period.
- The desired cycle time for the compressor.
- If the chiller plant has a reasonable turndown, the water volume should be two to three times the chilled water gpm flow rate. If the system components do not provide the required water volume, add a storage tank.

VARIABLE WATER FLOW

A large range of SMARTD chillers are well suited to installations where the chilled water and condenser water flow rates are changed in the chiller, relative to the instantaneous building load and outdoor conditions. When applying SMARTD chillers to variable volume (variable speed) pumping applications, the designer must make sure SMARTD's design parameters are met as follows:

1. That water flow shall not be altered at a rate greater than 10% per minute.
2. That the water flow rates shall not exceed the maximum and minimum flows detailed in the chiller selection sheet.

Variable speed pumping is a design feature of the SMARTD air-cooled chiller, which reduces the water flow through the evaporator as the load decreases. This feature will function successfully if the design and minimum flow rates are not exceeded. Check individual rating sheets for maximum and minimum flow rates.

OPERATING LIMITS

- Maximum standby ambient temperature = 54°C (130°F)
- Maximum operating ambient temperature = 41°C (105°F)
- Minimum operating ambient temperature (standard) = 3°C (38°F)
- Minimum operating ambient temperature (operational low-ambient control) = -10°C (14°F)
- Leaving chilled water temperature (LCWT) = 3°C to 16°C (38°F to 60°F)
Operating ΔT = 3K to 9K (6°F to 16°F)
- Maximum operating inlet fluid temperature = 24°C (76°F)
- Maximum startup inlet fluid temperature = 32°C (90°F)

- Maximum non-operating inlet fluid temperature = 38°C (100°F)

FLOW SWITCH

A flow switch for the chilled water system is necessary to ensure adequate water flow to the evaporator before starting the unit. Prior to starting the unit, and to ensure adequate water flow to the evaporator, it is necessary to install a flow switch for the chilled water system. A flow switch will guard against possible evaporator freezing, should water flow be interrupted. The flow switch is to be field installed in the chilled water piping and wired to the control panel by the installation contractor.

HIGH PRESSURE & LOW PRESSURE SWITCHES

The High Pressure (HP) & Low Pressure (LP) switches provide an additional safety feature, which prevents overpressure or

water freezing. The cut-off pressures for the HP and LP switches are as follows:

HP: 1586 kPa (230 psig) ($\approx 60^{\circ}\text{C} / 140^{\circ}\text{F}$),
reset at 1276 kPa (185 psig) ($\approx 52^{\circ}\text{C} / 125^{\circ}\text{F}$) (installed on discharge header)

LP: 179 kPa (26 psig) ($\approx -1.7^{\circ}\text{C} / 29^{\circ}\text{F}$),
reset at 345 kPa (50 psig) ($\approx 12.2^{\circ}\text{C} / 54^{\circ}\text{F}$),
(installed on the evaporator, except for low ambient/glycol applications, where the LP switch is not installed).

RELIEF VALVES

Ensure relief valves vent outside a building in accordance with national safety regulations and jurisdictional requirements. Concentrations of refrigerant in enclosed spaces can displace oxygen and lead to asphyxiation. Do not displace any safety devices.

RELIEF VALVE CHARACTERISTICS

The following table gives SMARDT Pressure Relief Valve parameters for the noted chiller model. Refer to SMARDT specification for other model specific values.

SMARDT Pressure Relief Valves		
	EVAPORATOR	
	Dual relief valves (2)	
	Set pressure 1310 kPa (190 psig)	
TAG	Discharge Rates (C_r) min kg/min (lbs/min)	Outlet size (NPT)
AA031.1BXX.44N	8.7 (19.1)	19 mm (3/4")

Table 4: Pressure Relief Valve Parameters

SMARDT Air Cooled chillers are supplied with dual pressure relief valves mounted on the evaporator. The valves are connected to a changeover manifold. Using a common body chamber that serves as the base for

two independent relief valves, a system can remain fully operational when valves need to be serviced and replaced.

All pressure relief valves on SMARTD chillers have been sized, selected and supplied in accordance with ASHRAE 15 and the ASME unfired pressure vessel code. All discharge rates are certified by the National Board of Boiler and Pressure Vessel Inspectors.

RELIEF VALVE APPLICATION

The ASHRAE 15 Safety Standard for Refrigeration Systems provides guidelines for sizing refrigerant relief valves and vent piping. Without attempting to provide a complete and thorough interpretation, this document provides the necessary data to properly determine piping requirements.

VENT LINE SIZING

Piping. ASHRAE 15-2004, Section 9.7.8 outlines acceptable relief piping locations and sizing. Summarized, the relief piping should vent R-134a refrigerant at least 15 feet above ground level and at least 20¹ feet from any window, ventilation opening, or building exit. The discharge piping should prevent a discharged refrigerant from being sprayed directly on personnel and prevent foreign material or debris from entering the piping. Additionally, discharge piping for a fusible plug or rupture disc shall have provisions to prevent plugging the pipe in the event of a discharge by the plug or disc.

As indicated in SMARTD Installation Instructions (Form 160.73-N1), each vent line must contain a dirt trap in the vertical section to allow collection and removal for any stack condensation or debris. The piping MUST be arranged to avoid strain on the relief valves - *SMARTD recommends the use of a flexible connector*. The vent line should be sized in accordance with ANSI/ASHRAE 15, and local codes, but should never be smaller than the relief valve outlet sizes provided in specific chiller documentation.

Common Header. ASHRAE 15 section 9.7.8.4 allows for multiple relief devices (on

the same or multiple units) to be connected into a common line or header. The sizing of the common discharge header and vent piping for relief devices - expected to operate simultaneously - shall be based on the sum of their outlet areas, with due allowance for the pressure drop in all downstream sections and back-pressure resulting from the discharge of multiple relief devices.

Maximum Length. ASHRAE 15 section 9.7.8.5 and Appendix H define the maximum length of discharge piping downstream of the pressure-relief device as:

$$L = \frac{0.2146d^5(P_0^2 - P_2^2)}{fC_r^2} - \frac{d \times \ln(P_0/P_2)}{6f}$$

[feet] Eq. (2)a

$$L = \frac{7.4381 \times 10^{-15} d^5(P_0^2 - P_2^2)}{fC_r^2} - \frac{d \times \ln(P_0/P_2)}{500f}$$

[meters] Eq.(2)b

Where:

L = equivalent length of discharge piping, m (ft)

C_r = rated capacity as stamped on the device in kg/sec (lb/min)

f = moody friction factor in fully turbulent flow

d = inside diameter of pipe or tube, mm (inches)

ln = natural logarithm

P₂ = absolute pressure at the outlet of discharge piping, kPa (psia)

P₀ = allowed back pressure (absolute) at the outlet of pressure release device, kPa (psi) = (0.15 x relief valve set pressure + atmospheric pressure)

The ASHRAE 15 users manual states that when the length of the vent pipe exceeds approximately 220 diameters (L/d > 220), the first term in equation (2)a or (2)b may be used to solve for the diameter, d.

$$d = 1.36 \times \left(\frac{fLC_r^2}{P_0^2 - P_2^2} \right)^{0.2} \text{ [inches] Eq. (3)a}$$

$$d = 2521 \times \left(\frac{fLC_r^2}{P_0^2 - P_2^2} \right)^{0.2} \text{ [millimeters] Eq.}$$

(3)b

An average friction factor $f = 0.02$, may be used when the pipe size is not known.

This section on the discharge vent line is to be used as a guide only. For a complete description of the relief valve vent line sizing, please refer to ASHRAE Standard 15 or local overriding codes.

¹CSAB-52 requires 25' from any opening.

CONTROLS

CONTROLS WIRING

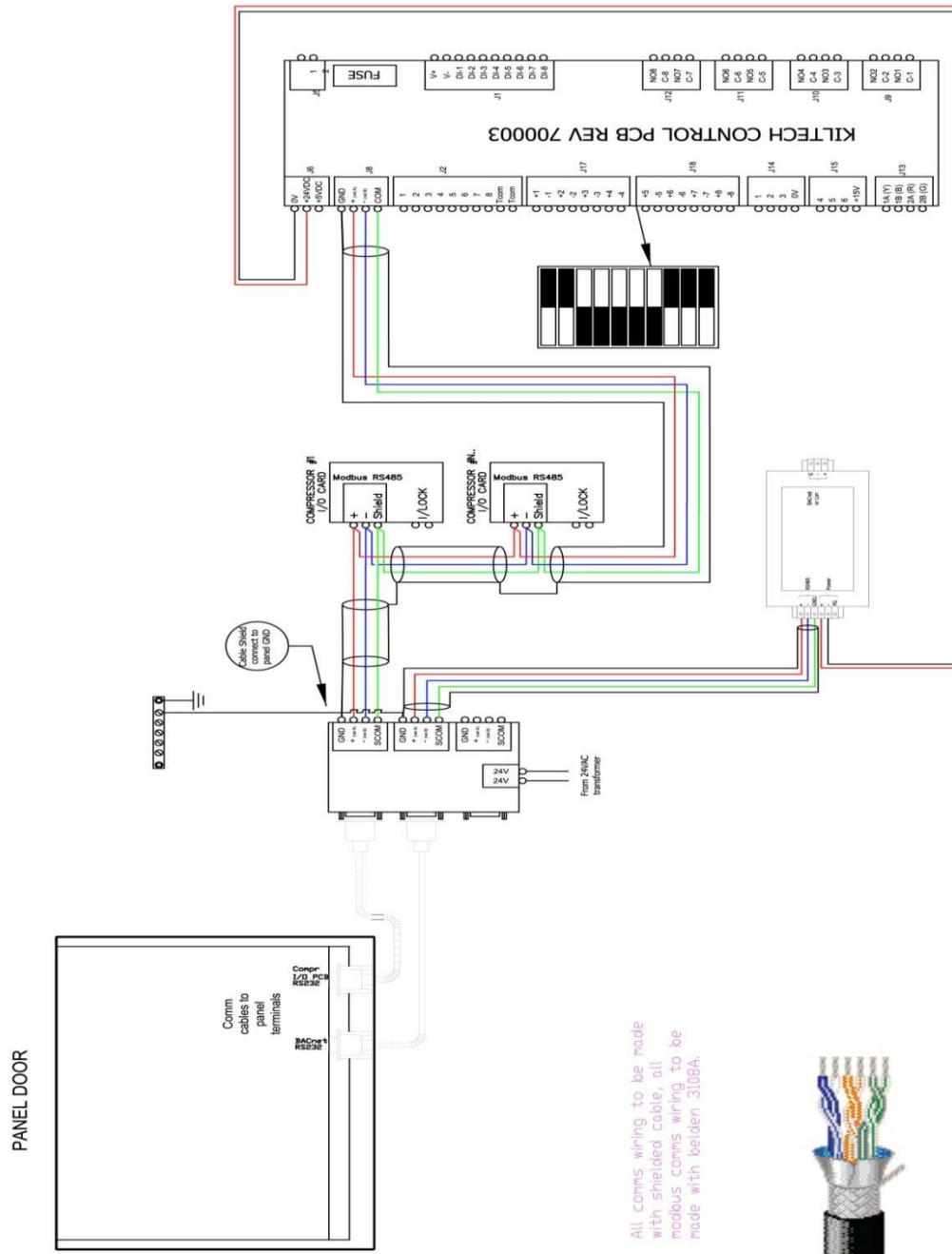


Figure 12: G3 Controls Wiring Diagram - Optical Isolated Converter - G3 Touch Panel

CONTROL PANEL WIRING

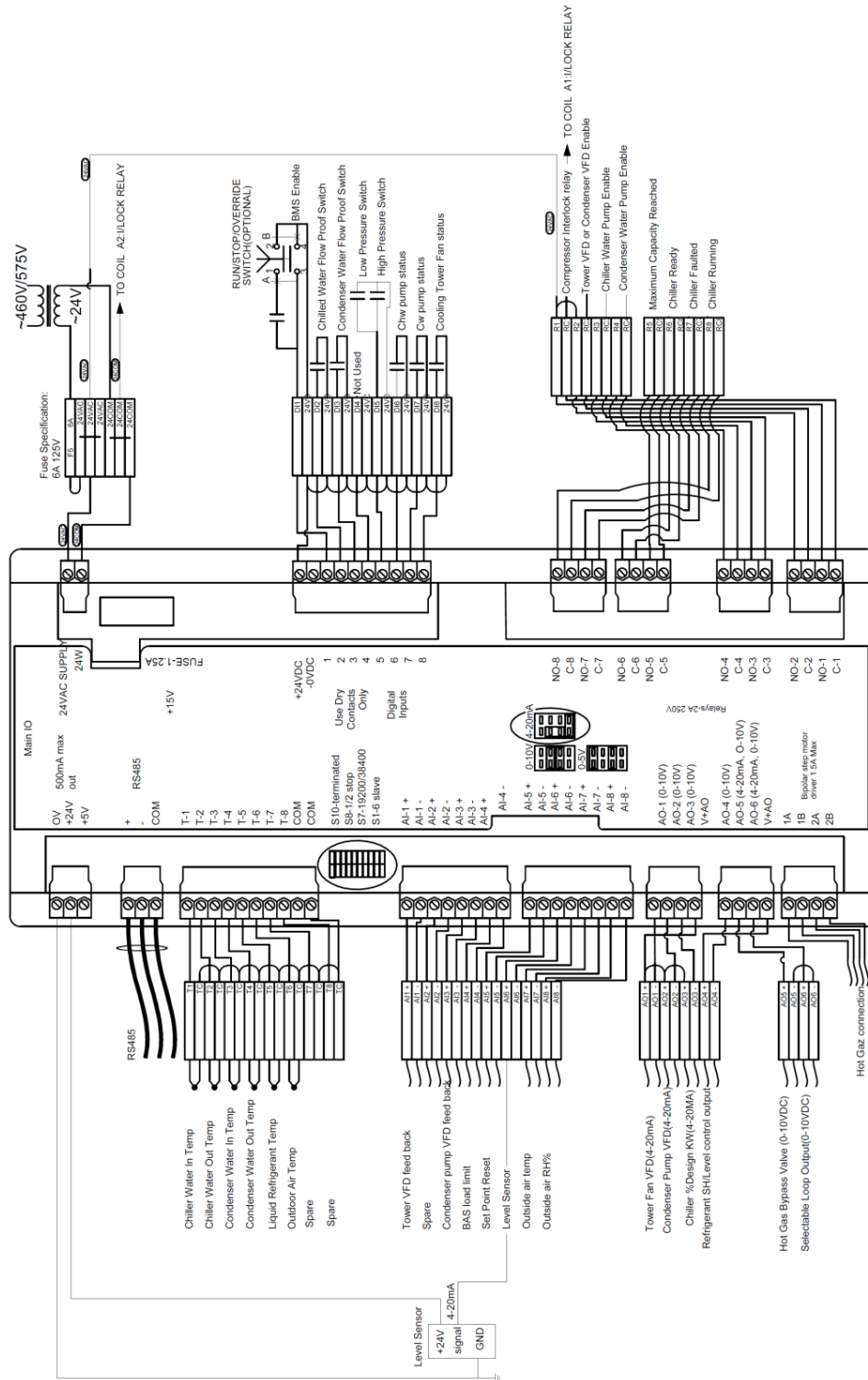


Figure 13: Control Panel Wiring Schematic - 460V/575V

SPECIFICATIONS - SMARTD AIR COOLED CHILLERS

GENERAL

1.1 SUMMARY

This Section includes design, performance criteria, refrigerants, controls, and installation requirements for air cooled centrifugal chillers.

1.2 REFERENCES

Compliance is with the following codes and standards:

- ARI 550/590 NEC
- ANSI/ASHRAE 15
- ASME Section VIII
- ETL Listed
- ANSI UL 1995
- CSA C22.2 No. 236 (Canada)
- OSHA as adopted by the State

1.3 SUBMITTALS

Submittals shall include the following:

A. Dimensioned plan and elevation drawings, including required service clearances and location of all field piping and electrical connections.

B. Electrical and water quality requirements during operation, standby and shutdown.

C. Control system diagram showing points for field interface and connection to external BMS systems. Drawings shall show field and factory wiring.

D. Installation and Operation Manuals.

E. Manufacturers certified performance data as per AHRI at full load and IPLV or NPLV.

1.4 QUALITY ASSURANCE

A. Regulatory Requirements: Compliance with the standards in Section 1.2.

1.5 DELIVERY AND HANDLING

A. Chillers shall be delivered to the job site completely assembled (unless otherwise specified).

B. Compliance shall be with the manufacturer's instructions for transportation and rigging.

1.6 WARRANTY and MAINTENANCE

A. The chiller manufacturer's warranty shall be for a period of one year from date of equipment start up or 18 months from the date of shipment, whichever occurs first.

B. The warranty shall include parts and labor costs for the repair or replacement of parts found to be defective in material or workmanship.

C. Maintenance of the chiller equipment while under warranty, is mandatory and shall be the responsibility of the purchaser, unless supplied by the manufacturer.

Optional:

1. Extended chiller parts and labor warranty.

2. 2-5-year compressor parts and labor.

3. 2-5 year chiller parts and labor warranty.

PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Smardt Inc.

B. Approved Equal. Note approved equal does not automatically imply the alternate product matches this specification, functionality or delivered quality.

2.2 PRODUCT DESCRIPTION

A. Provide and install as shown on the plans, a factory assembled air-cooled packaged chiller.

B. Each unit shall include one or more Turbocor oil-free magnetic bearing and variable-speed centrifugal compressors. Integrated variable frequency drive shall operate with inlet guide vanes to optimize part load efficiency. Chillers shall operate with HCF-134a refrigerant - not subject to phase-out by the Montreal Protocol and the U.S. EPA clean air act.

C. The evaporator, condenser, and expansion valve shall be configured to operate as a single refrigerant circuit unless otherwise specified. The chiller unit compressors shall be designed for mechanical and electrical isolation to facilitate service and removal.

2.3 DESIGN REQUIREMENTS

A. Unit shall consist of one or more magnetic bearing oil-free centrifugal compressors with integrated variable frequency drive, refrigerant flooded evaporator, air cooled condenser, and operating controls with equipment protection.

B. Performance: Refer to schedule for specific operating conditions. When utilizing Turbocor model TT300 compressors the chiller shall be capable

of stable operation down to 20 tons. When utilizing Turbocor model TT350 compressors, the chiller shall be capable of stable operation down to 35 tons. All these ratings are measured at standard AHRI entering condenser water temperatures and without utilizing hot gas bypass.

C. Acoustics: Sound pressure for the unit shall not exceed 83 dBA, measured at 1 meter (3.28 ft). Sound data shall be measured according to AHRI Standard 370.

Global	63	125	250	500	1k	2k	4k	8k

D. Chiller shall be equipped for single-point power connection.

2.4 CHILLER COMPONENTS

A. Compressors:

1. Compressors shall be of semi-hermetic centrifugal design and operate oil-free with two-stages of compression, magnetic bearings, movable inlet guide vanes and integrated variable frequency drive system.

2. Automatically positioned and controlled inlet guide vanes shall operate with compressor speed controls.

3. The compressor shall be capable of coming to a controlled stop in the event of a power failure. The unit shall be capable of initializing an automatic restart in the case of power failure.

4. Each compressor shall have integrated microprocessor control capable of capacity and safety control.

5. Each compressor shall be installed with individual suction, discharge and motor cooling refrigerant line isolation valves. Chillers without discharge line isolation valves that rely on non-return

valves in the discharge line for compressor removal, shall not be accepted.

6. Each compressor shall have an individual disconnect switch. On chillers that are provided with more than one compressor, each compressor shall have mechanical and electrical isolation to allow the chiller to operate when a compressor is removed.

Optional:

1. EMI filters installed for each compressor.

B. Evaporator:

1. Evaporator shall be shell-and-tube type and shall be designed, constructed, tested and stamped according to the requirements of the ASME Code, Section VIII Code Case 1518-5. Refrigerant shall be in the shell and water inside the tubes. The water sides shall be designed for a minimum of 150 psig or as specified. Vents and drains shall be provided. The refrigerant side shall bear the ASME Code stamp. Vessels shall pass a test pressure of 1.1 times the working pressure but not less than 689 kPa (100 psig). Provide intermediate tube supports spaced to enable equal liquid and gas flow across multiple compressor suction ports. The evaporator water connections shall also be equipped with right-hand or left-hand connection, interchangeable.

2. A perforated plate designed for vapor disengagement shall be installed inside the evaporator above the tubing, to ensure effective liquid droplet removal, to prevent liquid damage to compressors, and to equalize suction pressure across evaporators with multiple compressors.

3. Tubes shall be individually replaceable and have internally and

externally enhanced surfaces designed for refrigeration duty. Tubes shall have smooth full tube wall landings at the tube-sheet ends and at intermediate tube supports. Tubes shall be mechanically roller expanded into steel tube sheets containing a minimum of three concentric grooves.

4. Minimum evaporator exiting water temperature shall be 3.3°C (38°F). Minimum entering condenser air temperature shall be 0°C (32°F). Minimum inlet condenser air to outlet chilled water difference shall be -11.1°C (12°F).

5. The evaporator, including chilled water boxes, compressor suction line, compressor end bell, and all other components, subject to condensing moisture, shall be insulated with UL recognized ¾ inch closed cell insulation. All joints and seams shall be sealed to form a vapor barrier.

Optional:

1. Marine water boxes.

2. Epoxy-coating of inside surfaces of water boxes and tube sheets.

3. Water side vessel design for of 300 psi operation.

4. Double insulation, 1½ inch, on evaporator, water boxes, suction piping.

C. Air-Cooled Condenser:

1. Air cooled packaged chillers and controls shall be capable of reliable operation between 0°C (32°F) and 40.6°C (105°F) ambient air temperature.

2. Air-cooled condensers shall utilize mill-coated hydrophilic-blue aluminum fins with refrigeration duty copper tubes mechanically expanded into fin collars. Condenser coils shall be arranged in a

W-configuration to reduce equipment footprint.

3. Condenser coils and fans shall be arranged such that one fan operates with one coil section so that the failure of a fan will not affect the CFM across any coil beyond that fan. The standard coating shall meet ASTM B117 2000hr salt spray test.

4. The condenser shall be equipped with an oversized liquid line and mechanical float to ensure liquid sub-cooling necessary for effective cooling of the compressor.

5. The condenser shall be equipped with packaged fixed or variable speed fans capable of delivering specified CFM of air according to ARI standard operating conditions. The fan motors shall be high efficiency, direct drive, 3-phase, insulation class "F", current protected, Totally Enclosed Air Over (TEAO), double sealed and with permanently lubricated ball bearings.

6. The fans shall be low sound. They shall be balanced dynamically and statically and direct drive. Also, the blades shall be corrosion resistant designed for low noise, full airfoil cross section, providing vertical air discharge from extended orifices. The guards shall be constructed of heavy duty 14 gauge steel and painted.

Optional:

1. The coating system for HVAC coil corrosion resistance provides a lifetime protection against micro-organism contamination that causes unwanted odors, and shall pass a 10,000 hour salt spray test. Next to anti-corrosion protection and energy conservation of the total system, the coating shall prevent adhesion of dirt and growth of micro-organisms, and shall also prevent

chemical, galvanic, and microbial corrosion.

2. Low ambient kit shall allow operation down to 9.4°C (15°F).

D. Refrigeration Components

Liquid Level Controls:

1. Control of refrigerant flow shall utilize a single or multiple 6,000 step electronic expansion valve (EXV), to operate within the full range from full load to the lowest loading capacity for the chiller. Fixed orifice metering devices or float controls using hot gas bypass are not acceptable. The EXV liquid line shall have a sight glass with moisture indicator and temperature sensor connected to the control system for validation of sub-cooling.

2. The condenser shall be provided with a capacitive type liquid level transducer with a resolution of not less than 1024 discrete steps. The transducer shall be wired to the chiller control system. Condenser liquid level measurement shall be used in the electronic expansion valve control algorithm with a minimum level set point to ensure adequate liquid seal is maintained in the condenser, to provide compressor motor cooling during operation. Condenser liquid level shall be clearly displayed on the graphical operator interface in a minimum of two screens. Chillers without direct level measurement are prohibited, due to possible over heating damage that may occur in compressors when liquid seal is lost.

3. Each compressor shall be installed with individual suction, discharge, and motor cooling refrigerant line isolation valves. Chillers without discharge line isolation valves that rely on non-return valves in the discharge line for

compressor removal, shall not be accepted.

4. To prevent unit operation with no water flow, factory mounted and wired thermal dispersion water flow switches shall be provided on the condenser.

5. The condenser shall be equipped with a mechanical stainless steel float for electronic actuation of the EXV, so as to provide a positive liquid seal to ensure effective cooling of the compressor

6. The evaporator shall be provided with spring loaded reseating type pressure relief valves, in accordance with ASHRAE-15. Rupture discs are not acceptable.

7. Load balancing valves shall be provided for capacity control and additional temperature stability.

8. There shall be a backup superheat control on the inlet of the compressor, in order to control the EXV in the event of a failure of the primary level sensing device.

E. Prime Mover:

1. A permanent-magnet, synchronous hermetically sealed motor of sufficient size to effectively provide compressor horsepower requirements. The motor shall include soft-start capabilities with an in-rush current of no more than 2 amps (TT300 models) and 4 amps (TT400 models). The motor shall be liquid refrigerant cooled with internal thermal overload protection devices embedded in the winding of each phase.

2. The compressor motor and chiller unit shall include variable frequency speed controls to match cooling load demand to compressor speed and inlet guide vane position.

3. Each compressor shall be equipped with an AC line reactor and individual disconnect.

F. Chiller Frame & Housing

1. All components shall be mounted onto a unitized construction, having a galvanized welded steel frame suitable for outdoor installation.

2. Compressors and controls shall be contained within a sheet metal enclosure to protect critical components from the weather.

G. Chiller Controls

The controller fitted to the oil-free centrifugal chiller package shall be an embedded real time microprocessor device that utilizes control software written specifically for chiller applications. User operation shall be accomplished using a panel mounted color touch-screen interface. The status of the compressors and all system parameters, including compressor alarms and temperature trends, shall be viewable.

G1. The chiller control system shall have the capability of storing one year of operational data. No less than 60 points of information shall be sampled at a maximum of 15 minute intervals.

G2. The chiller control system shall have full web based remote control capability; including the capability of remote operation and software updates.

Controller features must include the following:

1. Selectable control mode - leaving chilled water, entering chilled water, or suction pressure control.

2. 10.4-inch or 12.1-inch or 15-inch, 65,000 colors, touch panel operator

interface operating windows XP embedded.

3. Chiller documentation shall be viewable via touch panel in pdf format.

4. Operator interface shall be capable of connecting directly to compressors via serial communication protocol and display compressor information using Turbocor compressor monitoring / commissioning software.

5. Chiller control panel shall contain a minimum of three processors; all control functionality shall be carried out on a dedicated real time processor and data served to a remote graphical user interface via an open Ethernet protocol. Proprietary protocols between any pc based or micro based processor are strictly prohibited.

6. Chiller controls shall be native BacNet capable via MSTP or IP. Addition of gateway devices or additional processors or pluggable PCBs to achieve BacNet communications to the BAS is strictly prohibited.

7. Complete configuration of native BAS communications via Modbus RTU, Modbus TCP/IP, BacNet MSTP and BacNet IP shall be made via standard chiller controller graphical user interface. Chiller controls that utilize external software configuration tools to configure these protocols are explicitly prohibited.

8. Chiller control shall be capable of controlling up to eight Turbocor compressors on up to eight individual refrigerant circuits serving the same chilled water stream.

9. Chiller control panel user interface shall be capable of remote control via an internet connection without the use of any third party gateway device or additional hardware or software.

10. Chiller control shall be capable of operating in headless mode (no touch panel connected) and utilize standard windows XP or higher computer to display user interface via Ethernet connection.

11. Real time chiller control processor shall be capable of e-mailing a predefined list of recipients, should a fault occur. E-mail shall include details of fault, possible reason for fault, attachment of monthly data log of 195 or more compressor and chiller variables, and at a minimum interval of 30 seconds and with indication of severity of fault.

12. Ability to place all outputs in a manual state (hand, off, auto) via graphical user interface.

13. Alarm screen shall be capable of filtering faults into specific categories such as compressor, chiller and system faults in order to provide rapid diagnosis, and separation of failure modes.

14. Variable speed cooling tower control.

15. Optional variable speed condenser water pumping control.

16. Optional ability to turn on/off duty standby chilled water pumps.

17. Optional ability to turn on/off duty standby condenser water pumps.

18. Optional ability to operate chiller isolation valves for both evaporator and condenser.

19. Multiple compressor staging algorithm shall operate at the optimized power curves of each compressor simultaneously, and shall reset automatically every second during operation. Compressor staging methods that operate using simple incremental

percent of demand shall not be accepted.

20. Continuous data logging for operational trending and bin analysis shall be exportable to "CSV" format. (12 months data stored).

21. Embedded Web and FTP servers to enable remote encrypted control, log download, software version upload, and operational monitoring.

22. Built-in stepper motor controls for EXVs.

23. Controls lockup protection.

24. Ramp rate control - Peak energy demand limiting algorithms.

25. Three levels of alarm safety for minimum chiller down time.

26. Chiller control software shall employ an active fault avoidance algorithm to reduce chiller capacity and/or power level in the case of the chiller approaching within 10% of any trip limit value such as suction pressure, discharge pressure, chiller amp limit, leaving chilled water temperature limit, etc...

27. Store up to 32,000 alarm and fault events stored with date / time stamp.

28. Real time data trending viewable via touch panel.

29. Chiller load profile charts viewable via touch panel.

30. Chiller control graphical user interface shall be capable of displaying data in SI or I-P units without affecting control or BAS protocol units.

Optional:

1. BMS interface module for the interface with BacNET MSTP, BacNET IP or LonTalk FT10 is standard.

Data on Main Display Screen shall include:

a) Entering and leaving chilled water temperatures.

b) Entering and leaving condenser water temperatures.

c) Current operating state of chiller.

d) Active timers.

e) Chiller enable status.

f) Chiller water flow proof status.

g) Condenser water flow proof status.

h) Indication of compressor readiness.

i) Indication of clearance to run.

j) Chiller set point.

k) Total chiller kW.

l) Total chiller current input.

m) Three pages of data trends with zoom functionality.

n) Graphical dial indicators that clearly indicate safe and unsafe operating values.

o) Graphical representation of evaporator and condenser showing gas movement when chiller is running.

p) Current alarms (announce and manual reset provision).

q) Compressor actual rpm, maximum rpm, minimum rpm.

r) Compressor alarm description & fault description.

s) Compressor percentage motor demand.

t) Compressor safety interlock status.

u) Compressor modbus communication health status.

v) Compressor suction and discharge pressures.

w) Compressor suction and discharge temperatures.

x) Compressor internal cooling system temperatures and status.

y) Compressor motor kW and amps.

z) Compressor pressure ratio.

EXECUTION

3.1 INSTALLATION

A. Install per manufacturer's IOM documentation, shop drawings, and submittal documents.

B. Align chiller on foundations or mounting rails as specified on drawings.

C. Arrange piping to enable dismantling and permit head removal for tube cleaning.

D. Coordinate electrical installation with electrical contractor.

E. Coordinate controls and BMS interface with controls contractor.

F. Provide all material required for a fully operational and functional chiller.

3.2 START-UP

A. Units shall be field charged with ant. HFC-134a refrigerant.

B. Factory Start-Up Services: Provide factory supervised start-up on-site for a minimum of two working days and ensure proper operation of the equipment. During the period of start-up, the factory authorized technician shall instruct the owner's representative in proper care and operation of the equipment.



SMARTD

Smardt Inc.,
1800 Trans Canada Hwy,
Dorval,
QC, H9P 1H7,
Canada
Tel : +1 514 426 8989
Fax: +1 514 426 5757
sales@smardt.com
www.smardt.com

SMARTD

Smardt Chillers Inc.,
22 Colorado Avenue,
Plattsburgh,
New York, 12903
USA
Tel : +1 514 426 8989
Fax: +1 514 426 5757
sales@smardt.com
www.smardt.com

clever cooling powerpax

SMARTD Chillers (Asia-
Pacific) Pty Ltd.,
144 Colchester Road,
P.O. Box 2021,
Bayswater North,
Victoria 3153,
Australia
Tel: + 61 3 9761 7905
Fax: + 61 3 9761 6707
sales@powerpax.com.au
www.powerpax.com.au

