

SMARTD

Chiller Manual

Oil-Free Centrifugal Chiller



IOM-WC rev1

***Installation, Operation &
Maintenance Manual***

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TERMS AND DEFINITIONS

BMS	Building Management System
EXV	Electronic Expansion Valve
HP / LP	High Pressure / Low Pressure
MCA	Minimum Circuit Ampacity
MOCP	Maximum Over Current Protection
PLC	Programmable Logic Controller
RH	Relative Humidity
VFD	Variable Frequency Drive

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Downloadable Forms:

<http://interactions.smartd.com/Docs/SmartdCommissioningForm.pdf>

<http://interactions.smartd.com/Docs/SmartdControlWiringConnections.pdf>

http://interactions.smartd.com/Docs/Smartd_RequestStartUp_AcrobatForm.pdf

http://interactions.smartd.com/Docs/Smartd_IncidentReport_AcrobatForm.pdf

INSTALLATION and SAFETY GUIDELINES

The purpose of this manual is to inform contractors, building owners, and engineers of installation, sequence of operation and service requirements for the **Smardt** oil-free water-cooled centrifugal chiller. It is intended that this document be used with the applicable installation and wiring drawings.

The water-cooled centrifugal chiller consists of an evaporator, condenser, twin-turbine centrifugal compressor, compressor controller, and interconnecting refrigerant piping. The chiller set is a packaged unit, requiring connection to the condenser and chilled water circuits, as well as the main electrical supply and control wiring.

Safety precautions must be observed during installation, start-up, and service of the chiller due to the presence of refrigerant charge and low voltage hazards. Only qualified personnel should install, start up, and service this equipment.

Ensure that relief valves vent outside the building in accordance with safety regulations. Concentrations of refrigerant in enclosed spaces can displace oxygen and cause asphyxiation.

Do not disable any safety devices.

This instruction manual contains the generally valid safety regulations that are of the most importance to the operator of refrigeration units.

- Always ensure that the Smardt chiller is operated by qualified staff only.
- Provide suitable, fully operational fire extinguishing equipment.

Environmentally friendly handling

- Observe the instructions on handling and storing refrigerant (see safety data sheet).
- Ensure that refrigerant does not escape into the air, the ground or the sewage system.
- Ensure that installation, set-up, maintenance and cleaning are only carried out by certified companies that specialize in refrigeration units. Smardt recommends having the service department install, set up, service and clean the system.

Safe handling – staff

Staff involved with operation of the Smardt chiller should receive instruction with regard to the following points at regular intervals a minimum of once a year.

- Risks involved in dealing with refrigeration units
- Safety stipulations
- Conduct in the event of accidents and malfunctions
- Measures in the event of accidents and malfunctions

Personal safety equipment

Operator's obligations:

- To provide equipment to protect against the effects of refrigerants and coolants.
- To store fully operational personal safety equipment outside of the at-risk areas, within easy reach.

Personal safety equipment consists of:

- Protective gloves made from leather
- Protective goggles (for use with chemicals)



RISK of SUFFOCATION R-134a is ASPHYXIATING

Common name of the substance: 1,1,1,2 tetrafluoroethane

Chemical name: CF₃-CH₂F

In the event that refrigerant escapes, please observe the following

- Have first aid equipment on hand
- Have emergency shower on hand
- Wear self-contained breathing apparatus – R134a is asphyxiating.
- Ensure that everyone leaves the danger area immediately.
- Follow first aid measures relevant to refrigerant
- Inform the local safety personnel.
- Only enter rooms where refrigerant has escaped if wearing the appropriate safety equipment.
- Ventilate rooms in which refrigerant has escaped.
- Ventilate the hazardous area.
- Stop the gas escaping.
- Ensure that the refrigerant does not escape into the sewage system or into the environment.

If the refrigerant concentration is more than 0.25 kg/m³:

- Wear self-contained breathing apparatus.
- Ensure that at least one person with the necessary safety equipment is standing by to come to your aid. If the following are possible without putting yourself at further risk:
- Switch off the Smardt chilling system using the emergency-stop button or the master switch.
- Close the valves on the suction and liquid pipes.

- Observe instructions on the safety data sheet.

In case of contact with refrigerant observe the following

Cause	Symptoms	Measures
Gaseous refrigerant has come into contact with the eyes	Eye irritation	Rinse with plenty of clean water immediately. Consult a doctor immediately.
Liquid refrigerant has come into contact with the eyes	Extreme eye irritation, watery eyes, redness and swollen eyelids.	Rinse with plenty of clean water immediately. Consult a doctor immediately.
Gaseous refrigerant has come into contact with the skin	No risk	
Liquid refrigerant has come into contact with the skin	Frostbite with burn-like skin problems (redness, blistering)	Rinse with plenty of clean water immediately. Consult a doctor immediately.
Inhalation of gaseous refrigerant	Inability to move, unconsciousness Risk of suffocation!	Take person out into the fresh air immediately. Consult a doctor immediately. If patient stops breathing: artificial resuscitation. Inform the poison control center.

Storage and Handling

- Only use refrigerant in ventilated areas.
- Ensure that the container is sealed appropriately (cap, chain).
- Only use containers which are suitable for Refrigerant R 134a and for the intended pressure and temperature
- Store containers at a temperature of less than 50 °C in a ventilated area.
- Avoid long periods of exposure to heat.

Stability and Reactivity

Stability	Stable under normal conditions
Substances to be avoided	Refrigerant reacts strongly with alkali metals and alkaline earth metals Pulverized aluminum and pulverized zinc catalyzes the decomposition of the refrigerant.
Other information	If escaping vapors come into contact with fire or very hot objects, they form decomposition products which produce a high degree of irritation and have strong thermal effects. It is possible that an explosive mixture could be formed under high pressure and with a high proportion of air.

WARNING!

Low voltage in electrical equipment is potentially lethal. Isolate incoming electrical power before attempting installation or service of the equipment.

When AC power is first removed from the compressor, the capacitors store enough energy to cause injury. It is essential to allow sufficient time for the capacitors to discharge before proceeding. Only a qualified electrician should work on low-voltage electronic equipment.



Wait at least 10 minutes after isolating power before opening compressor access covers.

Before installing the chiller set, ensure that the supporting floor meets the load bearing requirements. Smardt is not responsible for the load bearing capacity of the floor.

Adequate clearance around the chiller set is essential to facilitate maintenance and service. Required minimum clearances are tabulated under Dimensions and clearances on page 8.

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.

When unpacking the unit, carefully inspect it for visible signs of damage. Check for damaged evaporator insulation, broken wires, and loose piping and bolts. Any damage should be reported to the shipping company immediately.

Open all containers and verify all parts against the packing list.

Report any shortages to Smardt.

RIGGING

Care must be exercised at all times when rigging or handling the chiller set to protect it from damage. Four rigging points (two at each end) are provided on the evaporator tube sheet corners. The chiller's high center of gravity must be considered when rigging to ensure that the chiller is secure and balanced when suspended. A spreader bar / I-beam combination should be used to safely position the chiller set into its final location. The typical rigging details are shown below in Figure 1.

Smardt is not responsible for the rigging and placement of the unit. Arrangements can be made through a local equipment mover.

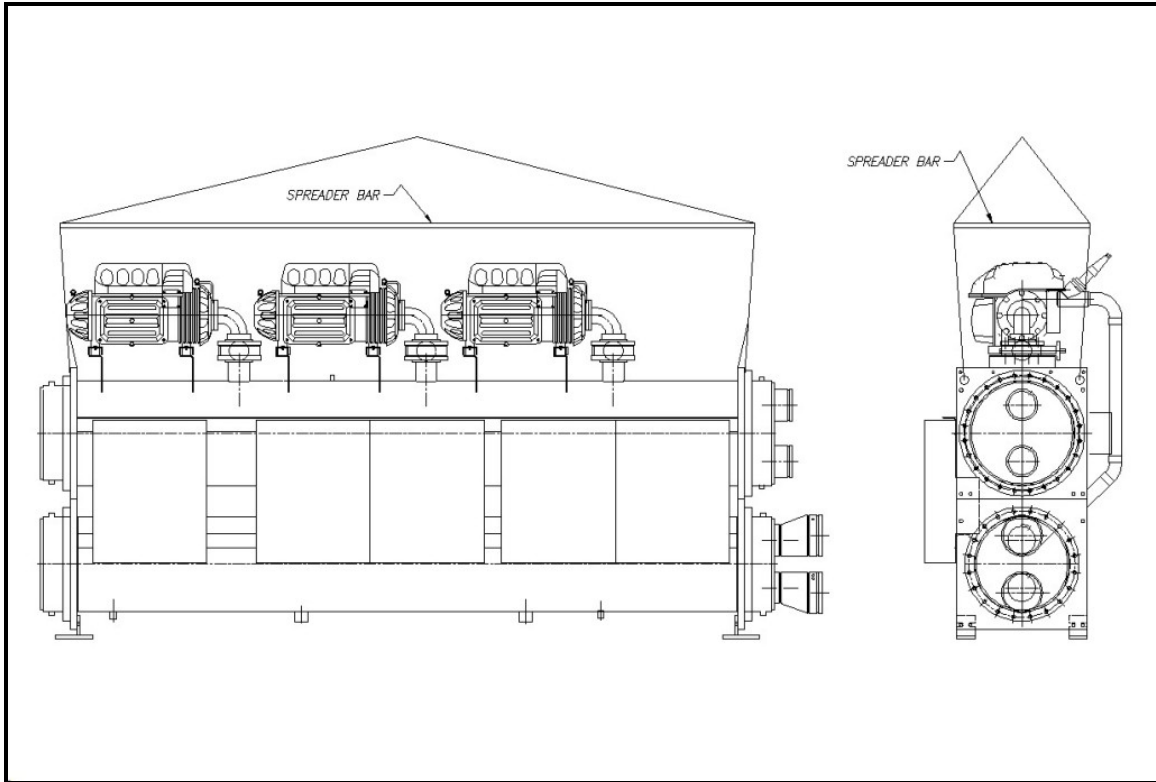


Figure 1: Rigging Diagram

Unit Placement

Install the chiller set on approved anti-vibration mounts. Each corner should be supported on vibration eliminators and steel plate or suitably isolated from the plant room floor. Generally waffle pads are considered suitable as the Smardt chiller is virtually vibration free. The chiller should be protected from excessive ground or pipe borne vibration from external sources such as pumps.

Once installed, remove the rigging equipment and check for longitudinal and transverse alignment. Add shims, if necessary, to level the unit along both axes.

Table 1 Dimensions and clearances

MODEL	H	W	L	Lbs *	Clearances		
					Tube removal	Controls access	Service top side
SW840S-3A	81.4"	41.53"	165"	19000	150" from tubesheet	36" min side	12" min above

*Includes full refrigerant charge – water circuits empty. Weights may vary with individual tube count.

NOTE: Values shown are typical. Refer to Smardt for product specific values.

Local codes may apply - ensure clearances comply with local codes/standards.

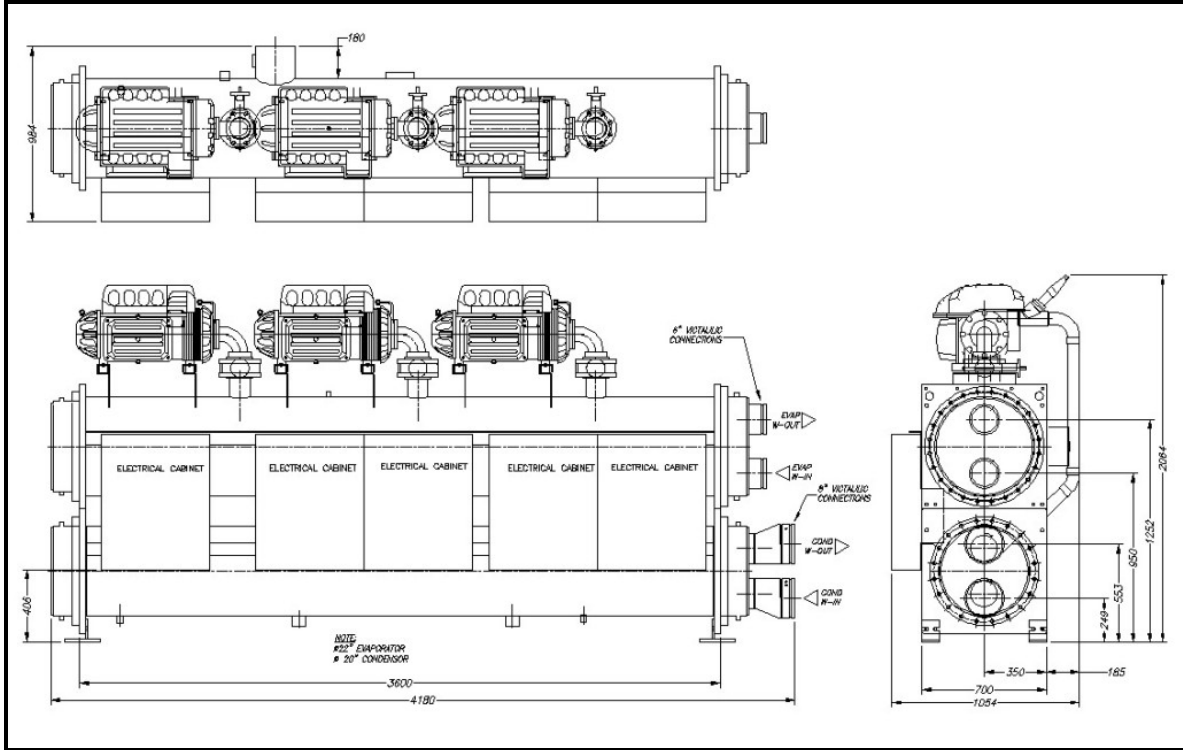


Figure 2: Dimensions and Clearances

The condenser and evaporator connections are grooved-type stubs (Victaulic®, Shurjoint®, or other equivalent) for interconnection to the external water circuits. All external piping must be adequately supported and aligned to prevent strain and distortion on the chiller headers and couplings.

Pressure drops and flows

Table 2 Pressure drops and Flows

	Design flow (GPM)	Pressure drop (PSI)	No. of Passes	Conn. Size (nominal) (inch)
Evaporator	957	3.3	2	8
Condenser	1153	5.9	2	8

NOTE: Values shown are typical. Refer to Smartdt for product specific values.

The chiller set performance and efficiency can be adversely affected by contaminants in the water circuits. Such contaminants may impede or block the flow of water through the circuits or reduce heat exchanger performance.

Strainers should be located on the inlet side of the evaporator and condenser. Water inlets to the chiller must be connected to the lower headers of the evaporator and condenser. All external water piping must be cleaned or flushed before being connected to the chiller set.

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

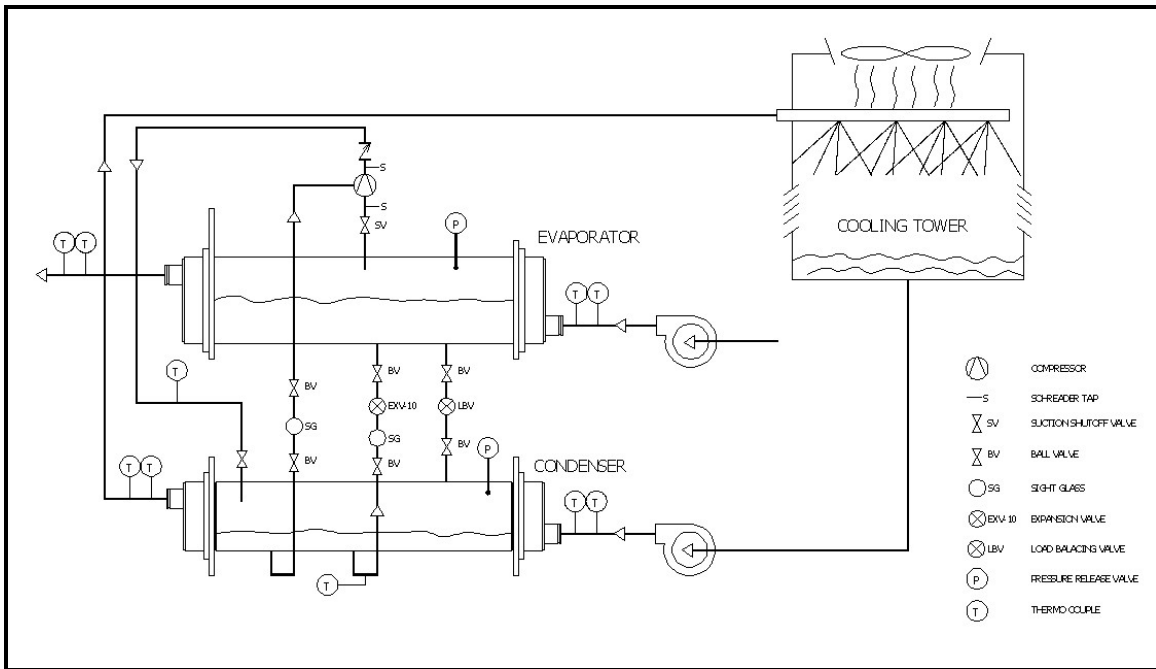


Figure 3 Piping Schematic

The primary chiller control functions are implemented either via a Carel® PLC, or the Kiltch controller which looks after the control of chilled water temperature, interlocks, and interfacing to the building system.

<http://interactions.smartd.com/Docs/SmartdControlWiringConnections.pdf>

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

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. A neutral and an earth are essential.

Table 3 Pressure drops and Flows

MODEL	Voltage	MCA	MOCP
SW series	460 v 60 Hz 3 Phases	260	300

NOTE: Values shown are maximum. Refer to Smartd for product specific values.

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

Note:

A Neutral is required for control purposes. The load is essentially a balanced 3 phase load and the neutral may be run in the minimum allowable cable size relative to the three phase mains.

COMMISSIONING

NOTE: Smardt requires equipment to be commissioned according to a detailed procedure and by a Smardt and Turbocor trained and certified technician. In order to activate the warranty, the commissioning form must be completed and submitted to Smardt. An interactive Adobe Acrobat Form is available on-line at:

<http://interactions.smar dt.com/Docs/SmardtCommissioningForm.pdf>

If Smardt is conducting the commissioning, or you request a factory supervised start-up, please submit the Smardt request for Start-Up Form available on-line at:

http://interactions.smar dt.com/Docs/Smardt_RequestStartUp_AcrobatForm.pdf

Before commissioning

- Obtain the Smardt Commissioning Form and understand its requirements
- Ensure that all the electrical connections and any pneumatic connections have been set up in accordance with the plans and the local regulations.
- Ensure that the PLC control system is available and is in working order.
- Ensure that all communication links to higher-level control systems and process control systems have been connected.
- Ensure that the cold water/brine circuit has been filled and is operational.
- Ensure that the refrigerating capacity is at 100%.
- Ensure that test operation is possible at a minimum of half capacity over a number of hours.
- Ensure that the cooling water circuit has been filled, purged and is operational.
- Check that a heat load is available during start-up.
- Check that insulation work has been completed.
- Clean dust and rubbish from the unit.
- Ensure that the unit is accessible from all directions.
- Check refrigerant or protective gas filling at least once a month if commissioning does not take place within 4 weeks after delivery. If this is the case, instruct the relevant service office to do this.
- Inform the relevant service office of any damages, prior to commissioning.
- Agree on the commissioning date with the Smardt service office.

- All materials needed for commissioning (refrigerant etc.) are to be requested or made available.

Clearances

Adequate clearance around the chiller set is essential to facilitate maintenance and service. Note and report if clearances are considered inadequate (re: Installation Guidelines).

Damage inspection

Inspect it for visible signs of damage. Check for damaged evaporator insulation, broken wires, and loose piping and bolts. Note any damage and report it to the appropriate personnel on site.

Piping connections

All external piping must be adequately supported and aligned to prevent strain and distortion on the chiller headers and couplings. Provision should be made to measure pressure drop across each heat exchanger.

Evaporator and condenser water circuits

Strainers should be located on the inlet side of the evaporator and condenser. Water inlets to the chiller must be connected to the lower headers of the evaporator and condenser. The water circuits should be arranged so that the pumps discharge through the evaporator and condenser, and controlled as necessary to maintain essentially constant chilled and condenser water flows through the unit at all load conditions.

Control wiring reference data

The primary chiller control functions are implemented via a Carel ® PLC or the Kiltech Controller which looks after the control of chilled water temperature, interlocks, and interfacing to the building system. These connections are made at a 24 v terminal strip inside the control cubicle. The Smardt Control Wiring Connections Form is on-line at:

<http://interactions.smardt.com/Docs/SmardtControlWiringConnections.pdf>

Chiller Controller I/O Functions for water cooled chillers (1~6 Compressors)

Temperature 1	EnChW_temp	Entering chilled water temperature for control and monitoring
Temperature 2	LvgChW_temp	Leaving chilled water temperature for control and monitoring
Temperature 3	EntCw_temp	Entering condenser water temperature for control and monitoring
Temperature 4	LvgCw_temp	Leaving condenser water temperature for control and monitoring
Temperature 5	LiquidRefrig_temp	Liquid refrigerant temperature before the expansion valve.
Temperature 6	OutsideAirTemp	Optional outside air temperature for data logging only
Temperature 7	Not used	
Temperature 8	Not used	
Digital Input 1	BMS Enable	BMS Enable contact – starts and stops the chiller
Digital Input 2	ChW Flow Proof	Chilled water flow proof switch
Digital Input 3	Cw Flow proof	Condenser water flow proof switch
Digital Input 4	Not used	
Digital Input 5	Ext LP Switch	External low pressure switch
Digital Input 6	Ext HP Switch	External high pressure switch
Digital Input 7	Gas Leak sensor	Gas leakage sensor
Digital Input 8	Ext FreezeStat	External Freezestat input

Digital Output 1	Comp Interlock Relay	Compressor interlock relay output
Digital Output 2	Tower VFD Enable	Cooling tower VFD enable
Digital Output 3	Chw Pump or vfd Relay	Chilled water pump enable output
Digital Output 4	Cw pump or vfd Relay	Condenser water pump enable output
Digital Output 5	Maximum capacity reached	Maximum capacity reached output, calls additional chillers
Digital Output 6	Chiller Ready	Closed when chiller is ready to run but not yet running
Digital Output 7	Chiller Fault	Closed when chiller is in fault state
Digital Output 8	Chiller Run	Closed when chiller is running
Analog Input 1	Tower fan VFD Feedback	Tower or condenser fan VFD feedback (4-20mA)
Analog Input 2	Chw Pump VFD Feedback	Chilled water pump VFD feedback (4-20 mA)
Analog Input 3	Cw Pump VFD Feedback	Condenser water pump VFD feedback (4-20mA)
Analog Input 4	BAS Load Limit Input	Building Automation System Amp Input feedback (4-20mA)
Analog Input 5	Set Point Reset Input	Set Point reset input , 0-5 VDC, 0-10 VDC or 4-20mA
Analog Input 6	Level Sensor or EXV Input	Refrigerant level sensor input for EXV, 0-5 VDC, 0-10 VDC, 4-20mA
Analog Input 7	Combo RH/Temp Sensor T in	Outside air temp input for tower control 0-5VDC, 0-10VDC or 4-20mA
Analog Input 8	Combo RH/Temp Rh in	Outside RH input for tower control. 0-5 VDC, 0-10 VDC or 4-20mA
Analog Output 1	Tower Fan VFD or 3-Way Valve	VFD cooling tower fan output. Controls Cw inlet temp. (4-20mA)
Analog Output 2	Cw Pump VFD Output	VFD condenser pump output (4-20mA)
Analog Output 3	ChW Pump VFD Output	VFD chilled water pump output (4-20mA)
Analog Output 4	Expansion Valve Output	Stepper motor output. Same loop for level control (4-20 mA)
Analog Output 5	Hot Gas Bypass Output	Hot gas bypass capacity control output. 4-20mA or 0-10VDC
Analog Output 6	Power Output 0-600 kW	Chiller power output power

Power Wiring

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.

SEQUENCE OF OPERATION

General

The purpose of this section is to provide guide on the sequence of operation for the Smartt oil-free centrifugal chiller. It is intended that this document be used with the applicable installation

Starting with stopped chiller (chiller at idle)

1. Enable signal sent from BAS sets digital input on chiller control to true.
 - a. Chiller controller waits 5 seconds before acting on BAS enable.
2. If the leaving chilled water temperature is greater than or equal to the “set point temperature” plus the “ ΔT over set point” and there are compressors available to run the chiller is set to “PULL DOWN STATE”.
3. Depending on the number of compressors configured to start up initially and the number of compressors available to run – compressors interlocks are closed and 15% demand is sent to each of the selected compressors.

4. Once the selected compressors are started up and begin to run the chiller demand is increased at a fixed ramp rate of 5% per minute until a demand of 100% is reached or the temperature is less than or equal to the set point.
 - a. At any point during this demand ramp up (temperature pull down) if the chiller demand goes over the “%Demand Stage Up” setting and a compressor is available to run a new compressor will be turned on.

OR

- b. At any point during this demand ramp up (temperature pull down) if the chiller power goes over a calculated optimum number to switch on another compressor and a compressor is available to run a new compressor will be turned on.

Each time a new compressor is turned on the chiller controller is placed into a “STAGE UP” state, initially in this state the demand to each of the operating compressors is reduced in order to lower the ΔP across the evaporator and condenser such that a new compressor easily without risk of surging – This may last for roughly 120seconds. When a new compressor is started it is started at the same demand as the other operating compressors, once this new compressor has reached the same RPM as the other operating compressors the “STAGE UP” sequence finishes and the fixed ramp to set point continues again.

5. Once the set point temperature is reached the chiller control mode is changed from “PULL DOWN” to “RUN MODE”. When the chiller is placed in “RUN MODE” the fuzzy pid loop takes over control of supplying demand to the compressors based on the error between the set point and leaving chilled water temperature.
 - a. If the chilled water temperature drops below the set point temperature for a period greater than 5 continuous seconds the chiller controller starts to look if it should shut down a compressor. The prerequisites for shutting down a compressor are:
 - i. The compressor RPM must be reduced to within 5% of the compressors lowest speed for the existing suction and discharge pressure.
 - ii. The minimum time between compressor turn offs has expired (generally set to 120seconds).

iii. The inlet guide vane must have remained at a position lower than the chiller controller IGV STAGE DOWN% for 60 seconds

OR

iv. The chiller demand has reduced to less than or equal to 10% (Minimum chiller loading).

6. If while the chiller is in the “RUN MODE” the heat load on the chiller increases again the compressors are turned back on as detailed in the pull down sequence.

7. While in “RUN MODE” if the chiller is unloaded where only one compressor is operational and the chilled water temperature drops to the chiller controller configured “SHUT DOWN TEMP” the chiller is turned off. A 180 second anti-recycle timer is started once this timer has expired the chiller control state is returned to “IDLE” and the chiller may be re-started.

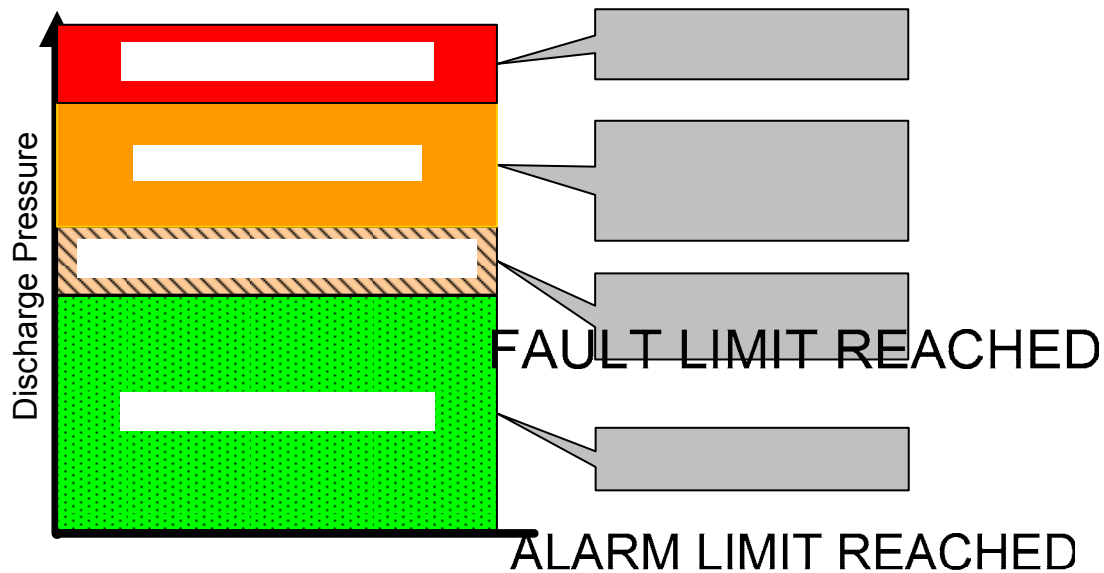
Abnormal operation sequences:

Chiller in alarm avoidance:

Chiller Management System continuously monitors for abnormal system conditions such as low suction pressure, high discharge pressure, low leaving temperature, high amp draw and others.

The controller implements a three stage alarm management strategy in order to stay online as long as possible. The alarm management routine operates as follows:

ALARM STATE	ACTION REQUIRED
All monitored values Normal	No Action Required
One or more monitored values is within 5% of the alarm setting	If system is loading the system stops loading.
One or more monitored values is equal to or greater than the alarm setting	System demand is reduced by 0.5% per second until demand reaches 10% or compressors ride to the surge speed. If the alarm is still present and the compressors are at the surge speed the controller will enter stage down state turning compressors off every 120seconds until the last compressor is left online.
One or more monitored values is equal to or greater than the trip setting	Chiller is turned off, all compressors shutdown. The Fault will be automatically reset after the time value setup in the advanced setting screen (default = 180sec). Once the fault has been reset the system is set back to idle state where it must wait for 180sec anti-recycle timer before starting the chiller again.



Chiller detected fault:

If at any time whilst the chiller is running a fault condition is detected the chiller is placed into fault state. The chiller will remain in the fault state for a pre-configured period of not less than 180seconds after which time the fault will be automatically reset and the chiller placed back to "IDLE" where the 180second anti-recycle timer is started again.

Compressor faults:

If a fault is generated inside the compressor:

- If the fault is reset able such as a suction pressure, bearing displacement or motor over temperature fault the chiller controller attempts to automatically reset the fault and make the compressor useful again.
- If the fault is not able to be reset such as a compressor over current trip or system component failure the chiller controller places that compressor in a not-useable state and flags on touch screen that the compressor is "LOCKED OUT".

A maximum of three compressor faults per hour are tolerated, if more than three faults in an hour are generated the compressor is placed offline for a 20minute period (until fault time expires).

If compressor does fault while the chiller is running and then reset that compressor is then selected as the last compressor to startup when the load increases.

MAINTENANCE

Maintenance inspections

The following list of preventative maintenance items must be carried out by authorized and qualified personal in a timely fashion.

Owner's responsibilities:

- Report any damage to the chiller set.
- Report any faults that occur with the chiller set.
- Turn off the chiller if fault condition persists.
- Maintain a safe working environment in the plant room, free from obstructions and debris.
- Provide adequate lighting.
- Ensure plant room ventilation is adequate and as per government regulations.
- Maintain water treatment to the chiller as per government regulations and maintain water quality to prevent premature failure of the system.

Smardt recommends that on-site operational checks be carried out as per Table Operational checks evaluate the system performance, fault history and trends.

Table 1. Frequency of maintenance for Smardt chillers:

ITEM	TASK	Frequency		
		3mths	6mths	12mths
Electrical checks	Check Main power supply voltages	✓		
	Check Electrical terminals are tight		✓	
	Check Hot spots / discoloration on power cables	✓		
	Check Amperages are as per design			
Electronic inspections	Check communication cables are secure	✓		
	Check pressure and temperature sensor connections are secure.		✓	
	Check there are no signs of physical damage / discoloration on printed circuit boards.		✓	
	Check the printed circuit boards are free of dust		✓	
Compressor refrigeration circuit inspections	Check EXV winding resistance (do NOT disturb connections unless repair is required)			✓
	Check all mounting bolts are secure	✓		
	Check for refrigerant leaks	✓		
	Check for mechanical damage	✓		
Chilled water circuit inspection	Check operating temperatures and pressures			✓
	Check for Insulation damage.	✓		
	Check chilled water sensors are secure and installed with adequate heat transfer medium.		✓	
	Check water flow / pressure drops are as per design.		✓	
	Check flow switch operation.			✓
Check for water leaks.	✓		✓	
Check water strainers.			✓	

Condenser water circuit inspection (if fitted)	Check condenser water sensors are secure and installed with adequate heat transfer medium.		✓	
	Check water flow / pressure drops are as per design.		✓	
	Check flow switch operation.			✓
	Check for water leaks.	✓		
	Check water strainers.	✓		
	Clean condenser tubes			✓
	Check cooling tower operation (refer manufacturers specification(s))	✓		
Air cooled condenser inspection (if fitted)	Check airflow is not obstructed.	✓		
	Check fin surfaces are clean	✓		
	Check fans rotation (direction).			✓
	Check fan motor overload devices	✓		

Table 2. Frequency of Maintenance – Turbocor compressor

Item	Task	Frequency		
		6 mths	12 mths	60 mths
General inspections	Check for visible mechanical damage to compressor	✓		
	Check for excessive vibration from other rotating equipment	✓		
Electrical inspections	Check main power supply voltages (refer to p 47 Turbocor service manual)	✓		
	Check electrical terminals are tight		✓	
	Check for signs of hotspots / discoloration on power cables	✓		
	Check amperages as per design	✓		
	Check DC Bus voltage	✓		
	Check capacitor mid bus voltage	✓		
	Replace capacitor set			✓
Electronic inspections	Check operation of all system safety devices and interlocks		✓	
	Check all communications cables are secure and tight	✓		
	Check all electronic modules are secure	✓		
	Check physical condition of all exposed Printed Circuit Boards (PCB's)	✓		
	Check all exposed PCB's for dust build-up and clean if necessary		✓	
Refrigeration	Check calibration pressure / temperature sensors		✓	
	Check operation of IGV assembly		✓	
	Check system refrigeration charge	✓		
	Check superheat level / control, if applicable		✓	
	Check system and motor cooling liquid line to ensure sufficient subcooling	✓		
	Check operating conditions external to the compressor	✓		
	Clean / inspect motor-cooling strainers (if service has taken place)	As Required		

TROUBLESHOOTING

The performance of the chiller set is largely dependent on the correct operation of the water circuits and the refrigeration system. When evaluating the refrigeration system, it is important to check the operation of the water circuits first. Failure to do this may lead to misdiagnosis of the refrigeration circuit. Ensure that the chiller has sufficient water flows in both the evaporator and condenser, as per specifications.

Table 2. Fault diagnosis chart

SYMPTOMS	POSSIBLE CAUSE	ACTION
Low suction pressure	Low chilled water flow Chilled water temperature too low Faulty pressure transducer Insufficient refrigerant charge Restricted refrigerant flow Suction valve closed Compressor IGV stuck open	Check flow as per design Check set points Check transducer Check evaporator liquid level Check sub-cooling Check discharge temperature Check EXV operation Check filter driers Check valve position Check indicated position and carry out standard IGV checks.
High discharge pressure (water-cooled machines)	Condenser water temp. too high Low condenser water flow Fouled water tubes Blocked water strainer Faulty pressure transducer Non-condensable in system. System overcharged Discharge valve closed Restriction in pipe work	Check tower set point Check flow as per design Clean tubes Clean strainer Replace transducer Dehydrate system Adjust charge Check valve position Correct pipe work
High discharge pressure (air-cooled machines)	Blocked / restricted airflow Air re-circulation Fans reversed Electrical overload(s) tripped Motor failure Faulty pressure transducer Non-condensable in system System overcharged Discharge valve closed Restriction in pipe work	Remove obstructions Remove cause of re-circulation Correct power supply connection Reset / investigate cause Repair / replace Replace transducer Dehydrate system Adjust charge Check valve position Correct pipe work

SYMPTOMS	POSSIBLE CAUSE	ACTION
High-evaporator pressure	Chilled water temperature too high Pressure sensor faulty IGV failure	Check temperature sensor. Check for excessive water flow. Replace transducer Check operation (refer procedure)
Low refrigerant temperature cutout	Insufficient refrigerant charge. Faulty sensor. Water temperature too low. Water flow blocked	Check refrigerant charge. Replace sensor. Check set points. Find / repair blockage
Drive temperature too high	No motor cooling. Insufficient sub-cooling. Faulty sensor	Check pipe work / valves. Check compressor solenoids (refer service manual). Check refrigerant charge. Check liquid line for restrictions. Replace sensor
Compressor does not start	No cooling demand. Faulty chilled water temperature sensors. Faulty pressure sensors. No mains power No chiller controller power	Check temperature set points. Replace faulty sensors. Replace faulty sensors. Check power at mains terminal block. Check control circuit fuses / CB's

SERVICE PROCEDURES

The following tools are required for servicing the chiller:

Service tools

Allen key set up to 14mm
Torx screwdriver #25
Manifold set
Thermometer
+1000VDC Multimeter
Computer with Turbocor Monitoring Software
Grounding wrist-strap

Connecting refrigerant gauges

It is extremely important that the manifold set is free of moisture and dust. It is also important that the gauge set is not contaminated with other refrigerants or oil. When performing any service procedure that requires the addition of refrigerant, do not use reclaimed refrigerant unless it is of guaranteed quality and oil-free.

1. Connect the low pressure hose (blue hose) to the access valve provided at the suction ball valve.
2. Connect the high pressure hose (red hose) to the access valve provided at the discharge ball valve.
3. Purge both gauge lines to ensure that non-condensables, which can lead to false pressure readings, are removed from the line. Once this is complete, the service technician can evaluate the refrigeration system.

Removing refrigerant

Whenever removing refrigerant from the evaporator and condenser vessels, water flow must be established prior to carrying out this procedure. Water flow prevents a freeze-up condition that will cause leaks between the water and refrigerant circuits, leading to major component failure. This procedure may vary, depending on the type of service required.

1. Install the gauge manifold set or refrigerant recovery lines to the chiller set in the appropriate area of service. Connect the common refrigerant hose to the suction side of an approved refrigerant recovery system.
2. Connect a hose between the discharge side of the recovery system and the recovery container.
3. Purge all lines of non-condensables.
4. Switch on the recovery system and transfer the refrigerant. (The time of transfer depends on the type of transfer system and the volume of refrigerant.) To assist the transfer, it is important to maintain a cool recovery cylinder. Once the system pressure is approximately 10 kPa, the system can be opened up to atmosphere and the necessary repairs carried out.

Once the system is open for inspection, turn the water pumps off or isolate flow if the system is in parallel with other chillers. If the water circuits are not shut down, condensation will occur in the refrigeration pipe work, leading to longer than normal evacuation times due to the presence of moisture in the system.

Refrigerant leak testing

Leak testing can be performed by the following means:

- Electronic leak detector
- Soapy water

Both of the above methods are adequate to locate leaks. Once the leak is isolated, the system should be shut down and the affected component(s) repaired

Machine not operating - no charge

1. Connect the service manifold set to the chiller as per procedure 4.2
2. Connect gauge set-up to the R134A refrigerant cylinder and add a trace gas (only required if electronic detection device is used).
3. Connect the gauge set-up to an industrial grade nitrogen cylinder and increase the pressure in the system to 1500 kpa.
4. Carry out leak detection as per the above procedure.

Once the leak has been repaired, pressurize the system with nitrogen and leave undisturbed for 24 hrs. Check the pressure gauge noting any change in pressure and ambient temperatures from the previous day. (There may be slight pressure changes if the ambient temperature has changed dramatically.) If the pressure in the system is maintained, the nitrogen can be removed and the dehydration procedure (4.5) can be performed on the chiller.

Dehydration procedure

When the system has been open for a lengthy period and contamination has occurred, it is important to dehydrate the system to remove any moisture.

ATTENTION: Never apply power to the unit while under a vacuum.

NOTE:

Use the same hoses as in the leak testing procedure, making sure the lines are free of leaks. If possible, use copper lines to minimize potential leaks between the chiller and the vacuum pump.

1. Install the evacuation hoses between the chiller and the vacuum pump.
2. Start the vacuum pump.
3. Open all isolation valves on the chiller to ensure that there is a vacuum achieved throughout the system.
4. Once a vacuum has been achieved, connect an approved vacuum testing device and check the results. If the vacuum reading is less than 500 microns, isolate the vacuum hoses in the event that the reading is affected by the running vacuum pump.
5. Let the chiller remain under vacuum for approx.1 hour. Recheck the vacuum reading. If the reading does not increase by 50 microns within this time, the chiller is ready to be recharged with refrigerant. If the system was severely contaminated by an internal electrical failure or by the presence of moisture, a triple dehydration procedure should be carried out, breaking the vacuum each time with refrigerant or nitrogen to remove all contamination.

During operation, carry out refrigerant analysis on a regular basis and change filter driers as required.

Charging the refrigeration system

Use pure refrigerant from non-contaminated cylinders.

1. Turn on the chilled water and condenser water pumps.
2. Connect up charging lines to the bottom of the evaporator vessel and the charging cylinder.
3. Purge lines, removing non-condensables.
4. Add the correct amount of refrigerant charge to the evaporator vessel as indicated by the name plate.

In the event that a minimum of 75% of the total refrigerant charge cannot be added to the chiller, use an approved refrigerant pump to attain the minimum charge. The machine will require restarting and the gas charge added during operation.

NOTE: The Turbocor compressors rely upon liquid refrigerant for the cooling of their mechanical, electro-mechanical, and electronic components. Therefore in order to bring the system to the correct operational refrigerant charge it may be necessary to connect your charging lines onto the bypass port on the operational compressor, and provide liquid to it during its operation. This will ensure adequate cooling for the compressor whilst completing the charging of the system.

Refer to procedures 4.7 and 4.8 to determine the operational refrigerant charge, to ensure system does not become over charged. During this procedure, it may be necessary to bypass some control functions in order to maintain chiller operation and thereby reach the desired refrigerant charge.

Check sub-cooling

Sub-cooling measurement procedure:

1. Set up the service manifold as per procedure 4.2; however, connect the discharge hose (red) to the liquid line upstream of the electronic expansion valve (EXV).
2. Note the corresponding saturation temperature of the refrigerant at the pressure indicated. (In order to have sub-cooling, the measured value must be less than the saturation temperature.)
3. With a temperature probe, measure the temperature on the liquid line upstream of the EXV.
4. Calculate the difference between the saturated temperature and the measured temperature. This difference is the amount of sub-cooling.

Design spec: 9-15° F (5-8° C).

Check superheat

Superheat Measurement Procedure:

1. Connect up the service manifold as per procedure 4.2.
2. Note the corresponding saturation temperature of the refrigerant at the pressure indicated. (In order to have superheat, the measured value must be greater than the saturation temperature.)
3. With a temperature probe, measure the temperature on the suction line.
4. Calculate the difference between the saturated temperature and the measured temperature. This difference is the amount of superheat.

Design spec: 0-5° F (0-3° C).

Soldering procedure

When components in the refrigeration system require replacement, soldering or sweating will be required to either remove or replace the components. To protect the internal pipe work, the use of industrial grade nitrogen must be used at all times during any procedure where a naked flame is applied to the pipe-work. The use of nitrogen prevents copper oxide formation in the internal pipe work during the soldering process. (This keeps the internal pipe work clean and free of contamination.)

1. Connect the gauge manifold set as per procedure 4.2.
2. Connect the common gauge line (yellow hose) to the nitrogen regulator.
3. Set the regulator to provide a positive pressure of 5 psig.
4. Open the nitrogen cylinder and manifold set to purge the area to be soldered. (Nitrogen displaces any oxygen present in the pipe work.) During the soldering process, be sure that any component that may be affected by the addition of heat to the area be cooled by means of a wet rag wrapped around the component.
5. Once the soldering process is complete, cool down the pipe work and shut off the nitrogen supply. Once cool, the system can be reassembled and tested for leaks.

Checking IGV operation

During compressor ramp-up, the inlet guide vanes open depending on load conditions, as indicated by the ball bearing on the outside of the IGV housing; refer to Figure 4. If the ball does not move, further testing will be required; refer to the Compressor Service Manual. When the Turbocor compressor is not in operation the Inlet Guide Vanes will move to the closed position.



Checking Electronic Expansion Valve operation

During operation, the EXV modulates, maintaining the pre-set liquid level in the evaporator. The EXV responds to the liquid level sensor via the chiller controller. Refer to procedure 4.12 to verify the operation of the liquid level sensor. If the liquid level sensor is operating correctly, use the chiller controller interface to manually drive the EXV. Verify that the liquid level fluctuates according to the drive signal, as observed through the sight glass on the cooler. If the EXV fails to respond to the manual input, the EXV is defective and requires replacement.

Checking liquid level sensor operation

Be sure control type: Level is selected in the controller. The level sensors have a display on the back of the sensor. Observe the indicated level to see that it varies (particularly during startup). At stable conditions the level should be maintained within 5 % of the set point (normally 45 to 55 %). The sensor is a 0 to 90 ohm resistive element (45 ohms at indicated 50%).



REMOVAL AND INSTALLATION OF COMPRESSORS

DANGER

Before performing any service on the compressor, electrical power must be isolated. To ensure safe and clear access to the compressor, follow these procedures:

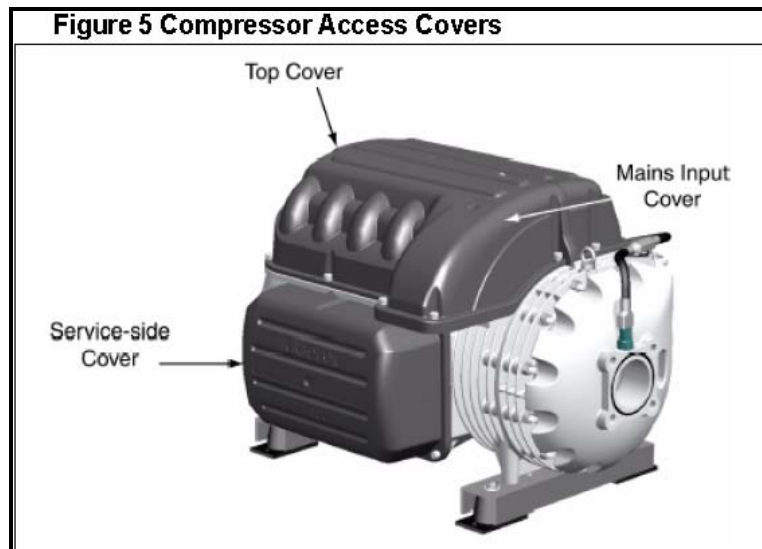
1. Switch off the AC mains at the disconnect switch. Install a lock-out device or place a placard at the switch alerting others that compressor servicing is in progress. **Wait at least 10 minutes** before opening any of the compressor access covers.



When AC power is first removed from the compressor, the DC link capacitors store enough energy to cause electrocution. Allow sufficient time for the capacitors to discharge before proceeding.

2. Using a #25 bit, remove the four Torx screws that secure the mains input cover to the main compressor housing. Refer to Figure 5.
3. NOTE: Ensure the removal of all four Torx screws, paying special attention to the removal of the screw in the top left of the mains input cover, as failure to remove may result in damage to the cover

4. Lift away the mains input cover and set aside.
5. With a voltmeter, verify that there is no voltage present on all three phases.
6. Using a #25 bit, remove the Torx screws that secure the top cover to the main compressor housing.
7. Lift away the top cover and set aside.
8. With a voltmeter, verify that there is no voltage present on the DC bus.
9. Remove the screws that secure the service-side cover.
10. Lift away the service-side cover and set aside.



Refrigerant Containment

Isolation and recovery of the refrigerant must be performed by a qualified service technician.

1. Close the suction butterfly valve.
2. Close the discharge ball valve.
3. Close the inter-stage ball valve (if fitted).
4. Close the motor cooling shut-off valve.
5. Connect the service gauge as per procedure 4.2.
6. Connect an approved refrigerant recovery system to the compressor as per procedure 4.3 and transfer the refrigerant into a clean cylinder.

Compressor Removal

Refer to 5.1 "Preparation for Service" steps 1 through 7 prior to commencing the removal procedures.

1. Remove the terminal nuts from the terminal block using a 16mm socket and wrench.

2. Remove the AC mains cables from the terminals.
3. Loosen the gland nut on the mains input bracket and pull the power cable through the opening until it is completely detached from the compressor.
4. Disconnect the communication/interlock cables from the compressor I/O connector module. Make sure that there is no secondary power source connected to the terminal block before disconnecting any sensors or relay inputs/outputs. Once the transfer of refrigerant is complete, disconnect the service isolation valves.
5. Using a 24mm wrench, remove the suction ball valve bolts.
6. Using a 8mm hex key, remove the discharge ball valve bolts.
7. Using a 8 mm hex key, remove the inter-stage ball valve bolts.
8. Remove the motor cooling connection at the rear of the compressor.
9. Replace the top cover and secure it using Torx screws.
10. Replace the main input cover and secure it using Torx screws.
11. Remove the four compressor mounting bolts using a 9/16" socket.
12. Connect an approved lifting device, such as a mobile hydraulic lifter, to the eyebolts provided on each side of the compressor.
13. Remove the compressor.
14. Using the blanking plates provided with the new compressor, seal up the compressor in preparation for shipment to the supplier; this will prevent moisture and foreign material from entering the compressor, possibly affecting the compressor strip-down and analysis procedures.

Compressor installation

Install new o-rings only when reattaching the ball valves to the compressor.

1. Remove the blanking plates provided with the new compressor.
2. Connect an approved lifting device, such as a mobile hydraulic lifter, to the eyebolts provided on each end of the compressor.
3. Position and align the compressor over the mounting base.
4. Insert the four compressor mounting bolts that secure the compressor to the chiller. Tighten the screws using a 16mm socket.
5. Attach the motor cooling connection at the front of the compressor.
6. Using a 8 mm hex key, tighten the inter-stage valve bolts.

7. Using a 8mm hex key, tighten the discharge service valve bolts.
8. Using a 14mm hex key, tighten the suction service valve bolts.
9. Connect the communication/interlock cables to the compressor I/O connector module.
10. Using a #25 bit, remove the four Torx screws that secure the main input cover. Lift away cover. Make sure that electrical power is isolated from the AC mains cables before handling them.
11. Route the power cable through the opening in the mains input bracket.
12. Attach the AC mains cables to the terminals, and the grounding cable to the grounding lug.
13. Attach the terminal nuts to the terminal block using a 16mm socket and wrench.
14. Tighten the gland nut on the mains input bracket.
15. Replace the main input cover and secure it using Torx screws.

NOTE: Suction and discharge valves are meant to be used for service only. Do not run the unit or leave open for extended periods of time. If it is intended it will be open for extended periods use planking plates with gaskets and test of leaks.

HEAT EXCHANGER SERVICE

Air-Cooled Condenser

The Smardt condenser is a vertical air flow cross finned coil heat exchanger design. The coil is horizontal and incorporates a separate sub cooling circuit and may have a liquid receiver located between the main and sub cooling circuits to ensure that the main circuit does not liquid lock.

No regular service is required; however the following checks should be made on a regular basis:

- Ensure that the motors protection devices (in the main cubicle) are not tripped.
- Check the general state of the fin surfaces for built up soiling. A build up of dust adhering to the fins in greasy environments can lead to air flow reduction and poor heat exchange. Generally steam or pressure spray cleaning in the most appropriate cleaning method.

Evaporator – shell-and-tube type

Shell-and-tube type evaporators should be treated as described for condensers above.

Evaporator – shell-and-plate type

An alternative Smardt flooded shell-and-plate evaporator may be fitted. This type is not mechanically cleanable. Chemical cleaning methods may be used but it is essential to ensure that the chemicals used are compatible with and will result in no harm to the

materials of construction.

Materials are:

Copper (coating – heat exchange plates)

Stainless steel (heat exchange plates)

Low carbon steel (water connections)

Proceed generally as follows:

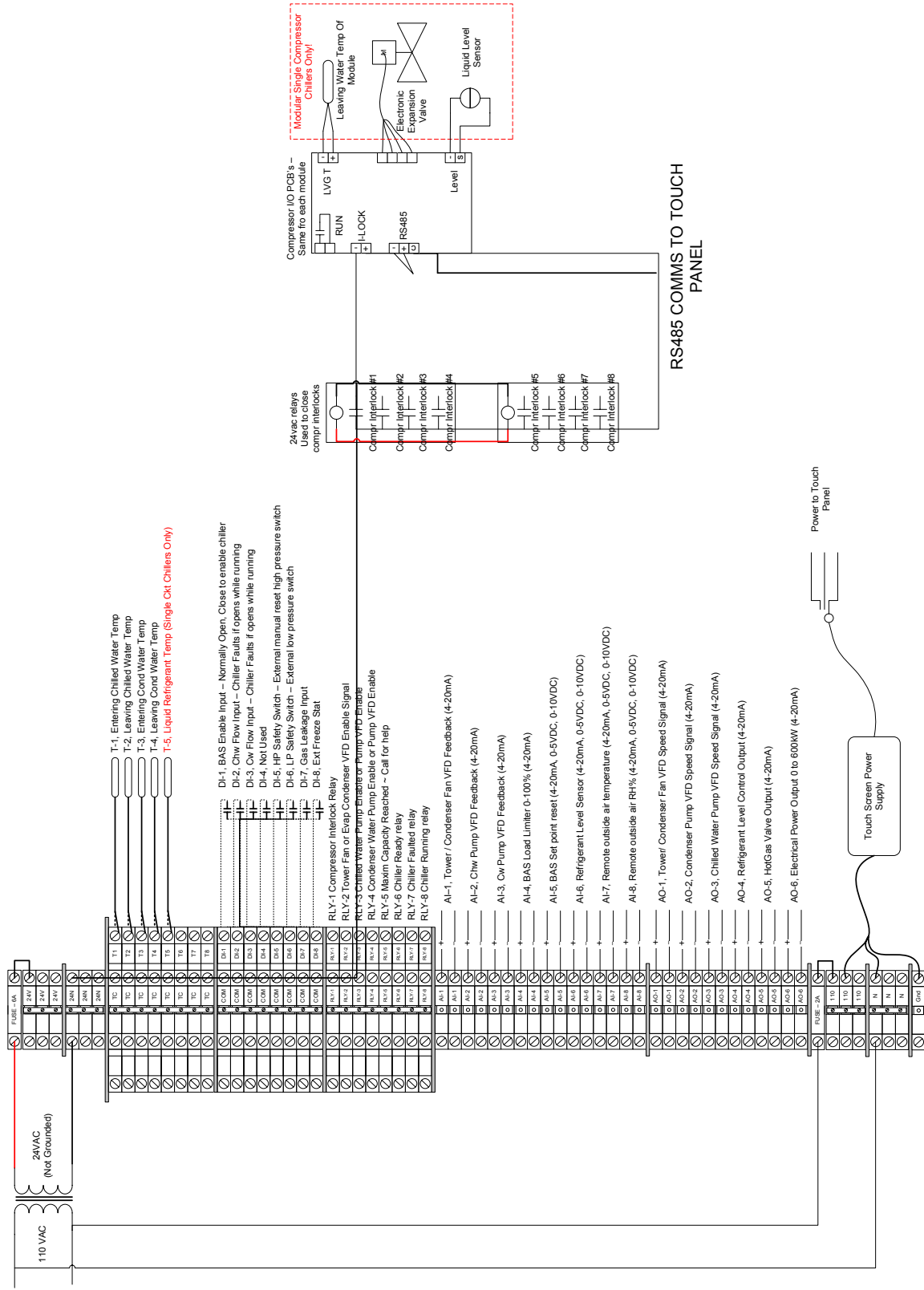
1. Shut down the chiller set and isolate from the power.
2. Isolate and drain down the cooler water circuit, including the pump and inlet filter.
3. Remove the inlet filter and inspect it for the possible cause of the problem.
4. Replace the filter.
5. Follow the chemical suppliers procedure to introduce the chemicals only to the cooler.
6. Flush thoroughly afterwards, then seal the water circuit and refill the system. Bleed the water circuit.
7. Re-connect power and monitor the chiller operation at startup.

INCIDENT REPORT PROCEDURE

Smardt strives for product excellence and maintains a competent staff of professionals in application design and service to serve our customers. If you have a problem with a Smardt chiller, we want to know about it. To report an incident and request an RMA, please submit a Chiller Incident Report. This form is available on-line at:

http://interactions.smardt.com/Docs/Smardt_IncidentReport_AcrobatForm.pdf

Wiring Diagram



RS485 COMMS TO TOUCH PANEL

Controller Default and Custom Settings

SETTING DESCRIPTION	Default	Setting	COMMENT
Temperature Regulation Settings			
Chilled air/water set point	45°F		
Leaving or entering air/water control	Leaving		
Dead Band	0.1°F		
Proportional band	18		
Integral Gain	2500		
Derivative Gain	5000		
Control Min	5%		
Max Slew Rate	5%		
ΔT Above Set point to Start	4°F		
Stop Chiller Temp (Safe shut down~ Set above alarm)	42°F		
Condenser Control Settings			
Minimum Set point temperature	65°F		
Maximum Set point temperature	85°F		
Starting%	25%		
Starting Timer	120sec		
Starting Set point	75°F		
Set point change per minute	0.5°F		
Proportional Band	20°F		
Integral Gain	2500		
Control Min	0%		
Max Slew Rate	5%		
Alarm Settings			
Suction pressure alarm	30 psig		
Suction pressure trip	26 psig		
Suction trip timer	15 sec		
Discharge pressure alarm	150 psig		
Discharge pressure trip	160 psig		
Discharge trip timer	15 sec		
System amp alarm (Chiller specific)	Xxx		
System amp trip (Chiller specific)	Xxx		
Over amp trip timer	45 sec		
Leaving temperature alarm	38°F		
Leaving temperature trip	36°F		
Leaving high temp limit while running	55°F		
Leaving high temp time limit	30 min		
Condenser water high temp alarm	95°F		
Condenser water high temp trip	100°F		
Auto fault reset delay timer	180 sec		
Compressor Staging Settings			
%Demand Stage Up	90%		
% RPM Stage Up	60%		
% RPM Stage Down	5%		
Power Stage Up %	100%		
Stage up time delay	240 sec		
Stage down time delay	120 sec		

Pressure ratio limit	2.2		
IGV% before stage down	75%		
Number of compressor to start (Chiller/ Site dependent)	Xxx		
Look forward time	1 sec		
Temperature Reset (upper) (only works if reset based on return temp is selected as reset mode)	0°R / 54°F		
Temperature Reset (lower) (only works if reset based on return temp is selected as reset mode)	4°R / 45°F		
Display Units	Imperial		
Comp Mode	Modbus		
Pass Code	0		
Chiller Address	1		
RS485Baud (Chiller to BAS comms)	19200		
Evaporator VFD Tuning	35		
Condenser VFD Tuning	45		
Design kW input (Chiller dependent)	Xxx		
System Setup			
Number of compressors (chiller dependent)	Xxx		
Number of refrigerant circuits (chiller dependent)	Xxx		
Three phase VAC (Site dependent)	Xxx		
Compressor Type	TT300		
Evaporator Type	Flooded		
Condenser Type	Water Cooled		
Control Mode	PID Leaving		
Condenser Control Mode	Cond Water In		
Stage Mode	Equal run time		
Chiller model (chiller dependent)	Xxx		
Temperature reset mode	AI #5		
<u>Hot Gas Valve Settings</u>			
Proportional Band	2°F		
Integral gain	1500		
Control Min	0%		
Max Slew Rate	5%		
Starting %	50%		
Starting Timer	180 sec		
Set point (ΔT Below the set point)	1°F		
Manual Valve %	0%		
Step Count	24000		
Sensor & Analogue Input Settings			
Temperature Input#1 Offset	0°R		
Temperature Input#2 Offset	0°R		
Temperature Input#3 Offset	0°R		
Temperature Input#4 Offset	0°R		
Temperature Input#5 Offset	0°R		
Temperature Input#6 Offset	0°R		
Temperature Input#7 Offset	0°R		
Temperature Input#8 Offset	0°R		

Analogue Input Scaling			
AI-1 Cond Fan VFD Speed Feed Back	0/0/100		
AI – 2 Chilled Water Pump VFD Speed Feed Back	0/0/100		
AI – 3 Condenser Water Pump VFD Speed Feed Back	0/0/100		
AI – 4 BAS Load Limit input	0/50/100		
AI – 5 Set point Reset	0/0/10		
AI – 6 Refrigerant Level Sensor	0/0/100		
AI – 7 Remote Temp Sensor	0/32/150		
AI- 8 Remote RH% Sensor	0/0/95		
Electronic Expansion Valve Settings			
Proportional Band	5°R		
Integral gain	500		
Control Minimum (min valve position per compressor)	7%		
Max Slew Rate	5%		
Starting %	25%		
Starting Timer	120sec		
Min SH Set point	-2°R		
Max SH Set point	1°R		
Minimum Sub-cooling	2.5°R		
Manual Valve %	0%		
Step Count	24000		

Record of compressor controller settings

SETTING DESCRIPTION	Default	Setting	COMMENT
Compressor Alarm and Trip Settings			
Compressor Control Mode	Modbus		
Display Units	Imperial		
Discharge pressure alarm limit	155		
Discharge temperature alarm limit	90		
Suction pressure alarm limit	28psig		
Leaving temperature alarm limit	38°F		
Current alarm limit (Chiller dependant)	Xxx		
Discharge pressure trip limit	170		
Discharge temperature trip limit	95		
Suction pressure trip limit	25psig		
Leaving temperature trip limit	36°F		
Current trip limit (Chiller dependant)	Xxx		
Electronic Expansion Valve Settings (Modular Chillers Only)			
Control Mode	Liquid Level 1		
Auto/Manual	Auto		
Stepper Startup%	25%		
Stepper Startup position delay	120 sec		
Stepper control set point	35%		
Stepper control loop speed	45%		
Stepper minimum count	10%		
Maximum step count	6000		
RS485 Modbus Settings			

Slave Address (Compressor dependent 1~6)	Xxx		
Baud Rate	38400		
Stop bits	2		