

<i>SAMPLE PROJECT- MECHANICAL EQUIPMENT</i>					
Centrifugal Chiller					
Contract Documents		PO Documents	Vendor Submittal	Contractual Comment	Comment
1.01	FACTORY PERFORMANCE TEST				
A	A factory test will be conducted on one chiller (as a representative of all chillers) to ensure that submitted performance parameters are realized as a	Complied in the PO Documents.	One of the chillers of this size will be tested at Full (100%) Load.	Complied.	--
B	The factory performance test shall be witnessed by the Engineer, the Contractor, and the Owner. The manufacturer shall be responsible for travel and hotel expenses for the Engineer and Owner.	Referenced in the PO Documents Factory witness testing included for 4 people.	Not Referenced.	Not Referenced.	--
C	At least nine hours shall be allotted for testing of one chiller.	Referenced in the PO Documents.	Not Referenced.	Not Referenced.	--
D	The chiller shall be tested at the six entering condenser water temperatures submitted with the bid. Additionally, following the 85°F entering condenser water test point, the Manufacturer shall maintain the 85°F test set up, open the chiller vanes to 100%, and record the chiller's "full out" capability.	Referenced in the PO Documents: The manufacturer shall include factory testing for 1 Cleveland chiller and 1 Cincinnati chiller both to be tested at 2 points. Factory testing of 1 chiller per site each 2 point test 100% load.	A factory performance test will be performed in accordance with project specification section 236416 1.04. One of the chillers of this size will be tested at Full (100%) Load with 85 degree condenser water and at 50% load with 65 degree condenser water.	Complied.	--
E	The test will be conducted in accordance with ARI guidelines subject to the following restrictions:		Performance will be certified in accordance with ARI Standard 550/590.	Complied.	--
1	At each entering condenser water test point, the chiller shall meet the following regardless of allowable ARI tolerances.				

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a	Specified tonnage (as a minimum).	Complied in the PO Documents.	One of the chillers of this size will be tested at Full (100%) Load.	Complied.	--
b	Specified chilled water temperature difference (as a minimum).	Complied in the PO Documents.	One of the chillers of this size will be tested at Full (100%) Load.	Complied.	--
c	Specified leaving chilled water temperature (as a maximum).	Complied in the PO Documents.	One of the chillers of this size will be tested at Full (100%) Load.	Complied.	--
d	Specified condenser water flow rate (as a maximum).	Complied in the PO Documents.	One of the chillers of this size will be tested at Full (100%) Load.	Complied.	--
e	Specified entering condenser water temperature (as a maximum).	Complied in the PO Documents.	One of the chillers of this size will be tested at Full (100%) Load.	Complied.	--
f	Specified condenser water temperature difference at peak conditions (as a maximum).	Complied in the PO Documents.	One of the chillers of this size will be tested at Full (100%) Load.	Complied.	--
F	The chiller manufacturer shall pay the Owner if the submitted parameters are not met. Should payment be realized, it shall be remitted for the tested representative chiller as well as all untested chillers.	Complied in the PO Documents.	Not Referenced.	Not Referenced.	--
1.02	WARRANTY				
A	Provide one year parts and labor warranty from date of acceptance.	Referenced in the PO Documents: One year of warranty.	Not Referenced.	Not Referenced.	--

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B	(Alternate 1) Provide a five year warranty, parts and labor, for the compressor.	Referenced in the PO Documents: Provide Parts and Labor Warranty for 5-years from date of acceptance (jan 1st 2008).	Not Referenced.	Not Referenced.	--
1.03 COMPRESSOR AND MOTOR					
A	Compressor shall be centrifugal type.	Complied in the PO Documents.	The compressor will be a single-stage centrifugal type.	Complied.	--
	Compressor castings shall be designed for 265 psig working pressure and hydrostatically pressure tested at 400 psig.	Complied in the PO Documents.	Compressor castings will be designed for 235 psig working pressure and hydrostatically pressure tested at 355 psig for R-134A units.	Not Complied.	--
B	Transmission shall be single ratio, single helical, parallel shaft speed increaser.	Complied in the PO Documents.	Internal single helical gears with crowned teeth.	Complied.	--
	A gravity fed oil reservoir shall be built into the top of the compressor to provide lubrication during coast down in the event of a power failure.	Complied in the PO Documents.	A gravity-fed oil reservoir will be built into the top of the compressor to provide lubrication during coastdown in the event of a power failure.	Complied.	--

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C	Capacity control shall be achieved by use of pre-rotation vanes. Pre-rotation vane position shall be automatically controlled to maintain constant leaving chilled water temperature.	Complied in the PO Documents.	Capacity control will be achieved by use of prerotation vanes. Prerotation vane position will be automatically controlled by an external electric actuator to maintain constant leaving chilled water temperature.	Complied.	--
D	Lubrication oil shall be force fed to all bearings, gears and rotating surfaces by an oil pump.	Complied in the PO Documents.	Lubrication oil shall be force fed to all compressor bearings, gears, and rotating surfaces by an external variable speed oil pump.	Complied.	--
	An oil reservoir, separate from the compressor, shall contain a submersible oil pump and immersion type oil heater, thermostatically controlled to remove refrigerant from the oil.	Complied in the PO Documents.	An oil reservoir, separate from the compressor, shall contain the submersible 2 HP oil pump and a 3000 watt oil heater, thermostatically controlled to remove refrigerant from the oil.	Complied.	--
	The oil reservoir shall be designed, tested and stamped in accordance with the ASME Boiler and Pressure Vessel Code, Section VIII - Division 1.	Complied in the PO Documents.	The oil reservoir shall be designed and stamped in accordance with ASME or applicable pressure vessel code.	Complied.	--

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E	Oil shall be filtered by an externally mounted replaceable cartridge oil filter equipped with service valves.	Complied in the PO Documents.	Oil shall be filtered by dual externally mounted ½ micron replaceable cartridge oil filters equipped with service valves.	Complied.	--
	Oil cooling shall be done via a refrigerant cooled oil cooler, with all piping factory installed.	Complied in the PO Documents.	Oil cooling shall be done via a refrigerant cooled oil cooler, with all piping factory installed.	Complied.	--
	Both the refrigerant and oil side of the oil cooler shall be provided with service valves.	Complied in the PO Documents.	Oil side of the oil cooler shall be provided with service valves.	Not Complied.	--
	An automatic oil return system to recover any oil that may have migrated to the evaporator shall be provided.	Complied in the PO Documents.	An automatic oil return system to recover any oil that may have migrated to the evaporator shall be provided.	Complied.	--
F	The compressor motor shall be a squirrel cage, induction type operating at 3550 rpm.	Complied in the PO Documents.	The compressor motor will be an open drip-proof, squirrel cage, induction type operating at 3570 RPM.	Complied.	--
	Motor may be an open drip proof or hermetic, liquid refrigerant cooled type.	Complied in the PO Documents.	The compressor motor will be an open drip-proof.		--
1.04	EVAPORATOR AND CONDENSER				
A	Evaporator and condenser respectively shall be of shell and tube type construction.	Complied in the PO Documents.	Evaporator and condenser will be of the shell-and-tube.	Complied.	--

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	Units shall be fabricated with high performance tubing, steel shell and tube sheets with fabricated steel waterboxes.	Referenced in the Scope of Work: Provide marine water boxes for each chiller on the condenser side only. The insulation for the marine water boxes and standard water boxes (evaporator side) will be furnished and installed by the installing contractor.	Shell will be fabricated from rolled carbon steel plate with fusion welded seams; have carbon steel tube sheets. Tubes shall be high-efficiency, internally and externally enhanced type. Water boxes shall be provided.	Complied.	--
	Waterboxes shall be nozzle in head type with stubout nozzles having Victaulic grooves to allow for use of Victaulic couplings.	Referenced in the PO Documents: All piping connections shall be flanged in lieu of the specified victualic. Complied in the CDE Document. Referenced in the Bid Summary: Flanged piping connections.	Water boxes will be removable to permit tube cleaning and replacement. Stubout water connections having flanged connection will be provided.	Complied.	--
B	Tubing shall be copper, high efficiency type, with integral internal and external enhancement.	Complied in the PO Documents.	Tubes shall be high-efficiency, internally and externally enhanced type having plain copper lands at all intermediate tube supports to provide maximum tube wall thickness at the support area.	Complied.	--
	Tubes shall be nominal 3/4" OD with nominal wall thickness of 0.025" measured at the root of the fin.	Referenced in the PO Documents: 0.025" thk. Tubes and 0.05" thk. At all tube supports.	Suitable diameter with 0.025" thickness.	Complied.	--

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	Intermediate support sheet spacing shall not exceed 36".	Complied in the PO Documents.	Intermediate tube supports spaced no more than four feet apart.	Complied.	--
C	Waterboxes and nozzle connections shall be designed for 150 psig minimum working pressure.	Complied in the PO Documents.	Operating pressure: 150 psig.	Complied.	--
D	The tube sheets of the cooler and condenser shall be bolted together to allow for field disassembly and re-assembly.	Complied in the PO Documents.	Not Referenced.	Not Referenced.	--
E	The vessels shall display an ASME nameplate which shows the pressure and temperature data and the "U" stamp for ASME Section VIII, Division 1. A refrigerant pressure relief valve shall be installed on each heat exchanger.	Complied in the PO Documents.	The refrigerant side will be designed, tested and stamped in accordance with ASME Boiler and Pressure Vessel Code.	Complied.	--
F	Waterboxes shall have vents, drains, and covers to permit tube cleaning.	Complied in the PO Documents.	Vent and drain connections with plugs will be provided on each water box.	Complied.	--
	A thermistor type temperature sensor shall be factory installed in each water nozzle.	Complied in the PO Documents.	Not Referenced.	Not Referenced.	--
H	Tubes shall be individually replaceable from either end of the heat exchanger.	Complied in the PO Documents.	Each tube will be roller expanded into the tube sheets providing a leak-proof seal, and be individually replaceable.	Complied.	--
I	The condenser shell shall include a refrigerant subcooler for improved cycle efficiency.	Complied in the PO Documents.	Factory packaged subcooler.	Complied.	--

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J	Liquid refrigerant shall be metered from the condenser to the cooler using a float type metering valve.		Complied in the PO Documents.	Refrigerant flow to the evaporator will be controlled by a variable orifice for improving unloading capabilities.	Complied.	--
K	Provide manual isolation valves to hold the full refrigerant charge in the condenser for servicing the compressor.		Complied in the PO Documents.	Not Referenced.	Not Referenced.	--
L	Any component subject to condensing moisture shall be insulated with ¾" thick closed cell insulation and shall conform to UL Standard 94.		Referenced in the PO Documents: Insulation as per section 2.04L shall be furnished and installed by vendor.	Factory-applied, anti-sweat insulation will be attached to the cooler shell, flow chamber, tube sheets, suction connection, and (as necessary) to the auxiliary tubing.	Complied.	--
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1.05	REFRIGERANT MONITORING SYSTEMS					--
A	Acceptable Manufacturer's	MSA-TGM, 2. Genesis International Inc., Sherlock 802, 3. Alternate manufacturers meeting the following criteria:	Not Referenced in the PO Documents.	By others.	Not Complied.	--

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B	Provide a complete monitoring system for each room of chiller plant.	Deviation in the PO Documents: The Manufacturer shall exclude the refrigerant monitor, sensors, and accessories for each site. This equipment will be furnished and installed by others. Refrigerant monitor purchased by owner for \$5000.	By others.	Not Complied.	--
C	For each monitoring system, the number of remote sensors shall equal the number of chillers served.	Not Referenced in the PO Documents.	By others.	Not Complied.	--
	Digital display accuracy shall be within plus or minus 2% of full scale.	Not Referenced in the PO Documents.	By others.	Not Complied.	--
	Monitors shall be capable of operation in ambient temperatures from 40 to 125aF.	Not Referenced in the PO Documents.	By others.	Not Complied.	--
D	Each monitoring system shall be complete with auxiliary contacts for use by the Building Automation System.	Not Referenced in the PO Documents.	By others.	Not Complied.	--
1.06 CONTROLS					
A	A microprocessor based control panel shall be furnished for each chiller and shall be fully wired and factory mounted on the chiller.	Referenced in the Scope of Work: Microprocessor based control panel with features as per section 2.06 of these specifications. Referenced in the Coordination Matrix: Control panel shall be furnished and installed by vendor.	The chiller shall be controlled by a stand-alone microprocessor based control center.	Complied.	--

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1	The display shall have a minimum of 40 character liquid crystal display and be backlit with a light emitting diode.	Complied in the PO Documents.	The control panel shall include a 10.4 in. diagonal color liquid crystal display (LCD).	Complied.	--
2	The following information shall be available on the display with simple entry on the keypad:				
a	Entering and leaving chilled water temperatures.	Complied in the PO Documents.	Provided.	Complied.	--
b	Entering and leaving condenser water temperatures.	Complied in the PO Documents.	Provided.	Complied.	--
c	Evaporator, suction, discharge, condenser, and liquid temperatures.	Complied in the PO Documents.	Provided.	Complied.	--
d	Suction and discharge superheat.	Complied in the PO Documents.	Provided.	Complied.	--
e	Liquid subcooling, evaporator and condenser approach temperatures.	Complied in the PO Documents.	Provided.	Complied.	--
f	Evaporator, condenser and lift pressures.	Complied in the PO Documents.	Provided.	Complied.	--
g	Oil feed and sump temperatures.	Complied in the PO Documents.	Provided.	Complied.	--
h	Oil pump discharge and oil differential	Complied in the PO Documents.	Provided.	Complied.	--
i	Motor amps and amps as a percent of rated load amps.	Complied in the PO Documents.	Provided.	Complied.	--
j	Hours of operation and number of starts, time of last start and stop.	Complied in the PO Documents.	Provided.	Complied.	--
k	Chilled water set point and reset temperature	Complied in the PO Documents.	Provided.	Complied.	--
l	Amp limit for manual and remote.	Complied in the PO Documents.	Provided.	Complied.	--
m	Fault history for last 8 failures with date, time, and critical sensor values.	Complied in the PO Documents.	Provided.	Complied.	--

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n	Unit status; start up and shutdown sequence, operational status.	Complied in the PO Documents.	Provided.	Complied.	--
3	The microprocessor shall either unload or shutdown compressor during an abnormal condition. At a minimum the following safeties shall be incorporated in the control system:	Complied in the PO Documents.			--
a	High and low discharge pressure.	Complied in the PO Documents.	Provided by vendor.	Complied.	--
b	Low evaporator pressure.	Complied in the PO Documents.	Provided by vendor.	Complied.	--
c	High discharge temperature.	Complied in the PO Documents.	Provided by vendor.	Complied.	--
d	Chilled or condenser water pump failure.	Complied in the PO Documents.	Provided by vendor.	Complied.	--
e	No evaporator or condenser water flow.	Complied in the PO Documents.	Provided by vendor.	Complied.	--
f	High or low oil feed temperature.	Complied in the PO Documents.	Provided by vendor.	Complied.	--
g	Low oil differential pressure.	Complied in the PO Documents.	Provided by vendor.	Complied.	--
h	High motor temperature, low motor current.	Complied in the PO Documents.	Provided by vendor.	Complied.	--
i	Surge high suction superheat.	Complied in the PO Documents.	Provided by vendor.	Complied.	--
j	Starter fault, no starter transition,	Complied in the PO Documents.	Provided by vendor.	Complied.	--
k	Vanes open during start sequence.	Complied in the PO Documents.	Provided by vendor.	Complied.	--
l	Sensor failure, specific to sensor.	Complied in the PO Documents.	Provided by vendor.	Complied.	--
4	Controller shall hold leaving chilled water temperature to within 0.2°F without hunting, droop, or overshooting.	Complied in the PO Documents.	Smart Freeze Point Protection shall run the chiller at 36.00 °F leaving chilled water temperature, and not have nuisance trips on low water temperature.	Complied.	--
5	Controller should be able to monitor and control amps from 30 to 100% of RLA based on a keypad entry or by a remote 4-20mA DC signal.	Complied in the PO Documents.	Provided.	Complied.	--

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6	The controller shall be able to reset chilled water supply temperature from a signal from the building automation system.	Complied in the PO Documents.	Provided.	Complied.	--
7	Soft loading shall be provided to prevent the unit from operating at pull down if desired.	Complied in the PO Documents.	Provided.	Complied.	--
8	The control system shall have automatic restart after a power failure and not require a battery backup for memory continuity.	Complied in the PO Documents.	The operating program stored in non-volatile memory (EPROM).	Complied.	--
9	The controller shall be capable of starting and stopping chilled water and condenser water pumps.	Complied in the PO Documents.	Six-week schedule for starting and stopping the chiller, pumps and tower.	Complied.	--
1.07 AUTOMATION INTEGRATION					
A	The centrifugal chillers shall be required to interface with the Building Automation System (BAS) in an Open Protocol environment.	Referenced in the PO Documents: Interface card shall be furnished by manufacturer.	Provided.	Complied.	--
1.08 LOW VOLTAGE UNIT MOUNTED					
A	<u>Variable Frequency Drive:</u>				
1	The centrifugal water chiller shall be furnished with a liquid cooled variable frequency drive (VFD).	Referenced in the PO Documents: VFD shall be factory mounted, wired and tested. Referenced in the Coordination Matrix: VFD shall be furnished by vendor. Referenced in the Bid Summary.	A variable speed drive will be factory installed on the chiller.	Complied.	Not indicated whether the VFD is Liquid cooled or Air cooled.

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2	All heat exchanger piping for the VFD cooling system shall be copper. Plastic tubing is not acceptable.	Not Referenced in the PO Documents.	Not indicated.	Not Referenced.	--
4	The drive efficiency shall be 97% or better at full speed and full load.	Complied in the PO Documents.	Power factor of 0.95 or better at all loads and speeds.	Complied.	--
	Fundamental power factor shall be a minimum 0.96 lagging at all speeds and loads.	Complied in the PO Documents.	Power factor of 0.95 or better at all loads and speeds.	Complied.	--
5	The adjustable frequency drives shall be 18 pulse solid state, microprocessor based pulse width modulated (PWM) design.	Not Referenced in the PO Documents.	Drive will be PWM type utilizing IGBT's.	Complied.	--
	The VFD shall have converter designed with differential autotransformer with 18 semiconductor inputs.	Not Referenced in the PO Documents.	Not indicated.	Not Referenced.	--
6	The VFD shall be voltage and current regulated. Output power devices shall be IGBT transistors.	Complied in the PO Documents.	Drive will be PWM type utilizing IGBT's.	Complied.	--
7	Power semi-conductor and capacitor cooling shall be from a liquid cooled heat sink.	Complied in the PO Documents.	Not indicated.	Not Referenced.	--
8	The VFDs shall each be furnished in a NEMA 1 gasketed/filtered metal enclosure	Complied in the PO Documents.	NEMA 1 enclosure	Complied.	--
	Enclosure shall include a padlockable, door-mounted circuit breaker with shunt trip and AIC rating of 65,000 amps.	Complied in the PO Documents.	Door interlocked circuit breaker capable of being padlocked.	Complied.	AIC rating not indicated.
9	The VFD shall be tested to ANSI/UL Standard 508 and shall be listed by a Nationally Recognized Testing Laboratory (NRTL) as designated by OSHA	Complied in the PO Documents.	Not indicated.	Not Referenced.	--

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10	Input shall be nominal 480 volts, three phase, 60 Hertz AC power, +/- 10 percent of nominal. Line frequency 38-60 hertz.	Complied in the PO Documents.	Not indicated.	Not Referenced.	--
11	The VFD shall include Bypass feature and input line reactor.	Complied in the PO Documents.	Not indicated.	Not Referenced.	--
12	<u>The drive units shall include the following</u>				
a	All control circuit voltages are physically and electrically isolated from power circuit voltage.	Complied in the PO Documents.	Not indicated.	Not Referenced.	--
b	One hundred fifty percent instantaneous torque available for improved surge control.	Complied in the PO Documents.	Not indicated.	Not Referenced.	--
c	Minimum and maximum speed adjustments.	Complied in the PO Documents.	Not indicated.	Not Referenced.	--
d	Soft start, adjustable linear acceleration, coast to stop.	Complied in the PO Documents.	Not indicated.	Not Referenced.	--
e	Adjustable current limiting and UL approved electronic motor overload protection.	Complied in the PO Documents.	Not indicated.	Not Referenced.	--
f	Insensitivity to incoming power phase sequence.	Complied in the PO Documents.	Insensitive to phase rotation.	Complied.	--
g	<u>VFD and motor protection from the following faults:</u>				
	Output line-to-line & line-to-ground short circuit.	Complied in the PO Documents.	UL listed ground fault protection.	Complied.	--
	Phase loss at VFD input.	Complied in the PO Documents.	Single phase protection.	Complied.	--
	Over-volt, under-volt, over temperature, phase reversal.	Complied in the PO Documents.	Over voltage and under voltage protection. Over temperature protection.	Complied.	--

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	DC Overvoltage, Drive Overload, Motor Overload	Complied in the PO Documents.	3-phase sensing motor over current protection.	Complied.	--
	Automatic operation at minimum speed if the input reference is lost.	Complied in the PO Documents.	Not indicated.	Not Referenced.	--
h	The following VFD status indicators shall be available to facilitate startup and maintenance:				
	Output speed in hertz and rpm	Complied in the PO Documents.	Digital readout at the chiller unit control panel.	Complied.	--
	Input line voltage	Complied in the PO Documents.	Digital readout at the chiller unit control panel.	Complied.	--
	Input line kW	Complied in the PO Documents.	displayed digitally via the unit's control panel.	Complied.	--
	Output/load amps	Complied in the PO Documents.	RMS digital readout via the unit control panel.	Complied.	--
	Average current in percent RLA	Complied in the PO Documents.	Digital readout at the chiller unit control panel.	Complied.	--
	Load power factor	Complied in the PO Documents.	Digital readout at the chiller unit control panel.	Complied.	--
	Fault	Complied in the PO Documents.	Digital readout at the chiller unit control panel.	Complied.	--
	VFD transistor temperature	Complied in the PO Documents.	Digital readout at the chiller unit control panel.	Complied.	--
13	Service Conditions - at run output power. No external venting or heat exchangers shall be required.	Complied in the PO Documents.	Not indicated.	Not Referenced.	--
	Operating ambient temperature 32aF to 104aF.	Complied in the PO Documents.	Not indicated.	Not Referenced.	--
	Room ambient 0-95% relative humidity.	Complied in the PO Documents.	Not indicated.	Not Referenced.	--

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	Elevation to 3,300 feet. For every 300 feet above 3,300 feet, the rated output current shall be decreased by one percent.	Complied in the PO Documents.	Not indicated.	Not Referenced.	--
14	The adjustable frequency drive shall be warranted by the manufacturer for a period of twelve months from the date of installation.	Complied in the PO Documents.	Not indicated.	Not Referenced.	--