

SEQUENCE OF OPERATION

SYSTEM CONTROL

GENERAL CONTROL OF THE CHILLER PLANT SHALL BE PROVIDED, INSTALLED AND COMMISSIONED BY THE CHILLER MANUFACTURER. THE CHILLER PLANT CONTROL SYSTEM SHALL MONITOR AND CONTROL THE CHILLED WATER SYSTEM INCLUDING THE CHILLERS, PUMPS, COOLING TOWERS, BY-PASS VALVE AND VARIABLE SPEED DRIVES AS APPROPRIATE. THE CHILLER PLANT CONTROL SYSTEM SHALL HAVE A FULLY EDITABLE USER INTERFACE SETUP VIA POINT AND CLICK ON A STANDARD WINDOWS SCREEN ON THE SAME OPERATORS WORKSTATION WHERE THE FACILITY HAS SYSTEM RESIDES. THE CHILLER PLANT CONTROL SYSTEM SHALL COMMUNICATE ON A SYSTEM LEVEL VIA ION PROTOCOL AND THE SPECIFIED POINTS LIST SHALL BE SERVED UP TO THE EXISTING BAS SYSTEM VIA BACNET OVER IP.

THE CHILLER PLANT CONTROL SYSTEM SHALL INCLUDE THE FOLLOWING FEATURES:

OPERATOR INTERFACE	FAILURE RECOVERY DIAGNOSTICS/PROTECTION
SYSTEM START/STOP	ENERGY OPTIMIZATION ROUTINES
CHILLER AND PUMP SEQUENCING	SYSTEM AND CHILLER STATUS REPORTS
CHILLER MINIMUM FLOW BY-PASS CONTROL	DEMAND LIMITING
SYSTEM SOFT START	COOLING TOWER SEQUENCING AND CONTROL
AUTOMATIC ROTATION OF CHILLERS AND PUMPS	

CONTROL OF THE SYSTEM COMPONENTS SHALL BE AS FOLLOWS:

- THE CHILLERS SHALL RECEIVE ENABLE/DISABLE SIGNALS EITHER THROUGH A COMMAND OR VIA A COMMUNICATION LINK.
- A CHILLER BINARY OUTPUT SHALL CONTROL THE OPERATION OF THE CHILLER EVAPORATOR ISOLATION VALVE.
- THE PUMPS SPEED SHALL BE MODULATED TO CONTROL THE CHILLED WATER SYSTEM SUPPLY/RETURN PRESSURE DIFFERENTIAL TO THE REQUIRED SETPOINT.
- THE SYSTEM MINIMUM FLOW BY-PASS VALVE SHALL BE A NORMALLY-OPEN VALVE.
- THE SYSTEM MINIMUM FLOW BY-PASS VALVE SHALL BE MODULATED TO THE FULLY OPEN POSITION WHENEVER THE SYSTEM IS SHUT DOWN TO ENSURE MINIMUM FLOW AND PREVENT THE POSSIBILITY OF WATER HAMMER WHENEVER A PUMP IS STARTED.
- THE SYSTEM MINIMUM FLOW BY-PASS VALVE POSITION SHALL BE MODULATED TO ENSURE OPERATING CHILLERS FLOW DOES NOT DROP BELOW THE MANUFACTURERS MINIMUM RECOMMENDED FLOW. CONTROL SHALL BE BASED ON FLOW THROUGH THE CHILLER EVAPORATOR BY MEASURING PRESSURE DROP ACROSS THE EVAPORATOR AND CALCULATING EVAPORATOR FLOW FROM MANUFACTURERS DATA.
- FLOW RATE FLUCTUATION THROUGH THE CHILLER SHALL NOT EXCEED 50 PERCENT OF THE DESIGN FLOW RATE PER MINUTE.
- A CHILLER BINARY OUTPUT SHALL CONTROL THE OPERATION OF THE CHILLER CONDENSER ISOLATION VALVE AND/OR CALL FOR PUMP OPERATION.
- DURING COLD START-UP THE CONDENSER WATER FLOW THROUGH THE CHILLER SHALL BE MODULATED PER THE MANUFACTURERS RECOMMENDATIONS TO MAINTAIN NOT LESS THAN THE MINIMUM CONDENSER/EVAPORATOR REFRIGERANT PRESSURE DIFFERENTIAL.

THE CHILLER PLANT CONTROL SYSTEM SHALL INCLUDE THE FOLLOWING OPERATOR INTERFACE ELEMENTS:

- OPERATIONAL STATUS SCREEN**
 - CHILLER SYSTEM STATUS (SOFT START/NORMAL/AMBIENT LOCKOUT/SHUTDOWN IN PROGRESS) CURRENT PLANT TONS
 - CHILLER PLANT WATER SUPPLY SETPOINT
 - CHILLED WATER SYSTEM SUPPLY WATER TEMPERATURE
 - CHILLED WATER SYSTEM RETURN WATER TEMPERATURE
 - PREDICTIVE CHILLER ADDITION/SUBTRACTION STATUS MESSAGES
 - INDIVIDUAL CHILLER FAILURE RESET (PUSH BUTTON)
 - ALL CHILLER FAILURE RESET (PUSH BUTTON)
 - SYSTEM PUMP FAILURE RESET (PUSH BUTTON)
 - MANUAL ADDITION OF CHILLER (PUSH BUTTON)
 - MANUAL SUBTRACTION OF CHILLER (PUSH BUTTON)
 - MANUAL ROTATION OF CHILLER SEQUENCE (PUSH BUTTON)
- EDITABLE PARAMETERS SCREEN:**
 - SUPPLY WATER SETPOINT
 - SYSTEM SOFT LOADING PARAMETERS
 - AMBIENT LOCKOUT PARAMETERS
 - ALARM HANDLING SETUP
 - SECURITY SETUP
 - CHILLER ADDITION PARAMETERS
 - CHILLER SUBTRACTION PARAMETERS
 - CHILLER ROTATION PARAMETERS
- INDIVIDUAL CHILLER GRAPHICS:**
 - CHILLER NAME
 - CHILLER OPERATING MODE
 - CHILLED WATER SETPOINT
 - CHILLER MFLA
 - ENTERING CHILLED WATER TEMPERATURE
 - LEAVING CHILLED WATER TEMPERATURE
 - EVAPORATOR FLOW RATE, GPM
 - CONDENSER FLOW RATE, GPM
 - EVAPORATOR FLOW STATUS
 - CONDENSER FLOW STATUS

SYSTEM START/STOP: THE CHILLED WATER SYSTEM SHALL START IN RESPONSE TO A NEED FOR CHILLED WATER FROM ANY SYSTEM LOAD, WITH THE OPTION TO USE OUTSIDE AMBIENT TEMPERATURE LOCKOUT. UPON THE START OF THE CHILLED WATER SYSTEM THE CHILLER PLANT CONTROL SYSTEM SHALL AUTOMATICALLY START TEND LOG REPORTS. THESE REPORTS SHALL INCLUDE HOURLY LOGGING OF THE FOLLOWING POINTS:

OUTSIDE AIR DRY BULB, OUTSIDE AIR WET BULB, SYSTEM CHILLED WATER SETPOINT, SYSTEM CHILLED WATER SUPPLY TEMPERATURE, SYSTEM CHILLED WATER RETURN TEMPERATURE, SYSTEM CONDENSER WATER SUPPLY TEMPERATURE, SYSTEM CONDENSER WATER RETURN TEMPERATURE, OPERATING STATUS OF EACH CHILLER, OPERATING STATUS OF SYSTEM PUMPS.

SEQUENCING:

THE CHILLER PLANT CONTROL SYSTEM WILL START AND STOP THE CHILLED WATER PUMPS AND CHILLERS BASED UPON SYSTEM LOAD. WHEN THE CHILLED WATER SYSTEM IS ENABLED, THE CHILLER PLANT CONTROL SYSTEM SHALL SEND AN ENABLE SIGNAL TO THE LEAD CHILLER. UPON RECEIVING THE ENABLE SIGNAL, THE CHILLER SHALL ENABLE THE CHILLER EVAPORATOR ISOLATION VALVE. THE ISOLATION VALVE SHALL BE CONTROLLED TO 100% OPEN. WHEN THE ISOLATION VALVE IS CONFIRMED TO BE 100% OPEN, THE CHILLER PLANT CONTROL SYSTEM SHALL START THE LEAD CHILLED WATER PUMP IN THE SEQUENCE. THE CHILLED WATER PUMP SHALL BE CONTROLLED TO MAINTAIN THE DESIGN PRESSURE SETPOINT FOR THE SYSTEM UPON CONFIRMATION OF EVAPORATOR WATER FLOW THE CHILLER SHALL ENABLE THE CHILLER CONDENSER ISOLATION VALVE AND CALL FOR THE LEAD CONDENSER PUMP OPERATION. UPON CONFIRMATION OF CONDENSER WATER FLOW THE CHILLER SHALL CONTINUE ITS PRE-START SEQUENCE AND START ITS COMPRESSOR. UPON THE START OF EACH CHILLER THE CHILLER PLANT CONTROL SYSTEM SHALL AUTOMATICALLY START CHILLER SPECIFIC TEND LOG REPORTS TO INCLUDE:

HOURLY LOGGING REPORTS	FIVE MINUTE LOGGING REPORTS
UNIT CHILLED WATER SETPOINT	UNIT CHILLED WATER SETPOINT
COMPRESSOR R/LA	COMPRESSOR R/LA
EVAPORATOR ENTERING WATER TEMP	EVAPORATOR ENTERING WATER TEMP
EVAPORATOR LEAVING WATER TEMP	EVAPORATOR LEAVING WATER TEMP
EVAPORATOR FLOW RATE	EVAPORATOR FLOW RATE
CONDENSER ENTERING WATER TEMP	CONDENSER ENTERING WATER TEMP
CONDENSER LEAVING WATER TEMP	CONDENSER LEAVING WATER TEMP
CONDENSER APPROACH TEMP	

THE CHILLER PLANT CONTROL SYSTEM SHALL MODULATE THE CHILLED WATER PUMP THROUGH ITS VFD TO MAINTAIN THE PRESSURE SETPOINT. THE CHILLER PLANT CONTROL SYSTEM SHALL INITIATE THE START OF THE SECOND LAG CHILLER WHENEVER THE CHILLED WATER LOAD, AS DETERMINED BY THE SYSTEM CHILLED WATER SUPPLY TEMPERATURE, IS NOT MET FOR 20 MINUTES. THE CHILLER PLANT CONTROL SYSTEM WILL UNLOAD THE OPERATING CHILLER TO AN OPERATOR EDITABLE CURRENT LIMIT PRIOR TO STARTING THE LAG CHILLER. THE LAG CHILLER SHALL START IN A SIMILAR MANNER TO THE LEAD CHILLER START SEQUENCE.

THE CHILLER PLANT CONTROL SYSTEM SHALL INITIATE THE SHUTDOWN OF THE LAG CHILLER WHENEVER EXCESS CHILLED WATER CAPACITY EXISTS, AS DETERMINED BY THE RUN LOAD AMPS. FOR 20 MINUTES UPON SENSING A CHILLER FAILURE, THE CHILLER PLANT CONTROL SYSTEM SHALL SHUT DOWN THE FAILED CHILLER IMMEDIATELY AND INITIATE THE START OF THE REMAINING CHILLER.

THE DESIGN SYSTEM CHILLED WATER SETPOINT SHALL BE 42 DEG F AND SHALL BE EDITABLE BY THE OPERATOR.

THE CHILLER MINIMUM FLOW BY-PASS LINE AND VALVE SHALL BE SIZED TO ALLOW FOR THE MANUFACTURERS RECOMMENDED MINIMUM FLOW THROUGH ONE CHILLER, WITH ALL LOAD CONTROL VALVES CLOSED. THE CHILLER MINIMUM FLOW BY-PASS VALVE SHALL BE A NORMALLY OPEN VALVE. THIS VALVE SHALL BE MODULATED TO THE FULLY OPEN POSITION WHEN THE SYSTEM IS SHUT DOWN, TO PREVENT WATER HAMMER AND ALLOW MINIMUM FLOW THROUGH A CHILLER WHEN THE CHILLED WATER PUMP IS STARTED. FOLLOWING THE CONFIRMED START OF THE LEAD CHILLER, AND WHENEVER THE SYSTEM IS ENABLED, THE CHILLER PLANT CONTROL SYSTEM SHALL MODULATE THE CHILLER MINIMUM FLOW BY-PASS VALVE SUCH THAT THE CHILLED WATER FLOW THROUGH EITHER OPERATING CHILLER SHALL NOT DROP BELOW THE MANUFACTURERS RECOMMENDED MINIMUM FLOW. THE CHILLER MINIMUM FLOW SHALL BE DETERMINED BASED ON THE PRESSURE DROP ACROSS THE CHILLER EVAPORATOR BARREL USING A HIGH ACCURACY (+/-0.2% AT CALIBRATED FLOW, +/-0.5% AT OTHER FLOW RATES) PRESSURE DIFFERENTIAL SENSOR. THE DIFFERENTIAL PRESSURE SETPOINT SHALL BE DETERMINED BASED ON THE MANUFACTURERS CHILLER PRESSURE DROP RATING CURVES.

SYSTEM SOFT START: THE CHILLER PLANT CONTROL SYSTEM SHALL INITIATE A "SOFT START" MODE WHENEVER THE SYSTEM CHILLED WATER TEMPERATURE EXCEEDS THE SPECIFIED CHILLED WATER SYSTEM SETPOINT BY 20 DEGREES AT SYSTEM START-UP. THE CHILLER PLANT CONTROL APPLICATION WILL ADD COOLING CAPACITY DURING THE SOFT START MODE ONLY IF RETURN WATER TEMPERATURE IS NOT DECLINING AT A RATE OF AT LEAST 0.5 DEGREES F PER MINUTE. "SOFT START" MODE SHALL PREVENT UNNECESSARY OPERATION OF CHILLERS AND SHALL LIMIT SYSTEM ELECTRICAL DEMAND DURING CHILLED WATER LOOP PULL DOWN.

AUTOMATIC ROTATION OF CHILLERS AND PUMPS: CHILLER ROTATION SHALL BE BASED ON AN OPERATOR ENTERED DAY INTERVAL OR BY THE CYCLING OF A BINARY POINT. THE METHOD OF SEQUENCE SHALL BE OPERATOR SELECTABLE. CHILLER CYCLING CAUSED BY NORMAL SYSTEM LOAD FLUCTUATIONS SHALL CAUSE THE CHILLERS TO CHANGE ROTATION SEQUENCE OR AT THE OPERATORS OPTION CHILLERS MAY BE FORCED INTO THE NEW ROTATION SEQUENCE AT THE TIME OF THE SEQUENCE CHANGE. PUMP ROTATION SHALL BE INITIATED BY A SCHEDULE OR BY THE CYCLING OF A BINARY POINT.

DIAGNOSTICS/PROTECTION: THE BUILDING AUTOMATION SYSTEM SHALL BE ABLE TO ALARM FROM ALL SENSED POINTS AND DIAGNOSTIC ALARMS MONITORED BY THE CHILLER CONTROL.

CHILLER STATUS REPORTS: PROVIDE OPERATING STATUS REPORTS FOR EACH CHILLER. THE REPORTS SHALL PROVIDE THE PRESENT FOR THE FOLLOWING INFORMATION TO PROVIDE THE OPERATOR WITH CRITICAL CHILLER OPERATING DATA:

COMPRESSOR ON/OFF STATUS	COMPRESSOR STARTS/RUN HOURS	COMPRESSOR PHASE 1-3 PERCENT R/LA FOR EACH COMPRESSOR
COMPRESSOR CURRENT DRAW, R/LA PERCENT	ACTIVE CHILLER DIAGNOSTICS OR ALARMS	LEAVING CHILLED WATER TEMPERATURE
EVAPORATOR FLOW RATE	CONDENSER WATER ENTERING/LEAVING TEMPERATURE	CHILLED WATER SETPOINT
EVAPORATOR/CONDENSER (FOR EACH CIRCUIT), OPERATING MODE	CHILLER MODEL AND SERIAL NUMBER	OUTSIDE AIR DRY BULB
		OUTSIDE AIR WET BULB

THESE REPORTS SHALL BE DISPLAYED AND SHALL BE PRINTED OUT AUTOMATICALLY DAILY AT THE TIME SET BY THE OPERATOR. IN ADDITION, THE CHILLER PLANT CONTROL SYSTEM SHALL PRINT OUT A CHILLER REPORT IN THE FORMAT SHOWN IN THE APPENDIX TO SPECIFICATION SECTION 29800. THIS REPORT SHALL BE PRINTED AUTOMATICALLY DAILY AT A TIME SELECTED BY THE OPERATOR.

DEMAND LIMITING: AS PART OF THE DEMAND LIMITING SCHEME FOR THE FACILITY, THE CHILLER PLANT CONTROL SYSTEM SHALL BE ABLE TO MONITOR AND REDUCE PEAK POWER DEMAND THROUGH THE LIMITING OF THE CHILLER CURRENT DRAW.

COOLING TOWER SEQUENCING AND CONTROL: THE CHILLER PLANT CONTROL SYSTEM SHALL MONITOR THE LEAVING WATER TEMPERATURE FOR EACH CHILLERS EVAPORATOR AND CONDENSER. THE CHILLER PLANT CONTROL SYSTEM SHALL CONTROL THE CHILLER CONDENSER PUMP VFD TO MAINTAIN NO LESS THAN THE MINIMUM TEMPERATURE DIFFERENTIAL SPECIFIED BY THE CHILLER MANUFACTURER. ANY TIME EITHER CONDENSER WATER PUMP IS ENABLED AND OPERATING THE CHILLER PLANT CONTROL SYSTEM SHALL ENABLE, MONITOR AND ALARM THE CONDENSER WATER SIDE STREAM STRAINER. WHEN A CHILLER IS OPERATING AND THE COOLING TOWER BASIN TEMPERATURE RISES TO 2 DEGREES F ABOVE THE CURRENT TOWER LEAVING WATER SETPOINT, THE COOLING TOWER FAN SHALL BE TURNED ON AT MINIMUM SPEED AND THE CONTROL LOOP SHALL BE ENABLED. THE COOLING TOWER FAN SPEED SHALL BE MODULATED TO MAINTAIN THE DESIRED COOLING TOWER LEAVING WATER TEMPERATURE. COOLING TOWER FANS SHALL HAVE 5 MINUTE MINIMUM ON AND OFF TIME.

OPERATOR TRAINING AND SYSTEM SOFTWARE: 4 HOURS OF OPERATOR TRAINING IN THE CHILLER PLANT CONTROL SYSTEM SHALL BE PROVIDED. AT THE OWNERS CHOICE, THE TRAINING SHALL BE RECORDED BY THE CHILLER PLANT CONTROL SYSTEM VENDOR. A COPY OF THE CHILLER PLANT CONTROL SYSTEM SOFTWARE ON A CD SHALL BE PROVIDED TO THE OPERATOR.

SHEET NOTES

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THESE DRAWINGS ARE ISSUED FOR CONSTRUCTION AND REFLECT ALL AMEC ISSUED BULLETINS AND SKETCHES.

Issue	Date & Issue Description	By	Check
01	12/03/08	PWZ	RHB
02	01/23/09	PWZ	RHB
03	10/26/09	PWZ	RHB
04	11/12/09	PWZ	RHB
05	09/01/11	PWZ	RHB

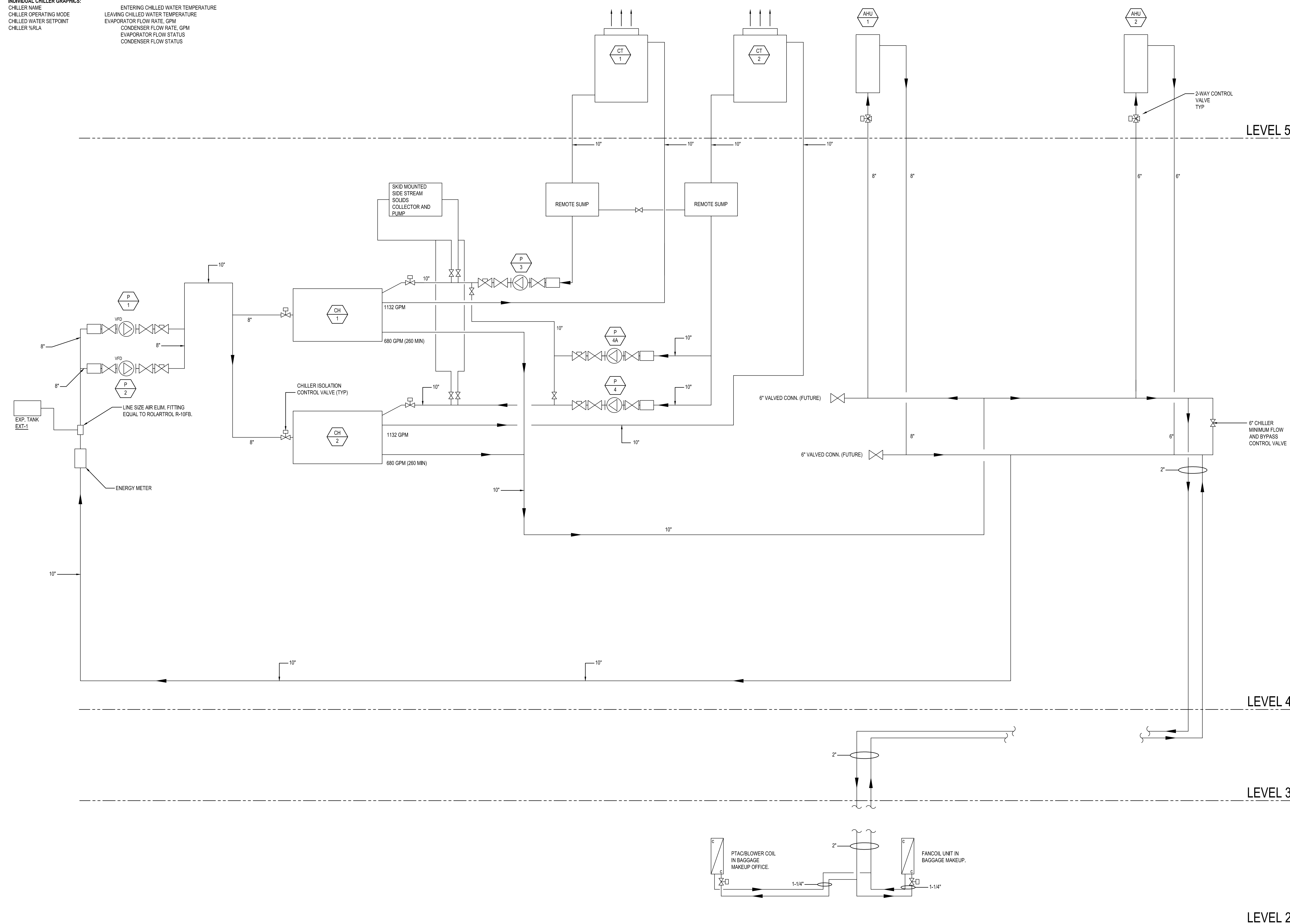
GENERAL NOTES

A SEE SHEET M00.00 FOR LEGEND AND GENERAL NOTES.

Project Name	PWM Terminal Enhancement
Project Number	08.0395.000
CAD File Name	T:\SS30101\Sheets\M12.02.dwg
Description	SYSTEM SCHEMATIC VARIABLE PRIMARY CHILLER PLANT
Scale	NOT TO SCALE

M12.02

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MECHANICAL PIPING SYSTEM SCHEMATIC

SCALE: NOT TO SCALE