

**SEQUENCE OF OPERATIONS: CHILLED/CONDENSER WATER SYSTEM**

**CHILLED WATER PUMPS - CHP 1 & 2**  
 WHEN THERE IS A CALL FOR THE CHILLER PLANT, CHP1 OR 2 SHALL BE STARTED DEPENDING UPON WHICH CHILLED WATER PUMP IS PLACED FOR OPERATION. THE PUMP SELECTION SHALL BE DONE AUTOMATICALLY BASED UPON RUNTIME HOURS TO EQUALIZE EQUIPMENT WEAR. THE DUTY PUMP SHALL BE SWITCHED AUTOMATICALLY AFTER 300 HOURS (ADJ) OR BASED UPON AN OPERATOR ASSIGNED SCHEDULE. PUMP ENABLE AND SPEED SHALL BE CONTROLLED BY THE EXISTING CONTROL METHODOLOGY OF THE EXISTING CONTROL SYSTEM. AN ADDITIONAL DIFFERENTIAL PRESSURE SENSOR SHALL BE INSTALLED 2/3 DOWNSTREAM TO THE MURPHY KELLER FACILITY AND SHALL BE USED IN CONJUNCTION TO THE SENSOR IN THE MAIN BUILDING TO DETERMINE PUMP SPEEDS. THE PUMP SPEED SHALL BE MODULATED TO MAINTAIN THE LOWEST PRESSURE READING AT THE MINIMUM DIFFERENTIAL PRESSURE SETPOINT (AS DETERMINED BY THE BALANCE CONTRACTOR).

THE MANUAL OVERRIDE IN THE SYSTEM GRAPHIC TO RUN THE CHILLED WATER SYSTEM SHALL REMAIN UNCHANGED. THIS WILL ALLOW FOR START OF ALL EQUIPMENT REGARDLESS OF THE BUILDINGS 'NEED' FOR CHILLED WATER. ALL RESPECTIVE EQUIPMENT SHALL START IN SEQUENCE IN THE SAME MANNER AS UNDER AUTOMATIC CONTROL.

CHILLED WATER PLANT INITIATION ALSO REQUIRES THE ISOLATION VALVES TO BE OPENED OR CLOSED AS REQUIRED FOR OPERATION OF THE RESPECTIVE PIECES OF EQUIPMENT.

EACH CHILLER'S EVAPORATOR DIFFERENTIAL PRESSURE SHALL BE MONITORED BY THE NEW ROSEMOUNT DIFFERENTIAL PRESSURE TRANSMITTERS. THE FORMULA  $(GPM/2/GPM)^2 = \Delta P2/\Delta P1$  SHALL BE USED TO CALCULATE THE ACTUAL FLOW IN GPM THROUGH THE CHILLER, WHERE

GPM1= ACTUAL FLOW  
 GPM2= DESIGN MAXIMUM FLOW  
 $\Delta P1$ = ACTUAL DIFFERENTIAL PRESSURE  
 $\Delta P2$ = DESIGN DIFFERENTIAL PRESSURE AT DESIGN MAXIMUM FLOW.

EACH CHILLER'S DESIGN SPECIFICATIONS TO SOLVE THE ABOVE FORMULA FOR THE ACTUAL FLOW ARE AS FOLLOWS:

CH-1 MAXIMUM DESIGN FLOW =300 GPM  
 CH-1 DIFFERENTIAL PRESSURE AT MAXIMUM DESIGN FLOW = 16.3FT=7.065PSI

CH-2 MAXIMUM DESIGN FLOW =200 GPM  
 CH-2 DIFFERENTIAL PRESSURE AT MAXIMUM DESIGN FLOW = 16FT=6.938PSI

THE CONTROL SYSTEM SHALL MODULATE EACH CHILLER'S RESPECTIVE BYPASS VALVES AS REQUIRED TO MAINTAIN THEIR MINIMUM FLOW SETPOINTS OF 225 GPM FOR CH-1 AND 65 GPM FOR CH-2. (CH-1 IS ASSOCIATED WITH THE NEW 2.5" BUTTERFLY VALVE AND CH-2 IS ASSOCIATED WITH THE NEW 1.5" GLOBE VALVE.)

**CONDENSER WATER PUMP**

CWP-1 SHALL BE DEDICATED FOR CHILLER 1&2 AND CWP-2 SHALL BE DEDICATED FOR HX-1  
 WHEN THERE IS A CALL FOR THE CHILLER PLANT, CWP1 AND OR CWP2 SHALL BE STARTED DEPENDING ON WHICH UNIT IS CALLED FOR OPERATION. PUMP ENABLE SHALL BE CONTROLLED BY THE EXISTING CONTROL METHODOLOGY OF THE EXISTING CONTROL SYSTEM. THE PUMP SPEED SHALL BE SET AT A FIXED SPEED SETPOINT TO MAINTAIN THE MINIMUM FLOW REQUIRED THROUGH EACH OPERATING PIECE OF EQUIPMENT (TOTAL FLOW CAN BE CONFIRMED AS SENSED AT THE EXISTING TOTAL TOWER SUPPLY FLOW METER).

THE BALANCE CONTRACTOR SHALL PROVIDE THE CONTROLS CONTRACTOR THE REQUIRED PUMP SPEED TO SATISFY THE FLOW REQUIREMENTS UNDER THE FOLLOWING CONDITIONS:

HX-1 =500GPM =? VFD%  
 OMITTED

CH2=240GPM=? VFD%

CH1=1000GPM=? VFD%

CH1/CH2=1240GPM= 100 VFD% (BOTH CHILLERS COMBINED REQUIRED A TOTAL OF 1240 GPM CONDENSER WATER FLOW WHICH EXCEEDS THE DESIGN POTENTIAL FLOW OF EITHER CONDENSER PUMP BY 240 GPM. THE OPERATING PUMP THEREFORE SHALL RUN AT FULL SPEED WHEN THE CHILLERS ARE RUNNING TOGETHER).

THERE WILL NOT BE A TIME WHEN CH-1 AND HX-1 ARE IN OPERATION TOGETHER. THERE MAY BE A TIME WHEN CH-1 & 2 ARE OPERATED TOGETHER AND THE FLOW RATE IF NOT SUFFICIENT SHALL BE PROPORTED TO THE GPM AVAILABLE ON A PERCENTAGE BASIS (ALL BY BALANCE CONTRACTOR).

**CHILLERS CH-1 & 2 AND HEAT EXCHANGER HX-1**

WHEN THE CHILLER PLANT IS CALLED FOR BY THE OCCUPIED PROGRAM THE CONDENSER WATER PUMP, CHILLED WATER PUMP, COOLING TOWER FANS AND THE APPROPRIATE CHILLER OR HEAT EXCHANGER SHALL START IN THE SEQUENCE PREVIOUSLY DESIGNED. A NEW GRAPHIC SHALL BE DESIGNED FOR THE NEW CHILLER CH-2 LISTING ITS OPERATING SETPOINTS AND LOCKOUT TEMPERATURES. A NEW ADVANCED SET UP GRAPHIC WILL BE DESIGNED FOR THE PARAMETERS OF THE NEW CHILLER.

WHEN THE CHILLER PLANT IS STARTING, THE APPROPRIATE CHILLED WATER EQUIPMENT SHALL BE SELECTED AS FOLLOWS FOR SYSTEM STARTUP.

- WHEN THE OUTSIDE AIR (OSA) WET BULB (WB) IS BELOW THE LOCKOUT TEMPERATURE OF THE HEAT EXCHANGER (50°F WB ADJ) THE SYSTEM SHALL STARTUP WITH ONLY HX-1 IN OPERATION. NOTE(ADD A LOCKOUT TEMP FOR HX-1)
- WHEN THE OSA WB IS ABOVE THE LOCKOUT TEMPERATURE FOR CH-2 (50°F WB ADJ) THE SYSTEM SHALL STARTUP CH-2 AND HX-1 SHALL CONTINUE TO OPERATE.
- WHEN THE OSA WB IS ABOVE THE CH-2 LOCKOUT TEMPERATURE 62°F (ADJ), THE SYSTEM SHALL STARTUP WITH ONLY CH-2 IN OPERATION.

WHEN THE CHILLER PLANT IS RUNNING, THE APPROPRIATE CHILLED WATER EQUIPMENT SHALL BE SELECTED AS FOLLOWS FOR CHILLER LOADING/UNLOADING.

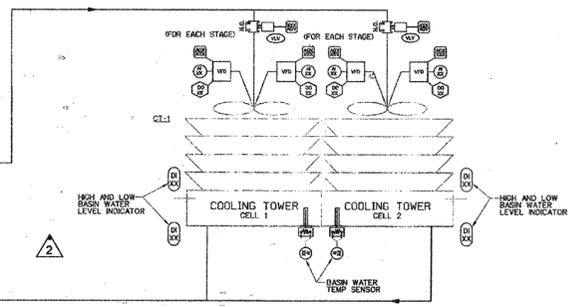
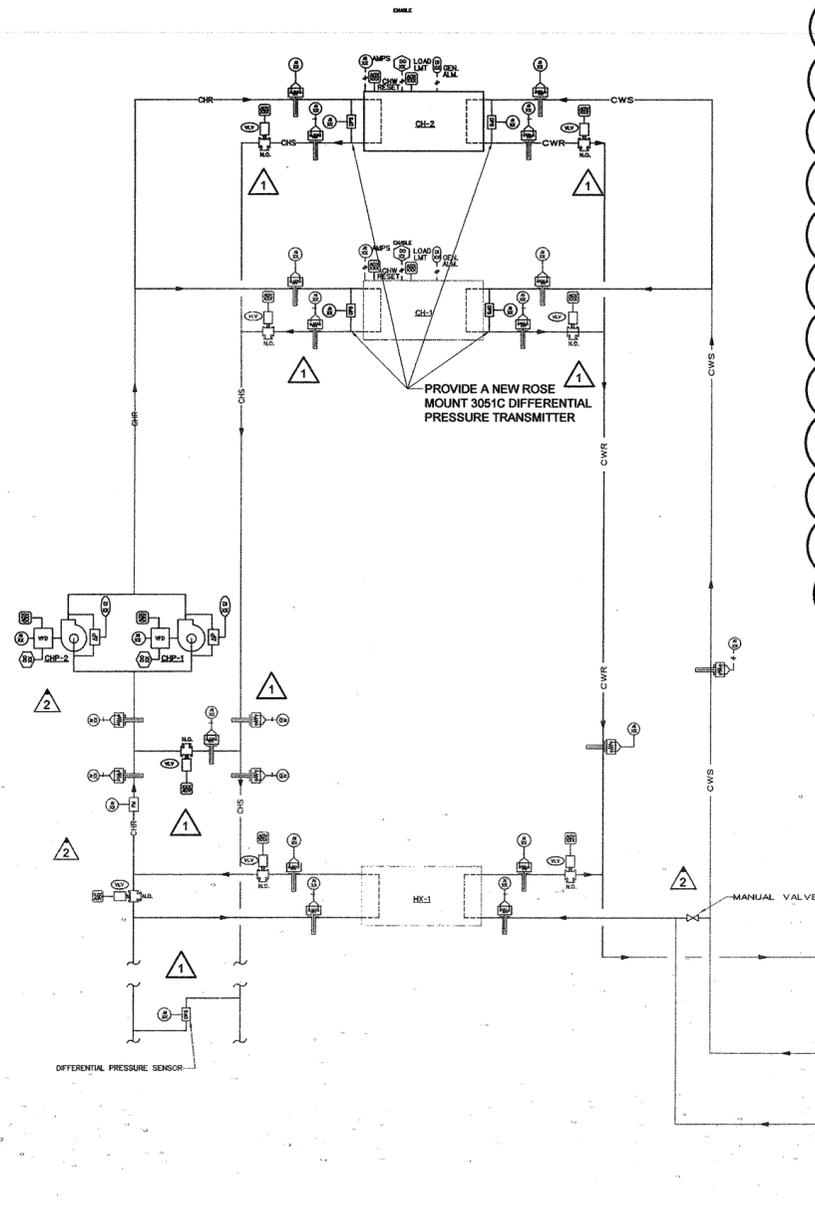
- WHEN HX-1 IS RUNNING ALONE AND THE OSA WB RISES ABOVE THE LOCKOUT SETPOINT OF 50°F, CH-2 SHALL BE STARTED AND HX-1 SHALL CONTINUE TO RUN.
- HX-1 SHALL CONTINUE TO RUN UNTIL THE PERFORMANCE OF THE HEAT EXCHANGER FALLS TO A POINT WHERE THE LEAVING CHILLED WATER TEMPERATURE IS LESS THAN 2°F FROM THE ENTERING CHILLED WATER TEMPERATURE. AT THIS POINT HX-1 SHALL BE STOPPED AND CH-2 SHALL CONTINUE TO RUN. IF THE OSA WB DROPS 2°F BELOW THE RECORDED OSA WB WHEN THE HX-1 WAS STOPPED, THEN IT WILL BE ALLOWED TO RESTART AND OPERATE WITH CH-2. IF CH-2 HAS FAILED AS DETERMINED BY THE ALARM FAILURE CONTACTS ON CH-2, THEN STOP CH-2 AND START CH-1.
- WHEN CH-2 HAS BEEN OPERATING ALONE FOR A MINIMUM OF 30 MINUTES (ADJ), CH-2 SHALL BE STOPPED AND CH-1 STARTED IF THE LEAVING WATER TEMPERATURE IS 5°F (ADJ) ABOVE THE CHILLED WATER SET POINT AND THE WB TEMPERATURE IS ABOVE THE LOCKOUT TEMPERATURE OF CH-1 (OVERLOADED CONDITION).
- WHEN CH-1 IS OPERATING AND THE LOAD AS SEEN ON THE CHILLER KW DEMAND METER DROPS TO 60 KW (ADJ), THEN TURN OFF CH-1 AND TURN ON CH-2.
- WHEN CH-2 IS RUNNING AND THE OSA WB DROPS BELOW HX-1'S OSA WB LOCKOUT SETPOINT, STOP CH-2 AND START HX-1.

THE CHILLED WATER SETPOINT SHALL CONTROL FROM 42°F TO 50°F DEPENDING UPON THE REQUIREMENT OF THE VENTILATION UNITS. IF THE VENTILATION UNITS ARE OFF, THE CHILLED WATER SETPOINT WILL BE 50°F (ADJ). THIS WILL REMAIN THE SAME AS CURRENTLY DESIGNED. THE CHILLED WATER SETPOINT SHALL BE RESET COLDER WHEN ANY SPACE HUMIDITY SENSOR IN EITHER BUILDING EXCEEDS THE MAXIMUM HUMIDITY LEVEL OF 55% (ADJ). THE TEMPERATURE SHALL BE RESET COLDER BY 2°F EVERY 60 MIN (ADJ). WHEN ALL SPACE HUMIDITY SENSORS ARE 5% (ADJ) BELOW THE MAXIMUM HUMIDITY SETPOINT, THE CHILLED WATER SETPOINT SHALL BE ADJUSTED WARMER BY 2°F EVERY 60 MIN (ADJ) UNTIL THE SETPOINT HAS REACHED THE 'DESIRED NORMAL SETPOINT' AS DETERMINED AND DESCRIBED PREVIOUSLY.

**COOLING TOWERS**  
 CH-2 AND HX-1 WILL USE ONLY ONE COOLING TOWER CELL. CH-1 WILL USE BOTH CELLS.

USE THE SAME CONTROL STRATEGY FOR THE HEAT EXCHANGER THAT IS CURRENTLY BEING USED.

THE COOLING TOWER FANS WHEN OPERATING WITHOUT THE HEAT EXCHANGER WILL CONTROL THE FAN SPEED TO ACHIEVE A LEAVING CONDENSER WATER 5 DEGREES WARMER THAN THE CURRENT WET BULB READING.



**INPUT/OUTPUT SUMMARY: CHILLED/CONDENSER WATER SYSTEM**

- ANALOG INPUTS (AI)**
- Water System Flow
  - Water System Supply Temperature
  - Water System Return Temperature
  - Water System Load - tons
  - Individual Remote Differential Pressure Signals
  - Chilled Water By-pass Position
  - Chiller Supply Temperature
  - Condenser Water Return Temperature
  - Chilled Water Bypass Temperature
  - Outside Air Temperature
  - Outside Air Wet Bulb Temperature
  - Cooling Tower Basin Temperature (each tower)
  - Cooling Tower Return Temperature
  - Cooling Tower Supply Temperature
  - Chiller Differential Pressure
- DIGITAL INPUTS (DI)**
- Pump Fail Indication - (each pump)
  - Individual H-O-A Switch Position
  - Cooling Tower Basin High Level (each tower)
  - Cooling Tower Basin Low Level (each tower)
  - Condenser Water Chemical Feed Alarm Status
  - Chilled Water Chemical Feed Alarm Status
  - Cooling Tower Alarm Status (each tower)

- ANALOG OUTPUTS (AO)**
- Water System Differential Pressure Setpoint
  - Water Temperature Setpoint
  - Condenser Water By-pass Position
  - Free Cooling Bypass Position
  - Cooling Tower VFD Speed (each Tower)
- DIGITAL OUTPUTS (DO)**
- Chiller Start/Stop (each chiller)
  - Chiller Isolation Valves (2 per chiller) Provide End Switches.
  - Cooling Tower Isolation Valves (3 per tower) Provide End Switches.
  - Cooling Tower VFD Start (each Tower)

Note: Dewpoint shall be calculated and displayed for all humidity sensing points, outside the building, inside the building, in the air handlers, and in the dessicant units.

CONTROL LEGEND			
SYMBOL	DESCRIPTION	SYMBOL	DESCRIPTION
(AI)	ANALOG INPUT POINT	WFD	VARIABLE FREQUENCY DRIVE
(AO)	ANALOG OUTPUT POINT	AFMS	AIR FLOW MONITOR
(DI)	DIGITAL INPUT POINT	CC	CHILLED WATER COIL
(DO)	DIGITAL OUTPUT POINT	HC	HOT WATER COIL
(DPS)	DIFFERENTIAL PRESSURE SENSOR	HSL	HIGH STATIC LIMIT
SP	STATIC PRESSURE SENSOR	T	ROOM TEMPERATURE SENSOR
SD	SMOKE DETECTOR	H	HUMIDITY SENSOR
DA	DAMPER ACTUATOR	CO2	CO2 SENSOR
FBD	FACE & BYPASS DAMPER	NO	NORMALLY OPEN
SAT	SUPPLY AIR TEMPERATURE SENSOR	NC	NORMALLY CLOSED
PHT	PREHEAT TEMPERATURE	C	COMMON
CCT	COOLING COIL TEMPERATURE	S	SUPPLY
MAT	MIXED AIR TEMPERATURE	R	RETURN
LTD	LOW TEMPERATURE DETECTOR	DM	DAMPER MOTOR
HWV	HOT WATER VALVE	SDM	SMOKE DAMPER MOTOR
CWV	CHILLED WATER VALVE	CWV	CHILLED WATER VALVE
DTS	DISCHARGE AIR TEMPERATURE	CHR	CHILLED WATER RETURN
OSAT	OUTSIDE AIR TEMPERATURE SENSOR	CHS	CHILLED WATER SUPPLY
MAH	MIXED AIR HUMIDITY	HR	HOT WATER RETURN
SAH	SUPPLY AIR HUMIDITY SENSOR	HS	HOT WATER SUPPLY
RAT	RETURN AIR TEMPERATURE SENSOR		

CHILLER, HEAT EXCHANGER, & COOLING TOWER CONTROLS 1  
 NO SCALE

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 MECH., ELEC., PLUMB. ENGINEER: CROMWELL ENGINEERS INC.  
 GLOBAL VILLAGE CONSULTANT: CAMBRIDGE SEVEN ASSOCIATES  
 INTERIOR DESIGNER: POLK STANLEY ROWLAND CURZON PORTER ARCHITECTS  
 GENERAL CONTRACTOR: CDI CONTRACTORS, INC.

NOTES:

ISSUE DATE: 17 SEPTEMBER 2007

REVISIONS:

#	DATE:	DESCRIPTION:
1	09/27/07	ADDENDUM 01
2	03/04/08	ASI #6
3	08/19/08	ASI #16

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 CONTENTS: MECHANICAL CONTROLS

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