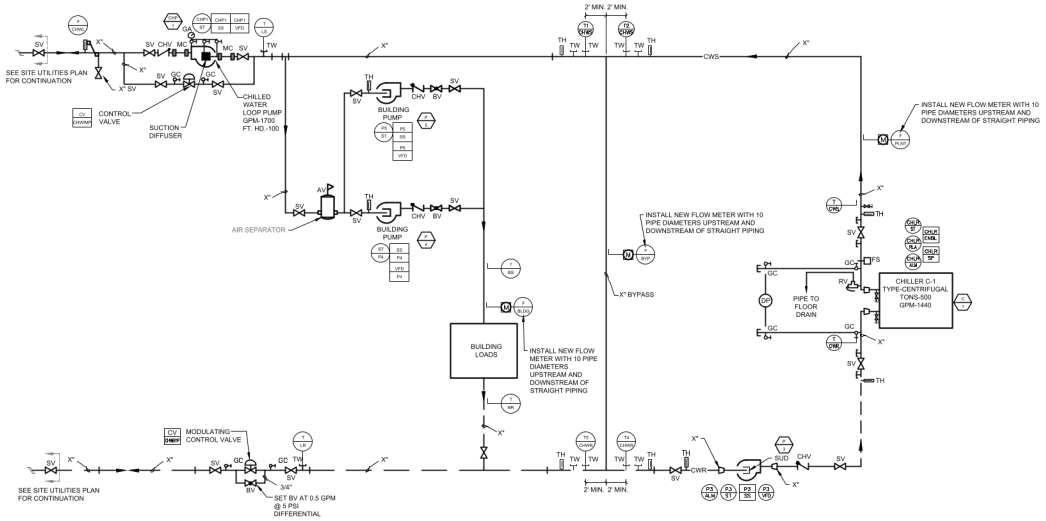


REGULAR DUTY CHILLER PLANT
CHILLED WATER FLOW DIAGRAM

SCALE: NONE

GENERAL NOTE:

ALL SERVICE VALVES AND CONTROL VALVES TO BE LINE SIZE UNLESS SHOWN WITH REDUCER AND EXPANDER FITTINGS OR NOTED OTHERWISE.

BUILDING WITH PLANT AND IMPORT FROM/EXPORT TO CAMPUS LOOP

POINT DESCRIPTION					FIELD DEVICE DESCRIPTION			NOTES
TYPE	NAME	DESCRIPTION	TYPE	UNITS	INSTRUMENT TYPE	SIGNAL	RANGE	
GLOBAL POINTS (TO BE MAPPED TO UNIT CONTROLLER)								
AV	OA-T	OUTSIDE AIR TEMP.	TEMP.	°F	MAP BUILDING GLOBAL OUTDOOR AIR TEMP.	-	-	NETWORK SHARED POINT
AV	OA-H	OUTSIDE AIR RELATIVE HUMIDITY	HUMIDITY	% RH	MAP BUILDING GLOBAL OUTDOOR AIR HUMIDITY	-	-	NETWORK SHARED POINT
AV	OA-WB	OUTSIDE AIR WET BULB TEMPERATURE	TEMP	°F	MAP BUILDING GLOBAL OUTDOOR AIR WET BULB	-	-	NETWORK SHARED POINT
PLANT/ BUILDING LEVEL CONTROL POINTS								
AI	T1-CHWS	SECONDARY CHW SUPPLY TEMPERATURE	TEMP	°F	RIGID PLATINUM RTD MOUNTED IN THERMOWELL	RESISTANCE	0 - 220°F	
AI	T2-CHWS	PRIMARY CHW SUPPLY TEMPERATURE	TEMP	°F	RIGID PLATINUM RTD MOUNTED IN THERMOWELL	RESISTANCE	0 - 220°F	
AI	T-LS	LOOP CHW SUPPLY TEMPERATURE	TEMP	°F	RIGID PLATINUM RTD MOUNTED IN THERMOWELL	RESISTANCE	0 - 220°F	
AI	T-BS	BUILDING CHW SUPPLY TEMPERATURE	TEMP	°F	RIGID PLATINUM RTD MOUNTED IN THERMOWELL	RESISTANCE	0 - 220°F	
AI	T4-CHWR	SECONDARY CHW RETURN TEMPERATURE	TEMP	°F	RIGID PLATINUM RTD MOUNTED IN THERMOWELL	RESISTANCE	0 - 220°F	
AI	T5-CHWR	SECONDARY CHW RETURN TEMPERATURE	TEMP	°F	RIGID PLATINUM RTD MOUNTED IN THERMOWELL	RESISTANCE	0 - 220°F	
AI	T-LR	LOOP CHW RETURN TEMPERATURE	TEMP	°F	RIGID PLATINUM RTD MOUNTED IN THERMOWELL	RESISTANCE	0 - 220°F	
AI	T-BR	BUILDING CHW RETURN TEMPERATURE	TEMP	°F	RIGID PLATINUM RTD MOUNTED IN THERMOWELL	RESISTANCE	0 - 220°F	
AI	F-BYP	CHW FLOW - PLANT BYPASS LEG	FLOWMETER	GPM	ULTRASONIC STRAP-ON FLOWMETER	0-10 VDC	SEE SEQ	
AI	F-CHWL	CHW FLOW - LOOP SUPPLY PIPING	FLOWMETER	GPM	ULTRASONIC STRAP-ON FLOWMETER	0-10 VDC	SEE SEQ	
AI	F-PLNT	CHW FLOW - PLANT SUPPLY PIPING	FLOWMETER	GPM	ULTRASONIC STRAP-ON FLOWMETER	0-10 VDC	SEE SEQ	
AI	F-BLDG	CHW FLOW - PLANT BLDG SUPPLY PIPING	FLOWMETER	GPM	ULTRASONIC STRAP-ON FLOWMETER	0-10 VDC	SEE SEQ	
DI	CHLR-ST	CHILLER RUN STATUS	ON / OFF	ON / OFF	CHILLER CONTROL PANEL TO BAS	CONTACT	-	
DI	CHP1-ST	LOOP CHW PUMP RUN STATUS	ON / OFF	ON / OFF	ADJ. THRESHOLD CURRENT SENSING RELAY	CONTACT	-	
DI	BLDGPMP1-ST	BUILDING CHW PUMP #1 RUN STATUS	ON / OFF	ON / OFF	ADJ. THRESHOLD CURRENT SENSING RELAY	CONTACT	-	
DI	BLDGPMP2-ST	BUILDING CHW PUMP #2 RUN STATUS	ON / OFF	ON / OFF	ADJ. THRESHOLD CURRENT SENSING RELAY	CONTACT	-	
BI	P4-ST	CHILLED WATER PUMP 1 STATUS	OFF / ON	OFF / ON	CHILLED, WATER, PUMP, RUN, SENSOR	CONTACT	-	
BI	P5-ST	CHILLED WATER PUMP 2 STATUS	OFF / ON	OFF / ON	CHILLED, WATER, PUMP, RUN, SENSOR	CONTACT	-	
BO	P4-SS	CHILLED WATER PUMP 1 START/STOP	OFF / ON	OFF / ON	CHILLED, WATER, PUMP, RUN, CMD	CONTACT	-	
BO	P5-SS	CHILLED WATER PUMP 2 START/STOP	OFF / ON	OFF / ON	CHILLED, WATER, PUMP, RUN, CMD	CONTACT	-	
AO	P4-VFD	CHILLED WATER PUMP 4 SPEED COMMAND	VFD	% SPEED	CHILLED, WATER, PUMP, SPEED, CMD	4-20 mA	0-100%	
AO	P5-VFD	CHILLED WATER PUMP 5 SPEED COMMAND	VFD	% SPEED	CHILLED, WATER, PUMP, SPEED, CMD	4-20 mA	0-100%	
DO	P3-SS	EVAP PUMP START/STOP COMMAND	ON / OFF	ON / OFF	RELAY OUTPUT TO VFD	CONTACT	-	
DI	P3-ST	EVAP PUMP RUN STATUS	ON / OFF	ON / OFF	ADJ. THRESHOLD CURRENT SENSING RELAY	CONTACT	-	
AO	P3-VFD	EVAP PUMP VFD SPEED COMMAND	VFD	% SPEED	BAS TO VFD INPUT TERMINAL	4-20 mA	0-100%	
DI	P3-ALM	EVAP PUMP ALARM	ON / OFF	ON / OFF	PUMP VFD ALARM	CONTACT	-	
AO	CHLR-SP	CHW SET-POINT FOR REGULAR CHILLER	SIGNAL	°F	BAS TO CHILLER CONTROL PANEL	4-20 mA	42 - 48°F	
AO	CV-CHWBYP	CHW BYPASS FLOW CONTROL VALVE COMMAND	MODULATING	%	MODULATING VALVE ACTUATOR	2-10 VDC	0-100%	
AO	CHP1-VFD	CHW LOOP EXPORT PUMP SPEED COMMAND	VFD	% SPEED	BAS TO VFD INPUT TERMINAL	0-10 VDC	0-100%	
DO	CHLR-ST	REG CHILLER ENABLE COMMAND	ON / OFF	ON / OFF	BAS TO CHILLER CONTROL PANEL	CONTACT	-	
DO	CHLR-ENBL	CHILLER ENABLE CMD TO CHILLER CNTRL PNL	ON / OFF	ON / OFF	BAS TO CHILLER CONTROL PANEL	CONTACT	-	
DI	CHLR-RLA	CHILLER RLA% FROM CHILLER CNTRL PNL	MODULATING	%	BAS TO CHILLER CONTROL PANEL	CONTACT	-	
NW	CHLR-ALM	CHILLER ALARM STATUS FROM CHILLER CNTRL PNL	ON / OFF	ON / OFF	BAS TO CHILLER CONTROL PANEL	CONTACT	-	
DO	CHP1-SS	CHW LOOP EXPORT PUMP START/STOP COMMAND	ON / OFF	ON / OFF	RELAY OUTPUT TO VFD	CONTACT	-	
AO	CV-CHWIMP	CAMPUS CHW LOOP IMPORT VALVE	MODULATING	% OPEN	RELAY OUTPUT TO MODULATING VALVE ACTUATOR	4-20 mA	-	

DI	DIGITAL INPUT
DO	DIGITAL OUTPUT
DV	DIGITAL VIRTUAL POINT
AI	ANALOG INPUT
AO	ANALOG OUTPUT
AV	ANALOG VIRTUAL POINT
HW	HARD WIRED INTERLOCK/SAFETY
COS	CHANGE OF STATE

UPDATED: 3/16

PROJECT STANDARDS
Missouri University of Science & Technology
S & T Project #RCXXXXXX

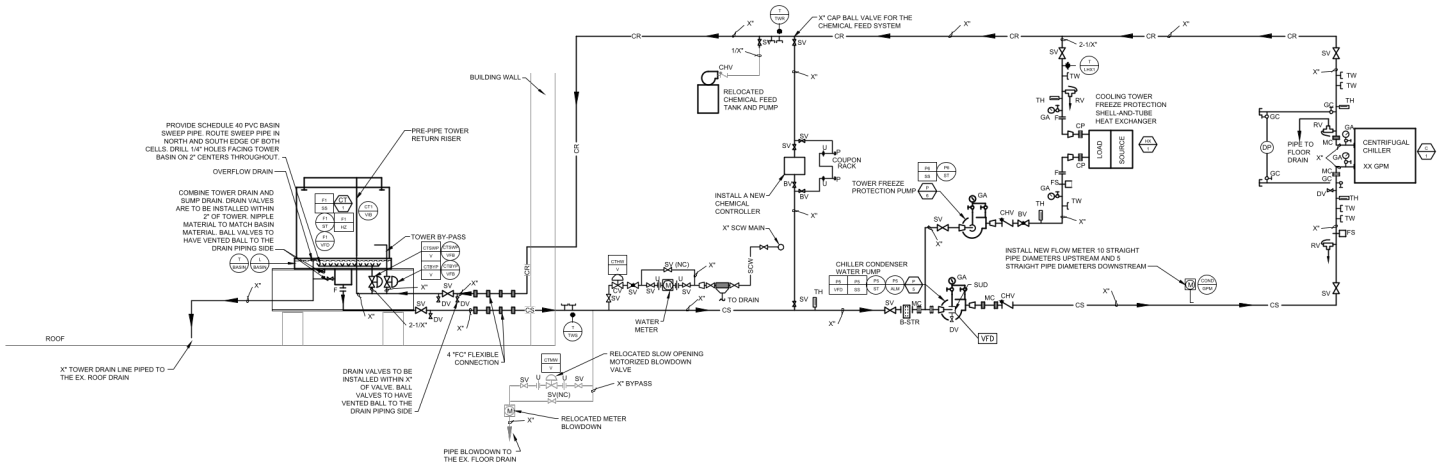
401 West 16th Street
Rolla, MO

PROJECT ENGINEER
LICENSE #

DATE: XX/XX/XXXX
PROJECT #: XXXXXX
DRAWN BY: XXX
CHECKED BY: XXX

CHILLED WATER FLOW DIAGRAM

M5.4



CONDENSER WATER FLOW DIAGRAM

SCALE: NONE

GENERAL NOTE:

ALL SERVICE VALVES AND CONTROL VALVES TO BE LINE SIZE UNLESS SHOWN WITH REDUCER AND EXPANDER FITTINGS OR NOTED OTHERWISE.

COOLING TOWER WATER SYSTEM HARDWARE POINTS

POINT DESCRIPTION					FIELD DEVICE DESCRIPTION			NOTES
TYPE	NAME	DESCRIPTION	TYPE	UNITS	INSTRUMENT TYPE	SIGNAL	RANGE	
GLOBAL POINTS (TO BE MAPPED TO UNIT CONTROLLER)								
AV	OA-T	OUTSIDE AIR TEMP.	TEMP.	°F	MAP BUILDING GLOBAL OUTDOOR AIR TEMP.	-	-	NETWORK SHARED POINT
AV	OA-H	OUTSIDE AIR RELATIVE HUMIDITY	HUMIDITY	% RH	MAP BUILDING GLOBAL OUTDOOR AIR HUMIDITY	-	-	NETWORK SHARED POINT
AV	OA-WB	OUTSIDE AIR WET BULB TEMPERATURE	TEMP	°F	MAP BUILDING GLOBAL OUTDOOR AIR WET BULB	-	-	NETWORK SHARED POINT
PLANT/ BUILDING LEVEL CONTROL POINTS								
AI	T-TWS	TOWER WATER SUPPLY TEMPERATURE	TEMP	°F	RIGID PLATINUM RTD MOUNTED IN THERMOWELL	RESISTANCE	0 - 220°F	
AI	T-TWR	TOWER WATER RETURN TEMPERATURE	TEMP	°F	RIGID PLATINUM RTD MOUNTED IN THERMOWELL	RESISTANCE	0 - 220°F	
AI	T-BASIN	TOWER BASIN WATER TEMPERATURE	TEMP	°F	RIGID PLATINUM RTD MOUNTED IN THERMOWELL	RESISTANCE	0 - 220°F	
AI	T-LHX1	LEAVING HX #1 TOWER WATER TEMPERATURE	TEMP	°F	RIGID PLATINUM RTD MOUNTED IN THERMOWELL	RESISTANCE	0 - 220°F	
AI	T4-HWR2	LEAVING HX #1 HEATING WATER TEMPERATURE	TEMP	°F	RIGID PLATINUM RTD MOUNTED IN THERMOWELL	RESISTANCE	0 - 220°F	
DO	P5-SS	CONDENSER WATER PUMP START/STOP COMMAND	ON / OFF	ON / OFF	RELAY OUTPUT TO VFD	CONTACT	-	
DI	P5-ST	CHILLER CONDENSER PUMP RUN STATUS	ON / OFF	ON / OFF	ADJ. THRESHOLD CURRENT SENSING RELAY	CONTACT	-	
AO	P5-VFD	CONDENSER PUMP VFD SPEED COMMAND	VFD	% SPEED	BAS TO VFD INPUT TERMINAL	0-10 VDC	0-100%	
AI	COND-GPM	CDW FLOW - CONDENSER WATER FLOW	FLOWMETER	GPM	ULTRASONIC STRAP-ON FLOWMETER	0-10 VDC	SEE SEQ	
DI	P6-ST	TOWER FREEZE PROTECTION PUMP RUN STATUS	ON / OFF	ON / OFF	ADJ. THRESHOLD CURRENT SENSING RELAY	CONTACT	-	
DO	P6-SS	TOWER FRZ PROT PUMP START/STOP COMMAND	ON / OFF	ON / OFF	RELAY OUTPUT TO VFD	CONTACT	-	
DI	F1-ST	TOWER FAN RUN STATUS	ON / OFF	ON / OFF	ADJ. THRESHOLD CURRENT SENSING RELAY	CONTACT	-	
DO	F1-SS	TOWER FAN START/STOP COMMAND	ON / OFF	ON / OFF	RELAY OUTPUT TO VFD	CONTACT	-	
AO	F1-VFD	TOWER FAN VFD SPEED COMMAND	VFD	% SPEED	BAS TO VFD INPUT TERMINAL	0-10 VDC	0-100%	
HW	CT1-VIB	TOWER VIBRATION SWITCH	ON / OFF	ON / OFF	SAFETY	CONTACT	-	WIRE DIRECT TO VFD
DI	CTBYP-VFB	TOWER BYPASS VALVE FEEDBACK	VALVE	ON / OFF	FEEDBACK	CONTACT	1 OR 0	
DI	CTSWP-VFB	TOWER SWEEPER VALVE FEEDBACK	VALVE	ON / OFF	FEEDBACK	CONTACT	1 OR 0	
AO	HWV-1	HX #1 HEATING WATER CONTROL VALVE COMMAND	% OPEN	%	MODULATING VALVE ACTUATOR	2-10 VDC	0-100%	
DO	CTMW-V	TOWER MAKE UP WATER CNTRL VALVE COMMAND	% OPEN	%	MODULATING VALVE ACTUATOR	2-10 VDC	0-100%	
DO	CTBYP-V	TOWER BYPASS CNTRL VALVE COMMAND	ON / OFF	ON / OFF	RELAY OUTPUT TO 2-POSITION ELECTRIC VALVE	CONTACT	-	
DO	CTSWP-V	TOWER SWEEPER CNTRL VALVE COMMAND	ON / OFF	ON / OFF	RELAY OUTPUT TO 2-POSITION ELECTRIC VALVE	CONTACT	-	
AI	L-BASIN	TOWER BASIN WATER LEVEL SENSOR	PRESSURE	INCHES OF WTR	HERMETICALLY SEALED DP SENSOR	0-10 VDC	-12" TO +24" WC	BOTTOM OF BASIN AS ZERO REF.

DI	DIGITAL INPUT
DO	DIGITAL OUTPUT
DV	DIGITAL VIRTUAL POINT
AI	ANALOG INPUT
AO	ANALOG OUTPUT
AV	ANALOG VIRTUAL POINT
HW	HARD WIRED INTERLOCK/SAFETY
COS	CHANGE OF STATE

UPDATED: 3/18

PROJECT STANDARDS
Missouri University of Science & Technology
S & T Project #RCXXXXXX

Rolla, MO
401 West 16th Street

PROJECT ENGINEER
LICENSE #

DATE: XX/XX/XXXX
PROJECT #: XXXXX
DRAWN BY: XXX
CHECKED BY: XXX

CONDENSER WATER FLOW DIAGRAM

M5.2

SEQUENCE OF OPERATION – CHILLED WATER - REGULAR DUTY CHILLER PLANT

A. Overview: This system consists of (1) ZZZ Ton regular duty chiller with a variable speed chiller evaporator pump and a variable speed chilled water (CHW) loop pump. The loop pump enables the chiller plant to deliver CHW to the campus loop (export function). In case the chiller plant is disabled, a modulating chilled water bypass flow control valve and a modulating import control valve are used in tandem for tight control of CHW, imported from the loop (import function), to meet the plant building CHW demand.

B. Software Point Definitions (LCT Programming Required):

Point Number	Point Name	Point Description and Formula
1.	PLNTCHW EVAPGPM2	This software point defines the combined flow rate of all evaporator pumps that are energized at the chiller plant. Use maximum of calculated evaporator flow and metered evaporator flow.
		EVAPGPM2 = MAX [0, EVAPGPM1, (EVAPGPM * EP1ST)]
2.	PLNTCHW BYPGPM	The amount and direction of flow in the chiller plant bypass (a bypass flow rate greater than zero indicates forward flow in the bypass such that building/ loop chilled water supply temperature will be higher than the plant chilled water supply temperature
		BYPGPM = Reading from Bypass Flowmeter based on sign convention as stated above
3.	PLNTCHW BYPGPMDB	CHW Bypass GPM dead band is utilized for determining when to stop a chiller (used only for local start/stop decision)
		BYPGPMDB = 0.2 * EVAPGPM2
4.	PLNTCHW CHWSP	Chiller CHW Set-Point sent to CCP from BAS, deg F
		CHWSP = Span Block Output [OAWBAVG, 30, 46, 50, 44]
5.	PLNTCHW MAXCHWT	Maximum acceptable building chilled water supply temperature
		MAXCHWT = CHWSP + 2
6.	PLNTCHW DTMAX	This software point defines the largest possible temperature difference across the CHW plant.
		DTMAX = MAX [0.1, (T5CHWR – MIN (MAXCHWT, T2CHWS)]
7.	PLNTCHW MAXTONS	This point defines the rated capacity of the online chiller in the chiller plant.
		MAXTONS = (CH1ST = TRUE) * ZZZ * CAPCORR
8.	PLNTCHW DTDESIGN	This software point defines the dynamic design temperature difference across the CHW plant as a function of evaporator flow for full loading of the chiller
		DTDESIGN = MAX (5, MIN (20, (ZZZ * CAPCORR * 24) / MAX (1, EVAPGPM2)))
9.	PLNTCHW BYPGPMSP	This software point defines bypass flow required to ensure that the primary return chilled water temperature is <= design value for the online chiller at the plant.
		BYPGPMSP = MAX ((-0.8 * EVAPGPM2), MIN (0, EVAPGPM2 * ((DTDESIGN / DTMAX2) – 1)) + MINBYPGPM2). Averaged over 8 scans.

10.	PLNTCHW OFFEVAPGPM	This software point is utilized for determining when to stop the next chiller. This point shall equal the rated pump capacity of the next chiller that is to be stopped based upon the chiller sequencing database
		OFFEVAPGPM = EVAPGPM2
11.	PLNTCHW LOAD	This point defines the number of tons of cooling produced by the chiller plant.
		LOAD = MAX (0, MIN (MAXTONS, (EVAPGPM2 * (T4CHWR – T2CHWS) / 24)))
12.	PLNTCHW PEAKLOAD	This point defines the MAX amount of load the online chiller can see for the combined loop/ building return water temperature.
		PEAKLOAD = MIN (MAXTONS, EVAPGPM2 * DTMAX/ 24)
13.	PLNTCHW GPMPKIN	Campus loop peak possible GPM that can be imported to the plant building, based on loop pump design flow of YYY GPM
		GPMPKIN = - (YYY * 1.1)
14.	PLNTCHW GPMPKOUT	Campus loop peak possible GPM that can be exported from the plant, based on loop pump design flow of YYY GPM
		GPMPKOUT = + (YYY * 1.1)
15.	PLNTCHW GPMLPMPS	Installed Loop Pump(s) Total Online GPM Capacity
		GPMLPMPS = GPMPKOUT * LP1ST
16.	PLNTCHW GPMPKTRNS	Leftover plant flow capacity that is available to pump out to the campus loop.
		GPMPKTRNS = MAX (0, MIN (GPMPKOUT, GPMLPMPS, {(CHWBYPGPMSP – CHWBYPGPM) + (QE60 – EVAPGPM2) * EP1ST}))
17.	PLNTCHW CH1AVAIL	This software point is utilized for communicating the availability of a chiller for operation based upon the chiller plant sequencing database.

		IF AND (CH1OOS = FALSE, CH1FTR = FALSE, EP1AVAIL = TRUE, PLNTCDW_CP1AVAIL = TRUE, PLNTCDW_CT1AVAIL = TRUE, LP1AVAIL = TRUE) THEN
		CH1AVAIL = TRUE
		ELSE
		CH1AVAIL = FALSE after 30 second off delay

18.	PLNTCHW AVAILTON1	This software point defines the amount of excess cooling capacity available from the chiller plant (without having forward flow in the bypass)
		AVAILTON1 = MAX (0, (MIN (MAXTONS, PEAKLOAD) – LOAD))
19.	PLNTCHW AVAILTON2	This software point defines the amount of excess cooling capacity available from the chiller plant when loop transfer pump is at full output
		AVAILTON2 = MIN (AVAILTON1, (GPMPKTRNS * DTMAX2 / 24))
20.	PLNTCHW CHLRSAVAIL	This point is utilized for counting the number of chiller available to run at the plant
		CHLRSAVAIL = CH1AVAIL
21.	PLNTCHW CHLRSENA	This point is utilized for counting the number of chiller that are enabled to run at the chiller plant
		CHLRSENA = CH1ENA

22.	PLNTCHW DTMAX1	This software point defines the largest possible temperature difference across the chilled water plant with correction for MAX acceptable chilled water supply temperature.
		DTMAX1 = MAX (0.1, (T5CHWR – MAXCHWT))
23.	PLNTCHW DTMAX2	This software point defines the MAX of DTMAX and DTMAX1
		DTMAX2 = MAX [MIN (DTDESIGN, DTMAX), DTMAX1]
24.	PLNTCHW MINBYPGPM	This software point defines minimum bypass GPM (user adjustable) under design OAWB conditions
		MINBYPGPM = -10
25.	PLNTCHW MINBYPGPM2	This software point calculates OAWB based reset to minimum bypass GPM to allow for recirculation of building flow at lower OAWBs
		MINBYPGPM2 = SPAN Block Output [OAWBAVG, 30, 100, 50, MINBYPGPM]
26.	PLNTCHW CAPCORR	This software point defines the correction factor (user adjustable) to be applied to MAXTONS calculation. it applies to correction due condenser water temperature relief and age of chiller. Use SPAN BLOCK for calculation.
		CAPCORR = SPAN Block Output [OAWBAVG, 30, 1.03, 80, 0.97]
27.	PLNTCHW BLDGGPM	Calculated Building CHW Flow, GPM
		BLDGGPM = EVAPGPM2 + BYPGPM - LOOPGPM
28.	PLNTCHW CLEARCMD1	Campus All Clear Command is False for 1200 seconds (User Adjustable) if a Chiller is Enabled or Disabled anywhere on Shared Campus Loop. Map from Campus Controller to Plant Controller
		CLEARCMD1 = CAMPUS_CLEARCMD1
29.	PLNTCHW LD2USECAP	Chiller Plant Load to Capacity based on Dynamic Conditions %
		LD2USECAP = LOAD / MAX (0.1, PEAKLOAD) * 100
30.	PLNTCHW LD2MAXCAP	Chiller Plant Load to Maximum Achievable Capacity %
		LD2MAXCAP = LOAD / MAX (0.1, MAXTONS) * 100
31.	PLNTCHW OAWBAVG	Time averaged value of OAWB over 108 consecutive scans
		OAWBAVG = Average of 108 scans
32.	PLNTCHW QEDES	Design evaporator flow thru chiller, as per chiller submittal, AAA GPM
		QEDES = AAA
33.	PLNTCHW QEHI	Maximum Operator desired evaporator flow thru chiller, GPM
		QEHI = 1.20 * QEDES
34.	PLNTCHW QEMIN1	Minimum Operator desired evaporator flow thru chiller, GPM
		QEMIN1 = 0.30 * QEDES
35.	PLNTCHW QE60	Measured flow thru chiller evaporator with evaporator pump running at 60 Hz
		QE60 = Measured flow thru Chiller Evaporator with Evaporator Pump running at 60 Hz
36.	PLNTCHW QE18	Measured flow thru chiller evaporator with evaporator pump running at 18 Hz
		QE18 = Measured flow thru Chiller Evaporator with Evaporator Pump running at 18 Hz
37.	PLNTCHW QEMIN2	Minimum acceptable flow, as fraction of design flow (0.XX), thru evaporator bundle as specified by chiller manufacturer, GPM
		QEMIN2 = 0.XX * QEDES

39.	PLNTCHW QELO	Minimum allowed flow thru chiller evaporator, GPM
		QELO = MAX (QEMIN1, QEMIN2, QE18)
40.	PLNTCHW Z	VFD speed in Hertz for measured chiller evaporator flow of QELO
		Z = Evaporator Pump Speed in Hertz to deliver chiller evaporator flow of QELO. Determined during commissioning phase.
41.	PLNTCHW EVAPGPM1	Calculated flow thru chiller evaporator, GPM
		EVAPGPM1 = EP1ST * SPAN Block Output [EPSPDCMD, 0, QELO, 100, QE60]
42.	PLNTCHW EP1OOS	Evaporator Pump in Out Of Service. User Specified.
		EP1OOS = FALSE
44.	PLNTCHW EP1FTR	Evaporator Pump Fail to Run Alarm with Latching. Plant Operator needs to confirm run status via manual operation or issue a remote FTR alarm reset to reset the alarm.

		IF FTRRESET = TRUE THEN
		EP1FTR = FALSE
		ELSE
		EP1FTR = Latched Value of (IF (AND (EP1SS = TRUE, XOR (EP1SS = TRUE, EP1ST = TRUE)) = TRUE for 90 seconds continuously).

45.	PLNTCHW EP1AVAIL	Evaporator Pump Available for Service
		EP1AVAIL = NOT (OR (EP1OOS, EP1FTR))
46.	PLNTCHW FTRRESET	Operator Button on Graphics to Reset a FTR Alarm
		IF FTRESET = TRUE THEN trigger 10 second pulse timer FTRESET = Output from 10 second pulse timer ELSE FTRRESET = FALSE

C. Chiller Sequencing Database: The DDC system shall include a database that lists the accumulated run time, service availability, run status, start/stop command and alarm status for the chiller at the plant.

D. Chiller Start/ Stop Command: Advisories for starting and stopping chiller in the chiller plant shall be issued by the Global Campus Chilled Water Control system. When a start or stop command is generated, an alarm message shall be generated at the operator workstation graphics along with chiller ID that has been selected to start/stop. Start/Stop logic for the chiller, evaporator pump and the condenser pump shall be as follows and will require LCT programming. Chiller Fail to Run Alarm shall also require LCT programming.

1) Chiller Start Advisory (PLNTCHW_ADVISORY_STRT = True): An advisory to start a chiller at the E-Building Plant shall be issued if the following conditions are true:

```
IF AND (CAMPUS_START = TRUE, CAMPUS_PLNTCHW_NEXTSTRT = TRUE,
CAMPUS_CLEARMCD = TRUE) THEN
  PLNTCHW_ADVISORY_STRT = TRUE
END IF
```

The automation system shall start specific chiller (CH1ENA = TRUE) that is recommended by the Sequencer Block based on run hour, service availability, and offline status. JCI Metasys shall command the evaporator pump and condenser pump to run immediately once the chiller is enabled to run.

2) Chiller Stop Advisory (PLNTCHW_ADVISORY_STOP = TRUE): An advisory to stop a chiller at the E-Building plant shall be issued if the following conditions are true:

IF OR (AND (CH1FTR = TRUE, CH1ENA = TRUE), AND (CAMPUS_STOP = YES, CAMPUS_PLNTCHW_NEXTSTOP = YES, CAMPUS_CLEARCMD = TRUE)) THEN
  PLNTCHW_ADVISORY_STOP = TRUE
END IF

The automation system shall stop specific chiller (CH1ENA = FALSE) that is recommended by the Sequencer Block based on run hours, service availability, and online status. JCI Metasys shall command the evaporator pump and condenser pump to stop, 90 seconds after the chiller run status has gone false.

3) Chiller Fail to Run Alarm (CH1FTR): If a chiller is commanded to run at the plant and the chiller run status stays false for 300 seconds continuously, then the chiller will be disabled and tagged with a fail to run alarm. The fail to run alarm can be reset only when the chiller run status returns to true state or the operator issues an FTR alarm reset.

IF FTRRESET = TRUE THEN
  CH1FTR = FALSE
ELSE
  CH1FTR = Latched Value of (IF (AND (CH1ENA = TRUE, XOR (CH1ENA = TRUE, CH1ST = TRUE)) = TRUE for 300 seconds continuously)

SEQUENCE OF OPERATION – CHILLER PLANT CHW LOOP PUMPS AND LOOP VALVES

A. Overview: This system consists of one (1) variable speed chilled water loop export pump with a VFD, a modulating bypass chilled water flow control valve and a modulating import control valve. With this system, the chiller plant can export chilled water to the campus chilled water loop. Additionally, chilled water can be imported into the plant building from the campus chilled water system if the building plant is offline. The chiller plant bypass leg decouples the plant building CHW pump(s) from the other pumps.

B. PID Loop Definitions: The following PID loop shall be provided at the system device controller:

PID Loop 3 (Chiller Plant CHW Bypass Flow Control PID Loop)

PID Loop Description		Point Name	Units	Point Description
1.	Input Point Name:	FLOWINP3	%	Bypass Flow Error
2.	Setpoint:	0.0	%	Error Set-Point
3.	Output Point Name:	FLOWCMD3	%	PID Output Range: See Section C for PID Output Range (Low and High Values)
4.	PID Loop Action:	Reverse Acting		
5.	Loop Reset:	See Section C for PID Enable/ Disable & Start Value & Stop Value for PID Output		

C. Software Point Definitions (LCT Programming Required):

Point Number	Point Name	Point Description and Formula
1.	PLNTCHW FLOWINP3	This software point is the linearized input to the PID loop for the campus loop pump and bypass control valve. Map PID input to PID loop controller.
		FLOWINP3 = 100 * (BYPGPM – BYPGPMSP) / (GPMPKIN – GPMPKOUT)
2.	PLNTCHW TRANSCMD3	This software point is a reverse linear fit of FLOWCMD3 such that for FLOWCMD3 = 0 and 50, TRANSCMD3 = 100% and 0% respectively.
		TRANSCMD3 = SPAN Block Output [FLOWCMD, 0, 100, 50, 0]
3.	PLNTCHW EVAPCMD3	This software point is a reverse linear fit of FLOWCMD3 such that for FLOWCMD3 = LOWVAL3 and 0, EVAPCMD3 = 0% and 100% respectively.
		EVAPCMD3 = SPAN Block Output [FLOWCMD3, LOWVAL3, 0, 0, 100]
4.	PLNTCHW LOOPCMD3	Campus Chilled Water Loop Pump Global Speed Command: This point is utilized to issue a global speed command to all online campus loop pumps.
		LOOPCMD3 = CAMPUS_LOOPCMD3

5.	PLNTCHW LPMPCMD3	LOOP PUMP COMMAND: This value is used for controlling pump speed and the bypass control valve. It is minimum of the campus loop speed command (LOOPCMD3) and the local loop speed pump command (TRANSCMD3).
		LPMPCMD3 = MIN (LOOPCMD3, TRANSCMD3)
6.	PLNTCHW LP1OOS	CHW Loop Pump Out Of Service. If the plant operator needs to have the loop pump out of service, then the operator will make LP1OOS = YES else the operator will make LP1OOS = NO on the Plant Graphics.
		LP1OOS = NO
7.	PLNTCHW LP1FTR	CHW Loop Pump Fail to Run Alarm with Latching. Plant Operator needs to confirm run status via manual operation or issue a remote FTR alarm reset to reset the alarm.

		IF FTRRESET = TRUE THEN
		LP1FTR = FALSE
		ELSE
		LP1FTR = Latched Value of (IF (AND (LP1SS = TRUE, XOR (LP1SS = TRUE, LP1ST = TRUE)) = TRUE for 90 seconds continuously).

8.	PLNTCHW LP1AVAIL	CHW Loop Pump Availability for Operation. If the loop pump is not out for service and is not having fail to run alarm then the loop pump is available for service
		LP1AVAIL = AND [LP1OOS = NO, LP1FTR = FALSE]
9.	PLNTCHW PB3	PID Loop 3: Proportional Band Term (User Adjustable). Map to PID loop controller.
		PB3 = 600
10.	PLNTCHW IT3	PID Loop 3: Integral Term (User Adjustable). Map to PID loop controller.
		IT3 = 48 sec
11.	PLNTCHW STARTVAL3	PID Loop 3: PID loop output value when PID loop goes from Disabled to Enabled Condition

		IF the command to enable a chiller goes from True to False THEN
		STARTVAL3 = Output of SPAN Block [OAWBAVG, 30, 60, 60, 70]
		ELSE
		STARTVAL3 = 49

12.	PLNTCHW STOPVAL3	PID Loop 3: PID loop output value when loop goes from Enabled to Disabled Condition

		IF LP1ST = TRUE THEN
		STOPVAL3 = 49
		ELSE
		STOPVAL = 50

13.	PLNTCHW ENABLE3	PID Loop 3: PID loop enable and disable commands
		When the command to enable a chiller goes from False to True or from True to False then ENABLE3 = FALSE for elapsed time of 120 seconds and then goes TRUE
14.	PLNTCHW LOWVAL3	PID Loop 3: PID loop minimum output value
		LOWVAL3 = -50
15.	PLNTCHW HIGHVAL3	PID Loop 3: PID loop maximum output value
		HIGHVAL3 = 100

D. Hardware Output Point Definitions (LCT Programming Required):

Point Number	Point Name	Point Description and Formula
1.	PLNTCHW LP1SS	Start / Stop Command for the Campus CHW Loop Pump #1. Map command to device controller.

		IF LPMPCMD3 > 3 THEN
		LP1SS = TRUE
		ELSE IF LPMPCMD3 < 1 THEN
		LP1SS = FALSE
		END IF

2.	PLNTCHW LP1VFD	LOOP PUMP #1 VFD COMMAND: The CHW loop pump VFD speed command shall be calculated given LPMPCMD and a linear curve fit equation. Map command to device controller.

		IF LP1ST = TRUE THEN
		LP1VFD = OFFSET + SPAN Block Output [LPMPCMD3, 0, 0, 100, 100]
		ELSE
		LP1VFD = 0
		where
		OFFSET1 = User Adjustable, customized user input to address oversized/undersized loop pumps and provide preferential plant loading at lower campus speeds; Default Value = 0%

3.	PLNTCHW IMPVLV	Command for modulating CHW Import Valve, % Open. Map to device controller.

		IF LP1ST = FALSE THEN
		IMPVLV = Output from SPAN Block [BYPVLV, 0, 10, 70, 100]
		ELSE
		IMPVLV = 0% after 30 seconds off delay

4.	PLNTCHW BYPVLV	Command for modulating CHW bypass valve, % Open. Map to device controller.

		IF FLOWCMD3 > = 50 THEN
		BYPVLV = SPAN Block Output [FLOWCMD3, 50, 0, HIGHVAL3, 100]
		ELSE
		BYPVLV = SPAN Block Output [LPMPCMD3, 0, 0, 30, 100] * LP1ST

5.	PLNTCHW EP1VFD	Evaporator Pump VFD Speed Command where 0% = 4 mA = Z Hz and 100% = 20 mA = 60 Hz. Set up required during Commissioning
		EP1VFD = EVAPCMD3 * EP1ST
6.	PLNTCHW CH1SS	Chiller Start/ Stop Command to Chiller Control Panel (CCP). Map to device controller.

		IF AND (CH1ENA = TRUE, CH1AVAIL = TRUE) THEN
		IF AND (EP1ST = TRUE, CNP1ST = TRUE) THEN
		CH1SS = TRUE
		ELSE
		CH1SS = FALSE after 120 seconds off delay
		ENDIF

7.	PLNTCHW EP1SS	Main Evaporator Water Pump Start/Stop Control. Map to device controller.

		IF AND (CH1ENA = TRUE, EP1OOS = FALSE, EP1FTR = FALSE)
		THEN
		EP1SS = TRUE
		ELSE
		IF CH1ST = FALSE THEN
		EP1SS = FALSE with off delay of 90 seconds
		ENDIF

BUILDING CHW PUMPS CONTROL – E-BUILDING

A. Overview: This system consists of two (2) variable speed building chilled water pumps each with a VFD. Each pump is sized for 100% of design flow capacity. The speed of the online pump is controlled with a PID loop such that the differential pressure (DP) sensor, located remotely in the building CHW pipe run, reads equals to DP setpoint.

B. PID Loop Definitions: The following PID loop shall be provided at the system device controller:

PID Loop 4 (Building DP Control)

PID Loop Description		Point Name	Units	Point Description
1.	Input Point Name:	DP	psig	Differential Pressure
2.	Setpoint:	DPSP	psig	Set-Point Reset per Section C
3.	Output Point Name:	PID4OUT	%	PID Output Range: 0 to 100% PID Output Range
4.	PID Loop Action:	Reverse Acting		
5.	Loop Reset:	See Section C for PID Enable/ Disable & Start Value & Stop Value for PID Output		

C. Software Point Definitions (LCT Programming Required):

Point Number	Point Name	Point Description and Formula
1.	PLNTCHW DPSP	Building Differential Pressure Setpoint (psig) with OAWB based Reset.
		DPSP = Output from SPAN Block [OAWBAVG, 30, 10, 70, 15]
2.	PLNTCHW REQPMPS	Required Building CHW Pumps to be Online; User Specified.
		REQPMPS = 1
3.	PLNTCHW BP1OOS	Building pump BP-1 in Out Of Service. User Specified.
		BP1OOS = FALSE
4.	PLNTCHW BP1FTR	CHW Building Pump BP-1 Fail to Run Alarm with Latching. Plant Operator needs to confirm run status via manual operation or issue a remote FTR alarm reset to reset the alarm.

		IF FTRRESET = TRUE THEN
		BP1FTR = FALSE
		ELSE
		BP1FTR = Latched Value of (IF (AND (BP1SS = TRUE, XOR (BP1SS = TRUE, BP1ST = TRUE)) = TRUE for 90 seconds continuously).

5.	PLNTCHW BP2OOS	Building pump BP-2 in Out Of Service. User Specified.
		BP2OOS = FALSE
6.		CHW Building Pump BP-2 Fail to Run Alarm with Latching. Plant Operator needs to confirm run status via manual operation or issue a remote FTR alarm reset to reset the alarm.

	PLNTCHW BP2FTR	IF FTRRESET = TRUE THEN
		BP2FTR = FALSE
		ELSE
		BP2FTR = Latched Value of (IF (AND (BP2SS = TRUE, XOR (BP2SS = TRUE, BP2ST = TRUE)) = TRUE for 90 seconds continuously).

7.	PLNTCHW PB4	PID #4 Proportional Band Term. Remote User Adjustable.
		PB4 = 80
8.	PLNTCHW IT4	PID #4 Integral Term. Remote User Adjustable, sec.
		IT = 30
9.	PLNTCHW STRTVAL4	PID #4 Output when PID #4 State goes from Disable to Enable
		STRTVAL4 = SPAN [OAWBAVG, 30, 30, 70, 50]
10.	PLNTCHW STOPVAL4	PID #4 Output when PID #4 State goes from Enable to Disable
		STOPVAL4 = 0
11.	PLNTCHW PID4ENA	Criteria for Enabling PID Loop #4

		IF OR (BP1ST = TRUE, BP2ST = TRUE) THEN
		PID4ENA = TRUE
		ELSE
		PID4ENA = FALSE after 30 seconds off delay

D. Hardware Output Point Definitions (LCT Programming Required):

Point Number	Point Name	Point Description and Formula
1.	PLNTCHW BP1SS	Start/ Stop Command for building CHW pump BP-1
		Use Sequencer Block for Two Pumps and select number of pumps required (REQPMPS) based on Run Hours, Pumps OOS Flag and Pumps FTR Flag
2.	PLNTCHW BP2SS	Start/ Stop Command for building CHW pump BP-2
		Use Sequencer Block for Two Pumps and select number of pumps required (REQPMPS) based on Run Hours, Pumps OOS Flag and Pumps FTR Flag
3.	PLNTCHW BP1VFD	Speed Command for Building CHW Pump BP-1, %. Program VFD Controller during Commissioning such that 0% Speed Command corresponds to 18 Hz and 50% speed command corresponds to 39 Hz
		BP1VFD = BP1SS * BP1ST * PID4OUT
4.	PLNTCHW BP2VFD	Speed Command for Building CHW Pump BP-2, %. Program VFD Controller during Commissioning such that 0% Speed Command corresponds to 18 Hz and 50% speed command corresponds to 39 Hz
		BP2VFD = BP2SS * BP2ST * PID4OUT