At Section 33 62 00 (currently as follows):

Document	Version Date	Description
SK1 (AutoCAD file) (PDF Document)		Campus chilled water system service entrance detail for buildings that do NOT require a heat exchanger.
Sequence of Operation		Sequence of Operation for campus chilled water system service entrance detail for buildings that do NOT require a heat exchanger.
SK-2 (AutoCAD file) (PDF Document)		Campus chilled water system service entrance detail for buildings that require a heat exchanger.
Sequence of Operation		Sequence of Operation for campus chilled water system service entrance detail for buildings that require a heat exchanger.
Isolation Valve (AutoCAD file) (PDF Document)		Details of a campus chilled water isolation valve installation.
Air Vent (AutoCAD file) (PDF Document)		Detail of a campus chilled water air vent.
Sediment Blowoff (AutoCAD file) (PDF Document)		Detail of a campus cilled water sediment blowoff.
Building Wall Penetration (AutoCAD file) (PDF Document)		Detail of a campus chilled water building penetration.

Update the Document Descriptions as follows:

At SK1 (Campus chilled water system service entrance detail for buildings that do NOT require a heat exchanger), replace the documents and update the version date.

At the Sequence of Operation for campus chilled water system service entrance detail for buildings that do NOT require a heat exchanger, replace the documents and update the version date.

At SK2 (Campus chilled water system service entrance detail for buildings that require a heat exchanger), replace the documents and update the version date.

At the Sequence of Operation for campus chilled water system service entrance detail for buildings that require a heat exchanger, replace the documents and update the version date.

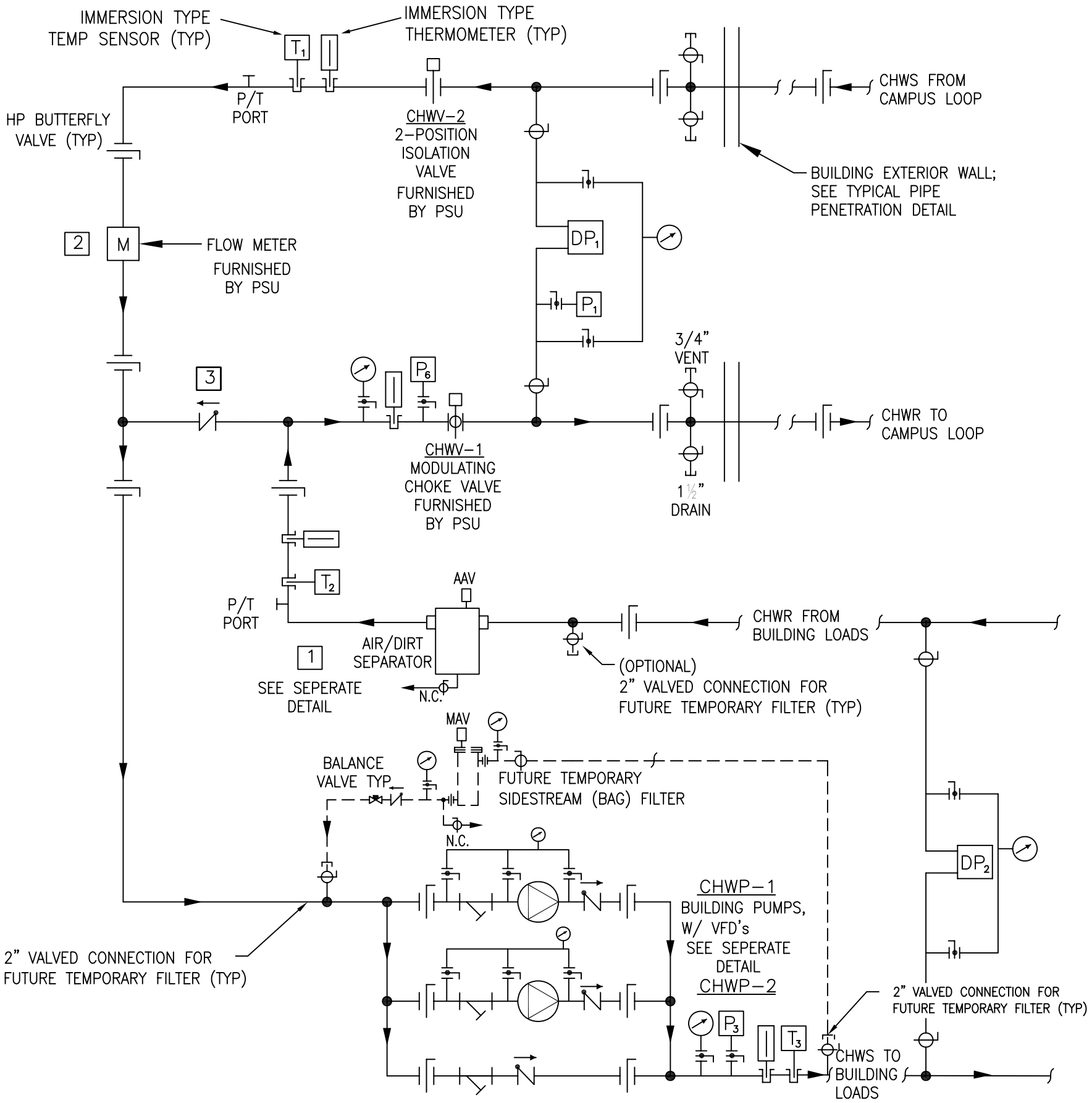
In the Description for a Sediment Blowoff, correct the spelling of “chilled”.

END of revision

Update Commentary:

Section was updated primarily for the following reasons:

1) Update service entrance details to eliminate redundant strainers, add notes to Design Professional, and cross reference with other details.
2) Correct pen colors in Acrobat documents.
3) Revise sequences of operation.
4) Correct a misspelling.



CHILLED WATER SERVICE –

BUILDING ENTRANCE PIPING DIAGRAM

DRAWING NOTES:

A. PIPING DIAGRAM IS PROVIDED TO DESIGN ENGINEER AS A BASIS OF DESIGN. ENGINEER IS SOLELY RESPONSIBLE FOR FINAL DESIGN. ENGINEER SHOULD MODIFY DESIGN AS REQUIRED TO MEET SPECIFIC PROJECT REQUIREMENTS. DEVIATIONS FROM STANDARD DIAGRAM SHOULD BE COMMUNICATED TO PSU IN WRITTEN FORM FOR REVIEW AND APPROVAL.

B. VALVES, GAUGES, SENSORS, ETC ARE SHOWN TO PROVIDE AN OVERALL REPRESENTATION OF SYSTEM. EXPECTION IS THAT FURTHER REQUIREMENTS ARE INDICATED ON RESPECTIVE DETAILS, PLANS, CONTROL DRAWINGS ETC REFER TO OTHER APPLICABLE PSU STANDARDS.

C. ADDITIONAL PUMPS MAY BE REQUIRED TO SUPPORT EXTREME PART LOAD CONDITIONS.

D. THE LOCATION OF HIGH PERFORMANCE (HP) BUTTERFLY ISOLATION VALVES, AND THE NUMBER OF ISOLATION VALVES MUST BE REVIEWED BY THE DESIGNER. VALVES SHOULD BE DELETED WHEN MULTIPLE VALVES ARE CLOSE TO EACH OTHER , OR ADDED WHERE NECESSARY TO PROVIDE ADEQUATE ISOLATION FOR FUTURE MAINTENANCE.

E. REFER TO BAS SPECIFICATIONS FOR THE SPECIFIC APPLIICATIONS OF SENSOR TYPES AND PARTICULAR REQUIREMENTS

KEYNOTES:

1. REQUIREMENTS FOR AIR/DIRT SEPARATOR ARE PROJECT SPECIFIC. CONTACT GLENN LELKO (GAL8@PSU.EDU).
2. PROVIDE 5 PIPE DIAMETERS UPSTREAM AND 2 PIPE DIAMETERS DOWNSTREAM OF METER.
3. CHECK VALVE ALLOWS FOR CWP-1/2 RECIRCULATION AND PREVENTS BYPASS FLOW FROM CAMPUS CHWS TO CHWR.

CAMPUS CHILLED WATER SYSTEM STANDARD DETAIL #1	PROJ.# BLDG.# UNIVERSITY PARK	PENNSTATE Office of Physical Plant OPERATIONS DIVISION ENGINEERING SERVICES	
DATE: 2/4/11	SCALE: NONE	DRAWN BY:	CHECKED BY: gal8	SK-1 1 of 1

Sequence of Operation
Campus Chilled Water Service Entrance
Without Heat Exchanger
November 11, 2010

PENNSTATE

Office of Physical Plant
Operations Division
Engineering Services

The Pennsylvania State University
Physical Plant Building
University Park, PA 16802-1118

SEQUENCE OF OPERATION SUMMARY

February 4, 2011

CAMPUS CHILLED WATER SERVICE ENTRANCE – WITHOUT HEAT EXCHANGER
The following sequence summary is based on the equipment shown in the Campus Chilled Water System Standard Detail #1, "Chilled Water Service – Building Entrance Piping Diagram", SK-1, dated 12/1/10. This document is provided to the project design engineer as a basis of design. The engineer is solely responsible for the final design. Further sequence details are expected to be provided by the engineer and/or BAS provider. Engineer should modify design if required to meet specific project requirements. Deviation from this standard shall be communicated to PSU in written form and in sufficient time for review and approval prior to final construction issue. The engineer shall also follow and issue the PSU BAS specification for this project.

A. GENERAL

1. The building is served with chilled water from the campus chilled water system. In general the system is designed to operate at a chilled water supply temperature of 42°F in the summer and a maximum of 48°F in the winter. The building systems connected to the campus chilled water system shall be designed to operate at a 12°F temperature differential between the supply and return when supplied with a chilled water supply temperature of 42°F in the summer.
2. The chilled water system in the building consists of a piping connection between the campus loop and the building system including but not limited to components such as; building chilled water pumps, water flow meter, temperature sensors, pressure sensors, an air/dirt separator (project specific), an isolation valve, a choke valve (temperature control), and check valves.
3. The purpose of the chilled water system is to distribute chilled water to air handling units [and other equipment] throughout the building for the purpose of space cooling [and process cooling]. Campus chilled water is available throughout the year, and as such, the cooling system in this building is designed to operate whenever necessary.
4. All setpoints will be adjustable in the software logic. In general use values indicated with exception of those that are indicated as being project specific. Setpoints involved with choke valve control shall not be changed without specific direction from PSU OPP.

B. FLOW METER

1. Measurement of instantaneous building tonnage will be calculated by the building BAS using the following inputs:
   a. Campus chilled water supply flow from the flow meter
   b. Campus chilled water supply temperature sensor, T1
   c. Building chilled water return temperature sensor, T2
   d. Building supply chilled water temperature sensor, T3

C. **PRESSURE**

1. Campus differential pressure, DP1, between the campus chilled water supply and return pipes will be sensed and used by the campus chilled water plants for plant pump speed control, as well as on/off control of the building pump. DP1 will also be used as a safety shut-off isolation trigger.
2. Building differential pressure, DP2, which is the DP at a remote location in the building chilled water distribution system, will be sensed and used to control the speed of the Duty building chilled water pump. There may be multiple remote DP required.
3. Pressure P1, campus chilled water return pipe pressure, will be sensed and used as a safety shut-off isolation trigger.
4. Pressure P6 (at the inlet to choke valve) will be monitored to calculate differential pressure across the choke valve for diagnostic purposes.
5. The campus chilled water supply pressure will be calculated from the campus DP and the campus chilled water return pressure. Value will be compared with required building specific chilled water system pressure to assure that static head is sufficient to maintain the fill pressure.
6. Pressures P2 and P3 will be used by the BAS for monitoring only.

D. **SYSTEM ENABLE**

1. All the building's equipment provided with chilled water shall be capable of issuing cooling requests for chilled water flow thru the BAS network. Where specific cooling requests from equipment are impractical, then some other appropriate representative conditions will be used in place of specific requests to enable the system.
2. For purposes of system enable only, if any equipment chilled water control valve in the system is open > 10% (or other condition used as a substitute request), or if the network connection is lost, then the following shall occur:
   a. Isolation valve (CHWV-2) shall open.
   b. And Choke valve (CHWV-1) shall modulate open to maintain (with a minimum position) the chilled water return temperature of 54°F or greater (refer to CAMPUS CHILLED WATER VALVES FLOW AND TEMPERATURE CONTROL).
   c. If equipment chilled water control valve is opened in response to chemical treatment flushing or freeze protection sequences then pump will run but this will not cause system to be enabled with regard campus valves opening and temperature control.
3. The system shall be enabled for 1 hour minimum time. After 1 hour if all the equipment chilled water control valves have closed to 1% (9% hysteresis) the system will be disabled.
4. After system is enabled and prior to starting building duty pump, system shall be operated using only campus supply and return differential pressure to distribute chilled water to the building's equipment. CWHV-1 shall modulate as required from minimum position to maintain chilled water return temperature, T2 setpoint. Based on cooling requests input and use of an optimized setpoint block the T2 setpoint shall be reset in order to satisfy requests and minimize campus chilled water flow without causing Duty pump to start. (refer to CAMPUS CHILLED WATER VALVES FLOW AND TEMPERATURE CONTROL).

E. **BUILDING PUMPING STARTING/STOPPING**

1. The building chilled water system generally has [two] building pumps, [CWP01 and CWP02,] each sized at 100% design flow rate. When required to operate, only one pump is required to provide the required chilled water flow to satisfy the building cooling needs. One [CWP01] is designated the Duty pump, and the other [CWP02] is designated the Standby pump. Each pump is provided with a VFD to control the flow rate of the pump. Refer to PSU standards for the VFD and BAS interface requirements.

2. The building chilled water pumps will operate in accordance with the University's standard Duty/Standby sequence with an exercise cycle (runtime hrs of 720 for Duty and 24 for Standby). The specific details of this sequence are given elsewhere.
3. System shall calculate and reset two different setpoints for pump starting/stopping and pump VFD speed. One setpoint shall be used to start and stop Duty pump and the other shall be used to control pump speed through the VFD.
4. The pump enable setpoint shall be reset from 1-20 (initial SP is 2) if:
   a. The OA temperature is > 55°F (only for systems where all equipment served has economizer cooling). The primary OA temperature shall be the base OPP sensor value from network. The secondary OA temperature shall be the building OA value.
   b. And there is a cooling request. A cooling request is defined as condition where the requesting equipment's control valve is 100% open and the controlled value is off setpoint for 1 request, the further from setpoint the greater the number of requests. The system controls to the highest number of requests from only one given valve controller (requests are not added from various valves).
   c. And the optimized setpoint block for T2 has reset down to the 54°F minimum.
5. The Duty pump shall be started at minimum speed if:
   a. The pump enable setpoint is > than campus DP1.
   b. And there is a cooling request.
   c. And the optimized setpoint block for T2 has reset down to the 54°F minimum.
6. Duty pump shall also be started if the network connection is lost. In some applications the pumps may be required to operate continuously due to process loads or other critical loads.
7. Pump shall remain on for a minimum runtime of 1 hr and continue on until:
   a. Campus DP1 is > 5psi above the value of DP1 when pump was most recently started and the pump speed control PID output = 0.
   b. Or (when checked every (1) hr) if the campus DP1 is > than the pump enable setpoint for 15 minutes and the pump speed control PID output = 0.

F. PUMP SPEED CONTROL - OPTIMIZED DIFFERENTIAL PRESSURE RESET (TRIM AND RESPOND)

1. General: The objective is to minimize pump energy by always operating the pump(s) at the lowest speed possible such that at least one cooling control valve is fully open and maintaining its temperature control setpoint within an acceptable range.
2. **Basic VFD speed control:** The pump VFD speed DP2 setpoint shall modulate the pump VFD speed to maintain a differential pressure setpoint that shall be automatically reset with a Trim and Respond function as described below.
   a. The pump VFD speed DP2 setpoint shall be recalculated every 5 minutes (adj.). The incremental change per interval shall be based on the maximum cooling requests from any one of the associated Primary or Terminal Application Controllers served by each pump system.
   b. Cooling requests are not accumulated for pump VFD speed DP2 reset until after pump has started.
   c. Cooling requests are the same as described in the Building Pump Starting and Stopping Section.
   d. The pump VFD speed DP2 setpoint shall be rest from [3-10] psi. The initial differential pressure setpoints shall be [3] psig (adj.). If network communication is lost, the setpoint shall be reset to 0.75 x maximum pump VFD speed DP2 setpoint and alarm issued.
   e. With no cooling requests, the setpoint shall incrementally be trimmed down by 0.5 psi (adj.) per period to a minimum of [3] psig (adj.). [The minimum pressure limit is the pressure correlating to the lowest speed the pump motor is allowed to be operated at (per VFD and motor manuf. and TAB).]

   f. As cooling demand increases, the setpoint shall incrementally respond up by 0.5 psi per request value, limited to [3] psi (adj.) per period, to a maximum of [10] psig (adj.). [The maximum pressure limit is the pressure required to provide full flow to all control valves simultaneously (per TAB).]
4. **VFD speed control adjust to prevent recirculation:** If building CHWS temperature (T3) is 3°F greater than the campus CHWS temperature (T1) for an adjustable time, then the pump speed will be reduced incrementally even though the actual building remote DP2 may be less than the setpoint. The pump speed shall be reduced (with a ramp) by resetting the pump VFD speed DP2 setpoint. This control logic is needed due to the condition that when campus pressure is too low to support required campus chilled water supply flow into the building system, then the equipment control valves will respond by opening further and lowering the actual remote DP2. The basic pump VFD speed control will respond by increasing the pump speed. The result will be higher building CHWS temperatures and associated potential loss of dehumidification and wasted pump energy.
5. **Pump (building chilled water) deadhead protection:** If actual remote DP2, with the Duty pump controlled to its minimum, is 3 psi > DP2 setpoint (for 15 minutes), then pump shall be turned off (for 15 minutes) and an alarm issued. Further control logic may be necessary to insure that pump is operating in accordance with manufacturer's recommendations.
6. Pump (building chilled water) deadhead protection explanation: The design engineer responsible for the Chilled Water Entrance Project needs to design and provide for all expected low flow conditions that the system will see over the course of a typical year. In some cases campus DP1 will be adequate enough to support low flow needs, in other applications an additional smaller pump may be required for required flows that are too low for building pump operation but too high for campus only operation. Both flow and associated required head combination should be considered. The flow and head do not neatly follow the max condition system curve. For example, some buildings may have a CRAC unit whose branch DP requires 5 psi, but a relatively very low flow, that overall, is a fraction of the max flow. The main building pumps cannot meet this condition without operating in a region of the pump curve that would cause damage to the pump based on mfr recommendations.

F. CAMPUS CHILLED WATER VALVES FLOW AND TEMPERATURE CONTROL

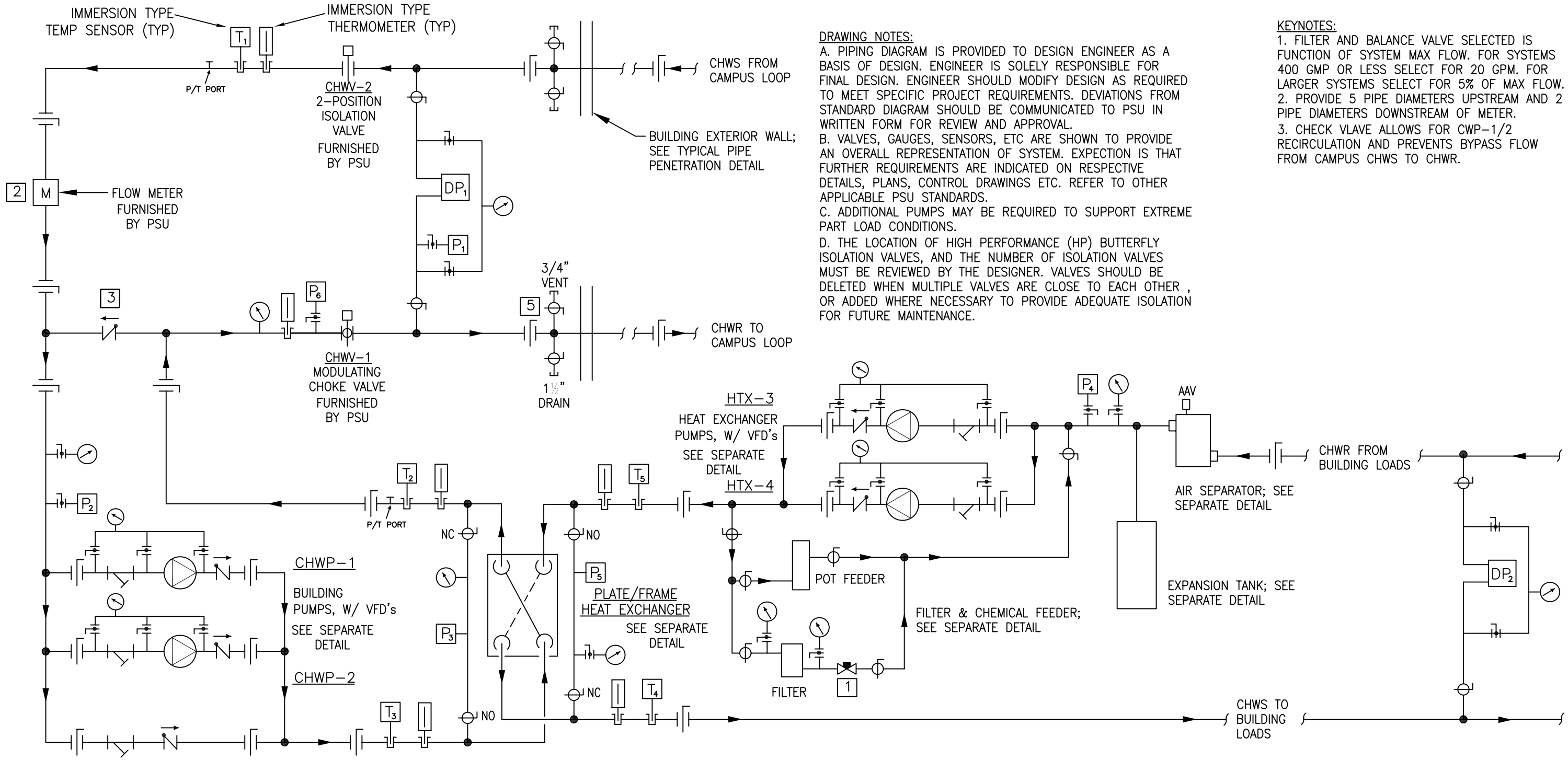
1. When the building cooling is OFF, the choke valve, CHWV-1, and the isolation valve, CHWV-2 will be closed completely.
2. When the building cooling is enabled, the isolation valve, CHWV-2 will be open and CHWV-1, the choke valve shall modulate with the constraints of a minimum position to maintain T2 setpoint. A linear converter block shall reset the minimum valve position form 10% to 20% as the campus chilled water DP ranges from 0 psi to 10 psi. These values may be adjusted during the commissioning process based on particular building conditions. When the building chilled water Duty pump is operating there is no minimum position for CHWV-2.
3. CWHV-1 shall modulate as required from minimum position to 100% open to maintain chilled water return temperature, T2 setpoint. Based on cooling requests input and use of an optimized setpoint block the T2 setpoint shall be reset from 54°F to 60°F when the building chilled water pumps are off.
4. Once Duty pump is started and operating <30% speed (based on cooling requests input and use of an optimized setpoint block) the T2 setpoint shall be reset from 54°F to 60°F. The lower limit of the setpoint range shall be reduced back to 52°F if:
   a. Building CHWS temperature (T3) is 2°F greater than the campus CHWS temperature (T1) for an adjustable time.
   b. And there is a cooling request.

G. CAMPUS CHILLED WATER VALVES SAFETY SHUT-OFF

1. If the campus differential pressure, DP2, is 0 psi or less for 30 seconds, the Duty campus chilled water pump will be stopped, the choke valve, CWV-1, and the isolation valve, CWV-2 will be closed completely and an alarm will be issued. The valves will be released to reopen when the differential pressure is re-established at 0.5 psi or greater for 30 seconds.
2. If the pressure sensed in the campus chilled water return pipe by P1 is 5 psi below the minimum system pressure (determined during commissioning under various operating conditions) for 30 seconds, the Duty campus pump will be stopped, the choke valve, CWV-1, and the isolation valve, CWV-2 will be closed completely. The Duty pump shall be restarted and the valves will be released to reopen when the system pressure is re-established for 30 seconds. An alarm will be issued.

H. MISCELLANEOUS ALARMS & SYSTEM DIAGNOSTICS

1. Commissioning Alarms: When the associated pump status is on, the following monitoring and alarm functions shall initiate one of several primary categories of commissioning “CCX” alarms displayed at the BAS workstation. At the equipment controller level, each alarm within each category shall be labeled independently for easy, diagnostic purposes. Primary Categories shall be as follows in bold:
   a. Pump Control Fault
      1) Unstable PID loop: If any pump speed PID loop continues to cycle its output more than 40% of its range (adj.) 3 times (adj.) in any 60 minute internal.
      2) “Excessive Pump Speed” Alarm: If the pump speed output remains above 95% for more than 8 hours (adj.) accumulated per occupied period for at least 3 (adj.) consecutive occupied periods.
      3) Continuous Request Alarm: If one or more application controllers is sending continuous cooling requests, and differential pressure has reset to maximum setpoint, and the combined condition remains for more than 8 hours (adj.) continuously.
      4) Flow signal out of range (This option needs to be reviewed more to determine if practical/feasible/cost effective): if measured flow varies significantly from the initial baseline pump/system non-linear operating curve.



DRAWING NOTES:

A. PIPING DIAGRAM IS PROVIDED TO DESIGN ENGINEER AS A BASIS OF DESIGN. ENGINEER IS SOLELY RESPONSIBLE FOR FINAL DESIGN. ENGINEER SHOULD MODIFY DESIGN AS REQUIRED TO MEET SPECIFIC PROJECT REQUIREMENTS. DEVIATIONS FROM STANDARD DIAGRAM SHOULD BE COMMUNICATED TO PSU IN WRITTEN FORM FOR REVIEW AND APPROVAL.

B. VALVES, GAUGES, SENSORS, ETC ARE SHOWN TO PROVIDE AN OVERALL REPRESENTATION OF SYSTEM. EXPECTION IS THAT FURTHER REQUIREMENTS ARE INDICATED ON RESPECTIVE DETAILS, PLANS, CONTROL DRAWINGS ETC. REFER TO OTHER APPLICABLE PSU STANDARDS.

C. ADDITIONAL PUMPS MAY BE REQUIRED TO SUPPORT EXTREME PART LOAD CONDITIONS.

D. THE LOCATION OF HIGH PERFORMANCE (HP) BUTTERFLY ISOLATION VALVES, AND THE NUMBER OF ISOLATION VALVES MUST BE REVIEWED BY THE DESIGNER. VALVES SHOULD BE DELETED WHEN MULTIPLE VALVES ARE CLOSE TO EACH OTHER , OR ADDED WHERE NECESSARY TO PROVIDE ADEQUATE ISOLATION FOR FUTURE MAINTENANCE.

KEYNOTES:

1. FILTER AND BALANCE VALVE SELECTED IS FUNCTION OF SYSTEM MAX FLOW. FOR SYSTEMS 400 GMP OR LESS SELECT FOR 20 GPM. FOR LARGER SYSTEMS SELECT FOR 5% OF MAX FLOW.
2. PROVIDE 5 PIPE DIAMETERS UPSTREAM AND 2 PIPE DIAMETERS DOWNSTREAM OF METER.
3. CHECK VLAVE ALLOWS FOR CWP-1/2 RECIRCULATION AND PREVENTS BYPASS FLOW FROM CAMPUS CHWS TO CHWR.

CHILLED WATER SERVICE –

BUILDING ENTRANCE PIPING DIAGRAM

REFERENCE	BUILDING	DESIGNED BY	SHEET
		gal8	SK-2
CASE	DRAWER	SECT.	NO.

PENNSTATE
Office of Physical Plant
ENGINEERING SERVICES
University Park, PA

DO NOT SCALE DRAWINGS. CHECK AND VERIFY ALL EXISTING CONDITIONS AND DIMENSIONS ON SITE.

SYM	DATE	DESCRIPTION

SCALE: NONE DATE: 2/4/11

UNIVERSITY PARK CAMPUS

1 of 1

CAMPUS CHILLED WATER SYSTEM
STANDARD DETAIL #2

Sequence of Operation
Campus Chilled Water Service Entrance
With Heat Exchanger
November 22, 2010

PENNSTATE

Office of Physical Plant
Operations Division
Engineering Services

The Pennsylvania State University
Physical Plant Building
University Park, PA 16802-1118

SEQUENCE OF OPERATION SUMMARY

February 4, 2011

CAMPUS CHILLED WATER SERVICE ENTRANCE – WITH HEAT EXCHANGER
The following sequence summary is based on the equipment shown in the Campus Chilled Water System Standard Detail #2, "Chilled Water Service – Building Entrance Piping Diagram", SK-2, dated 12/1/10. This document is provided to the project design engineer as a basis of design. The engineer is solely responsible for the final design. Further sequence details are expected to be provided by the engineer and/or BAS provider. Engineer should modify design if required to meet specific project requirements. Deviation from this standard shall be communicated to PSU in written form and in sufficient time for review and approval prior to final construction issue. The engineer shall also follow and issue the PSU BAS specification for this project.

A. GENERAL

1. The building is served with chilled water from the campus chilled water system. A heat exchanger(s) is provided to isolate the campus system from the building heat exchanger side distribution system. The heat exchanger system may have a glycol and water solution in some cases. In general the system is designed to operate at a campus chilled water supply temperature of 42°F in the summer and a maximum of 48°F in the winter. The campus chilled water system shall be designed to operate at a 12°F temperature differential between the supply and return when supplied with a chilled water supply temperature of 42°F in the summer.
2. The chilled water system consists of a piping connection between the campus loop and the building system including but not limited to components such as; building chilled water pumps, water flow meter, temperature sensors, pressure sensors, an air/dirt separator (project specific), an isolation valve, a choke valve (temperature control), and check valves.
3. The heat exchanger system includes but is not limited to components such as; heat exchanger chilled water pumps, temperature sensors, pressure sensors, an air separator, a heat exchanger control valve (temperature control), and check valves.
4. The heat exchanger distribution system shall provide chilled water to air handling units [and other equipment] throughout the building for the purpose of space cooling [and process cooling]. Campus chilled water is available throughout the year, and as such, the cooling system in this building is designed to operate whenever necessary.
5. All setpoints will be adjustable in the software logic. In general use values indicated with exception of those that are indicated as being project specific. Setpoints involved with choke valve control shall not be changed without specific direction from PSU OPP.

B. FLOW METER

1. Measurement of instantaneous building tonnage will be calculated by the building BAS using the following inputs:

a. Campus chilled water supply flow from the flow meter
b. Campus chilled water supply temperature sensor, T1
c. Building chilled water return temperature sensor, T2
d. Building supply chilled water temperature sensor, T3

C. **PRESSURE**

1. Campus differential pressure, DP1, between the campus chilled water supply and return pipes will be sensed and used by the campus chilled water plants for plant pump speed control, as well as on/off control of the building pump. DP1 will also be used as a safety shut-off isolation trigger.
2. Heat exchanger (HTX) system differential pressure, DP2, which is the DP at a remote location in the HTX chilled water distribution system, will be sensed and used to control the speed of the Duty HTX chilled water pump. There may be multiple remote DP required.
3. Pressure P1, campus chilled water return pipe pressure, will be sensed and used as a safety shut-off isolation trigger.
4. Pressure P6 (at the inlet to choke valve) will be monitored to calculate differential pressure across the choke valve for diagnostic purposes.
5. The campus chilled water supply pressure will be calculated from the campus DP and the campus chilled water return pressure. Value will be compared with required building specific chilled water system pressure to assure that static head is sufficient to maintain the fill pressure.
6. Pressures P2, P3, P4, and P5 will be used by the BAS for monitoring only.

D. **HTX SYSTEM PUMP STARTING/STOPPING**

1. All the building's equipment provided with chilled water shall be capable of issuing cooling requests for chilled water flow thru the BAS network. Where specific cooling requests from equipment are impractical, then some other appropriate representative conditions will be used in place of specific requests to enable the system.
2. For purposes of pump starting only, if any equipment chilled water control valve in the system is open > 10% (or other condition used as a substitute request), or if the network connection is lost, then the following shall occur:
   a. DUTY HTX pump will start at minimum speed.
   b. If equipment chilled water control valve is opened in response to chemical treatment flushing or freeze protection sequences then pump will run but this will not cause system to be enabled with regard campus valves opening, building pump operastion, and temperature control.
3. The HTX chilled water system generally has [two] HTX pumps, [HTX03 and HTX04] each sized at 100% design flow rate. When required to operate, only one pump is required to provide the required chilled water flow to satisfy the building cooling needs. One [HTX03] is designated the Duty pump, and the other [HTX04] is designated the Standby pump. Each pump is provided with a VFD to control the flow rate of the pump. Refer to PSU standards for the VFD and BAS interface requirements.
4. The HTX chilled water pumps will operate in accordance with the University's standard Duty/Standby sequence with an exercise cycle (runtime hrs of 720 for Duty and 24 for Standby). The specific details of this sequence are given elsewhere.
5. Pump shall remain on for a minimum runtime of 5 minutes.

E. **HTX PUMP SPEED CONTROL - OPTIMIZED DIFFERENTIAL PRESSURE RESET (TRIM AND RESPOND)**

1. General: The objective is to minimize pump energy by always operating the pump(s) at the lowest speed possible such that at least one cooling control valve is fully open and maintaining its temperature control setpoint within an acceptable range.
2. **Basic VFD speed control:** The pump VFD speed DP2 setpoint shall modulate the pump VFD speed to maintain a differential pressure setpoint that shall be automatically reset with a Trim and Respond function as described below.
    a. The pump VFD speed DP2 setpoint shall be recalculated every 5 minutes (adj.). The incremental change per interval shall be based on the maximum cooling requests from any one of the associated Primary or Terminal Application Controllers served by each pump system.
    b. A cooling request is defined as condition where the requesting equipment's control valve is 100% open and the controlled value is off setpoint for 1 request, the further from setpoint the greater the number of requests. The system controls to the highest number of requests from only one given valve controller (requests are not added from various valves).
    c. The pump VFD speed DP2 setpoint shall be rest from [3-10] psi. The initial differential pressure setpoints shall be [3] psig (adj.). If network communication is lost, the setpoint shall be reset to 0.75 x maximum pump VFD speed DP2 setpoint and alarm issued.
    d. With no cooling requests, the setpoint shall incrementally be trimmed down by 0.5 psi (adj.) per period to a minimum of [3] psig (adj.). [The minimum pressure limit is the pressure correlating to the lowest speed the pump motor is allowed to be operated at (per VFD and motor manuf. and TAB).]
    e. As cooling demand increases, the setpoint shall incrementally respond up by 0.5 psi per request value, limited to [3] psi (adj.) per period, to a maximum of [10] psig (adj.). [The maximum pressure limit is the pressure required to provide full flow to all control valves simultaneously (per TAB).]
4. **HTX Pump deadhead protection:** If actual remote DP2, with the Duty pump controlled to its minimum, is 3 psi > DP2 setpoint (for 15 minutes), then pump shall be turned off (for 15 minutes) and an alarm issued. Further control logic may be necessary to insure that pump is operating in accordance with manufacturer's recommendations. If the system is provided with a HTX system bypass valve then the valve shall be modulated open when above conditions are present.
5. Pump (building chilled water) deadhead protection explanation: The design engineer responsible for the Chilled Water Entrance Project needs to design and provide for all expected low flow conditions that the system will see over the course of a typical year. Both flow and associated required head combination should be considered. The flow and head do not neatly follow the max condition system curve. For example, some buildings may have a CRAC unit whose branch DP requires 5 psi, but a relatively very low flow, that overall, is a fraction of the max flow.

F. BUILDING SYSTEM ENABLE

1. All the building's equipment provided with chilled water shall be capable of issuing cooling requests for chilled water flow thru the BAS network. Where specific cooling requests from equipment are impractical, then some other appropriate representative conditions will be used in place of specific requests to enable the system.
2. For purposes of system enable only, the same conditions that start the HTX Duty pump shall enable the building system: if any equipment chilled water control valve in the system is open > 10%, (or other condition used as a substitute request) and the HTX Duty pump status is on, or if the network connection is lost, then the following shall occur:
    a. Isolation valve (CHWV-2) shall open.
    b. And Choke valve (CHWV-1) shall modulate open to maintain (with a minimum position) the chilled water return temperature of 54°F or greater (refer to CAMPUS CHILLED WATER VALVES FLOW AND TEMPERATURE CONTROL).

   c. If equipment chilled water control valve is opened in response to chemical treatment flushing or freeze protection sequences then pump will run but this will not cause system to be enabled with regard campus valves opening and temperature control.
3. The system shall be enabled for 5 minute minimum time.
4. After system is enabled and prior to starting building duty pump, system shall be operated using only campus supply and return differential pressure to distribute chilled water to the building's equipment. CWHV-1 shall modulate as required from minimum position to maintain chilled water return temperature, T2 setpoint. Based on cooling requests input and use of an optimized setpoint block the T2 setpoint shall be reset in order to satisfy requests and minimize campus chilled water flow without causing Duty pump to start. (refer to CAMPUS CHILLED WATER VALVES FLOW AND TEMPERATURE CONTROL).

G. BUILDING PUMPING STARTING/STOPPING

1. The building chilled water system generally has [two] building pumps, [CWP01 and CWP02,] each sized at 100% design flow rate. When required to operate, only one pump is required to provide the required chilled water flow to satisfy the building cooling needs. One [CWP01] is designated the Duty pump, and the other [CWP02] is designated the Standby pump. Each pump is provided with a VFD to control the flow rate of the pump. Refer to PSU standards for the VFD and BAS interface requirements.
2. The building chilled water pumps will operate in accordance with the University's standard Duty/Standby sequence with an exercise cycle (runtime hrs of 720 for Duty and 24 for Standby). The specific details of this sequence are given elsewhere.
3. The duty pump shall be started at minimum speed to maintain HTX chilled water supply temperature setpoint, T4 if:
   a. T4 is 1°F above its setpoint. Setpoint of T4 is typically 2°F plus campus chilled water supply temperature, T1.
   b. And the duty HTX pump status is on.
   c. And the optimized setpoint block for T2 has reset down to the 54°F minimum, for 5 minutes.
4. Duty pump shall also be started if the network connection is lost. In some applications the pumps may be required to operate continuously due to process loads or other critical loads.
5. Pump shall remain on for a minimum runtime of 1 hr and continue on until:
   a. Campus DP1 is > 5psi above the value of DP1 when pump was most recently started and the pump speed control PID output = 0.
   b. Or (when checked every (1) hr) if T4 is within 2°F of setpoint for 15 minutes and the pump speed control PID output < 50% then pump shall be stopped.

H. BUILDING PUMP SPEED CONTROL

1. General: The objective is to minimize pump energy by always operating the pump(s) at the lowest speed possible.
2. **Basic VFD speed control:** The pump VFD speed shall modulate the pump VFD speed to maintain HTX chilled water supply temperature setpoint, T4.
   a. If network communication is lost, the speed shall be reset to 0.75 x maximum pump VFD speed and alarm issued.
   b. As PID output increases, the pump speed shall increase to maximu, 100% (adj.). [The maximum speed limit is the speed required to provide full flow to all control valves simultaneously (per TAB).]
6. **VFD speed control adjust to prevent recirculation:** If building CHWS temperature (T3) is 3°F greater than the campus CHWS temperature (T1) for an adjustable time, then the pump speed will be reduced incrementally even though the PID output to maintain T4 is requesting a higher speed. The pump speed shall be reduced (with a ramp) by resetting the pump VFD speed. This

control logic is needed due to the condition that the campus pressure is too low to support required campus chilled water supply flow to the HTX, then the basic pump VFD speed control will respond by increasing the pump speed. The result will be higher building CHWS temperatures and wasted pump energy.

F. CAMPUS CHILLED WATER VALVES FLOW AND TEMPERATURE CONTROL

1. When the building cooling is OFF, the choke valve, CHWV-1, and the isolation valve, CHWV-2 will be closed completely.
2. When the building cooling is enabled, the isolation valve, CHWV-2 will be open and CHWV-1, the choke valve shall modulate with the constraints of a minimum position to maintain T2 setpoint. A linear converter block shall reset the minimum valve position form 10% to 20% as the campus chilled water DP ranges from 0 psi to 10 psi. These values may be adjusted during the commissioning process based on particular building conditions. When the building chilled water Duty pump is operating there is no minimum position for CHWV-2.
3. CWHV-1 shall modulate as required from minimum position to 100% open to maintain chilled water return temperature, T2 setpoint. Based on HTX chilled water supply temperature setpoint, T4, CHWV-1 setpoint shall be reset from 54°F to 60°F when the building chilled water pumps are off.
4. Once Duty pump is started and operating <30% speed (based on maintaining HTX chilled water supply temperature setpoint, T4) the T2 setpoint shall be reset from 54°F to 60°F. The lower limit of the setpoint range shall be reduced back to 52°F if:
   a. Building CHWS temperature (T3) is 2°F greater than the campus CHWS temperature (T1) for an adjustable time.
   b. And HTX chilled water supply temperature, T4, is above setpoint.

G. CAMPUS CHILLED WATER VALVES SAFETY SHUT-OFF

1. If the campus differential pressure, DP2, is 0 psi or less for 30 seconds, the Duty campus chilled water pump will be stopped, the choke valve, CWV-1, and the isolation valve, CWV-2 will be closed completely and an alarm will be issued. The valves will be released to reopen when the differential pressure is re-established at 0.5 psi or greater for 30 seconds.
2. If the pressure sensed in the campus chilled water return pipe by P1 is 5 psi below the minimum system pressure (determined during commissioning under various operating conditions) for 30 seconds, the Duty campus pump will be stopped, the choke valve, CWV-1, and the isolation valve, CWV-2 will be closed completely. The Duty pump shall be restarted and the valves will be released to reopen when the system pressure is re-established for 30 seconds. An alarm will be issued.

H. MISCELLANEOUS ALARMS & SYSTEM DIAGNOSTICS

1. Commissioning Alarms: When the associated pump status is on, the following monitoring and alarm functions shall initiate one of several primary categories of commissioning “CCX” alarms displayed at the BAS workstation. At the equipment controller level, each alarm within each category shall be labeled independently for easy, diagnostic purposes. Primary Categories shall be as follows in bold:
   a. Pump Control Fault
      1) Unstable PID loop: If any pump speed PID loop continues to cycle its output more than 40% of its range (adj.) 3 times (adj.) in any 60 minute internal.
      2) “Excessive Pump Speed” Alarm: If the pump speed output remains above 95% for more than 8 hours (adj.) accumulated per occupied period for at least 3 (adj.) consecutive occupied periods.

3) Continuous Request Alarm: If one or more application controllers is sending continuous cooling requests, and differential pressure has reset to maximum setpoint, and the combined condition remains for more than 8 hours (adj.) continuously.
4) Flow signal out of range (This option needs to be reviewed more to determine if practical/feasible/cost effective): if measured flow varies significantly from the initial baseline pump/system non-linear operating curve.