

Chilled Water Plants

Building Connection Basis of Design,
Operations and Maintenance

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Revision 2



**Facilities Operations
and Development**

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1.01 INTRODUCTION

- A. This guideline summarizes the technical requirements, and informs planners, designers and building operators of the buildings served by centralized chiller plants on the basis of design of the buildings' interconnection with the central chiller plant systems. These guidelines impact the design for all buildings to be connected and served by these central chiller plants.

- B. The plant systems, distribution systems, and building chilled water systems function as a system. The system components are interactive, and each section of the system, even if designed and operated by different entities, must function interactively. Most important, the connected buildings must maintain system performance so the central plant is not degraded by a single failed building system.

- C. Energy efficiency is a high priority. The efficiency of the plant is impacted by the chilled water supply and return temperatures, hours of operation and seasonal requirements. The building designer must consider the impact of the building design on demands on the central chilled water plant, and take all reasonable and necessary steps to design an efficient system, minimizing the demands on the plant.

- D. See Figure 1 at the end of this document for plans of the campus central chilled water systems.

1.02 ABBREVIATIONS

A/E	Architect / Engineer
ASHRAE	American Society of Heating, Refrigerating, and Air Conditioning Engineers
ASTM	American Society for Testing and Materials
BAS	Building Automation System
BOD	Basis of Design
CHW	Chilled Water
DSAW	Double Submerged Arc Welded
DCS	Digital Control System
°F	Fahrenheit
FOD	Facilities Operations and Development
FPS	Feet per Second
GPM	Gallons per Minute
HVAC	Heating Ventilating and Air Conditioning
KSI	Kilo-Pound per Square Inch
MC	Wexner Medical Center
OPR	Owner's Project Requirements
OSU	The Ohio State University

NRD	North Residential District
PID	Proportional Integral Derivative
P&ID	Process / Piping and Instrumentation Diagram
PSIG	Pressure, Pounds per Square Inch Gauge
RTD	Resistance Temperature Detector
ΔT	Temperature Differential
VFD	Variable Frequency Drive

1.03 DEFINITIONS

- A. BACnet – Building Automation Control network. A control network developed by ASHRAE primarily for interoperability between commercial automation systems.
- B. Basis of Design – The BoD is a document that records the general expectations, performance criteria and special requirements as they relate to the project technical design elements. The BoD includes both narrative descriptions and lists of individual items that support the design process documenting the primary thought processes and assumptions behind design decisions that were made to meet the OPR.
- C. Building Chilled Water Pumps, Secondary - Pumps installed to circulate chilled water from the plant and to the building.
- D. Building Chilled Water Pumps, Tertiary - Pumps to circulate chilled water through the building. These pumps are only required when a plate & frame isolation is employed.
- E. Building Operator: The person or group responsible for maintenance building cooling system and responding to alarms. Building Automation Shop (BAS) or Wexner Medical Center Building Engineer.
- F. Chilled Water - Needed to cool and dehumidify supply air of the Ohio State Campus and Wexner Medical Center buildings.
- G. Chilled Water Delta-T - The change from entering to leaving chilled water temperature through a chiller, cooling coil, or building service entrance.
- H. Chiller – A machine to remove heat from a liquid (chilled water) via a vapor-compression refrigeration cycle.
- I. Cooling Tower – Device that uses evaporation to reduce water temperature, and is the primary means of rejecting heat from condenser water. Cooling tower effectiveness is heavily dependent upon significant quantities of drier air. Towers are sized based on approach to outside air wet bulb temperature. During colder

weather, may be used to generate building chilled water directly, without the use of chillers.

- J. Cooling Tower Plume – Visual plume often seen during cold weather operation. Plume is moist air, often perceived to be, but not necessarily contaminated. Depending upon wind and air temperatures, the plume may have to be controlled. The plume or air currents from the tower outlet may adversely effect aircraft operation. The cooling tower removes particulates from the air and requires a sand filter to remove the particulates from the circulating water.
- K. Commissioning – A systematic quality assurance process to ensure that systems are designed, installed, functionally tested, and capable of being operated and maintained to perform in conformity with the design intent. Commissioning starts with clarification of the Program of Requirements, and continues through the warranty phase.
- L. Ethernet – Is a family of frame-based computer networking technologies for local area networks (LANs).
- M. Expansion Tank – Required in a closed loop water system to compensate for the expansion or contraction of the fluid with varying operating temperatures. For a chilled water system, a properly sized expansion tank will accommodate the expansion of the system fluid during plant shutdown, or reduced cooling (warmer water) cycle without the system exceeding the upper pressure limits of the system.
- N. Firm Capacity – Plant chiller capacity with one of the largest chillers out of service.
- O. Industrial Grade – Higher quality and more robust equipment designed and manufactured to withstand more demanding duty, closer tolerances and/or harsh environments.
- P. Isolation Valve – A valve to isolate equipment from the remainder of the system for maintenance or replacement. This may be a manual or automatic, and normally open (NO) or normally closed (NC).
- Q. Magnetic Flow Meter (Magmeter) – A high quality, high accuracy electronic flow meter that measures flow by electromagnetic induction.
- R. Modbus – An “open” protocol developed by Modicon in the 1970s. This communication protocol is commonly used in electrical and industrial market segments. This protocol uses master / slave or client / server relationships and ASCII or RTU.

- S. Modulate – To gradually open or close a control device in response to a control signal to vary fluid or air flows.
- T. Owner’s Project Requirements – A document that outlines measurable objectives for use during the project design, construction and operation.
- U. Plate and Frame Heat Exchanger – A static device that uses metal plates to separate two fluid systems, with heat transfer between the fluids in the two systems. May be used for tower free cooling and/or building service entrance applications. A plate & frame exchanger is required in tall buildings, for the isolation of contaminated systems or for systems with cooling coils that are unable to achieve the design 16 degree delta T.
- V. Programmable Logic Controller (PLC) – An industrial grade programmable control device that is of higher quality, faster, more reliable, and more capable of programming variations.
- W. Primary Chilled Water Loop – The chilled water supply and return distribution piping and equipment in the Chiller Plant, including the supply and return distribution piping to each building service entrance.
- X. Secondary Chilled Water Loop – The chilled water distribution system that draws chilled water from the primary chilled water loop, circulates it to the building service entrance, and returns the chilled water to the primary chilled water loop. A secondary chilled water loop can provide chilled water directly to building HVAC equipment, or it can be separated from the building equipment by a plate and frame heat exchanger
- Y. Standby Generation – Equipment to provide electrical power to ‘mission critical’ plant equipment during a power outage.
- Z. Static Pressure – The fluid pressure in the system, influenced by the height of the water column above that point in the system. Each foot of elevation change above that point will require a 0.43 psi increase in pressure to maintain water in the pipe above. The static pressure required at the top of the highest building or at the plate and frame heat exchanger should be 10 psi over the pressure required to keep the system full at that elevation. Static Pressure is typically defined in feet of head, not psi. 1 foot of head equals 0.43 psi; 1 psi equals 2.33 feet of head.
- AA. Tertiary Chilled Water Loop – The chilled water distribution system on the building side of a plate and frame heat exchanger. This pumping is required with building plate and frame heat exchangers.

- BB. Three-Way Control Valve – Automatic control valve that modulates between open and closed positions with bypass from supply to return. This valve is ported with normally open, normally closed and common ports. Commercial control valves typically have the normally open control valve as the “bottom” port.
- CC. Total Capacity – Capacity available with all chillers operating.
- DD. Two-Way Control Valve – Automatic control valve that modulates between open and closed positions with no bypass from supply to return.
- EE. Ultrasonic Flow Meter – A device that measures flow by sensing its Doppler effect on an ultrasonic signal transmitted into the fluid.
- FF. Variable Frequency / Variable Speed Drives – A technology to control the speed of an alternating current (AC) electric motor by varying the frequency of the electrical power supplied to the motor. A variable speed drive also functions as a starter, or soft start device.
- GG. Water Treatment – Chemical additives for to clean, treat, and to prevent corrosion in the chilled water piping. Chemical treatment is also used in tower water piping to prevent corrosion and microbiological growth. Blowdown is draining part of the system water to reduce dissolved solids in the system and prevent scale formation. Makeup is city water added to the system to replace water lost through evaporation or blowdown.

1.04 CHILLED WATER PLANTS - OVERVIEW

- A. The **McCracken Chilled Water Plant (MCWP)** has 15,550-tons of total capacity. This plant mainly serves academic buildings located on the core of Main Campus. The plant has seven R-134a chillers sized at 2,000 tons and two 775-ton R-123 chillers. One chiller is in reserve to satisfy cooling requirements (N+1). 736 feet elevation is the reference level for the MCWP system pressure.
- B. The **South Campus Central Chiller Plant (SCCCP)** has 20,000 ton plant of total capacity (as of mid 2014). The plant serves the Wexner Medical Center and the 12th Avenue research corridor facilities. The plant has chillers sized at 2,500 tons.. Expansion plans are to maintain one chiller in reserve to satisfy cooling requirements (N+1). At full build out, the plant will have 27,500 tons firm capacity, and 30,000 tons of total capacity. Of the 27,500 ton firm capacity, 17,500 tons is designated for Wexner Medical Center facilities, and 10,000 tons for the 12th Avenue research corridor facilities. The initial phase of the SCCCPC included standby generator capacity to operate 5,000 tons of chilled water production dedicated to the Wexner Medical Center during a utility power outage. 719 feet elevation is the reference level for SCCCPC system pressure.

- C. The **East Regional Chilled Water Plant** (ERCWP) will initially be a 5,000 ton total plant capacity, and ultimately built to 15,000 tons. The plant will serve the majority of the Academic Core North buildings and portions of the North Housing District. The plant will have chillers sized at 2,500 tons, initially required to produce a firm capacity of 2500 tons. One chiller is in reserve to satisfy cooling requirements (N+1). At full build out, the plant will have 12,500 tons firm capacity, and 15,000 tons of total capacity. Of the 12,500 ton firm capacity, 3,000 tons is designated for the North Housing District. 736 feet elevation is the reference level for the ERCWP system pressure.
- D. Each central chiller plant operates continuously on a year 24/7/365 basis, providing 42°F chilled water supply. In the future, plants may be cross connected to optimize winter operations or to share reserve capacity.
- E. In compliance with University sustainability goals, the plant chilled water system and associated equipment is operated to optimize energy savings.
- F. The Architect-Engineer of any new or renovated building system to be connected to and served by central chiller plants shall coordinate with Facilities Operations and Development and with Utilities for the technical requirements of the building systems, as they relate to chilled water needs and use.
 - 1. The project location, building height, existing building HVAC equipment, and building chilled water requirements will determine whether or not the project will be directly or indirectly connected to the primary chilled water loop.
 - 2. The new building systems must be designed with cooling coils and other HVAC devices compatible with the intended chilled water supply and return water temperatures to and from the central chiller plant.
 - 3. The building shall not be designed to require extraordinary or excessive cooling requirements that will force excessive operation, or override normal operation of the plant. The plant normal operating guidelines are stated in this document.

2.01 BUILDING SYSTEM REQUIREMENTS

- A. Building Interfaces and Interconnections (either direct connect or indirect with plate and frame, described in the following two sections).
 - 1. Direct Connect to the Plant Chilled Water (Figure 2)
 - a. The building chilled water system will direct connect to the distribution piping and share chilled water with the central plant.

- b. The entering campus supply chilled water design conditions will be 42°F at the building with a 16°F delta-T for the building chilled water system.
- c. The chilled water system static pressure at the Plants shall be set to 80 PSIG (185 feet of water). All facilities connected to this system shall assume this maximum static pressure value with a direct connection. When the building system exceeds this static pressure value, an indirect connection is required. See the “Indirect Connect via Plate and Frame Heat Exchanger” section.
- d. Building HVAC components shall be rated for 150 psig and piping installations shall comply with ASME B31.1.
- e. The expansion and contraction of the volume of water in the building will be accounted for at the central plants. Expansion tanks shall not be permitted for building systems that are directly connected to the central plant chilled water.
- f. Existing buildings with aging equipment, piping, and HVAC systems designed for less than a 16°F delta T shall not be direct connected to the central chiller plants’ chilled water system
- g. As a shared piping system, all direct connect building chilled water systems shall have makeup water supplied by the central plant makeup water system only. For initial fill requirements see Section 2.01 B. 7. g. and Commissioning Section 2.01 D.
- h. The physical interconnection of the building systems with the plant chilled water system will require special attention to cleaning, pressure testing, filling, and flushing (see section B.7.g. below).
- i. Direct Connect Secondary Chilled Water Pump Control:
 - 1) Each building will have one set of variable speed secondary chilled water pumps.
 - 2) The secondary chilled water pump speed will vary to provide the required chilled water differential pressure to provide adequate building flows.
- j. Direct Connect Process Load Sequence
 - 1) When connecting a process load that requires a constant flow, there must be separate pumps on the supply side after the bypass

section. The bypass section must also have a 3-way valve that is common to the return from the process and normally open to the plant return.

- 2) When a process load has a variable flow rate, it is treated the same configuration that is used for the constant flow system.
 - 3) The process loops that have been connected to central distributed chilled water run between 58-60°F supply water to the process to minimize the possibility of condensation on the equipment it is serving.
 - 4) One type of process load control scheme is to modulate a 3-way valve to maintain the process water supply temperature.
- k. Direct connect Sequence of Operation
- 1) When the cooling enable flag is turned on based on the outside air temperature exceeding the enable temperature, the automatic isolation valves shall be commanded open.
 - 2) Upon proof that both automatic isolation valves opened, the lead pump (secondary) shall be commanded on, and the PID control loop shall modulate the VFD pump control and the 2-way valve to maintain the differential pressure set point of the furthest coil on the system.
 - 3) 2-way valves on coil chilled water flow will be modulated to meet air handler discharge temperature.
 - 4) When the cooling enable flag is reset, when the outside air temperature goes 2° below the enable temperature (adj), the pump shall be commanded off.
 - 5) Upon proof that the pump went off, all automatic isolation valves shall be closed.
 - 6) There shall be timers to track the run hours of each pump.
 - 7) Upon failure of the differential pressure sensor or signal, the control point shall switch to the return water temperature sensor, and maintain 58°F return. There shall also be a minimum speed on the flow that is 10% of total balanced flow set point (adj.). An alarm flag to the Building Operator shall also be set.
 - 8) Alarms shall be annunciated for the following conditions:

- a) VFD Fault.
 - b) Low Flow Fault - System running with no flow.
 - c) Low Delta T Fault while running, 5 minute on delay timer.
 - d) High Delta T Fault while running, 5 minute on delay timer.
 - e) Automated isolation valve failed to open/close.
2. Indirect connect via Plate and Frame Heat Exchanger (Figure 3)
- a. Use a plate and frame heat exchanger to pressure isolate the tertiary chilled water system from the secondary chilled water when:
 - 1) the buildings' chilled water system pressure exceeds 80 PSIG, or
 - 2) the buildings' HVAC systems are designed with less than a 16°F delta T, or
 - 3) there are aged and deteriorating piping systems that could cause piping leaks or chilled water contamination.
 - b. Plate and frame heat exchangers
 - 1) Selected to maximize the plant chilled water system temperature differentials, considering losses on both the supply and return water side. Therefore, the flow rates on the plant and building side must closely match for heat transfer and system performance. The supply water temperature on the building side of the plate and frame will be 2°F to 3°F warmer than the central plant supply chilled water temperature (to account for heat exchanger efficiency losses). The entering campus supply chilled water design conditions will be 42°F, and the campus return chilled water design conditions at 58°F therefore the buildings should expect 44 to 45°F design entering water and 60 to 61°F design leaving water.
 - 2) The plate and frame heat exchanger shall be ASME Stamped.
 - 3) A minimum of two plate and frame heat exchangers will be provided for each building.
 - 4) Two units will permit cleaning and maintenance operations while operating the building under partial loads.

- 5) Each unit shall be equally sized, and sized to support 60% or more of the total building load.
 - 6) Both units will remain in service (with the exception of maintenance or control sequence operation) at all times to maximize heat transfer surfaces and minimize water temperature differences between plant and building side chilled water.
- c. The expansion and contraction of the volume of water in the building side of the plate and frame will require expansion capabilities. All plant side expansion shall be accommodated at the central plant.
 - d. Building Makeup Water – (for indirect connect only)
 - 1) A fill connection with appropriate back-flow prevention is required for facilities to be connected to the system.
 - 2) Make-up water meter is required and provided with a flow meter that is monitored and alarmed by the building chilled water system control system.
 - e. The physical interconnection of the building systems with the plant chilled water system will require special attention to cleaning, pressure testing, filling, and flushing (see section 2.01 B.7.g below).
 - f. Indirect Connect Secondary Chilled Water Pump Control
 - 1) Each building will have one set of variable speed secondary chilled water pumps
 - 2) The secondary chilled water pumps will control secondary flow to track tertiary flow plus 5% (adjustable).
 - g. Indirect Connect Tertiary Chilled Water Pump Control
 - 1) Each building will have one set of variable speed tertiary chilled water pumps.
 - 2) The tertiary chilled water pump speed will vary to provide the required chilled water differential pressure to provide adequate building flows.
 - h. Indirect Connection Sequence of Operation (New Building Systems):

- 1) When the cooling enable flag is turned on based on the outside air temperature exceeding the enable temperature, the automatic isolation valves shall be commanded open.
- 2) Upon proof that both automatic isolation valves are open, the isolation valves on the lead plate and frame on the plant and building return water lines, shall be modulated open.
- 3) Upon an open indication of the isolation valves on the lead plate and frame, the building (tertiary) lead pump shall be commanded on, and the PID control loop shall modulate the VFD pump control and the 2-way isolation valve to maintain the differential pressure set point of the furthest coil on the system.
- 4) 2-way valves on coil chilled water flow will be modulated to meet air handler discharge temperature.
- 5) The plant side (secondary) lead pump shall also be started when the building side pump proof is made. The plant side PID control of the pump speed and 2-way valve control shall modulate to maintain a flow rate that is 5% greater (adj.) than that being maintained on the building side.
- 6) When the plant side pump speed is greater than 50% (adj.), for 15 minutes (adj.), the lag plate and frame shall be enabled and the isolation valves shall be modulated open. It shall remain enabled until the cooling enable flag is turned off or the pump speed goes below 48% (adj.) for a period of 15 minutes (adj.) when the cooling enable flag is reset.
- 7) When the outside air temperature goes 2°F below the enable temperature, the pump shall be commanded off. Upon proof that the pump went off, all automatic isolation valves shall be closed.
- 8) There shall be timers to track the run hours of each pump and plate and frame individually.
- 9) Upon failure of the differential pressure signal or sensor on the building side, the control point shall switch to the building return water temperature sensor, and maintain a 58°F set point (adj.) at high cooling loads and 54°F at part cooling loads. An alarm flag to the Building Operator shall also be set.
- 10) Upon failure of the building side chilled water supply flow sensor or the plant side flow sensor, the plant side shall switch control points

to the plant return water temperature to the central plant. It shall maintain a 58°F set point (adj.) at high cooling loads and 54°F at part cooling loads. An alarm flag to the Building Operator shall also be set.

- 11) Makeup supply water flow shall be monitored and when it reaches 5 GPM for more than 15 minutes, an alarm flag to the Building Operator shall be set and the cooling system shall be shut down.
 - 12) Monitor flows and provide leak detection per section 2.01 B. 9. b.
- i. Indirect connect Sequence of Operation (Existing Building Systems)
- 1) When the cooling enable flag is turned on based on the outside air temperature exceeding the enable temperature, the automatic isolation valves shall be commanded open.
 - 2) Upon proof that both automatic isolation valves are open, the isolation valves on the lead plate and frame on the plant and building return water lines shall be modulated open.
 - 3) Upon an open indication of the isolation valves on the lead plate and frame, the building (tertiary) lead pump shall be commanded on, and the PID control loop shall modulate the VFD pump control and the 2-way isolation valve to maintain the differential pressure set point of the furthest coil on the system.
 - 4) 2-way valves on coil chilled water flow will be modulated to meet air handler discharge temperature.
 - 5) The plant side (secondary) lead pump shall also be started when the building side pump proof is made. The plant side PID control of the pump speed and 2-way valve control shall modulate to maintain a flow rate that is 5% greater (adj.) than that being maintained on the building side.
 - 6) When the plant side pump speed is greater than 50% (adj.) for 15 minutes (adj.), the lag plate and frame shall be enabled and the isolation valves shall be modulated open. It shall remain enabled until the cooling enable flag is turned off or the pump speed goes below 48% (adj.) for a period of 15 minutes (adj.). When the cooling enable flag is reset.

- 7) When the outside air temperature goes 2°F below the enable temperature, the pump shall be commanded off. Upon proof that the pump went off, all automatic isolation valves shall be closed.
- 8) There shall be timers to track the run hours of each pump and plate and frame individually.
- 9) Upon failure of the differential pressure signal or sensor on the building side, the control point shall switch to the building return water temperature sensor and maintain a 50°F set point (adjustable based on commissioning or test results). An alarm flag to the Building Operator shall also be set.
- 10) Upon failure of the building side chilled water supply flow sensor or the plant side flow sensor, the plant side shall switch control points to the central plant return water temperature. It shall maintain a 58°F set point on the plant return (adjustable based on commissioning or test results). An alarm flag to the Building Operator shall also be set.
- 11) Makeup supply water flow shall be monitored and when it reaches 5 GPM for more than 15 minutes, an alarm flag to the Building Operator shall be set and the cooling system shall be shut down.
- 12) Monitor flows and provide leak detection per section 2.01 B. 9. b.
- 13) If an isolation valve fails to open or close, a fault alarm shall annunciate to the BAS shop.. System should not start up until valve fault is cleared. If a VFD faults during startup or while running, the backup VFD shall start. If there is no back VFD, a fault alarm shall annunciate to the BAS shop.

B. Common Requirements (for all systems)

1. Installation shall comply with the Ohio State University Building Design Standards.
2. Secondary Chilled Water Pumps
 - a. In instances where existing or renovated building systems to be served from the plant have existing systems designed for a 10°F delta-T (or less), it is usually not feasible to obtain a 16°F delta-T unless these existing systems are replaced. Recognizing this, building pump selections must accommodate higher flow rates to obtain the required cooling capacity of the terminal units with the lower delta-T.

- b. All secondary pumps to be designed, procured, and installed as part of the building to be served.
 - c. All secondary and tertiary chilled water pumps are to be located and powered at the individual buildings and shall include normal and standby power (if required, see Risk Management section 2.01 B. 9.)
 - d. All pumps shall be variable speed, variable flow, and pressure pumps.
 - e. The secondary chilled water pumps shall be designed to overcome the pressure drop of the distribution piping from the plant to the buildings, **AND** to offset the pressure drop in the building chilled water piping system, including the plate and frame heat exchanger, if installed.
2. Pump Head Pressure Requirements
- a. The secondary chilled water pumps must overcome the primary loop distribution piping losses from the Chiller Plant to the building, in addition to other requirements.
 - 1) The primary loop distribution system losses have been calculated through a hydraulic analysis based on assumptions of need for all buildings to be connected to the Chiller Plant distribution loop.
 - 2) Ohio State uses KYPIPE software to maintain Ohio State's existing distribution systems. The campus hydraulic analysis has been predicted by a KYPIPE hydraulic model and will be maintained by Utilities for the life of the chilled water systems.
 - 3) The design engineer for any building to be connected to the plant is required to determine the building needs and consult with Utilities to determine variances (if any) from the estimated flow requirements used in the model.
 - 4) OSU Utilities will model new buildings and inform the design engineer of the required pressure drop between the chilled water supply and return connection points for the maximum building flow. The building design engineer will determine the pump head requirements to meet the connection point pressure drop plus the pressure drop through all building equipment.
 - b. Modeling is based on full system flow rates including future connections.

3. Secondary Loop and Tertiary Loop Chilled Water Pump Selections

The number and sizing of the building secondary loop and, if required, tertiary loop chilled water pumps to be provided for each building shall be based on:

- a. If three chilled water pumps are provided, each loop pump shall be capable of delivering at least 50% of the maximum expected flow.
- b. If two chilled water pumps are provided, each loop pump shall be capable of delivering 100% of the maximum expected flow.

4. Emergency Isolation Valves

- a. Where specified for emergency isolation, actuated valves on the building chilled water supply and return shall be provided to isolate the building piping system from the distribution loop. The valves shall be located just inside the building in an easily accessible location.
- b. Where specified for emergency isolation, actuated valves shall be provided on the tertiary chilled water supply and return piping.

5. Chilled Water Cooling Coils

- a. Coils to be selected and sized to perform all cooling functions with the design chilled water supply temperature and the design chilled water delta-T (16°F).
- b. The plant supply temperature is 42°F chilled water to the building. If the building has a plate and frame heat exchanger, tertiary design supply water temperature should be 45°F with a 16°F delta-T. Coils of the air handler units shall be selected for a supply temperature of 45°F and a delta-T of 16°F.
- c. The plant is intended to operate with a 16°F chilled water delta-T. All future renovations of buildings will require 16°F delta-T cooling coil selections, designed for not less than 42°F for direct connections and 45°F with the plate and frame heat exchanger.

6. Air Removal

An air and dirt separator shall be provided for each building distribution system. Automatic or manual air vents will be required at all high points in each system. Air vents must have manual isolation valves to permit replacing a failed vent without shutting down the system.

7. Piping and System Components
 - a. Minimum Pressure Ratings
 - 1) The pressure rating of all components used in the building's chilled water system must be suitable for the maximum of system static pressure and system operating dynamic pressures.
 - 2) All chilled water system components shall have at least 150 PSIG rating. Note that some building design applications will require components rated at pressures higher than 150 PSIG.
 - b. Plant, System Distribution and Direct Connect Building Piping
 - 1) All building chilled water systems will be designed for variable flow, without bypass, to obtain maximum delta-T from the chilled water.
 - 2) Direct connect building piping shall comply with Division 33 Chilled water Distribution Piping Requirements in the Building Design Standards.
 - 3) Taps for new building service will be addressed on a case-by-case basis as negotiated between the building Client and Utilities.
 - 4) Provide provisions in the design for stress, expansion, and contraction.
 - 5) Isolation valves are required to isolate all pumps and heat exchange devices for service.
 - 6) All entering and leaving piping from each pump and heat exchange device to have pressure and temperature taps (P&T plugs).
 - 7) All devices piped in parallel to have balancing valves, except variable speed drive pumps.
 - 8) Pumps shall be provided with sufficient turn-down to account for minimum flow conditions. Minimum pump flow operation characteristics shall be approved by Utilities.
 - c. Valves – Secondary and Tertiary

- 1) All control valves used in the secondary and tertiary chilled water system must be modulating, 2-way control valves. The intent is to limit chilled water flow to only what is needed and to maximize the efficiency of the system.
 - 2) Provide proper valve features as determined by the manufacturer for the design and installation requirements.
 - 3) Shutoff Valves – All shutoff valves shall be bi-directional double offset design with flange end connections.
- d. Equipment and Piping Support
- 1) Provide hangers, supports, concrete inserts, and support accessories required for installed piping and equipment.
 - 2) For plant and distribution, piping supports and parts shall conform to ASME B31.1.
 - 3) For plant, distribution, and secondary piping, provides provisions in the design for stress, expansion, and contraction. Thermal stress analysis of new chilled water piping systems shall be performed by the A/E and must be submitted to Utilities for review, acceptance, and filing.
- e. Strainers
- 1) Construction and Start-up strainers shall be specified at a minimum of 40 mesh and are required on each pump
 - 2) Permanent duty strainers shall not exceed 20 mesh.
 - 3) Permanent strainers shall be installed to protect pumps and plate and frame heat exchangers.
- f. Inspection and Startup Requirements
- 1) The engineer of record, in association with the commissioning agent (if applicable) and coordinated with Utilities, shall develop an inspection, flush, and startup plan.
 - 2) Each contractor shall be responsible for the integrity their own welds. Third-party inspection of all welds shall be in accordance with the State of Ohio Piping Code.

- 3) Each contractor shall perform their own hydrostatic test.
- 4) Cleaning, Flushing, and Water Treatment:
 - a) Each contractor shall flush, fill and treat their system before being connected to the distribution system.
 - b) The initial filling of the building system from the plant distribution system is prohibited to prevent damage to the Central Plant equipment and /or introduce air to the Central Plant system.
 - c) Each contractor shall install all bypasses necessary for flushing. This contractor shall also remove bypasses to a permanent configuration when flushing is complete.
 - d) For initial building system start-up, the system shall be pumped by building system pumps for flushing.
 - e) After start-up all plant side chilled water chemistry and make-up shall be controlled at the Central chiller Plant. Tertiary side chilled water chemistry and makeup shall be controlled by the building facilities staff.
 - f) Utilities will sign-off on the water chemistry before any valves being opened.
- 5) Complete system balance and commissioning (Section 2.01 C. and D.)
- g. Country of Origin and Fabrication
 - 1) All piping, fittings, valves, valve components, and piping accessories to be manufactured, and/or assembled in the United States of America or Canada, except as noted below.
 - 2) Any manufacturing or fabrication outside of the United States or Canada must be manufactured, fabricated, and/or assembled by an ISO 9001 registered corporation. Submit ISO 9001 registered certificates.
 - 3) No piping, fittings, and piping accessories manufactured, fabricated, and/or assembled in China, including Taiwan will be permitted.

8. Chilled Water Metering

- a. The main chilled water supply meter shall conform to the Hydronic Energy Distribution Standard, DIV 33 Section 33 61 33 of the Ohio State Building Design Standards. Hydronic Energy Distribution Meter installations shall be reviewed and approved by Utilities. The flow meter and temperature signals shall be accessible to Utilities for remote monitoring purposes. Instep eDNA is acceptable method for monitoring.
- b. Building and leak detection flow meters shall meet Project specifications.
- c. Shared sensors between metering and building controls are not allowed.

9. Risk Management Issues

- a. Loss of Power: Central chilled water is not normally available during a utility power outage. The exception is the Wexner Medical Center which provided for standby electrical generation to support critical cooling loads out of the South Chiller Plant (see section 12 below).
- b. Leak Detection: Evaluate the risk of building system leaks and specify detection where directed as follows:
 - 1) Tertiary Chilled Water System
 - a) If the tertiary chilled water system make-up water flow meter exceeds 5 gpm (adjustable) for greater than 10 minutes (adjustable), a high flow suspected leak alarm will be sent for facilities staff immediate action.
 - b) (Where specified) Monitor flows and if the supply and return flows differ by 10% (adjustable) for a period of 5 minutes (adjustable), shutdown the building system pumps and modulate close the building system isolation valves, preventing water hammer. Send an alarm flag to the Building Operator.
 - 2) Building Chilled Water Leak Detection Systems (where applied)
 - a) Monitor supply and return flows. If the secondary chilled water supply flow is greater than the secondary chilled water return flow back to the Chiller Plant by 10% (adjustable) for 5 minutes (adjustable), or either flow device reads a negative flow for the same period, stop the building pumps and modulate close the isolation valves on the supply and return

pipng from the plant, preventing water hammer. A high flow suspected leak alarm will be sent for facilities staff immediate action. In buildings with 24/7 staffing the Leak Detection shutoff can be manually initiated instead of automatic.

- b) The secondary chilled water supply and return motor actuated isolation valves shall be located just inside the building in an easily accessible location.

10. Building Interfaces

- a. The facility shall be provided with an interface to the Instep eDNA server for metering process and monitoring through Instep. See Section 33 61 33 of DIV 33.
- b. Sequences of Operation shall be in accordance with this guideline, developed by the A/E, and submitted to the University and the Commissioning Agent for review and approval.
- c. The building chilled water pump speed controller shall be controlled and connected to a local Building Automation System and monitored by the Building Operator.

11. Building & Plant Chilled Water Supply and Return Temperature Optimization

- a. Central Plant efficiency is heavily influenced by the supply and return water temperatures, to and from the building. If buildings are over pumping, the central plant must operate additional pumps, chillers and cooling towers, increasing purchased electrical costs by more than \$100/hour for a 2000-ton chiller.
 - 1) Supply water temperature will be as required to satisfy the building, considering space temperatures and dehumidification needs.
 - 2) Return water temperature will be a function of plate and frame heat exchange and cooling coil performance.
 - 3) Cooling capacity of the chilled water is often underutilized, over pumping occurs and low return temperatures result.
 - 4) As a general guideline, return temperatures less than 54°F in the summer and 50°F in the winter are an indication that building

cooling system is underperforming and lowering central plant efficiency.

- b. Short term over pumping may be required to meet building loads, but should be addressed promptly.
 - d. Monitor and alarm supply and return temperatures, notifying operations of potential malfunctions, and permitting investigations and remedial actions.
 - e. Metering and billing procedure shall address the cost of over pumping.
12. South Campus Standby Chilled Water Signaling
- a. With 5000 tons of standby chilled water production available at the South Campus plant, it is necessary for connected facilities to shed load in the event of standby chilled water production. As of this revision of this document, 4,000 Tons are allocated to the Cancer and Critical Care Tower (CCCT) and 1,000 Tons are allocated to Ross Heart Hospital.
 - b. Upon a full power failure, the Chiller Plant will initiate the standby chilled water production sequence. The plant operators will confirm the plant is in fact under standby chilled water production and initiate the standby chilled water production signal. This manual intervention is intended to prevent nuisance interruptions for the chilled water clients. Upon a return of utility power, Utilities High Voltage Services will de-energize the standby generators and the plant operators will disable the standby chilled water production sequence and control signal.
 - c. The South Chiller Plant PCS shall generate a 120 VAC signal. The Wexner Medical Center Campus has a relay located in the CCCT medium voltage room on the 1st Floor. Multiple normally open dry contacts are provided for the Building Automation System to pick up and initiate the appropriate actions at their respective facilities. A second set of cables are located in a junction box near the chilled water distribution valves for the 12th Avenue tunnel for future connections. Buildings connected to this section of the distribution will be required to extend this cabling, install a utilities approved relay in an approved location.
 - d. Upon closing of the contacts, the standby sequence shall be initiated. All buildings other than those designated to receive standby chilled water shall stop all secondary pumps and close all building isolation valves. Upon opening of the contacts, the connected buildings shall begin their own start-up sequence for chilled water usage.

C. Test, Adjust, and Balance (TAB)

1. TAB Contractor's Requirements

- a. Work under contract and management of the Engineer of Record or the Commissioning Agent.
- b. Act and perform as an extension of the commissioning program in form and in intent.
- c. Act in the best interests of the University.
- d. Be unaffiliated, directly or indirectly, with any contractor on this project.
- e. Provide test results and recommendations for any corrections needed.
- f. The TAB Contractor must be certified by:
 - 1) American Air Balance Council (AABC),
 - 2) National Environmental Balancing Bureau, Inc. (NEBB).

Qualified in the disciplines specific to the project applications and needs, and able to make recommendations for balancing of air and water systems.

2. Balancing Devices

The design shall provide balancing valves for each parallel flow device and all other devices that requires a water flow balance.

3. Required TAB Preparation

Before balancing, complete the following:

- a. The hydronic systems shall be circulated and shall be determined to be internally clean and leak-free.
- b. The hydronic system contractor shall remove the startup strainer and install a clean permanent strainer.
- c. Remove air from all high points in the system and at all coils.

- d. Verify system static pressure 10 psi or greater at the highest point in the system.
- e. Set system differential pressure to lowest level with all devices open and with adequate flow to the most restricted portion of the system.

4. Reporting

- a. Interim balance reports (orally and in written format) may be required anytime during the course of testing.
- b. Provide three copies of the final balance report indicating:
 - 1) Pump curves with operational points plotted.
 - 2) Specified and actual performance.
 - 3) Verification of equipment performance.
 - 4) Investigation (within the capabilities of a TAB contractor) with recommendations for any variation from specified conditions.

D. Commissioning

- 1. Definition by ASHRAE as a systematic process of ensuring that systems are designed, installed, functionally tested, and capable of being operated and maintained to perform in conformity with the design intent.
- 2. Building commissioning shall be provided:
 - a) to ensure that the building chilled water systems are designed and function in accordance with this Basis of Design
 - b) Initial filling of the building system shall be metered to obtain a total building system chilled water volume. Document and submit this total water volume to the project's Commissioning Agent.
 - c) by an independent third party hired by the University.

E. Responsibility Matrix

1. Responsibility for the various design, startup and maintenance activities associated with the equipment described in this document is a shared responsibility among business units at OSU.
2. Refer to Figure 4 at the end of this document for a matrix of responsibilities.

Figure 1

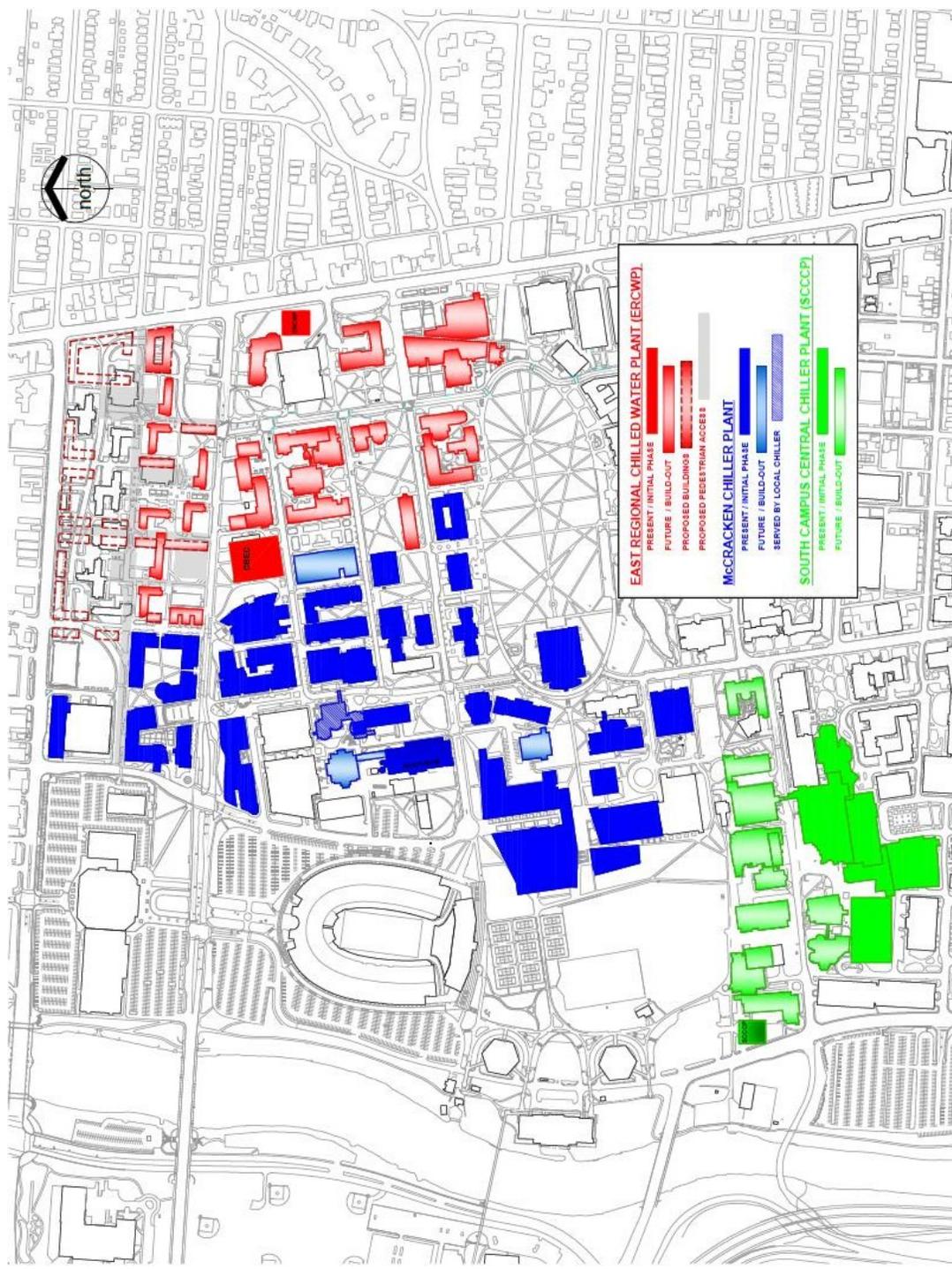
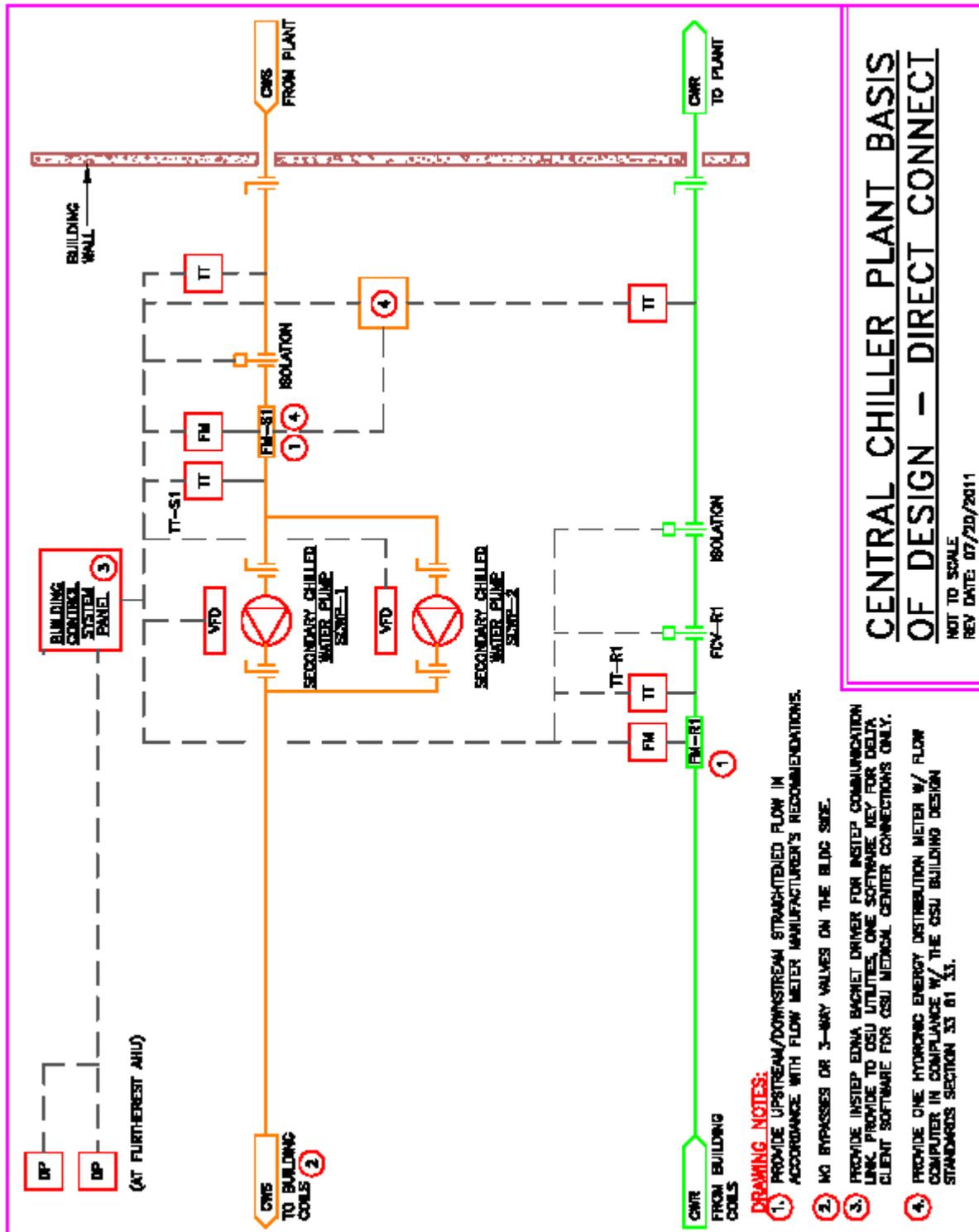


Figure 2



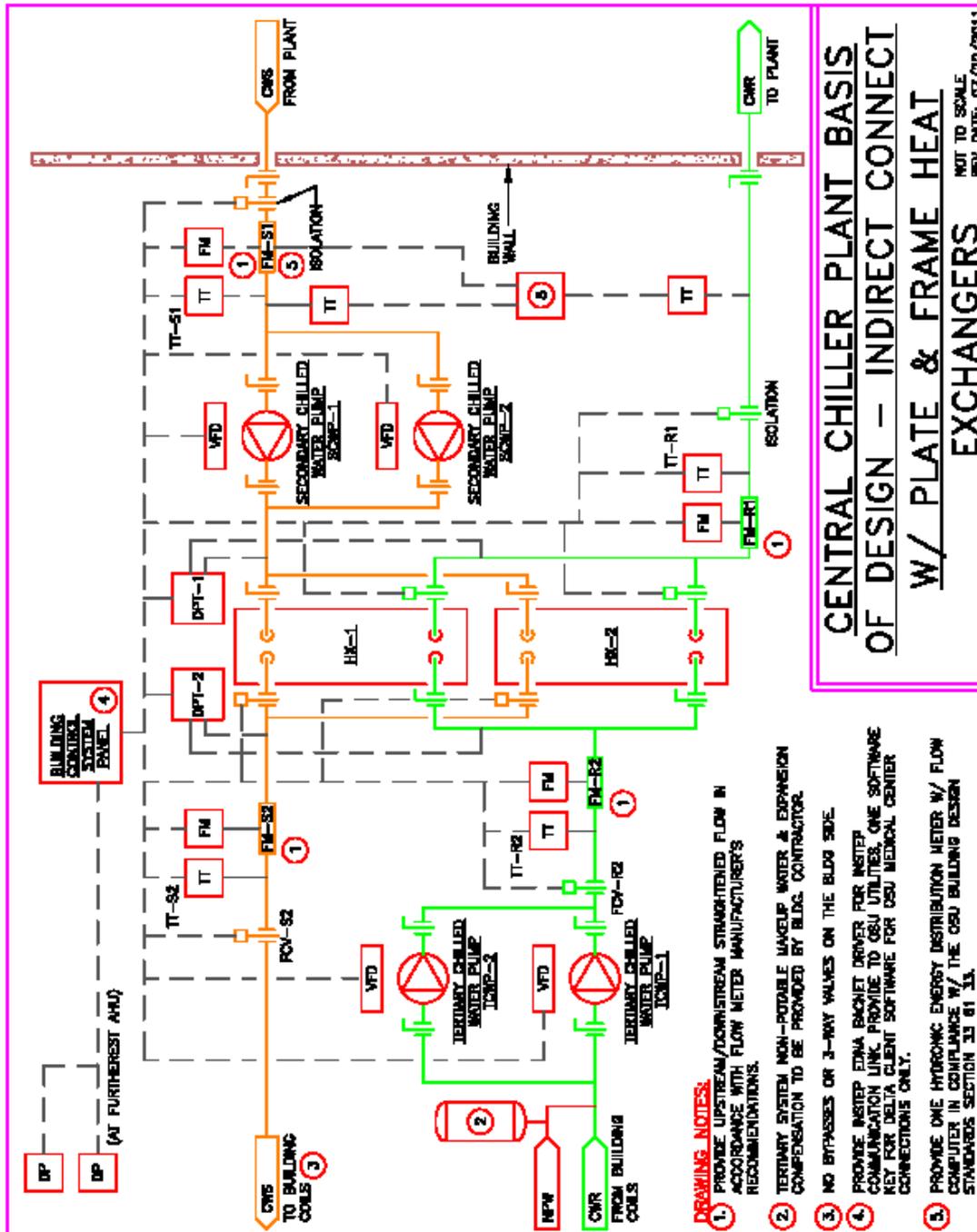


Figure 4

CHILLED WATER SYSTEM RESPONSIBILITY MATRIX

ITEM	FOD Utilities	FOD ESS	Building Operator	FOD FDC
Central or Regional Plant Chillers Operation and Maintenance	P			
Central or Regional Plant Cooling Tower Operation and Maintenance	P			
Central or Regional Chilled Water Loop Water Treatment	P			
Central or Regional Plant Tower Water Treatment	P			
Central or Regional Plant Chilled Water System Distribution Piping to Building Shutoff Valve	P			
Loop Chilled Water Supply Temperature Control	P			
Central or Regional Plant Internal Flow Meters	P			
Distribution chilled water piping fill and flush at startup	A		A	P
Building chilled water metering and billing		P		
Direct Connect Secondary Chilled Water Pumps and strainers			P	
Direct Connect Secondary Chilled Water Pumps and Flow Controls			P	
Direct Connect Process Load Control and Sequence			P	
Direct Connect Building Piping after Shutoff Valve			P	
Indirect Connect Secondary Chilled Water Pumps and Strainers			P	
Indirect Connect Secondary Chilled Water Pumps and Flow Controls			P	
Indirect Connect Plate and Frame Heat Exchanger			P	
Indirect Connect Tertiary (Building) Makeup Water			P	
Indirect Connect Tertiary Chilled Water Pumps and Strainers			P	
Indirect Connect Tertiary Chilled Water Pumps and Flow Controls			P	
Indirect Connect – Water Treatment on Building Side of Plate and Frame Heat Exchanger			P	
Building Chilled Water Cooling Coils			P	
Building piping fill and flush at building startup	A		A	P
Building Return Temperature Optimization	A		P	
Design and commission chilled water load shedding (where supplied)	A		A	P
Building Emergency Isolation Valves (where supplied)			P	
Leak Detection (where supplied)			P	

KEY:
P - Prime Responsibility
A - Assist
FOD - Facilities Operations and Development;
ESS - Energy Services and Sustainability
FDC - Facilities Design and Construction
Building Operator - group having responsibility for operation and maintenance of building systems