ENWAVE COOLING DESIGN GUIDELINES

Introduction

The following is a detailed description of design guidelines to be incorporated into the Energy Transfer Station, new building, or retrofit design. Enwave's engineering team is available at any time to review any of the items below in further detail.

Chilled Water Connection Schematic

The attached schematic shows the components of a typical Enwave Chilled Water Energy Transfer Station ('ETS') and associated equipment. Equipment shown in grey in the schematic is to be supplied be Enwave. All Enwave installed components shall be readily accessible (ie. less than 7 ft A.F.F or via access platforms if required). The notes below are contained within the schematic:

A. Pressure transducers (*supplied by Enwave*) are to be installed on the E-CHWS and E-CHWR lines at the same elevation, to be used by Enwave for manual differential pressure calculations. The sensor on the E-CHWR line is to have an additional normally closed port upstream of the control valve as shown.

B. Temperature Sensors (*supplied by Enwave*) are to be installed on the E-CHWS, E-CHWR, C-CHWS, and C-CHWR lines as shown in the schematic and wired back to the Enwave Panel. The temperature sensor on the E-CHWR line shall be installed as close to the HX(s) as possible, on the HX header.

C. The electro-magnetic flow meter (*supplied by Enwave*) shall be installed with straight pipe lengths 5 to 10 pipe diameters upstream and 2 pipe diameters downstream to ensure accurate readings. No valves are to be installed immediately upstream or downstream of the flow meter.

D. Ports to be provided on all inlet and outlet connections to heat exchangers to facilitate future draining and/or cleaning in place. Ports shall be a minimum of 1" and a maximum of 2" depending on the inlet/outlet sizes.

E. Provide automatic air vents at high points in the system

F. The number of heat exchangers installed to be dependent upon the capacity and redundancy requirements of the Customer. A single heat exchanger typically ranges from 400 Tr to 1000 Tr of capacity depending on the height constraints of the space in which they are being installed.

G. Enwave control valve setup consists of the following

a. Full port ball valve (*supplied by Enwave*) serves as the main control valve ('CV'). For larger service installations (typically over 14"), two (2) CVs may be installed in parallel to facilitate better control under low flow condition by staging the valves.

b. A full size bypass line is provided to provide a means of providing flow in the event that the control valve is out of service.

c. A minimum flow bypass is provided to ensure flow through the heat exchangers at all times. This ensures acceptable water chemistry is maintained within the system and allows for proper control feedback when the CV is closed. The bypass shall be a minimum of 2".

H. Customer side pumps shall operate under variable speed control maintaining C-CHWS to C-CHWR pressure differential. Number of pumps shall be determined based on the Customer's requirements.

I. Outputs (including pulse ton-hr outputs) can be provided to the Customer as required from the Enwave Panel. Requirements to be coordinated with Enwave.

J. A 120V power supply is to be provided for the Enwave panel on emergency power (if available) and a separate circuit. Communications are to be provided via a CAT6 cable from the Bell cage in the buildings POP room.

Pipework, Valves and Insulation

Detailed specifications are available from Enwave's engineering team.

Heat Exchangers

The heat exchanger(s) ('HX(s)') shall be plate and frame, 304 stainless steel plates with EPDM gaskets. Detailed specifications are available from Enwave's engineering team.

<u>Enwave (Cold) Side</u>

The design (HX selection) temperatures of the Enwave (Cold) side of the HX(s) are nominally 40°F EWT and 56°F LWT. Enwave district cooling loop temperatures vary seasonally as follows:

- Summer (May – September); Typically 38.0°F - 40.0°F, to a maximum of 41.5°F
- Winter (October – April); Typically 38.0°F – 42.0°F, to a maximum of 44.0°F

The lowest chilled water temperatures are typically delivered on business days during typical office hours. If the building load profile is such that peaks could be expected

during evenings or weekends (i.e. retail, hotels, etc), then the specific design conditions for this application should be reviewed with Enwave's engineering team.

Customer (Hot) Side

The design temperatures on the Customer (Hot) side of the HX(s) shall be dependent on the specific design of the building. HX(s) shall be selected with an LMTD = 2.0°F.

Optimal primary loop building design day temperatures are:
- CHWS = 44.0°F
- CHWR = 60.0°F or greater
- Delta T = 16.0°F or greater

Note: The final HX selections shall be reviewed with Enwave's engineering team.

Cooling Coil Selections

It is recommended that cooling coil selections are based on a 16 °F delta T (EWT to LWT differential) to facilitate the primary loop C-CHWR temperatures in line with Enwave's requirements. It is especially important to maximize the delta T on larger loads (ie. main AHUs). This can also be accomplished through cascading systems with the resulting delta T of 16.0°F.

Enwave and Customer Side Flow Control

Maximizing Enwave's chilled water return ('E-CHWR') temperature is critical to the success of the Deep Lake Water Cooling ('DLWC') system; therefore it is of the utmost importance that E-CHWR temperatures are maximized under all load conditions (ie. winter/summer, day/night). Maximizing the building's CHWR temperature ensures the renewable resource (ie. DLWC) is maximized as well. To achieve this, both the Enwave and Customer chilled water flow rates must be varied in proportion to the load. Maximizing the buildings delta T will also benefit the building by minimizing the energy use of the pumps.

Enwave Return Temperature Maximization Control

The Enwave supplied controller operates based on the following control narrative.
The CV is controlled based on two (2) inputs:
- E-CHWR Temperature
- C-CHWS Temperature

The CV will modulate to control to the C-CHWS temperature at setpoint. If the E-CHWR temperature drops below the minimum threshold, typically 56.0°F, the control valve will modulate to maintain the E-CHWR at this setpoint. The CV will revert back to controlling

to the C-CHWS temperature setpoint when the C-CHWS temperature reading is less than the setpoint.

A Customer side CHWS re-set schedule shall be developed to facilitate higher CHWR temperatures during the shoulder and winter periods (see below). The seasonal chilled water temperature requirements will ultimately be incorporated into the Supplier/ Customer Agreement, and will require coordination between Enwave and the Customer. Below is a sample table of seasonal set points for discussion purposes. The seasonal definitions and C-CHWS set points will be dependent upon the specific requirements of the building. The specific Temperature Schedule shall be developed by the Customer's engineers and communicated to Enwave, when available, for discussion.

Table 1: Sample C-CHWS & E-CHWR Temperature Schedule

Season	Outdoor Air Temperature (°F)	Ts (C-CHWS) Setpoint	Tr (E-CHWR) Minimum
Summer	TBD	44.0	56.0
Shoulder	TBD	46.0	56.0
Winter	TBD	50.0	56.0

Customer Side Flow Control

The Customer chilled water flow shall be modulated by varying the pump speed in response to the chilled water supply and return pressure differential. In selecting pumps, consideration should be given to low load (ie. minimum flow) conditions to ensure the pumps can adequately ramp down without the need for bypass.

For the flow to vary appropriately with the load, greater than 90% of the building load needs to be controlled through two-way modulating control valves. Two-way solenoid valves (ie. ON-OFF valves), three-way control valves, or coils without control valves must be reduced as much is practical to ensure the flow varies proportionate to the load and maximizes the building's delta T. If this is not achievable, other technical solutions should be reviewed with Enwave's engineering team to ensure a "healthy" building delta T is realized.

In existing buildings, a review of the Customer's chilled water system shall be conducted to identify opportunities to eliminate constant flow elements in the system.

Other Considerations:

- Secondary and tertiary loops shall utilize two-way modulating valves for injection as opposed to three-way valves. If separated by pressure break heat

exchangers, these shall be selected with LMTDs between 2.0°F and 2.5°F to facilitate maximum primary loop CHWR temperatures.

- Bypasses between CHWS & R shall be eliminated. Pressure differential bypass valves shall be appropriately set to ensure they are rarely operated.
- Computer room air conditioning units shall be selected without internal 3-way valves
- Tenant or IT condenser water systems can be integrated with the Enwave system. Preferential rates can be offered for these systems. This can be delivered through a separate HX or through a cascading loop within the Customer's building. Condenser water service requirements shall be reviewed with Enwave's engineering team if required.