1. DEFINITIONS

A. BTU - The amount of Heat (“Q”) to change One Pound of Water 1F

A Gallon of Water at 70F (room temperature) is 8.33 Pounds
A Pint is a Pound the World Around
A Pint of Water is 1.04 Pounds
$Q = M * C * \Delta T$ (Mass * Specific Heat * Temperature Differential)

B. BTUH – Hourly Rate of change in Mass Heat

$BTUH = 1.085 * CFM * \Delta T$ (Air Heat Transfer)

$BTUH = 500 * GPM * \Delta T$ (Water Heat Transfer)

C. MBH – 1,000 BTUH

Also Equal to KBTUH (Metric - Kilo)
“M” is Roman Numeral for 1,000

D. Ton – 12,000 BTUH

Capacity of Heat Removal at a Rate of Time
From Early days of Refrigeration.
Hourly Rate of Latent Heat to Melt (1) Ton of Ice in 24 Hours
(144 BTU/LB) * (2,000 LB) / (24 Hours) = 12,000 BTUH
$Ton = GPM * \Delta T / 24$

2. CHILLER PLANT DESIGN CONSIDERATIONS

A. Chiller Plant Range in type, size and complexity. Samples to follow.

B. Size of Plant is determined by necessary load; Process or HVAC

C. Complexity is partially dependent upon:

Load Variation; Peak, Normal, Minimum

- Multiple Chillers of Various Size
- ARI Chiller IPLV – Integrated Part Load Value (EER or COP at % Load)
  - ILPV = (0.01)(100%) + (0.42)(75%) + (0.45)(50%) + (0.12)(25%)
- VFD Chiller or Dual Compressor Chiller

Chiller & Pump Redundancy

Future Plant Expansion / Growth

D. Design Chilled Water Temperatures:

Higher CWS Temperature improves Plant Efficiency

CWR Temperature should be lower than AHU Coil Leaving Air Temper

E. Design Flow ΔT Parameters:

10F ΔT	45F CWS – 55F CWR	2.4 GPM / Ton
12F ΔT	44F CWS – 56F CWR	2.0 GPM / Ton
14F ΔT	42F CWS – 56F CWR	1.71 GPM / Ton
16F ΔT	40F CWS – 56F CWR	1.5 GPM / Ton

3. CHILLER PLANT SAMPLES

A. Single Chiller – HVAC
   Constant Flow

B. Multiple Chillers / Buildings - HVAC
   Tertiary Pumps

C. Multiple Chillers - Process - 1

D. Multiple Chillers - Process - 2

E. Multiple Chillers – Process

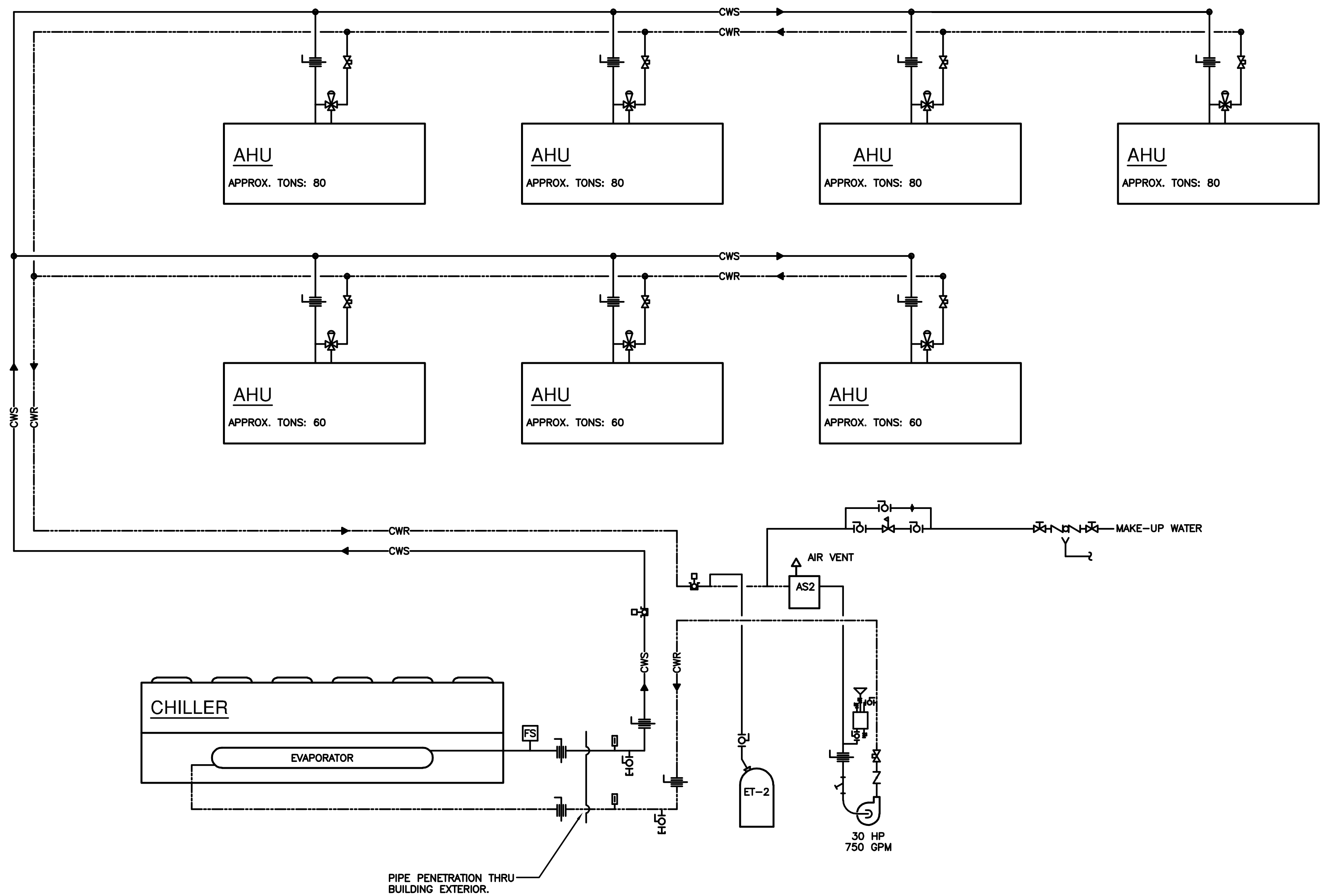
F. Single Chiller Constant Flow Discussion Diagram

G. Single Chiller Constant Primary / Variable Secondary Flow Discussion Diagram

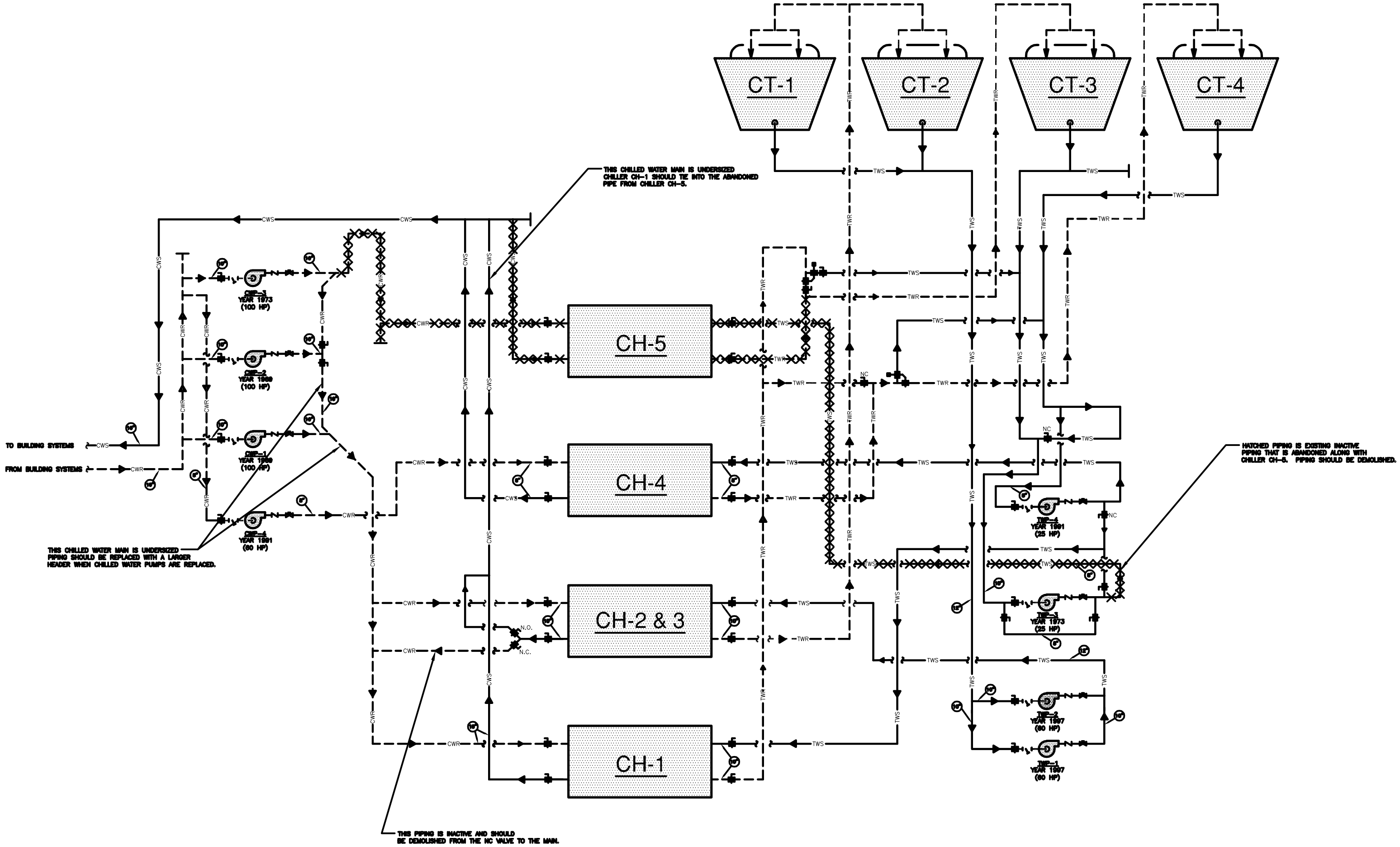
H. Multiple Chiller Constant Primary / Variable Secondary Flow Discussion Diagram

I. Three – Way Control Valve Application

J. Two – Way Control Valve Application



SINGLE CHILLER - HVAC
CONSTANT FLOW
NOT TO SCALE



EXISTING CONDITIONS 2010

CHILLER PLANT SCHEMATIC

NO SCALE

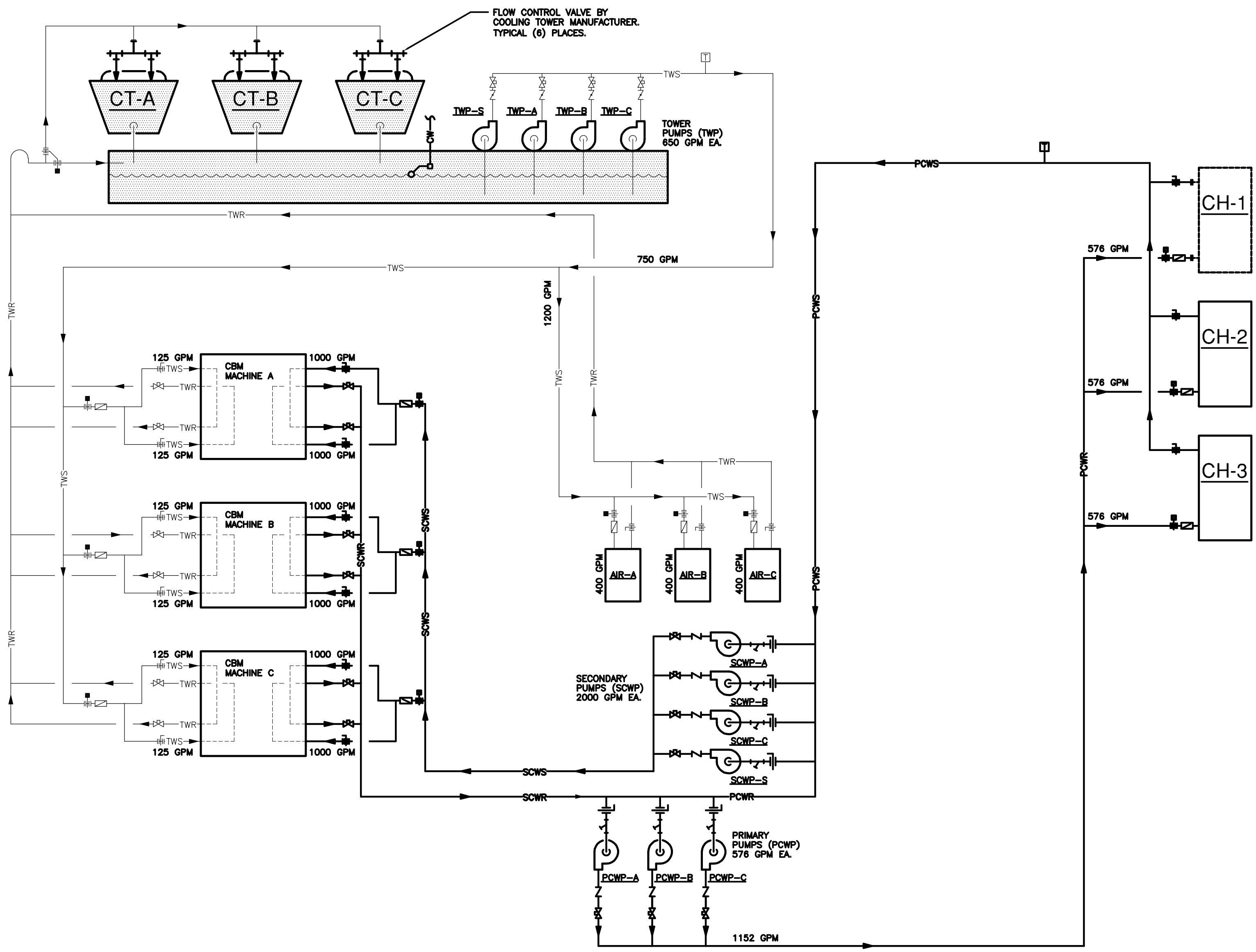
PLANT DESCRIPTION

* (4) NOMINAL 400 TON CHILLERS
* (4) NOMINAL 400 TON COOLING TOWERS
* 1600 NOMINAL PLANT CAPACITY

MULTIPLE CHILLERS / BUILDINGS - HVAC

TERIARY PUMPS

NOT TO SCALE

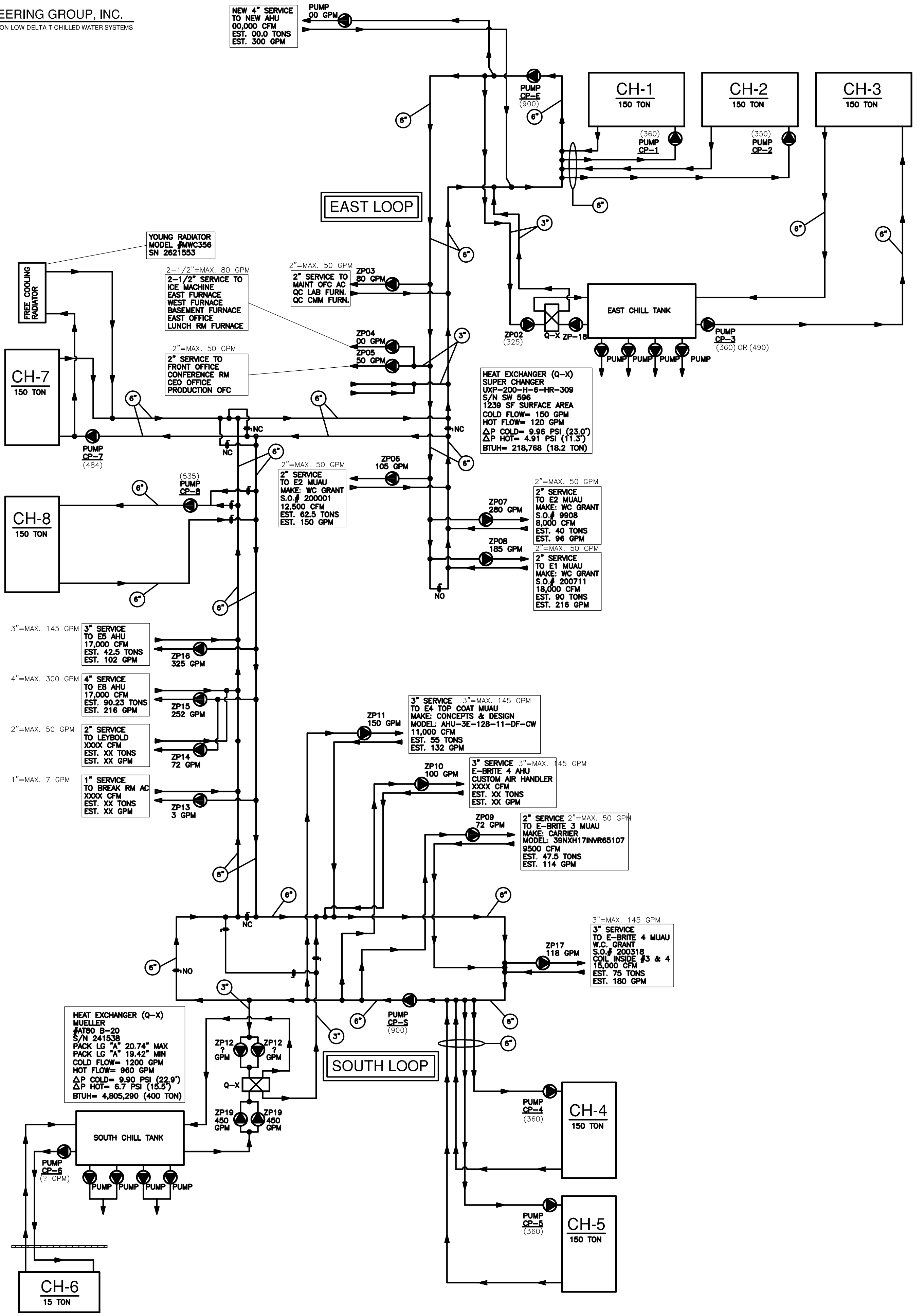


MULTIPLE CHILLERS - PROCESS - 1

NOT TO SCALE

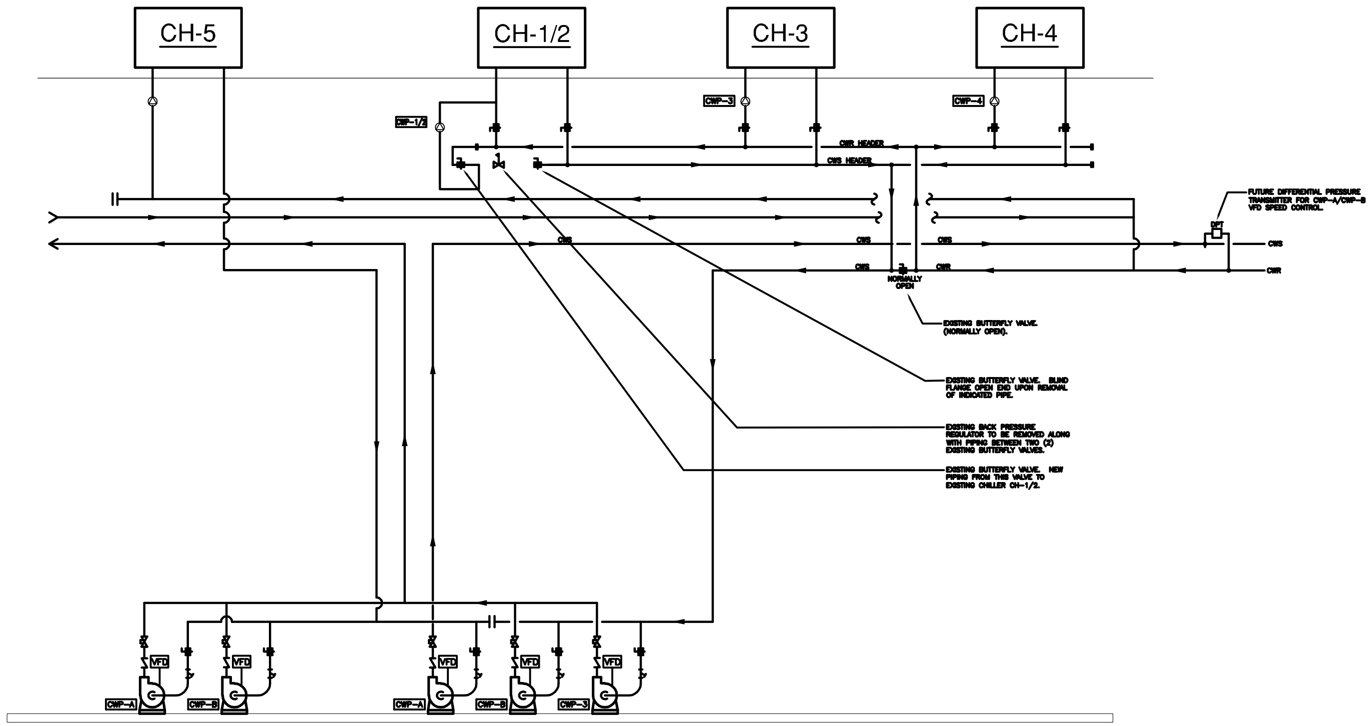
HEI ENGINEERING GROUP, INC.

AEE PRESENTATION ON LOW DELTA T CHILLED WATER SYSTEMS



MULTIPLE CHILLERS - PROCESS - 2

NOT TO SCALE



MULTIPLE CHILLERS - PROCESS

NOT TO SCALE

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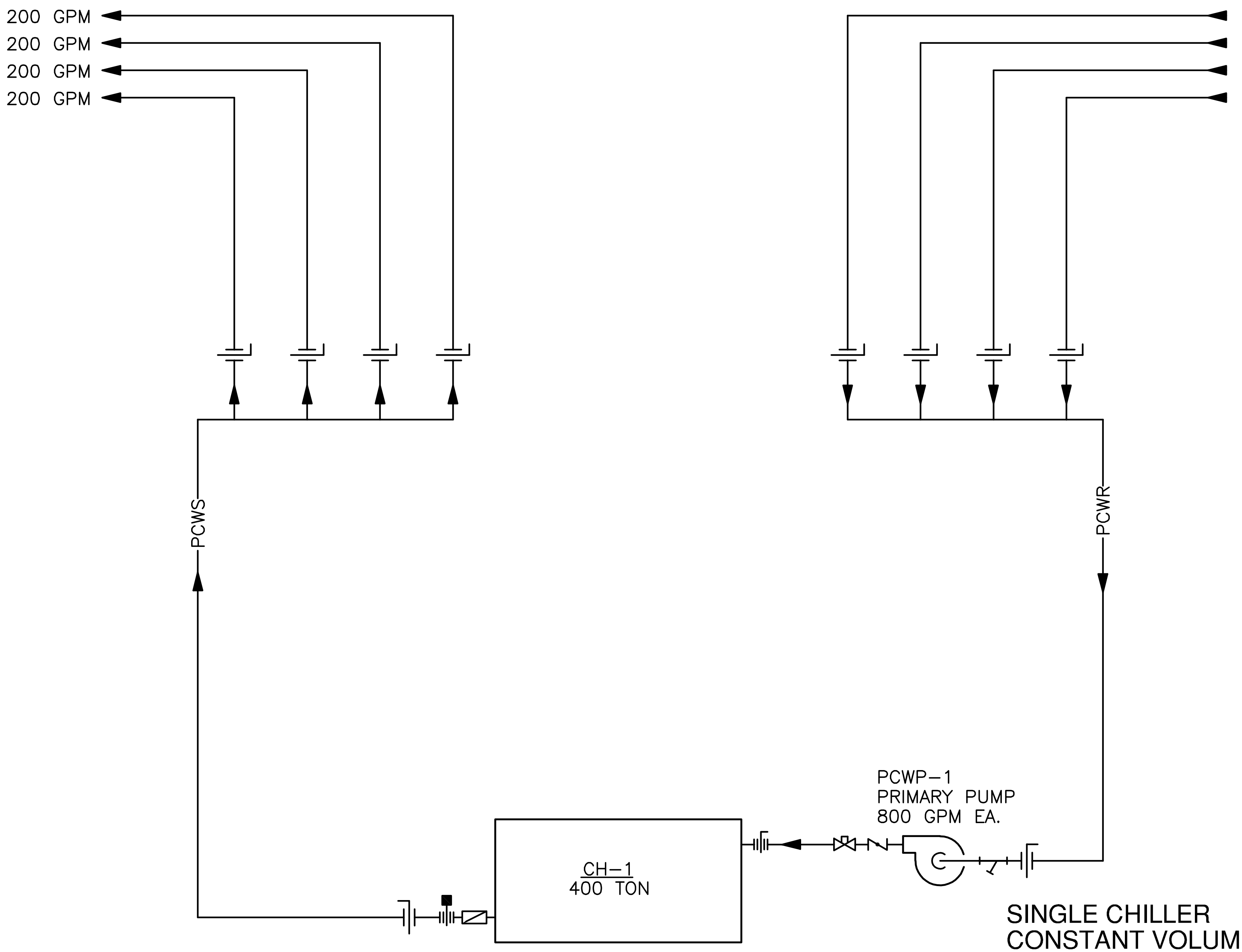
AEE PRESENTATION ON LOW DELTA T CHILLED WATER SYSTEMS



SINGLE CHILLER
CONSTANT VOLUME PUMPING

NOT TO SCALE

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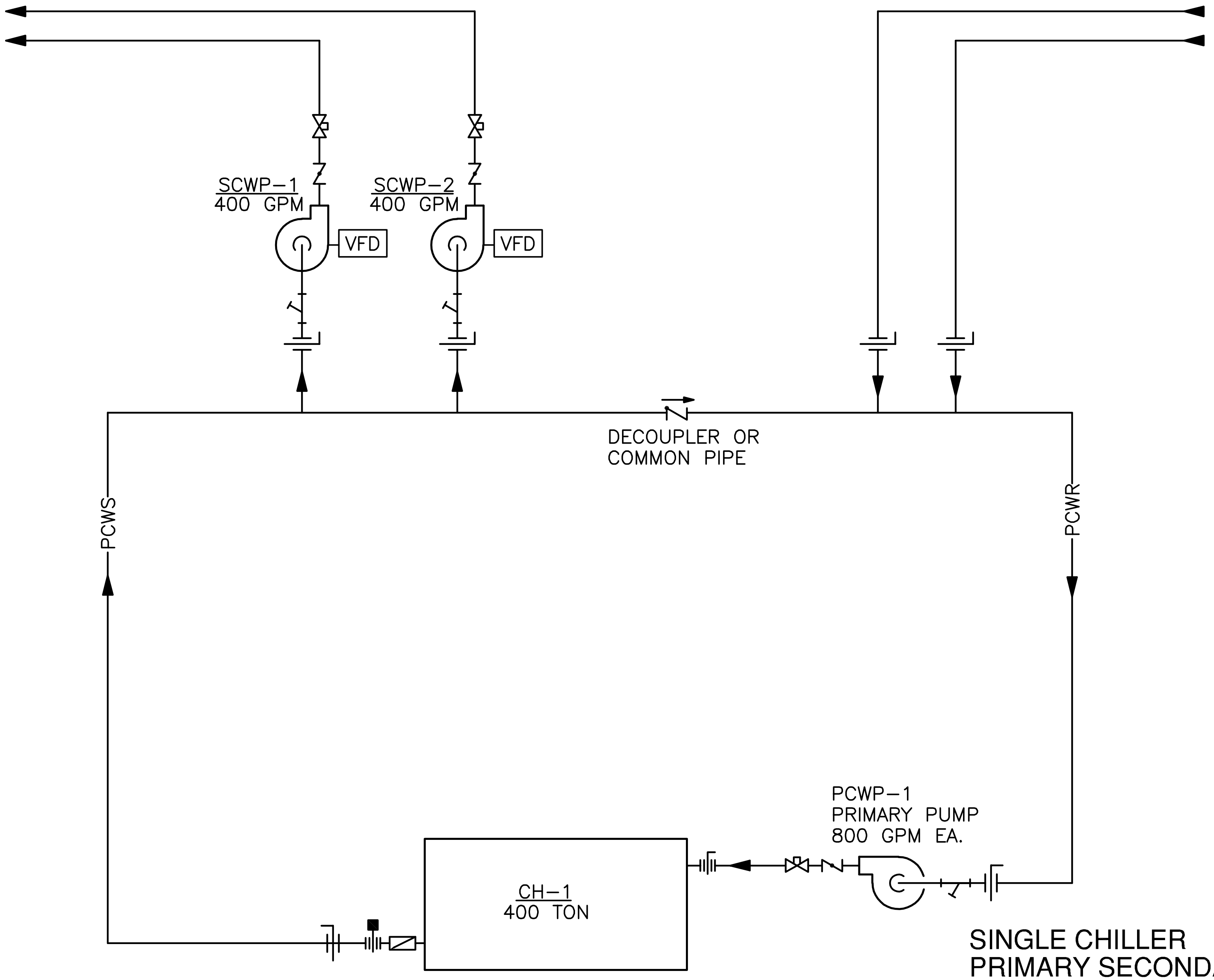
AEE PRESENTATION ON LOW DELTA T CHILLED WATER SYSTEMS



SINGLE CHILLER
PRIMARY SECONDARY PUMPING

NOT TO SCALE

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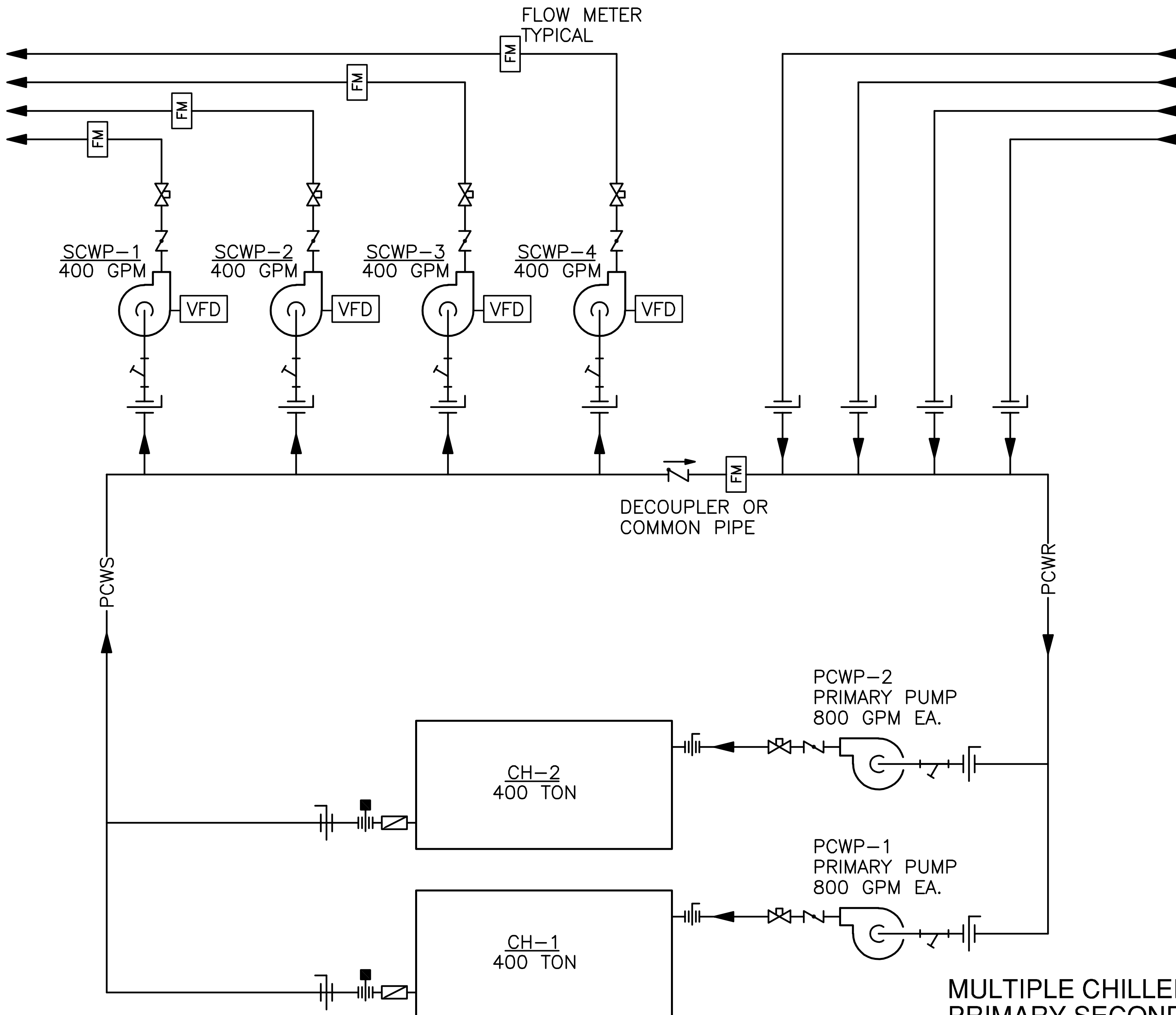
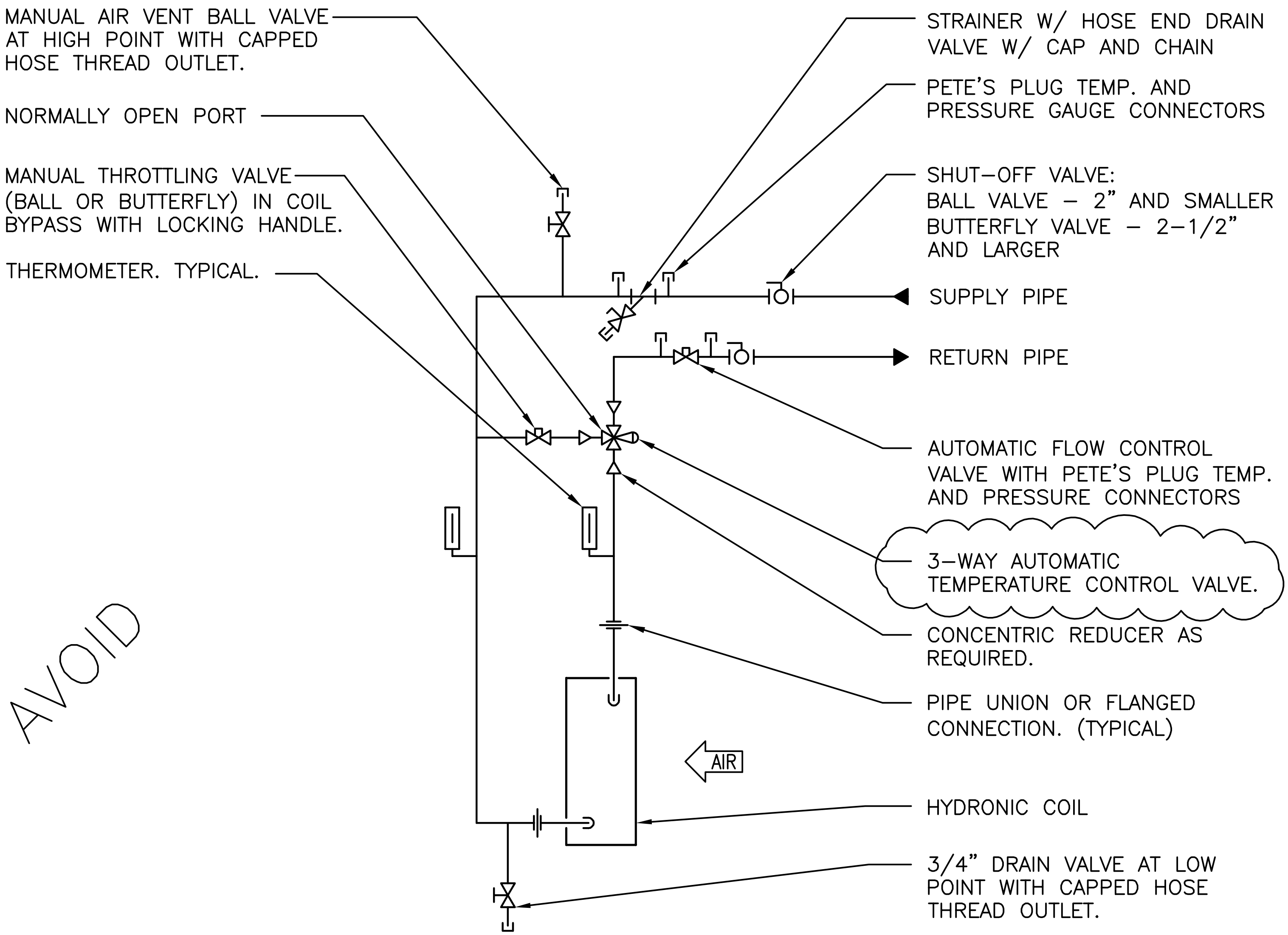
AEE PRESENTATION ON LOW DELTA T CHILLED WATER SYSTEMS



MULTIPLE CHILLER PRIMARY SECONDARY PUMPING

NOT TO SCALE

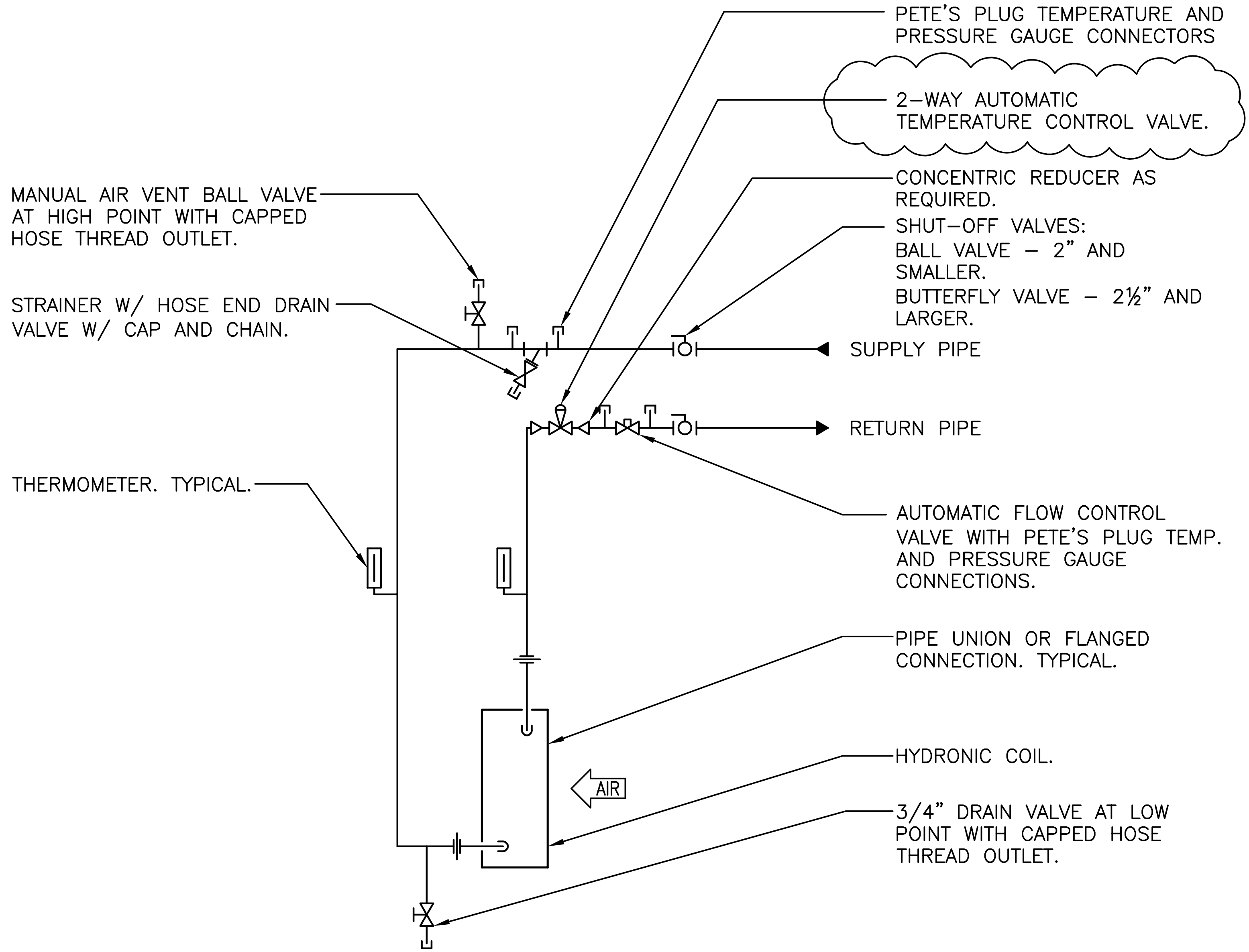


CHILLED WATER COIL PIPING THREE WAY CONTROL VALVES

NOT TO SCALE

HEI ENGINEERING GROUP, INC.

AEE PRESENTATION ON LOW DELTA T CHILLED WATER SYSTEMS



CHILLED WATER COIL PIPING TWO WAY CONTROL VALVES

NOT TO SCALE

4. LOW ΔT; What is it??

LOW ΔT is a Discrepancy between System Flow (GPM) and Temperature Difference

LOW ΔT can be caused by Design & Installation Issues
- System Layout
- Coil Piping
- Coil Selection
- Control Valve Type & Selection
- Balance Valves
- Lack of Control Valves
- Control Valve Operational when AHU Not

LOW ΔT can be caused Plant Operation & Maintenance Issues
- Modified System Operating Parameters
  - CWS Temperature
  - AHU Supply Air Temperature
- Coil Cleaning
- Control Valve Type & Selection

LOW ΔT can be caused Normal System Aging Issues
- Heat Transfer Material Degradation

LOW ΔT can be caused Normal System Operation
- Low System Load
- Air Side Economizer

<u>5.</u> LOW ΔT; Why is it Bad??

Energy is Wasted from Reduced Chiller Capacity

500 Ton Chiller at 12F ΔT = 1000 GPM Fixed

If CWR is lower and there is only 10F ΔT Than Chiller Capacity is reduced to

Tons = 500 * 1000 GPM * 10F ΔT / 12,000 = 416.6 Tons (83%)

This reduced capacity causes more chillers to run; more pumps to operate.

Typical Chillers are less efficient at part load operation. Higher Energy Consumption.

Pump Energy is a Cube Function of Flow which can be dramatic in Large Systems.

Higher Energy Consumption = Higher Operating Cost

Greater Run Time on Chillers = Reduced Service Life

Frequent Start / Stop of Chillers = Reduced Service Life

<u>6.</u> LOW ΔT; How Can it Be Avoided / Mitigated??

Design using Chillers that adapt to part load conditions
- Variable Speed Chillers / Dual Compressor Chillers
- Multiple Sized Chillers to adapt to range
- Consider Variable Primary Flow within range of Chiller

Design Primary Loop at Lower ΔT (Higher Flow) than Secondary Loop

Stage Chillers based upon Load Rather than Flow

Eliminate Sources of Chilled Water Bypass
- Close Balance Valve in 3-Way Control Valves on Variable Flow Systems
- Isolate Non-Operating Equipment
- Add Check Valves in Decoupler Loops

Check for Proper Coil Piping (Counter Flow Arrangement)

Add Control Valves or at Least Isolation Valves on Process Loads

Add Automatic Flow Control Valves

Raise CWS Temperature as High as Possible

Clean & Flush Heat Transfer Devices

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