CHAPTER/REGIONAL TECHNOLOGY AWARD - SHORT FORM

1. **Category (Check one and indicate New or Existing, if applicable)**

- ○ Commercial Buildings — ○ New or ○ Existing
- Institutional Buildings:
  - ○ Educational Facilities — ○ New or ○ Existing
  - ○ Other Institutional — ○ New or ○ Existing
- ● Health Care Facilities — ○ New or ● Existing
- ○ Industrial Facilities or Processes — ○ New or ○ Existing
- ○ Public Assembly — ○ New or ○ Existing
- ○ Residential (Single and Multi-Family)

2. **Name of building or project:** Saint Joseph's Regional Medical Center

City/State: Plymouth, IN

3. **Project Description:** Surgical Suite HVAC System Renovation

Project Study/Design Period: January 1, 2015 (Begin date (mm/yyyy)) to July 31, 2015 (End date (mm/yyyy))

Percent Occupancy at time of submission: 100%

4. **Entrant (ASHRAE member with significant role in project):**

a. Name: Wilson (Last) Laurence (First) V. (Middle)

Membership Number: 2015263

Chapter: Chicago

Region: VI

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c. Telephone: (O) (312) 374-9219 d. Email: lwilson@pepractice.com

e. Member's Role in Project: Principal-in-Charge

f. Member's Signature: Laurence V. Wilson

5. **Engineer of Record:** Laurence V. Wilson, P.E. and Robert D. Benzuly, P.E.

By affixing my signature above, I certify that the information contained in this application is accurate to the best of my knowledge. In addition, I certify that I have discussed this entry with the owner and have received permission from the owner to submit this project to the ASHRAE Technology Awards Competition.

SAINT JOSEPH REGIONAL MEDICAL CENTER
PLYMOUTH CAMPUS
SURGICAL SUITE HVAC SYSTEM RENOVATION

Introduction

This renovation project focused on the HVAC system serving the Plymouth Hospital surgical suite. The 7,270 square foot suite was part of a 2001-2002 project that involved the construction of a two story addition to the existing hospital and included the following spaces:

Pre-Op Area
Four (4) Class C Operating Rooms located along the perimeter of the building
Post Anesthesia Care Unit (4 open bays and 2 enclosed rooms)
Surgical Waiting Room and a number of other support spaces

Statement of the Problem

Occupants in the Surgical Suite voiced complaints regarding high relative humidity during periods that the space temperature in the OR's was driven down into the low- to- mid- 60's. The primary goal of this project was to provide an immediate solution aimed at providing comfortable working conditions in each of the four (4) operating rooms.

Basic Parameters

The outdoor design conditions were based on ASHRAE climate data as defined in the 2013 Handbook of Fundamentals:

Annual 0.4% Frequency Peak Sensible Cooling
90.6 F Dry Bulb with 74.0 F Mean Coincident Wet Bulb (hot/moderately humid weather)

Annual 0.4% Frequency Peak Dehumidification
74.5 F Dew Point with 83.0 F Mean Coincident Dry Bulb (warm/very humid weather)

The indoor design condition for operating room during the summer was defined as 62 F dry bulb with 60% relative humidity based on discussions with the Owner (indoor design conditions for all other spaces was defined as 68 F dry bulb with 60% relative humidity).

Computerized heating and cooling load calculations were prepared for each room serviced by the existing HVAC system. An outdoor air analysis of each individual space was performed. Psychrometric analysis was used to address both the space loads and the outdoor air loads, among other factors, in order to establish (1) the required discharge air condition (dry bulb and wet bulb temperatures leaving the existing air handling unit), (2) the resulting supply air flow requirements to each space, and (3) the peak load imposed on the cooling coil.

To meet the sensible cooling and dehumidification loads of both the spaces and the outdoor air, our analyses estimated that the existing HVAC system would need to provide a discharge air condition of 45.9 F dry bulb temperature/ 45.7 F wet bulb temperature instead of the originally designed discharge air condition of 47.0 F dry bulb temperature/ 46.8 F wet bulb temperature.

Innovation

The small campus has an air-cooled chilled water plant that circulates a 100% water solution with a +/- 42 F chilled water supply temperature generated at the plant and +/- 43 F delivered at the existing air handling unit (original design values). The chilled water system has previously had difficulty providing both adequate temperature and flow to the existing air handling unit serving the surgical suite. Therefore, in order to avoid the necessity of overcoming the existing chilled water system deficiencies while also needing to provide an immediate solution to the comfort problems in the OR's, it was agreed that a supplementary cooling system was to be provided to service the existing surgical suite HVAC system.

The existing air handling unit has a blow through cooling coil configuration that delivers air through common supply ductwork to the entire surgical suite, including the four (4) OR's. In order to implement an immediate solution, the Owner elected not to move forward with any solution that involved segregating the existing supply air ductwork within the penthouse, within the riser or within the ceiling plenum above the surgical suite such that sub-cooling could be provided only for the supply air delivered to each of the four (4) OR's. Instead, all the air passing through the existing air handling unit would be sub-cooled and subsequently reheated in order to simultaneously meet both the dry bulb temperature and relative humidity set-points in each OR.

Two broad categories of sub-cooling solutions were discussed: dessicant cooling and refrigerant cooling. Dessicant cooling was rejected by the Owner not only because of the significant first cost but also because the urgent nature of the problem required a more conventional solution. Several refrigerant cooling solutions were studied. The chosen solution included a roof-mounted air-cooled liquid chiller that was installed on the roof with the refrigerant evaporator (cooler) located in the adjacent fan room. Refrigerant was piped between the air-cooled liquid chiller on the roof and the cooler. This allowed the continued use of 100% water solution throughout the chilled water network (i.e. no propylene glycol/water solution and the associated fill equipment was required). In addition, the lack of chilled water piping outdoors eliminated the need for electric heat tracing on that piping. An injection circuit was proposed in order to provide the appropriate flow rate of chilled water at the appropriate temperature to the existing cooling coil. This sort of arrangement helped overcome the base building chilled water flow deficiency at the existing surgical suite air handling unit.

Further, analyses were undertaken to explore how the existing cooling coil could be reused, thereby absolutely minimizing downtime of the existing HVAC system (there was no redundancy built into the original design). The existing cooling coil was modeled electronically to match the original design parameters. Then, the proposed parameters were modeled in order to determine if the existing cooling coil would be able to meet the new discharge air condition. The result of this analysis was that the existing cooling coil would be able to provide the necessary discharge air condition with the provision of the supplemental cooling system and the injection circuit while overcoming the existing central cooling plant deficiencies.

The system upgrade was successfully implemented in a several week timeframe using a design-build delivery method. Collaborators included the Owners' team and the team of extremely capable contractors from Edward J. White, Inc.

Indoor Air Quality

The primary objective of this project was to deliver supply air cold enough and dry enough to each OR in order to achieve the desired OR temperature set-point while simultaneously limiting the relative humidity to 60%. This was achieved and, by all accounts, the occupants of the four (4) OR's were satisfied with the environmental conditions within those OR's throughout the recent hot, humid summer season.

Environmental Impact

Reduced emissions associated with consumption of electricity at the site and therefore the production of electricity at the source. No propylene glycol is necessary in order to implement this solution. Refrigerant R-410-A has zero ozone depletion potential.

Energy Efficiency

Energy efficiency was affected in that the sub-cooling required for just the surgical suite HVAC system did not require that the central cooling plant servicing the entire campus be operated to produce a 39 F chilled water supply temperature and deliver a 40 F chilled water temperature at the remote surgical suite fan room (that would have been at least 3 F cooler than the 42 F central plant was capable of producing based on the original design of the cooling plant). This would have penalized not only the central cooling plants' demand for power, but also would have resulted in excessive amounts of reheat energy across all the other non-surgical suite HVAC systems. Sub-cooling all the air passing through the surgical suite air handling unit necessitates reheating supply to non-OR spaces during some periods during the year; this is a local energy penalty associated with the surgical suite HVAC system and is the result of having to implement an immediate solution for an existing system.

The increase in reheat energy within the surgical suite was estimated to be about 500 therms per year which equates to about 190 btu/sf/year across the entire campus (at a cost of about $500 per year).

The increase in cooling energy across the campus if the base building cooling plant was operated to generate a colder chilled water supply temperature was estimated to be about 375,000 kWh per year which equates to about 5120 btu/sf/year across the entire campus (at a cost of about $37,500 per year). The increase in cooling energy within the surgical suite with the supplemental cooling system in place was estimated to be about 75,000 kWh per year which equates to about 1024 btu/sf/year across the entire campus (at a cost of about $7,500 per year). Therefore, there is a savings (i.e. a cost avoidance) of about 300,000 kWh per year (a cost savings of about $30,000 per year).

Overall, there is net savings in annual energy consumption (and annual energy cost) when considering both the natural gas and the electricity.

Results show that using a 100% water solution results in a more efficient transfer of heat.

Operation & Maintenance

The supplemental cooling system will only be operated when the base building cooling plant is unable to deliver chilled water cold enough to meet the demands of the surgical suite. The supplemental cooling system has two (2) independent refrigeration circuits providing a high level of redundancy. In addition, the chilled water injection circuit has duty and standby pumps that provide a high level of redundancy.

Cost Effectiveness

The Owner was spared significant first cost by reusing the existing surgical suite HVAC system, both the air handling unit including the cooling coil and the extensive supply and return duct distribution network. The Owner was also spared significant first cost by using a "split" air-cooled liquid chiller thereby eliminating the provision of a plate and frame heat exchanger inside the fan room, provision of electric heat traced chilled water (mixture of propylene glycol/water) piping on the roof and another set of chilled water pumps.

Key Contributors

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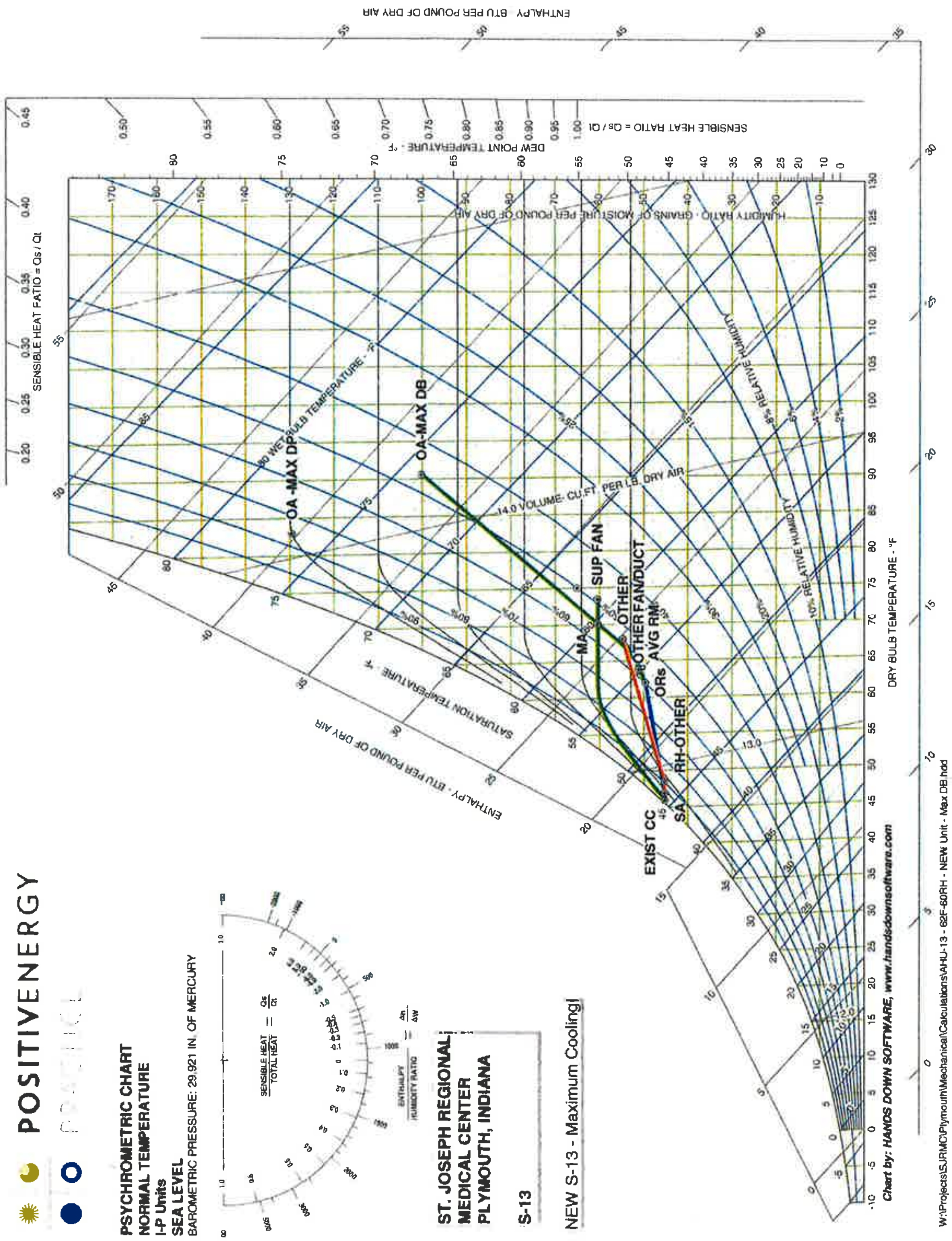


Figure 1 - Psychrometrics Using Existing Cooling Coil - Hot Weather

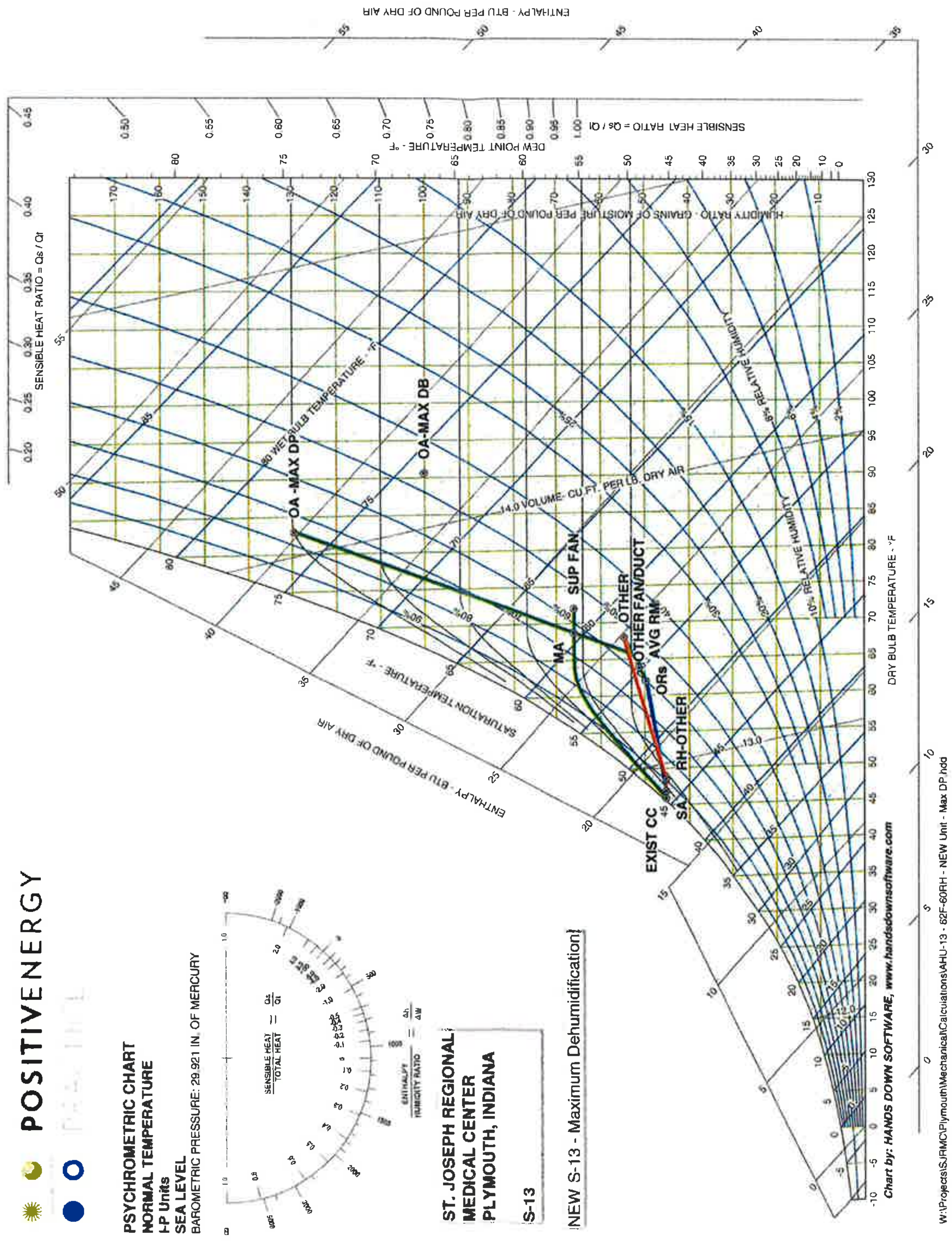
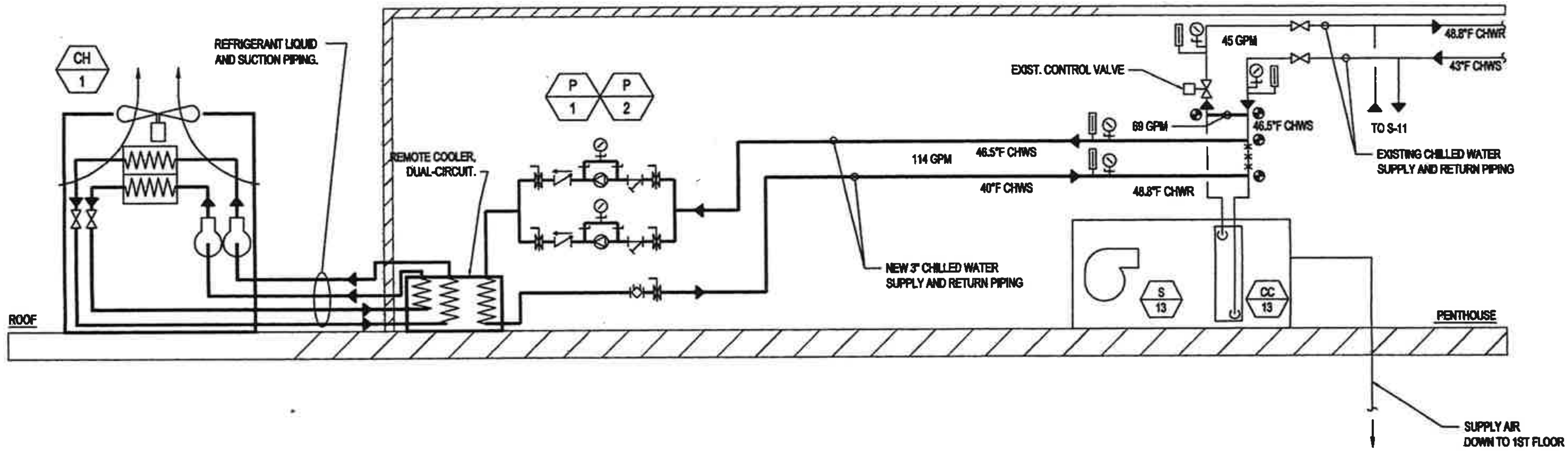


Figure 2 - Psychrometrics Using Existing Cooling Coil - Humid Weather



GENERAL NOTES

1. THIS SKETCH INDICATES DESIGN INTENT ONLY. DESIGN/BUILD CONTRACTOR TO DEVELOP ALL NEEDED DETAILS TO IMPLEMENT THIS DESIGN INTENT.
2. INTERCEPT CHWS PIPE TO AHU S-13 COOLING COIL DOWNSTREAM OF SERVICE VALVE.
3. LOCATE CHILLER CH-1 AND ITS REMOTE COOLER PER MANUFACTURER'S REQUIREMENTS.
4. REMOVAL, RELOCATION, PIPING AND WIRING OF REMOTE COOLER SHALL BE PER MANUFACTURER'S REQUIREMENTS. PROVIDE CERTIFICATION THAT MANUFACTURER'S WARRANTY REMAINS IN EFFECT AFTER RELOCATION.
5. PROVIDE REFRIGERANT LIQUID AND SUCTION COPPER PIPING. SIZE AS REQUIRED BASED ON EQUIPMENT LOCATION, PROPER OIL RETURN AND MANUFACTURER'S RECOMMENDATIONS.
6. PROVIDE SUPPORT FOR CHILLER CH-1, PIPING INSULATION, AND APPURTENANCES AS REQUIRED.

EQUIPMENT

1. CH-1 AIR-COOLED LIQUID CHILLER WITH DUAL SCROLL COMPRESSORS, DUAL REFRIGERANT R-410A CIRCUITS AND REMOTE COOLER OPTION. UNIT TO COOL 115 GPM OF CHILLED WATER FROM 46.5°F TO 40.0°F WITH 105°F AIR ENTERING CONDENSER. PROVIDE BACNET CONTROLS. CARRIER MODEL 30RAP035 OR APPROVED EQUAL. PROVIDE POWER FROM 460 VOLT, 3 PHASE, 60 HZ NORMAL POWER SOURCE.
2. P-1/P-2 120 GPM, 55 FT. W.C. HEAD, 3 HP, 3450 RPM. BELL & GOSSETT MODEL E-90, SIZE 2AAC OR APPROVED EQUAL. PROVIDE POWER FROM 460 VOLT, 3 PHASE, 60 HZ NORMAL POWER SOURCE.

TEMPERATURE CONTROLS

1. PROVIDE BACNET INTERFACE BETWEEN EXISTING BUILDING AUTOMATION SYSTEM AND CHILLER CH-1. PROVIDE START/STOP/STATUS OF EACH OF PUMPS P-1 AND P-2.
2. MODIFY EXISTING CONTROLS TO ACCOMMODATE THE FOLLOWING SEQUENCES WHEN AHU S-13 IS OPERATING.
3. ACTIVE LEAD PUMP OF P-1/P-2. PROVIDE LEAD/LAG ROTATION, ALTERNATED MONTHLY.
4. MODULATE EXISTING CONTROL VALVE TO MAINTAIN AHU S-13 DISCHARGE AIR TEMPERATURE SET POINT OF 45.5°F DRY BULB TEMPERATURE.
5. WHEN THE EXISTING CONTROL VALVE IS FULLY OPEN AND THE DISCHARGE AIR TEMPERATURE SET POINT IS NOT SATISFIED, ACTIVATE CHILLER CH-1. CHILLER CH-1 SHALL BE CONTROLLED TO PROVIDE LEAVING CHILLED WATER TEMPERATURE OF 40°F. EXISTING CONTROL VALVE SHALL REMAIN FULLY OPEN.
6. AT NO TIME SHALL CHILLER CH-1 BE ACTIVATE WHEN THE EXISTING CONTROL VALVE IS LESS THAN 50% OPEN.

LEGEND

- EXISTING TO REMAIN
- FURNISH/INSTALL NEW
- DEMOLISH
- POINT OF CONNECTION

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PLYMOUTH, IN

AHU S-13 COOLING SYSTEM MODIFICATIONS

JOB NO:	DATE:	DRAWN:	SCALE:	DRAWING NO:
714016	05/05/2015	RDB	N.T.S	MSK-001