# INPUT/OUTPUT SUMMARY FOR WATER CHILLERS CH-01, CH-02, & CH-03

| SYSTEM, APPARATUS, OR AREA POINT DESCRIPTION | INPUTS – ANALOG – MEASURED | | | | | | | INPUTS – ANALOG – CALCULATED | | | | INPUTS – BINARY | | | | | | | OUTPUTS – DIGITAL | | | | OUTPUTS – ANALOG | | | | SYSTEM FEATURES – ALARMS | | | | | | | SYSTEM FEATURES – PROGRAMS | | | | | | | | GENERAL | | | | | | | SUPPLEMENTARY NOTES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | TEMPERATURE | PRESSURE | RH | KW | AIR FLOW | LEVEL | VIBRATIONS | GPM | KWH | ENTHALPY | RUN TIME | EFFICIENCY | WET BULB TEMP | STATUS | FILTER | SMOKE | FREEZE | AIR FLOW METER | OFF-ON | OFF-AUTO-ON | OFF-HI-LO | OPEN-CLOSE | MULTI-STAGE | DAMPER POSITION | VALVE POSITION | SET POINT ADJUSTMENT | VANE POSITION | SCR CONTROL | HI ANALOG | LOW ANALOG | HI BINARY | LOW BINARY | PROOF | | TIME SCHEDULING | DEMAND LIMITING | DUTY CYCLE | START/STOP OPTION | ENTHALPY OPTION | SMOKE CNT | TREND | ALARM INSTRUCT | MAINT WK ORD | | | COLOR GRAPHIC | | | | | | |
| WATER CHILLER, CH-01 | ● | | | | | ● | | | | ● | | | | ● | | | | | ● | | | | | | | ● | | | ● | ● | | | | | ● | | | ● | | | | ● | ● | | | | | | | | | |
| WATER CHILLER, CH-02 | ● | | | | | ● | | | | ● | | | | ● | | | | | ● | | | | | | | ● | | | ● | ● | | | | | ● | | | ● | | | | ● | ● | | | | | | | | | |
| WATER CHILLER, CH-03 | ● | | | | | ● | | | | ● | | | | ● | | | | | ● | | | | | | | ● | | | ● | ● | | | | | ● | | | ● | | | | ● | ● | | | | | | | | | |
| CHILLED WATER PUMP, WP-01 | | ● | | | | ● | ● | | | ● | | | | ● | | | | | ● | | | | | | | | | | | | | ● | | | ● | | | ● | | | | | ● | | | | | | | | | |
| CHILLED WATER PUMP, WP-02 | | ● | | | | ● | ● | | | ● | | | | ● | | | | | ● | | | | | | | | | | | | | ● | | | ● | | | ● | | | | | ● | | | | | | | | | |
| CHILLED WATER PUMP, WP-03 | | ● | | | | ● | ● | | | ● | | | | ● | | | | | ● | | | | | | | | | | | | | ● | | | ● | | | ● | | | | | ● | | | | | | | | | |
| CHILLED WATER RETURN TEMP | ● | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | ● | | | | | | | | | | |
| CHILLED WATER SUPPLY TEMP | ● | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | ● | | | | | | | | | | |
| CHILLED WATER FLOW DIAGRAM | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | ● | | | | | | |
| FLOOR PLANS | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | ● | | | | | | |
| CHILLED WATER BOOSTER PUMP | | ● | | | | | | | | | | ● | | ● | | | | | ● | | | | | | | | | | | | | | | | | | | | ● | | ● | ● | | | | | | | | | PUMP BY VE CONTRACTOR |

FLOOR PLAN GRAPHICS WILL SHOW ALL EQUIPMENT LOCATION, CONTROL PANELS AND CONTROL COMPONENTS SUCH AS DAMPER, VALVES, TEMPERATURE SENSOR, PRESSURE SENSORS.... ETC.

## NOTES:

1. FOR LEGEND, ABBREVIATIONS AND GENERAL NOTES SEE SHEETS WA-H-001 AND WA-H-002.
2. SMOKE DETECTORS SHALL BE HARD WIRED TO THE SUPPLY FANS SF-01 & SF-02 MOTOR STARTER TO STOP FANS WHEN SMOKE IS DETECTED IN THE RETURN AIR STREAM. ALSO SMOKE DETECTORS WILL BE SOFTWARE CONNECTED TO DDC CONTROL PANEL AND THE FACILITY CONTROL ROOM.
3. CONTROL SYSTEM SHALL BE STAND ALONE TYPE AND CONNECTED TO THE MAIN CONTROL AND MONITORING SYSTEM AT THE FACILITY CONTROL ROOM IN THE CORNER STATION BUILDING.
4. LVEA ROOM SHALL BE PROVIDED WITH MULTIPLE TEMPERATURE SENSORS TO CONTROL THE RESPECTIVE DUCT HEATER. SYSTEM MAY AVERAGE THE READING OF THE ROOM TEMPERATURE SENSORS OR SELECT ANY SENSOR TO CONTROL THE DUCT HEATER. SEE FLOOR PLANS FOR LOCAITON AND NUMBER OF SENSORS FOR EACH ZONE.

## SEQUENCE OF OPERATION:

I. CHILLED WATER PLANT:

UPON A SIGNAL FROM THE CENTRAL CONTROL SYSTEM THE PACKAGED CONTROLS PROVIDED WITH THE WATER CHILLER WILL PERFORM THE FOLLOWING:

A. THE LEAD CHILLED WATER PUMPS (WP-01 & WP-02) WILL START TO ESTABLISH STEADY WATER FLOW THROUGH THE SYSTEM.

B. UPON PROOF OF ESTABLISHED WATER FLOW THE LEAD CHILLERS (CH-01 & CH-02) WILL START TO MAINTAIN THE LEAVING CHILLED WATER TEMPERATURE SETPIONT (42°F).

C. THE PACKAGED DDC CONTROLS ON THE WATER CHILLERS WILL CYCLE THE REFRIGERATION COMPRESSORS IN SEQUENCE TO MATCH THE SYSTEM THERMAL LOAD.

D. WHEN THE THERMAL LOAD DROPS BELOW THE MINIMUM OPERATING CAPACITY OF THE WATER CHILLER, THE PACKAGED CONTROL WILL ACTIVATE THE HOT GAS BYPASS CYCLE.

E. PACKAGED CONTROLS WILL RUN SELF DIAGNOSTICS TEST BEFORE STARTING THE REFRIGERATION COMPRESSORS TO PROVE THAT ALL OPERATING CONDITIONS ARE WITHIN THE NORMAL LIMITS.

F. PACKAGED CONTROLS WILL CONTINUOUSLY MONITOR THE CHILLER OPERATION AND REPORT ANY OPERATIONAL OR SAFETY ALARMS TO THE OPERATOR CONSOLE IN THE FACILITY CONTROL ROOM. PACKAGED CONTROLS WILL AUTOMATICALLY STOP THE MALFUNCTIONING WATER CHILLER AND START THE STANDBY CHILLER (CH-03).

G. CENTRAL CONTROL SYSTEM WILL ALTERNATE THE LEAD AND STANDBY WATER CHILLERS TO MAINTAIN EQUAL OPERATING PERIODS ON ALL WATER CHILLERS.

II. AIR HANDLING SYSTEM OF OSB(AH-03):

UPON A SIGNAL FROM THE CENTRAL CONTROL SYSTEM THE SUPPLY AIR FANS (SF-05 & SF-06) SHALL START TO ESTABLISH A STEADY AIR FLOW THROUGH THE SYSTEM. THE DDC CONTROLS WILL PERFORM THE FOLLOWING:

A. MODULATE THE CONTROLLABLE PITCH VANES ON THE SUPPLY AIR FANS TO MAINTAIN CONSTANT AIR VOLUME FLOW RATE REGARDLESS OF THE SYSTEM STATIC PRESSURE.

B. THE TEMPERATURE SENSORS DOWNSTREAM OF OUTSIDE AIR PREHEAT COILS WILL BE USED TO CONTROL THE CAPACITY OF THE DUCT ELECTRIC HEATERS TO MAINTAIN THE OUTSIDE AIR TEMPERATURE AT 50°F.

C. THE TEMPERATURE SENSORS DOWNSTREAM OF THE COOLING COILS (CC-05 & CC-06) WILL BE USED TO MODULATE THE 3-WAY CONTROL VALVE ON THE CHILLED WATER LOOP TO MAINTAIN THE LEAVING AIR TEMPERATURE AT THE SETPOINT (50°F).

D. THE TEMPERATURE SENSORS DOWNSTREAM OF THE HEATING COILS (HC-09 & HC-10) WILL BE USED TO SEQUENCE THE CAPACITY CONTROL STAGES OF THE ELECTRIC HEATERS TO MAINTAIN THE LEAVING AIR TEMPERATURE AT THE SETPOINT.

THE LEAVING WARM AIR TEMPERATURE SET POINT WILL BE PROPORTIONAL TO THE OUTSIDE TEMPERATURE AS FOLLOWS:

| OUTSIDE TEMPERATURE | WARM AIR TEMPERATURE SETPOINT |
|---|---|
| 0 TO 20 | 90 |
| 21 TO 30 | 85 |
| 31 TO 40 | 80 |
| 41 TO 50 | 75 |
| 51 TO 60 | 70 |
| ABOVE 60 | RECIRCULATED |

E. THE DDC CONTROLS SHALL COMPARE THE SPACE ROOM TEMPERATURES AND MODULATE THE CHILLED WATER CONTROL VALVE TO RESET THE COLD AIR SUPPLY TEMPERATURE (60 DEGREE F MAXIMUM) TO SATISFY THE MOST DEMANDING ZONE.

F. THE ROOM TEMPERATURE SENSORS OF EACH ZONE SHALL BE USED TO MODULATE RESPECTIVE CONTROL AIR DAMPERS INSIDE THE VAV TERMINAL TO MAINTAIN THE ROOM TEMPERATURE SETPOINT.

G. WHEN THE ROOM TEMPERATURE RISES 5°F ABOVE THE SETPOINT, THE CONTROL SYSTEM SHALL REPORT AN ALARM SIGNAL TO THE FACILITY CONTROL ROOM.

H. THE RELATIVE HUMIDITY SENSOR LOCATED INSIDE THE FACILITY CONTROL ROOM SHALL BE USED TO MODULATE THE CAPACITY OF THE ELECTRIC HUMIDIFIERS(HU-05 & HU-06) TO MAINTAIN THE SPACE MINIMUM RELATIVE HUMIDITY SETPOINT (30 % RH).

I. THE DUCT SMOKE DETECTOR IN THE RETURN AIR DUCT SHALL STOP THE SUPPLY AIR FANS WHEN SMOKE IS DETECTED IN THE RETURN AIR STREAM AND SHALL REPORT AN ALARM SIGNAL (AUDIO AND VISUAL) AT THE FACILITY CONTROL ROOM AND LOCAL CONTROL PANEL.

J. THE SPACE DIFFERENTIAL PRESSURE SENSOR SHALL BE USED TO MODULATE THE MOTORIZED CONTROL DAMPERS ON THE RETURN AIR DUCTS AND THE OUTSIDE AIR DUCTS TO MAINTAIN THE SPACE PRESSURIZATION AT SETPOINT.

III. AIR HANDLING SYSTEM OF OSB(AH-04):

UPON A SIGNAL FROM THE CENTRAL CONTROL SYSTEM THE AIR HANDLING UNIT AH-04 SHALL START TO ESTABLISH A STEADY AIR FLOW THROUGH THE SYSTEM. THE DDC CONTROLS SHALL PERFORM THE FOLLOWING:

A. THE STATIC PRESSURE SENSOR LOCATED AT THE END OF THE SUPPLY AIR DUCT WILL MODULATE THE INLET GUIDE VANES ON THE SUPPLY AIR FANS TO MAINTAIN CONSTANT AIR PRESSURE AT THE MOST REMOTE VAV TERMINAL.

B. THE TEMPERATURE SENSORS DOWNSTREAM OF THE OUTSIDE AIR PREHEAT COILS SHALL BE USED TO CONTROL THE CAPACITY OF THE DUCT ELECTRIC HEATERS TO MAINTAIN THE OUTSIDE AIR TEMPERATURE AT 50°F.

C. THE TEMPERATURE SENSORS DOWNSTREAM OF THE COOLING COILS SHAILL BE USED TO MODULATE THE 3-WAY CONTROL VALVES ON THE CHILLED WATER LOOP TO MAINTAIN THE LEAVING AIR TEMPERATURE AT THE SETPOINT (55°F).

D. THE DDC CONTROLS WILL COMPARE THE SPACE ROOM TEMPERATURES AND MODULATE THE CHILLED WATER CONTROL VALVES TO RESET THE COLD AIR SUPPLY TEMPERATURE (60°F MAXIMUM) TO SATISFY THE MOST DEMANDING ZONE.

E. THE ROOM TEMPERATURE SENSORS OF EACH ZONE WILL BE USED TO MODULATE RESPECTIVE CONTROL AIR DAMPERS INSIDE THE VAV TERMINAL(SINGLE DUCT WITH HEATING COIL) TO MAINTAIN THE ROOM TEMPERATURE SETPOINT.

F. WHEN THE SUPPLY AIR FLOW RATE DROPS TO THE MINIMUM SETPOINT AND THE ROOM TEMPERATURE CONTINUES TO DROP DOWN, THE CONTROLS SHALL ACTIVATE THE HEATING COIL LOCATED IN THE VAV TERMINAL TO MAINTAIN THE ROOM SETPOINT.

G. WHEN THE ROOM TEMPERATURE RISES 5°F ABOVE THE SETPOINT, THE CONTROL SYSTEM WILL REPORT AN ALARM SIGNAL TO THE FACILITY CONTROL ROOM.

H. THE RELATIVE HUMIDITY SENSOR LOCATED INSIDE THE OPEN OFFICES AREA WILL BE USED TO MODULATE THE CAPACITY OF THE ELECTRIC HUMIDIFIER TO MAINTAIN THE SPACE MINIMUM RELATIVE HUMIDITY SETPOINT (30 % RH).

I. THE DUCT SMOKE DETECTOR IN THE RETURN AIR DUCT SHALL STOP THE SUPPLY AIR FANS WHEN SMOKE IS DETECTED IN THE RETURN AIR STREAM AND SHALL REPORT AN ALARM SIGNAL (AUDIO AND VISUAL) AT THE FACILITY CONTROL ROOM AND LOCAL CONTROL PANEL.

IV. OPTICS LAB & VACUUM PREPARATION ROOMS PRESSURIZATION:

A. A DIFFERENTIAL PRESSURE SENSOR (ONE FOR EACH ROOM) SHALL BE USED TO MODULATE THE MOTORIZED CONTROL DAMPERS OF THE ROOM RETURN AIR TO MAINTAIN THE ROOM PRESSURE SETPOINT.

V. FUME HOODS OF OPTICS LAB & VACUUM PREPARATION:

A. THE FUME HOOD FANS (ONE FOR EACH HOOD) SHALL BE MANUALLY CONTROLLED (ON/OFF).

B. THE BAROMETRIC DAMPER ON THE FAN SUCTION SIDE SHALL MAINTAIN A CONSTANT NEGATIVE PRESSURE INSIDE THE FUME HOOD REGARDLESS OF THE SASH POSITION OF THE FUME HOOD.

VI. EQUIPMENT START UP:

A. ALL WATER CHILLERS SHALL BE SOFT START.

B. SUPPLY AIR FANS (SF-01 THRU SF-06) SHALL START AT THE MINIMUM STATIC PRESSURE AND GRADUALLY INCREASE THE SYSTEM STATIC PRESSURE TO MAINTAIN THE DESIRED AIR FLOW RATE.

C. BUILDING PRESSURIZATION SENSORS FOR LVEA AND OSB (LAB AREA) SHALL MODULATE THE MOTORIZED DAMPERS LOCATED ON THE RETURN AIR & OUTSIDE AIR DAMPERS TO START AT 100% RETURN AIR AND GRADUALLY MODULATE THE DAMPERS TO MAINTAIN THE BUILDING PRESSURIZATION SETPOINT.

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| REFERENCES | | REVISIONS | | | | | | |
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| | | 1 | 5-15-98 | CP | AA | AA | PR | ISSUED FOR AS-BUILT |

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**AS-BUILT DRAWINGS**

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100 WEST WALNUT STREET
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LIGO
CALIFORNIA INSTITUTE OF TECHNOLOGY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

LASER INTERFEROMETER
GRAVITATIONAL-WAVE OBSERVATORY
SITE NO. 1 - HANFORD, WASHINGTON

| TITLE | SCALE | CONTRACT NUMBER | PROJECT NUMBER |
|---|---|---|---|
| HVAC CORNER STATION SEQUENCES OF OPERATION & I/O SUMMARY SHEET 1 | NONE | PP150969 | 8094 |
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