

- 18 The DDC system enables each boiler system's pumps and boilers at the same time. When the boiler system is disabled, the boiler is first disabled, and then 5 minutes later the boiler pump is disabled.
- 19 The DDC system enables each pair of boilers (B1, B2, and B3) and the internal boiler controls cycle and modulate the burners of each boiler pair. The DDC system also provides a reset signal (B1STR, B2STR, and B3STR) to modulate the boiler supply temperature setpoint at the boiler controls.
- 20 The DDC system resets the high temperature water supply temperature setpoint (HTWST_SP) according to the outdoor air temperature (OAT):

Outdoor Air Temperature	HTW Supply Temperature Setpoint
-15°C	82°C
+15°C	55°C

- 21 If no boilers have been running for 10 minutes and the high temperature water supply temperature is below setpoint ($HTWST_CO > 40\%$), then the boiler system with the least run time is enabled.
- 22 If one boiler system has been running for 15 minutes, and the high temperature water supply temperature is below setpoint ($HWST < HWST_SP - 2$) and ($HTWST_CO = 100\%$) for 5 minutes, then the next boiler system with the least run time is enabled.
- 23 If two boiler systems have been running for 15 minutes, and the high temperature water supply temperature is below setpoint ($HWST < HWST_SP - 2$) and ($HTWST_CO = 100\%$) for 5 minutes, then the last boiler system is enabled.
- 24 If three boiler systems have been running for 15 minutes all boilers reset signals are less than 60% ($HTWST_CO < 40\%$) for 5 minutes, then the boiler system with the greatest run time is disabled.
- 25 If two boiler systems have been running for 15 minutes and both boilers reset signals are less than 40% ($HTWST_CO < 60\%$) for 5 minutes, then the running boiler system with the greatest run time is disabled.
- 26 If one boiler system has been running for 15 minutes, and the high temperature water supply temperature is above setpoint ($HWST > HWST_SP + 3$) and ($HTWST_CO = 0\%$) for 15 minutes, then that boiler system is disabled.
- 27 Once weekly the boiler stages are cycled to enable the first boiler stage as that with the least run time and the last boiler stage as that with the greatest run time.

28

29 *Shutdown Mode*

30

- 31 High temperature hot water system is disabled if:
 No demand for heating in greenhouse (when $OAT > 27\text{ }^\circ\text{C}$ or manually set by operator GREENHSE_ENABLE) and low temperature hot water loop heat exchanger HE-3 does not require hot water ($HTWVC = 0\%$ open) and $OAT > 14\text{ }^\circ\text{C}$.

32 Variable speed pumps HTWP1A and HTWP1B are disabled.

33 Boilers (B1, B2, and B3) are disabled and reset signals (B1STR, B2STR, and B3STR) set to 0.

34 Boiler pumps (BHWP1A, BHWP1B, and BHWP1C) stop 5 minutes after boilers are disabled

35

36 *Alarms*

37

38 Boiler fail.

39 Pump fail.

40 If one boiler system is enabled and the $HTWSRDT > 15\text{ }^\circ\text{C}$.

41 If one boiler system is enabled and the $HTWSRDT < 5\text{ }^\circ\text{C}$.

42 If two boiler systems are enabled and the $HTWSRDT > 25\text{ }^\circ\text{C}$.

43 If two boiler systems are enabled and the $HTWSRDT < 10\text{ }^\circ\text{C}$.

44 If three boiler systems are enabled and the $HTWSRDT > 30\text{ }^\circ\text{C}$.

45 If three boiler systems are enabled and the $HTWSRDT < 20\text{ }^\circ\text{C}$.

46 High boiler temperature $> 90\text{ }^\circ\text{C}$ (B1AST, B1BST, B2AST, B2BST, B3AST, B3BST) as sensed at the individual boiler supply line.

- 47 Extreme HTWS temperature: low -5°C, high +5°C from setpoint.
- 48 Boiler temperature alarms are inhibited for 15 minutes from start up of the high temperature hot water system.
- 49
- 50 *Failure Mode*
- 51
- 52 All boilers and boiler pumps are enabled.
- 53 Boiler supply temperature reset signals set to minimum.
- 54 Both HTW variable speed pumps are enabled at minimum speed (30%).
- 55
- 56 **Glycol Heating System**
- 57
- 58 The glycol heating system provides heated glycol to air handling units AHU-1 and AHU-2 heating coils by the low temperature hot water system heat exchanger HE-4.
- 59 Glycol make-up pump (GMUP) is controlled by stand-alone control system. The DDC system monitors its run status.
- 60
- 61 *Start-up Mode*
- 62
- 63 Glycol heating system is enabled when either AHU-1 or AHU-2 heating coil valves are opened (AHU1_HCV > 15% or AHU2_HCV > 15%) for 30 seconds.
- 64 Glycol pump HGLYP1A or HGLYP1B having the lesser run time is enabled.
- 65
- 66 *Normal Mode*
- 67
- 68 Glycol pump HGLYP1A or HGLYP1B runs continuously. If this pump fails then the other pump starts.
- 69 Two heat exchanger HE-4 primary control valves in parallel (LTHW1_3V and LTHW2_3V) are modulated in sequence to maintain the heated glycol supply water temperature (HGLYST) at setpoint (HGLYST_SP).
- 70 The 1/3rd valve is modulated open as first stage of heating. When the 1/3rd valve is fully open, then the 2/3rd valve is modulated from 50% to 100% open and the 1/3rd valve is closed as the second stage of heating. When the 2/3rd valve is fully opened then the 1/3rd valve is modulated open as the third stage of heating. The sequence is reversed if the glycol supply water temperature is above setpoint.
- 71 The DDC system resets the initial glycol supply water temperature setpoint (HGLYST_OAT_SP) according to the outdoor air temperature (OAT):
- | | |
|-------------------------|----------------------------------|
| Outdoor Air Temperature | HGLY Supply Temperature Setpoint |
| -20°C | 40.6°C |
| +15°C | 35.0°C |
- 72 The DDC system further resets the glycol supply temperature setpoint (HGLYST_SP), after the system has been enabled for 2 minutes, according to the positions of the heating coil valves at AHU-1 and AHU-2. The following reset calculations are repeated every 5 minutes.
- If either of the heating coil valve positions are greater than 80% open; and the supply air temperature (AHU1_SAT or AHU2_SAT) is less than or equal to setpoint, the HGLYST_SP is increased by 2°C.
- If both of the heating coil valve positions are less than 60% open, the HGLYST_SP is decreased by 2°C.
- A temperature increase does not occur until at least 15 minutes after the last temperature decrease and a temperature decrease does not occur until at least 15 minutes after the last temperature increase.



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Shutdown Mode

Glycol heating system is disabled when both AHU-1 or AHU-2 heating coil valves are fully closed (AHU1_HCV = 0% and AHU2_HCV = 0%) for 15 minutes.
Low temperature heating 1/3rd and 2/3rd water valves are closed to HE-4.

Alarms

Pump failure.
Extreme HGLYS temperature: low -5°C, high +5°C from setpoint.
Glycol supply temperature less than setpoint with both hot water control valves open.
Glycol make-up pump is operating.
Extreme glycol system pressure: high 350 kPa, low 50 kPa.
Glycol system temperature and pressure alarms are inhibited for 15 minutes from start up of the glycol heating system.

Failure Mode

Glycol pump HGLYP1A is enabled.
Low temperature heating 1/3rd and 2/3rd water valves are opened to HE-4.

Low Temperature Hot Water System and Heat Pump System

The low temperature hot water system provides low temperature hot water to fan coil units reheat coils, VAV units reheat coils, and the glycol system heat exchanger HE-4. Low temperature hot water is supplied by the heat pump in the heating season or the high temperature hot water valve (HTWVC) via heat exchanger HE-3 when the heat pump is not in operation.

Start-up Mode

Low temperature hot water system is enabled by either:
Demand for heating by fan coil units or VAV units (VAV_LO_VAR < -2°C, FC_LO_VAR < -2°C) or the glycol heating system is enabled (HGLY_ENABLE).
Variable speed pump HWP1A or HWP1B having the lesser run time is enabled in the normal mode.
If there is enough heating load for the heat pump to run (intended to run during fall, winter, and spring only), then the central heat pump is enabled (HEATPUMP_ENABLE manually set by operator) and the central heat pump disconnect switch is placed in the AUTO position, and the system reverts to the heat pump mode. Also, refer to the well water system sequence of operation (WELL_MODE is automatically set to HEAT).
If there is not enough heating load for the heat pump to run (intended to be disabled in the summer), then the central heat pump is disabled (HEATPUMP_ENABLE manually off by operator) and the central heat pump disconnect switch is placed in the OFF position, and the system reverts to the supplementary heat mode. Also, refer to the well water system sequence of operation (WELL_MODE is automatically set to COOL).

Normal Mode (Primary HWP1A/HWP1B)

- 191 If there is a demand for cooling by the fan coil unit or air handling unit cooling coils, the variable speed pump CHWP1A or CHWP1B, serving fan coil unit and air handling unit cooling coils, having the lesser run time is enabled. If this pump fails then the other pump is enabled.
- 192 If CHWP1A or CHWP1B is enabled, the speed of the operating pump CHWP1A or CHWP1B is modulated to maintain the required differential pressure between the supply and return cold water lines serving the fan coil unit cooling coils (FCUCHWDP setpoint 24.0 kPa) and the air handling unit cooling coils (AHUCHWDP setpoint 30.0 kPa). The pump speed is controlled to satisfy all lines to at least their minimum pressure differential setpoints. If none of the air-handling unit cooling coil valves are opened, the system maintains only the fan coil unit differential pressure at setpoint. If none of the fan coil unit cooling coil valves are opened, the system maintains only the air handling unit differential pressure at setpoint.
- 193 If there is no demand for cooling by the fan coil unit or air handling unit cooling coils for 15 minutes, the variable speed pump CHWP1A or CHWP1B, serving fan coil unit and air handling unit cooling coils is disabled.
- 194 CHWP1A/B and CHWP2A/B pump speeds are never varied by more than 0.5% per second.
- 195 If the heat pump system is enabled, then the well system operates in the heating mode (WELL_MODE is automatically set to HEAT).
- 196 If the heat pump system is disabled, then the well system operates in the cooling mode (WELL_MODE is automatically set to COOL).
- 197
- 198 *Well System Heat Mode (when heat pump is enabled)*
- 199
- 200 *Start-up Mode*
- 201
- 202 The lead heating well pump (WW2PC or WW4PC) is enabled at minimum speed (30%).
- 203 The lead heating well pump is determined every 24 hours by either:
1. The pump that serves the well with the cumulative return flow that exceeds the cumulative supply flow is the lead pump.
 2. If both cooling wells have more cumulative return flow than cumulative supply flow, then the pump serving the well with the greater differential between the cumulative return and cumulative supply flows is the lead pump.
 3. If neither cooling wells have a cumulative return flow that is greater than the cumulative supply flow, then the pump serving the well with lesser differential between cumulative supply and cumulative return flows is the lead pump.
- 204 The return well valve is fully opened to the selected cold well.
- 205 The cold well to return flow from the heat exchanger (HX-1 or HX-2) is determined every 24 hours by either:
1. The cooling well with the cumulative supply flow that exceeds the cumulative return flow is the return well.
 2. If both cooling wells have more cumulative supply flow than cumulative return flow, then the warm well with the greater differential between the cumulative supply and cumulative return flows is the return well.
 3. If neither cooling wells have a cumulative supply flow that is greater than the cumulative return flow, then the warm well with lesser differential between cumulative return and cumulative supply flows is the return well.
- 206
- 207 *Normal Mode*
- 208
- 209 The speed of the heating well lead pump is modulated to maintain the return well water temperature at 5.5°C.

- 229 The warm well to return flow from the heat exchanger (HX-1 or HX-2) is determined every 24 hours by either:
4. The heating well with the cumulative supply flow that exceeds the cumulative return flow is the return well.
 5. If both heating wells have more cumulative supply flow than cumulative return flow, then the warm well with the greater differential between the cumulative supply and cumulative return flows is the return well.
 6. If neither heating wells have a cumulative supply flow that is greater than the cumulative return flow, then the warm well with lesser differential between cumulative return and cumulative supply flows is the return well.

230

231 *Normal Mode*

232

233 The speed of the cooling well lead pump is modulated to maintain the return well water temperature at 14.4°C.

234 If the lead cooling well pump has been operating at maximum speed for 10 minutes and the well return temperature is above setpoint, then the pumps speed is set to minimum and the lag cooling well pump is enabled at minimum speed (30%).

235 If both the lead and lag cooling well pumps are enabled, then both pump speeds are modulated in unison to maintain the return well water temperature at setpoint.

236 If both the lead and lag cooling well pumps have been operating at minimum speed for 10 minutes, then the lag cooling pump is disabled.

237 If only the lead cooling well pump has been operating at minimum speed for 10 minutes and the well water return temperature has been below setpoint for 10 minutes, then the lead cooling pump is disabled.

238 If the lead cooling well pump has been disabled for 10 minutes and the chilled water supply temperature is above setpoint ($CHWST > CHWST_SP + 2$), then the lead cooling pump is enabled.

239 Well water supply pumps are disabled if the well water supply temperature at the inlet to the operating heat exchanger is 2°C above the chilled water return temperature in the chilled water loop.

240 Well water supply pumps are enabled if the lowest cooling well temperature is 2°C below the chilled water supply temperature setpoint ($CHWST_SP = 14.0^\circ\text{C}$).

241 If only the lead pump is enabled and the return water temperature is less than 0.5°C above the selected return well tank temperature, then the return water is sent to the dump well (warm well return valve closed and dump well return valve opened).

242 If both the lead and lag pumps are enabled and the return water temperature is more than 0.5°C above both return warm well tank temperatures, then both warm well valves are opened.

243 If both the lead and lag pumps are enabled the return water temperature is less than 0.5°C above both return well tank temperatures, then the return water is sent to the dump well (both warm well return valves closed and both dump well return valves opened).

244 If both the lead and lag pumps are enabled the return water temperature for only one warm well tank is less than 0.5°C above the return well tank temperature, then half of the return water is sent to the dump well (one warm well return valve opened, one warm well return valve closed, and one dump well return valve opened).

245

246 *Shutdown Mode*

247

248 When no fan coil unit cooling coil, air handling unit cooling coil, compressor, nor central heat pump requires chilled water, the chilled water system is disabled.

249 Variable speed pumps CHWP1A and CHWP1B are disabled.

250 Variable speed pumps CHWP2A and CHWP2B are disabled.

- 251 When the heat pump system is disabled and the chilled water system is disabled, the well water system is disabled.
- 252 Warm well pumps WW2P and WW4P are disabled.
- 253 Cold well pumps CW1P and CW3P are disabled.
- 254 Well water return valves are closed.
- 255
- 256 *Failure Mode*
- 257
- 258 Variable speed pumps CHWP1A and CHWP1B are enabled at minimum speed (30%).
- 259 Variable speed pumps CHWP2A and CHWP2B are enabled at minimum speed (30%).
- 260 Warm well pumps WW2P and WW4P are disabled.
- 261 Cold well pumps CW1P and CW3P are disabled.
- 262 Well water return valves remain in last position.
- 263
- 264 *Alarms*
- 265
- 266 Pump failure: CWP1, CWP3, WWP2, WWP4, CHWP1A, and CHWP1B.
- 267 Extreme chilled water supply temperature to air handling unit and fan coil unit cooling coils: low -4°C, high +4°C from setpoint.
- 268 Extreme well water return temperature: low 5°C, high 15°C.
- 269 Combined warm well water return flow greater than 30,000,000 Gallons in one month.
- 270 Extreme differential pressure to the fan coil units: low -10kPa, high +20kPa from setpoint.
- 271 Extreme differential pressure to the air handling units: low -20kPa, high +30kPa from setpoint.
- 272 Both warm well water pumps at maximum speed for 5 minutes, and chilled water supply temperature is less than setpoint.
- 273 Both cooling well water pumps at maximum speed for 5 minutes, and chilled water supply temperature is greater than setpoint.
- 274 Chilled water system temperature and pressure alarms are inhibited for 15 minutes from start up of the system.
- 275
- 276
- 277 **Air Handling Unit AHU-1 serves Laboratories**
- 278
- 279 AHU-1 provides 100% outside air to the VAV terminal units serving the Laboratory Area and Insect Rearing Laboratories.
- 280
- 281 *Start-up Mode*
- 282
- 283 AHU-1 is enabled in the occupied mode by either:
- Any Insect Rearing Laboratory occupied
 - Any Laboratory Fume hood or Exhaust Canopy switch on
 - AHU-1 weekly schedule.
- 284 AHU-1 is enabled in the unoccupied mode by a room temperature below 17°C or a high room temperature above 32°C.
- 285 AHU-1 is enabled in the morning warm-up mode by the optimum heating start program.
- 286 AHU-1 is enabled in the morning cool-down mode by the optimum cooling start program.
- 287 If outside air temperature is below 0°C, the heating coil valve is fully opened for 2 minutes before enabling the system.
- 288 The outside air damper is opened.
- 289 Hardwired outside air damper end switch enables the supply fan.



- 290 Supply fan variable speed drive is set at minimum speed (30%).
- 291
- 292 *Occupied Mode*
- 293
- 294 Supply fan speed is modulated to maintain duct static pressure at setpoint.
- 295 If the duct static pressure is above setpoint and the supply fan is operating at minimum speed, the closest VAV terminal unit damper (VAV-208 serving Vestibule 202) is opened.
- 296 The initial duct static pressure setpoint is set to 200 Pa.
- 297 The DDC system resets the duct static pressure setpoint (AHU1_DSP_SP) according to the demand for airflow from the VAV terminal units operating in the occupied mode. The following reset calculations are repeated every 5 minutes.
- 298 If the airflow through one or more VAV's is below 95% of its flow setpoint for 15 minutes, the AHU1_DSP_SP is increased by 10 Pa.
- 299 If the air flow through all VAV's is above 95% of their flow setpoints for 15 minutes, the AHU1_DSP_SP is decreased by 10 Pa.
- 300 A duct static pressure setpoint increase does not occur until at least 30 minutes after the last setpoint decrease and a setpoint decrease does not occur until at least 30 minutes after the last setpoint increase.
- 301 Heating and cooling valves are modulated in sequence to maintain supply air temperature at setpoint.
- 302 The initial supply air temperature setpoint (AHU1_SAT_SP) is set to 13°C.
- 303 The DDC system resets AHU1_SAT_SP according to the demand for heating from the VAV terminal units operating in the occupied mode. The following reset calculations are repeated every 10 minutes.
- 304 If the AHU heating coil valve (AHU1_HCV) is open, AHU1_SAT_SP is decreased by 0.5°C until either all of the VAV's are in heating mode or until one of the VAV's has a reheat coil valve more than 95% open, whichever occurs first.
- 305 If at any time a VAV has its reheat coil valve more than 95% open and the space temperature is below setpoint, the SAT_SP is increased by 0.5°C.
- 306 If the AHU cooling coil valve (AHU1_CCV) is open, AHU1_SAT_SP is increased by 0.5°C until either none of the VAV's are in heating mode or until one of the VAV's has a reheat coil valve less than 5% open for 5 minutes and the space temperature is at or above the setpoint, whichever occurs first.
- 307 If at any time a VAV has its reheat coil valve less than 5% open and the space temperature is at or above setpoint, the SAT_SP is decreased by 0.5°C.
- 308 The initial supply air relative humidity setpoint (AHU1_SAH_SP) is set to the space relative humidity setpoint.
- 309 The DDC system resets the room relative humidity setpoint (AHU1_RH_SP) according to the outdoor air temperature (OAT):
- | | |
|-------------------------|---------------------------------|
| Outdoor Air Temperature | Room Relative Humidity Setpoint |
| -20°C | 20% RH |
| +30°C | 40% RH |
- 310 The DDC system resets the supply air relative humidity setpoint according to the four measured room humidity sensors. The following reset calculations are repeated every 10 minutes.
- 311 If all room humidity sensors are below AHU1_RH_SP, then AHU1_SAH_SP is increased by 5% RH.
- 312 If all room humidity sensors are above AHU1_RH_SP then AHU1_SAH_SP is decreased by 5% RH.
- 313 Supply air relative humidity setpoint (AHU1_SAH_SP) is limited between 20% RH and 60% RH.
- 314 Supply air relative humidity high limit controller maintains duct humidity below 70% RH.

- 315 Two steam control valves in parallel (AHU1_V1_3C and AHU1_V2_3C) are modulated in sequence to maintain the supply air humidity at setpoint.
- 316 The 1/3rd valve is modulated open as first stage of humidification. When the 1/3rd valve is fully open, then the 2/3rd valve is modulated from 50% to 100% open and the 1/3rd valve is closed as the second stage of humidification. When the 2/3rd valve is fully opened then the 1/3rd valve is modulated open as the third stage of humidification. The sequence is reversed if the supply air humidity is above the setpoint.
- 317 Steam valves remain closed until the steam boiler pressure is above 25 kPa.
- 318
- 319 *Morning Warm-up Mode*
- 320
- 321 System reverts to the occupied mode with a supply air temperature setpoint of 26°C.
- 322
- 323 *Morning Cool-down Mode*
- 324
- 325 System reverts to the occupied mode with a supply air temperature setpoint of 12°C.
- 326
- 327 *Unoccupied Mode*
- 328
- 329 If the low room temperature is below 17°C, the system reverts to the occupied mode with a supply air temperature setpoint of 26°C.
- 330 If the high room temperature is above 32°C, the system reverts to the occupied mode with a supply air temperature setpoint of 12°C.
- 331
- 332 *Shutdown Mode*
- 333
- 334 AHU-1 is disabled when:
- All Insect Rearing Laboratory are unoccupied
 - All Laboratory Fume hood or Exhaust Canopy switches are off
 - AHU-1 weekly schedule is off
 - AHU-1 heating and cooling optimum starts are disabled
 - Lowest room temperature is above 19°C and a highest room temperature is below 28°C.
- 335 Supply fan is disabled.
- 336 Supply fan speed control set to 0%.
- 337 Outdoor air damper is closed.
- 338 Heating coil valve is closed.
- 339 Cooling coil valve is closed.
- 340 Steam humidification valves are closed.
- 341
- 342 *Freeze Protection*
- 343
- 344 Hardwired manual reset freezestat disables supply fan upon detection of temperature at the face of the cooling coil below 4°C.
- 345 DDC system upon sensing freezestat tripped:
- 346 - Supply fan is disabled.
 - 347 - Supply fan speed control set to 0%.
 - 348 - Outdoor air damper is closed.
 - 349 - Heating coil valve is opened fully (and glycol heating system enabled).
 - 350 - Cooling coil valve is closed.
 - 351 - Steam humidification valves are closed.

- 398 Heating and cooling valves are modulated in sequence to maintain supply air temperature at setpoint.
- 399 The initial supply air temperature setpoint (AHU2_SAT_SP) is set to 13°C.
- 400 The DDC system resets AHU2_SAT_SP according to the demand for heating from the fan coil units operating in the occupied mode. The following reset calculations are repeated every 10 minutes.
- 401 If the AHU heating coil valve (AHU2_HCV) is open, AHU2_SAT_SP is decreased by 0.5°C until either at least one FCU cooling only has its cooling coil valve closed (FCC_LO_CCV) and all space temperatures associated to the FCU cooling only are at or below setpoint (FCC_HI_VAR and FCC_LO_VAR). The intent is to eliminate unnecessary heating of the outside air at the AHU and the subsequent cooling of the air at the FCU while ensuring that the cooling only FCU's can meet their space temperature requirements.
- 402 If at any time, a cooling only FCU has its cooling coil valve closed for 5 minutes and the space temperature is below setpoint, the SAT_SP is increased by 0.5°C.
- 403 If the AHU cooling coil valve (AHU2_CCV) is open, AHU2_SAT_SP is increased by 0.5°C until all FCU heating coil valves are closed and at least one FCU has its cooling coil valve fully closed. The intent is to eliminate cooling of the outside air at the AHU and the subsequent heating of the air at the FCU.
- 404 The initial supply air relative humidity setpoint (AHU2_SAH_SP) is set to the space relative humidity setpoint.
- 405 The DDC system resets the room relative humidity setpoint (AHU2_RH_SP) according to the outdoor air temperature (OAT):
- | | |
|-------------------------|---------------------------------|
| Outdoor Air Temperature | Room Relative Humidity Setpoint |
| -20°C | 20% RH |
| +30°C | 40% RH |
- 406 The DDC system resets the supply air relative humidity setpoint according to the four measured room humidity sensors. The following reset calculations are repeated every 10 minutes.
- 407 If all room humidity sensors are below AHU2_RH_SP, then AHU2_SAH_SP is increased by 5% RH.
- 408 If all room humidity sensors are above AHU2_RH_SP then AHU2_SAH_SP is decreased by 5% RH.
- 409 Supply air relative humidity setpoint (AHU2_SAH_SP) is limited between 20% RH and 60% RH.
- 410 Supply air relative humidity high limit controller maintains duct humidity below 70% RH.
- 411 Two steam control valves in parallel (AHU2_V1_3C and AHU2_V2_3C) are modulated in sequence to maintain the supply air humidity at setpoint.
- 412 The 1/3rd valve is modulated open as first stage of humidification. When the 1/3rd valve is fully open, then the 2/3rd valve is modulated from 50% to 100% open and the 1/3rd valve is closed as the second stage of humidification. When the 2/3rd valve is fully opened then the 1/3rd valve is modulated open as the third stage of humidification. The sequence is reversed if the supply air humidity is above the setpoint.
- 413 Steam valves remain closed until the steam boiler pressure is above 25 kPa.
- 414
- 415 *Morning Warm-up Mode*
- 416
- 417 System reverts to the occupied mode with a supply air temperature setpoint of 26°C.
- 418
- 419 *Morning Cool-down Mode*
- 420
- 421 System reverts to the occupied mode with a supply air temperature setpoint of 12°C.
- 422
- 423 *Unoccupied Mode*
- 424

- 647
648 **Strobic Exhaust Fans EF-1A,B,C**
649
650 Strobic exhaust fans are staged and bypass dampers are modulated to maintain suction pressure in laboratory exhaust air system serving laboratory general exhaust VAV terminal units, fume hoods, and exhaust canopies.
651
652 *Start-up Mode*
653
654 If air handling unit AHU-1 is enabled in the occupied mode (by weekly schedule or laboratory fume hood or exhaust canopy override), the exhaust fan EF-1A, B, or C with the least run time is enabled and the bypass dampers are fully opened.
655
656 *Normal Mode*
657
658 Bypass dampers are ramped closed to maintain the exhaust duct suction pressure at setpoint of 400 Pa.
659 If one exhaust fan has been running for 5 minutes and the exhaust duct suction pressure is below setpoint then the next exhaust fan with the least run time is enabled and the bypass damper is opened.
660 If two exhaust fans have been running for 5 minutes and the exhaust duct suction pressure is below setpoint then the last exhaust fan is enabled and the bypass damper is opened.
661 If three exhaust fans have been running for 5 minutes and the exhaust duct suction pressure is above setpoint and the bypass damper is opened, then the exhaust fan with the most run time is disabled and the bypass damper is opened.
662 If two exhaust fans have been running for 5 minutes and the exhaust duct suction pressure is above setpoint and the bypass damper is opened, then the exhaust fan with the most run time is disabled and the bypass damper is opened.
663 If at any time the high limit pressure switch trips, then all the exhaust fans are disabled.
664
665 *Shutdown Mode*
666
667 If air handling unit AHU-1 weekly schedule is off and all fume hoods and exhaust canopies switches are off, then the strobic exhaust system is disabled.
668 Exhaust fans EF-1A, B, and C are disabled.
669 Bypass dampers are closed.
670
671 *Failure Mode*
672
673 Exhaust fan EF-1A is enabled.
674 Exhaust fans EF-1B and EF-1C are disabled.
675 Bypass dampers are closed.
676
677 *Alarms*
678
679 Exhaust fan failure.
680 Exhaust suction pressure alarm: low -25 Pa, high +25 Pa from setpoint.
681
682 **Laboratory Air Systems (excluding Insect Rearing Laboratories 179A.J)**
683

- 684 Each lab is served by: supply VAV terminal units, general exhaust VAV terminal units, fume hoods, and exhaust canopies.
- 685 Exhaust canopies and fume hoods are constant flow devices.
- 686 Supply VAV units are constant air volume units with reheat coils, whose valves are modulated to maintain the space temperature at setpoint.
- 687 General exhaust VAV units maintain constant flow differential between total supply flow into the lab and total exhaust flow out of the lab (in effect to maintain a negative pressure between laboratories and corridors).
- 688 Laboratory corridor fan coil units recirculate air to maintain corridor temperatures at setpoints (refer to fan coil units sequence of operation).
- 689 All supply VAV units are controlled by stand-alone IZC230 zone controllers with Delta Controls VAV unit VAV4 algorithm version 5.1. Refer to the Delta Controls documentation for more details on the sequence of operation.

690

691 *Start-up Mode*

692

- 693 If the associated air handling unit AHU-1 is enabled in the occupied mode, all the supply VAV units are set to their day mode of operation.
- 694 If the associated air handling unit AHU-1 is enabled in the morning warm-up or morning cool-down mode, all the supply VAV units are set to their morning mode of operation.
- 695 If any fume hood or exhaust canopy is enabled in the unoccupied mode (by local switch):
 - the associated air handling unit AHU-1 is enabled in the occupied mode
 - strobic exhaust fan system (EF-1A,B,C) is enabled
 - the supply VAV to that laboratory is set to its day mode of operation
 - corridor fan coil units on the same floor as that laboratory are set to their day mode of operation
 - corridor supply VAV units on the same floor as that laboratory are set to their day mode of operation.

696

697 *Day Mode*

698

- 699 Supply VAV terminal unit damper is modulated to maintain supply airflow at setpoint.
- 700 Supply VAV reheat coil valve is modulated to maintain space temperature at setpoint.
- 701 General exhaust VAV terminal unit damper is modulated to maintain exhaust airflow at setpoint.
- 702 Fume hood and exhaust canopy is enabled by local switch.
- 703 If a fume hood or exhaust canopy switch is on, the DDC system signals the Phoenix exhaust air damper controller to provide the required exhaust airflow.
- 704 When flow rate of the fume hood or exhaust canopy is greater than 50% of the required exhaust flow rate, the DDC system enables a green indicating light mounted on the fume hood or exhaust canopy switch plate.
- 705 If a fume hood or exhaust canopy switch is off, the DDC system signals the Phoenix exhaust air valve controller to close the exhaust air damper.

706

707 *Morning Mode*

708

- 709 Supply VAV terminal unit damper is modulated to maintain supply airflow at maximum setpoint.
- 710 If the space temperature is above setpoint, the reheat coil valve is fully closed.
- 711 If the space temperature is below setpoint, the heating coil valve is fully opened.
- 712 General exhaust VAV terminal unit damper is closed.
- 713 When the space temperature setpoint is reached, the supply VAV unit reverts to the day mode.

714

715 *Night Mode*



- 716
- 717 If the associated air handling unit AHU-1 weekly schedule is off (unoccupied mode) and the fume hoods and exhaust canopies associated to the laboratory are disabled, the VAV unit is set to its night mode of operation.
- 718 If the space temperature is below the night heating setpoint, the VAV unit is enabled in the heating mode (damper modulates to maintain supply airflow at setpoint and reheat coil valve opened).
- 719 If the space temperature is above the night cooling setpoint, the fan coil unit is enabled in the cooling mode (damper modulates to maintain supply airflow at setpoint and reheat coil valve closed).
- 720 If the space temperature is within the night heating and cooling setpoints, the VAV unit reverts to the shutdown mode.
- 721 General exhaust VAV terminal unit damper is closed.
- 722
- 723 *Shut-down Mode*
- 724
- 725 Supply VAV damper is closed.
- 726 Supply VAV reheat coil is closed.
- 727 General exhaust VAV damper is closed.
- 728 Fume hood and exhaust canopy dampers are closed.
- 729 Associated corridor VAV and fan coil units are shutdown.
- 730
- 731 *Fume Hood Washdown*
- 732
- 733 If at any time the fume hood washdown switch is enabled, washdown "A" is enabled for 10 minutes then disabled. Next, washdown "B" is enabled for 10 minutes then disabled.
- 734
- 735 *Alarms*
- 736
- 737 Extreme space temperature: low -4°C, high +4°C from setpoint.
- 738 Laboratory supply air flow is greater than the exhaust air flow.
- 739
- 740 *Failure Mode*
- 741
- 742 If the individual VAV unit zone controller fails:
- Supply VAV damper closes.
 - Exhaust VAV damper closes.
 - Reheat coil valve remains in its last position.
 - Fume hoods and exhaust canopies exhaust dampers close and indicating light is disabled.
- 743 If the main control panel (DCU) fails:
- Exhaust fan EF-17 is disabled.
 - Supply VAV damper continues to operate to maintain supply flow at setpoint.
 - Exhaust VAV damper continues to operate to maintain exhaust flow at setpoint
 - Reheat coil valves are controlled automatically to maintain space temperature at setpoint.
- 744
- 745 *Air Handling Unit AHU-4 serves Mechanical Room*
- 746
- 747 AHU-4 provides cooling to the Mechanical Room.
- 748
- 749 *Start-up Mode*
- 750

- 751 Supply fan is enabled if the space temperature is 2°C above setpoint.
 752 Space temperature setpoint is 26.5°C
 753
 754 *Normal Mode*
 755
 756 Outdoor air damper is opened and return air damper is closed as first stage of cooling.
 757 Cooling coil valve is cycled as the second stage of cooling
 758 If the cooling coil valve is opened, CHWP4A/B are enabled (whichever has the least accumulated run time).
 759 If chilled water is no longer required, CHWP4A/B is disabled. When the pump has been disabled for 5 minutes, the cooling coil valve is closed.
 760 Supply air temperature setpoint is reset by the space temperature:
 $AHU4_SAT_SP = 21 - 3 * (AHU4_RT - AHU4_RT_SP)$
 AHU4_SAT_SP is limited between 12°C and 18°C.
 761
 762 *Shut Down Mode*
 763
 764 Supply fan is disabled if the space temperature is 1°C below setpoint.
 765 Outdoor air damper closes.
 766 Return air damper opens.
 767 Cooling coil valve is closed.
 768 Chilled water pumps CHWP4A/B are disabled.
 769
 770 *Freeze Protection*
 771
 772 Hardwired manual reset freezestat disables supply fan upon detection of temperature at the face of the cooling coil below 4°C.
 773 DDC system upon sensing freezestat tripped:
 774 = Supply fan is disabled.
 775 = Outdoor air damper is closed.
 776 = Return air damper is opened.
 777 = Cooling coil valve is closed.
 778
 779 *Failure Mode*
 780
 781 Supply fan is disabled.
 782 Outdoor air damper closes.
 783 Return air damper opens.
 784 Cooling coil valve is closed.
 785 Chilled water pumps CHWP4A/B are disabled.
 786
 787 *Alarms*
 788
 789 Supply fan failure.
 790 Freezestat alarm.
 791 Filter alarm when differential pressure across filter is greater than 230 Pa.
 792 Extreme supply air temperature: low -5°C, high +5°C from setpoint.
 793 Extreme space temperature: low -8°C, high +8°C from setpoint.
 794 Space temperature below unoccupied mode of operation setpoint 17°C, and the AHU4 fails to start.
 795 AHU-4 supply air temperature alarm is inactive for first 15 minutes of fan operation.

- 834 If the industrial laboratories are in the unoccupied mode (by air handling unit AHU-3 weekly schedule off), then tempered water pump TWR-P1 is enabled.
- 835
- 836 **Domestic Hot Water System**
- 837
- 838 The domestic hot water recirc pump (DHW_PC) is enabled continuously.
- 839 The DDC system monitors the domestic hot water supply temperature (DHW_T).
- 840
- 841 *Alarms*
- 842
- 843 Domestic hot water pump fail.
- 844 Domestic hot water supply temperature below 25°C or above 70°C
- 845
- 846 **Reverse Osmosis System**
- 847
- 848 The reverse osmosis system is enabled continuously.
- 849 The DDC system modulates the three-way valve (ROVC) to maintain the reverse osmosis system supply water temperature at 25°C.
- 850 The DDC system monitors the run status of the reverse osmosis system pump (ROPS).
- 851
- 852 *Alarms*
- 853
- 854 Reverse osmosis system supply water temperature: low -5°C, high +5°C from setpoint.
- 855 Reverse osmosis system pump fail.
- 856
- 857 **Emergency Generator**
- 858
- 859 Room ventilation dampers are modulated to maintain the space temperature at setpoint.
- 860 Fuel oil pump FOP-1A or FOP-1B is enabled (whichever has the least run time) when the fuel oil level in the day tank drops to the "pump on" level.
- 861 Fuel oil pumps FOP-1A and FOP-1B are disabled when the fuel oil level in the day tank rises to the "pump off" level.
- 862
- 863 *Alarms*
- 864
- 865 High day tank level alarm.
- 866 Low day tank level alarm.
- 867 High storage tank level alarm.
- 868 Low storage tank level alarm.
- 869 Emergency generator fault.
- 870 Emergency generator running notification alarm.
- 871 Low day tank level and pump not operating.
- 872 Extreme space temperature: low 15°C, high 30°C.
- 873
- 874 **Dust Collectors DC-1 and DC-2**
- 875
- 876 Dust collectors are enabled by the DDC when the Industrial Area AHU-3 is in the occupied mode.
- 877 When the dust collectors are enabled, they are each controlled by local switches.

- 878 Dust collectors are disabled by the DDC when the Industrial Area AHU-3 is in the unoccupied mode.
- 879 When the dust collectors are disabled, the local switch control is also disabled.
- 880
- 881 **Washroom Exhaust Fan EF-2**
- 882
- 883 When any air-handling unit is in the occupied mode the exhaust fan is enabled.
- 884 When any air-handling unit is in the unoccupied the exhaust fan is disabled.
- 885
- 886 *Alarms*
- 887
- 888 Exhaust fan failure.
- 889
- 890 **General Exhaust Fan EF-3**
- 891
- 892 When any air-handling unit is in the occupied mode the exhaust fan is enabled.
- 893 When any air-handling unit is in the unoccupied the exhaust fan is disabled.
- 894
- 895 *Alarms*
- 896
- 897 Exhaust fan failure.
- 898
- 899 **Change Room Exhaust Fan EF-4**
- 900
- 901 When any air-handling unit is in the occupied mode the exhaust fan is enabled.
- 902 When any air-handling unit is in the unoccupied the exhaust fan is disabled.
- 903
- 904 *Alarms*
- 905
- 906 Exhaust fan failure.
- 907
- 908 **Mechanical Loft Exhaust Fan EF-5**
- 909
- 910 EF-5 is controlled by a wall-mounted line thermostat.
- 911 The DDC system can override the fan off by manual enable EF5_C.
- 912 Hardwired motorized damper is opened before exhaust fan is enabled.
- 913
- 914 **Elevator Machine Room Exhaust Fan EF-6**
- 915
- 916 EF-6 is controlled by a wall-mounted line thermostat.
- 917 The DDC system can override the fan off by manual enable EF6_C.
- 918 Hardwired motorized damper is opened before exhaust fan is enabled.
- 919
- 920 **Industrial Area Exhaust Fans EF-7...11, 19, 21**
- 921
- 922 When the Industrial Area AHU-3 is in the occupied mode and the exhaust fan switch DDC input is on, the exhaust fan is enabled.
- 923 When the Industrial Area AHU-3 is in the unoccupied mode or the exhaust fan switch DDC input is off, the exhaust fan is enabled.
- 924 Hardwired motorized damper is opened before exhaust fan is enabled.

- 925
- 926 *Alarms*
- 927
- 928 Exhaust fan failure.
- 929
- 930 **Industrial Area Wall Exhaust Fans EF-14, 15, 16**
- 931
- 932 When the space temperature is above 25°C the exhaust fans are enabled.
- 933 When the space temperature is below 22°C the exhaust fans are disabled.
- 934
- 935 *Alarms*
- 936
- 937 Exhaust fan failure.
- 938
- 939 **Industrial Area Exhaust Fan EF-18**
- 940
- 941 When the Industrial Area AHU-3 is in the occupied mode the exhaust fan is enabled.
- 942 When the Industrial Area AHU-3 is in the unoccupied the exhaust fan is disabled.
- 943 Hardwired motorized damper is opened before exhaust fan is enabled.
- 944
- 945 *Alarms*
- 946
- 947 Exhaust fan failure.
- 948
- 949 **Insect Library Exhaust Fan EF-22**
- 950
- 951 EF-22 is enabled by the DDC when AHU-1 is in the occupied mode.
- 952 When EF-22 is enabled, it is controlled by a local switch.
- 953 EF-22 is disabled by the DDC when AHU-1 is in the unoccupied mode.
- 954 When EF-22 is disabled, the local switch control is also disabled.
- 955
- 956 **Industrial Area Ventilation Dampers**
- 957
- 958 Three industrial area high level ventilation dampers (RLF1_D, RLF2_D, RLF3_D) are manually controlled by the DDC system operator. It is recommended that these dampers be opened to provide extra relief of hot air in the area and to provide airflow when the large sliding doors are opened.
- 959
- 960 **Vestibule and Stairwell Radiant Panels**
- 961
- 962 The DDC system modulates the radiant panel control valve to maintain the space temperature at setpoint.
- 963
- 964 **Unit Heaters, Radiation Cabinets, Infrared Gas Heaters, & Forceflow Units**
- 965
- 966 Thermostatically controlled and not connected to the DDC system.
- 967
- 968 **Water Cooled Dehumidifier**
- 969
- 970 Stand-alone humidity and temperature controller are not connected to the DDC system.

- 1010 The DDC system calculates the peak KW demand used for the following:
Present Day & Previous Day
Present Week & Previous Week
Present Month & Previous Month
Present Year & Previous Year
- 1011 The DDC system prints a weekly and monthly report to both a file on the operator workstation in a directory called c:\dl*.txt, to the printer connected to control panel CP3, and to the printer connected to the operator workstation. In order for the report printing feature to function, the user access object, UA1 must be allocated to the default DELTA user and IGRAPHW must be loaded on the operator workstation and must be left running at night.
- 1012
- 1013 **Well Flow Reporting**
- 1014
- 1015 The DDC system monitors the temperature and water flow into and out of each well (CW1, WW2, CW3, WW4, and DUMPW).
- 1016 The DDC system calculates the total flow in gallons for each well for the following time periods:
Previous Day
Previous Week
Previous Month
Previous Year
Cumulative Total since system start up
- 1017 The DDC system prints a daily, weekly, monthly, and yearly report to both a file on the operator workstation in a directory called c:\dl*.txt, to the printer connected to control panel CP3, and to the printer connected to the operator workstation. In order for the report printing feature to function, the user access object, UA1 must be allocated to the default DELTA user and IGRAPHW must be loaded on the operator workstation and must be left running at night.
- 1018
- 1019 **Control Panel Alarms**
- 1020
- 1021 Main control panel failure alarms are generated when any main control panel (CP-1..5) fails to communicate with another control panel.
- 1022 Zone controller failure alarms are generated when any zone control panel (fan coil unit or VAV) fails to communicate with the main control panel (CP-1..5).
