AIR CONDITIONING AND MECHANICAL VENTILATION SYSTEM WITH SPLIT DEHUMIDIFICATION UNIT

FIELD OF THE INVENTION

[0001] This invention relates to an air conditioning and mechanical ventilation (ACMV) system for adjusting the temperature and humidity of air delivered to a building, and more particularly to an ACMV system with increased energy efficiency.

BACKGROUND OF THE INVENTION

[0002] An ACMV system can comprise one or more air handling units and provide air at a preselected temperature and humidity. Known systems have an air handling unit with a refrigerant coil which cools incoming air and reduces moisture content, and second heating coil which heats the air up to a preferred temperature to create conditioned air for introduction into a building or other space. See for example PCT Patent Application WO2008/136763 to Namuangrak, for example. Such known designs typically required three sets of coils, a first cooling coil connected to a chiller in the building, a second cooling coil connected to an HRU Evaporator, and a third heating coil connected to an HRU condenser.

[0003] In many environments, especially tropical and equatorial regions where it is hot and humid most of the year, costs of operating such ACMV systems are relatively high.

It would therefore be desirable to provide an air conditioning and mechanical ventilation system which takes up less space, reduces the number of coils needed and enhances energy efficiency.

SUMMARY OF THE INVENTION

[0004] In accordance with a first aspect, an air conditioning and mechanical ventilation system for providing conditioned air to a building, comprises an air handling unit adapted to receive fresh air and deliver the conditioned air to the building, and provided with a chilled fluid cooling coil and a heating coil, a split dehumidification unit which generates heat, and a chiller adapted provide chilled fluid to the chilled fluid cooling coil of the air handling unit. A hot fluid pipe is operatively connected between the split dehumidification unit and the heating coil, and adapted to transfer heat from the split dehumidification unit to the heating coil.

[0005] From the foregoing disclosure and the following more detailed description of various embodiments it will be apparent to those skilled in the art that the present invention provides a significant advance in the technology of ACMV systems. Particularly significant in this regard is the potential the invention affords for providing a relatively low cost, energy efficient ACMV system. Additional elements and advantages of various embodiments will be better understood in view of the detailed description provided below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] Fig. 1 is a schematic view of an ACMV system in accordance with one embodiment, showing an air handling unit with a split dehumidification unit.

[0007] Fig. 2 is a schematic of one embodiment of a split dehumidification unit.

[0008] Fig. 3 is a flow chart representative of the logic of an air handling unit/heat recovery unit control in accordance with one embodiment.

[0009] Fig. 4 is a flow chart representative of a supply air/conditioned air dewpoint temperature control logic in accordance with one embodiment.

[0010] Fig. 5 is a flow chart representative of a supply air/conditioned air temperature control logic in accordance with one embodiment.

[0011] Fig. 6 is a flow chart representative of the logic of a heat recovery unit hot water temperature control in accordance with one embodiment.

[0012] Fig. 7 is a flow chart representative of the logic of the heat recovery unit water temperature control in accordance with one embodiment.

[0013] It should be understood that the appended drawings are not necessarily to scale, presenting a somewhat simplified representation of various features illustrative of the basic principles of the invention. The specific design features of the ACMV system as disclosed here, including, for example, the specific dimensions of air pipes and fluid lines, will be determined in part by the particular intended application and use environment. Certain features of the illustrated embodiments have been enlarged or distorted relative to others to help provide clear understanding. In particular, thin features may be thickened, for example, for clarity of illustration. All references to direction and position, unless otherwise indicated, refer to the orientation illustrated in the drawings.

DETAILED DESCRIPTION OF CERTAIN EMBODIMENTS

[0014] It will be apparent to those skilled in the art, that is, to those who have knowledge or experience in this area of technology, that many uses and design variations are possible for the ACMV system. The following detailed discussion of various alternate elements and embodiments will illustrate the general principles of the invention with reference to an ACMV system suitable for providing air cooling with enhanced energy efficiency and a reduced physical footprint. Other embodiments suitable for other applications will be apparent to those skilled in the art given the benefit of this disclosure.

[0015] Turning now to the drawings, Fig. 1 shows an air conditioning and mechanical ventilation (ACMV) system 10 in accordance with one embodiment for providing supply air/conditioned air to a building 100, such as a hospital, data center or other indoors or partially indoor structure. The ACMV 10 is provided with an air handling unit 30 where primary conditioning of inlet air occurs, a chiller 50 which provides cooling fluid to cool the inlet air (and typically reduce a moisture content of the inlet air), and, advantageously, a split dehumidification unit 20. Fresh air is introduced to the air handling unit at fresh air passageway 99. Supply air/conditioned air may be created at the air handling unit 20 and delivered to the building via supply air passageway 97. The building is also shown with an exit air passageway 96. Optionally a portion of the exit air may be routed back from the building to the air handling unit via return air passageway 98.

[0016] In tropical and equatorial climates, fresh air is typically hot and humid. Therefore, the air needs to be cooled and the humidity needs to be reduced to make it comfortable for people working inside the building 100. After filtration, the fresh air is routed through a chilled water cooling coil 32 which accomplishes temperature and humidity reduction. Often the temperature reduction needed to get the humidity reduction required is below a preferred temperature for the conditioned air. Therefore, a heating coil 34 is used to heat the air back to the preferred supply air temperature prior to introduction to the supply air passageway 97.

[0017] The chiller 50 provides chilled fluid to the chilled water cooling coil, and the split dehumidification unit provides heated fluid to the heating coil. This is accomplished through a series of delivery pipes (61, 71, 77) and return pipes (62, 72, 76). As shown in Fig. 1, a hot fluid pipe 61 is operatively connected between the split dehumidification unit 20 and the heating coil 34 of the air handling unit 30. The hot fluid pipe allows for transfer of heat from the split dehumidification unit to the heating coil. For example, a maximum temperature of hot fluid leaving the split dehumidification unit may be up to 45°C. After heat transfer is made to the previously cooled and dehumidified inlet air at the heating coil 34, the hot fluid cools and is returned to the split dehumidification unit via a return hot fluid pipe 62, where the temperature of the hot fluid can be about 40°C, for example, and the process can be continued as needed during operation of the air conditioning and mechanical ventilation system 10. Delivery pipe 61 and return pipe 62 form a closed circuit operatively connecting and transferring heat from the split dehumidification unit to the heating coil 34 of the air handling unit 30.

[0018] Chiller fluid pipe 71 is operatively connected between the air handling unit 30 and the chiller 50, and is adapted to deliver chiller fluid from the chiller to the air handling unit. A return chiller fluid pipe 72 (also 73 and 74) is operatively connected between the air handling unit and the chiller, and is adapted to return chiller fluid to the chiller. For example, chilled fluid having a temperature of about 7°C-10°C, and more preferably about 8.5°C may be delivered to the chilled water cooling coil 32 of the air handling unit. The act of cooling the inlet air causes heat transfer to the chiller fluid, heating the chiller fluid in the return chiller fluid pipe 72 to about 13.5°C, for example. The process of

cooling the chilled water cooling coil of the air handling unit can be continued as needed during operation of the air conditioning and mechanical ventilation system 10. Delivery chiller pipe 71 and return chiller pipe 72/73/74 form a closed circuit operatively connecting and transferring heat away inlet air (indirectly) at the air handling unit 30 and to the chiller 50. The return chiller fluid pipe has sections 72, a section 73 after a split to form the beginning of a return cooling line 76 and merged line 74 formed where a cooling fluid pipe 76 merges with section 73.

[0019] A cooling fluid pipe 77 is operatively connected between the split dehumidification unit 20 and the chiller 50, and is adapted to deliver cooling fluid from the split dehumidification unit to the chiller. A return cooling fluid pipe 76 is operatively connected between the chiller 50 and the split dehumidification unit 20, and is adapted to return fluid to the split dehumidification unit. Cooled fluid leaving the split dehumidification unit can have a temperature of about 7°C-10°C, and more preferably about 8.5°C, which is similar to the temperature of the chilled fluid. The cooling fluid line 77 merges with the return chiller line 73 between the chiller and the split. That is, as shown in Fig. 1, 77 and 73 merge to form merged section 74 of the return chiller line. At the split forming the beginning of the return cooling pipe 76, some of the fluid in the return chiller fluid pipe 72 is routed to the return cooling fluid pipe and in turn routed to the split dehumidification unit. The fluid in the return cooling fluid pipe 76 will have a temperature essentially the same as the temperature of the fluid in the return chiller pipe 72, or about 13.5°C, for example. Delivery cooling pipe 77 and return cooling pipe 76 also cooperate to form a closed circuit operatively connecting and transferring heat

away from the chiller (essentially the same as transferring cooling fluid to the chiller). Thus, the split dehumidification unit not only supplies heat to the heating coil 34, but also supplies cooled fluid to the chiller which helps the chiller in turn produce chilled fluid which is provided to the chilled water cooling coil 32 and reduce overall energy consumption of the system. The reduction of energy consumption occurs in part by using split dehumidification unit heating instead of heating using an electric heater, and by routing cooled fluid from the split dehumidification back to the chiller system, acting to reduce the return fluid /water temperature of the chiller and allow the chiller to be running at a lower load.

[0020] Each of the return lines 62, 72 and 76 may be provided with a pump. That is, a hot fluid pump 65 may be operatively positioned on at least the return hot fluid pipe 62. The hot fluid pump is moveable from an open position allowing flow of (relatively) hot fluid through the return hot fluid pipe to a closed position restricting flow of the hot fluid through the return hot fluid pipe. A cooling fluid pump 75 may be operatively positioned on at least the return cooling pipe 76. The cooling fluid pump 75 is moveable from an open position allowing flow of cooling fluid through the return cooling fluid pipe to a closed position restricting flow of the cooling fluid through the return cooling fluid pipe 76. Similarly, a chiller fluid pump 55 can be operatively positioned on the return chiller pipe 72. The chiller fluid pump 55 can be moveable from an open position allowing flow of the chiller fluid through the return chiller fluid pipe 72 to a closed position restricting flow of the chiller fluid through the return chiller fluid pipe. A controller can be provided in electrical communication with all of the pumps, as well as valves along the several

fluid lines, refrigerant lines and air passageways, which simultaneously controls a first position of the hot fluid pump, a second position of the cooling fluid pump, and a third position of the chiller fluid pump. Valve assemblies (53, 54 on the chilled fluid pathway, 66, 67 on the hot fluid pathway, 63 and 64 on the hot fluid pathway adjacent the split dehumidification unit, and 78 and 79 on the cooling fluid pathway, for example) can be operatively interconnected to the controller and positioned on each of the fluid pipes, refrigerant pipes and air passageways to regulate flow of fluid and/or air through each corresponding pipe or passageway. In addition to a valve (such as a three-way modulating valve for the chilled water valve, hot fluid/heating valve and cooling fluid valve), each of the valve assemblies can comprise a thermowell sensor, an analog pressure gauge, an analogue temperature gauge and a flexible connection.

[0021] Fig. 2 shows one embodiment of the split dehumidification unit 20, shown having a compressor 40, a condenser heat exchanger 22, an expansion valve 24, and an evaporator heat exchanger 26. Advantageously the split dehumidification unit and its elements may be located remote from the air handling unit 30, which helps reduce floor space needed for they system at important locations. The hot fluid pipe 61 and the return hot fluid pipe 62 are shown in fluid connection with the condenser heat exchanger 22. The cooling fluid pipe 77 and return cooling fluid pipe 76 are shown in fluid connection with a separate evaporator heat exchanger 26. Each of these pipes allows for remote connection to the air handling unit 30 and the chiller 50. A refrigerant may be provided in the refrigerant line which undergoes a phase change from gas to liquid and back to gas as the refrigerant absorbs and then releases heat. Looking at the

refrigerant line operation in more detail, a first refrigerant line 81 connects the compressor 40 and the condenser heat exchanger 22, a second refrigerant line 82 connects the condenser heat exchanger 22 to the expansion valve 24, a third refrigerant line 83 connects the expansion valve 24 to the evaporator heat exchanger 26, and a fourth refrigerant line 84 connects the evaporator heat exchanger 26 back to the compressor 40 to form a loop. That is, in normal operation refrigerant flows from 81 to 82 to 83 to 84 and back to 81. The condenser heat exchanger 22 acts to recycle waste heat cooling from the dehumidification process to generate a colder fluid. The expansion valve 24 is positioned between the condenser heat exchanger 22 and the evaporator heat exchanger 26 (refrigerant line 82 and refrigerant line 83 in Fig. 2). For example, during operation the compressor 40 compresses the refrigerant, which heats the refrigerant. Preferably the controller restricts refrigerant temperature leaving the compressor to a maximum temperature, such as 76°C, for example. Refrigerant is cooled at the condenser heat exchanger to a lower temperature, such as 45°C, for example, and then routed to the hot fluid pipe 61 and separately to the expansion valve 24 via second refrigerant line 82. The expansion valve allows for significant reduction in pressure of the refrigerant and consequently the temperature of the refrigerant as well. For example, the temperature of the third refrigerant line 83 during operation may be 3°C. Refrigerant at the evaporator heat exchanger may increase somewhat, such that the output temperature at the fourth refrigerant line 84 (and the cooling fluid pipe 77) is about 7°C-10°C, and more preferably about 8°C. Refrigerant line 84 returns refrigerant to the compressor 40 to complete the loop.

[0022] Figs. 3-7 show schematic flow charts describing various aspects to how a controller (not shown) controls the ACMV system and its constituent elements. The controller can regulate the compressor via a variable speed drive based on a temperature of the supply air. In this way the supply air temperature can be maintained at a desired and adjustable preset value. Fig. 3 shows a schematic flow chart of the air handling unit/split dehumidification unit start/stop control. During normal operation the split dehumidification unit is activated when an "on" status of the air handling unit is detected by the controller at step 110 via a voltage free normally open contact. When the air handling unit run status is "off", a temperature control loop is disabled, the chilled water valve actuator will be driven to the closed position, the compressor will be disabled, the heating valve will be driven to a closed position, the chilled water control loop will be disabled and the hot water pump control loop will be disabled. Thus, all parameters are set to a default setting. Step 115. When the air handling unit is "on", the split dehumidification unit remote mode is selected (Step 120). A chilled water valve is adjusted as required. A check is made of whether an alarm has been activated at step 130. In the event an alarm is activated a backup system will take over control of the chilled water valve. The heating modulating valve and split dehumidification compressor control loop will be enabled at step 150 only if all alarm conditions are normal, step 140. If there is an alarm, the air handling unit may be stopped and an alarm status signal may be sent, step 135. The hot water pump control loop will be enabled only if there are no split dehumidification alarm conditions, step 160. The chilled water pump control loop will be enabled only if there are no split dehumidification alarm conditions. If the split dehumidification unit has an alarm condition, the split

dehumidification unit may be stopped and an alarm signal may be sent, step 165. Assuming there are no alarms, the split dehumidification unit may be started, step 170. 180 is the end of this portion of the logic control of the controller for the ACMV system.

[0023] Fig. 4 shows representative supply air dewpoint temperature control logic in accordance with one embodiment. At step 240, the start command is issued and at step 210, the running status of the air handling unit is confirmed. Assuming the air handling unit status is normal, then the split dehumidification unit status is checked, step 220. The split dehumidification unit chilled water valve is controlled by the controller using a proportional plus integral control algorithm to maintain a required supply air dewpoint temperature setpoint, step 230. Checking the supply air dewpoint temperature, step 240 results in one of two conditions. If the supply air dewpoint temperature falls below the setpoint, the split dehumidification unit chilled water valve is driven towards the open position, step 250. If the supply air dewpoint temperature is above the setpoint, the chilled water valve may be moved toward the closed position, step 245. If an alarm status is indicated at either the air handling unit or the split dehumidification unit, then no additional steps are taken, and this is the end of the logic control for this algorithm, step 260. If the supply air dewpoint temperature set point cannot be determined, then the valves and pumps may remain at their last position, step 235.

[0024] Fig. 5 shows a representative supply air temperature control logic in accordance with one embodiment, which is similar to the control logic of the supply dewpoint

temperature control logic discussed in Fig. 4 above. To maintain the desired supply air temperature set point, the controller uses fuzzy logic and proportional plus integral control to regulate the hot water valve and the compressor. At start 300 the air handling unit status is determined. At step 310 the split dehumidification status is determined. If the SDU is on, the supply air temperature setpoint is determined, step 320. If the supply air temperature set point cannot be determined, the valves and pumps remain at their last position, step 325. At step 330 the supply air temperature is compared to the setpoint. If the supply air temperature is below the setpoint, a signal may be sent to increase hot water flow, step 340. An additional check may be made to see if the hot water actuator/valve is already at its maximum open position, step 350. If that is the case, then the compressor speed may be increased, step 360. If the supply air temperature is above the set point, a signal may be sent to decrease compressor operating speed, step 335. An additional check may be made to see if the compressor speed is already at a minimum, step 345. If that is the case, then the hot water actuator may be moved to further restrict hot fluid/water flow, step 355. Step 370 indicates the end of this portion of the logic of the controller for the ACMV system.

[0025] Fig. 6 shows a representative heat recovery unit hot water delta temperature control logic in accordance with one embodiment. Hot water recovery occurs at the condenser heat exchanger 22. At step 400 an initial check of the status of the air handling unit is performed. At step 410 the split dehumidification unit status is checked; if the SDU is not on then no further action is taken in the algorithm, step 450. Assuming the SDU is on, next the hot water delta temperature setpoint is determined, step 420. If

the hot water is at the same temperature as the setpoint the valves and pumps remain at their last position, step 425. The split dehumidification unit hot water pump is used to maintain the desired hot water delta temperature setpoint using a proportional plus integral control, step 430. If the hot water delta temperature falls below the setpoint, the controller will reduce pump speed via a variable speed signal, step 435. Conversely, if the hot water delta temperature rises above the setpoint, then the fluid pump speed will increase (via a variable speed signal) to maintain the desired set point, step 440.

[0027] Fig. 7 shows a representative heat recovery unit evaporative fluid/water delta temperature control logic in accordance with one embodiment, similar to the embodiment for control of the hot water pump control of Fig. 6. Evaporative water recovery occurs at the evaporative heat exchanger 26. At step 500 an initial check of the status of the heat recovery unit is performed. At step 510 the heat recovery unit status is checked; if the heat recovery unit is not on then no further action is taken in the algorithm, end step 550. Assuming the heat recovery unity is on, next the evaporative water delta temperature setpoint is determined, step 520. If the evaporative water is at the same temperature as the setpoint the valves and pumps remain at their last position, step 525. The split dehumidification unit evaporative water pump is used to maintain the desired evaporative water delta temperature setpoint using a proportional plus integral control, step 530. If the evaporative water delta temperature falls below the setpoint, the controller will reduce pump speed via a variable speed signal, step 535. Conversely, if the evaporative water delta temperature rises above the setpoint,

then the fluid pump speed will increase (via a variable speed signal) to maintain the desired set point, step 540.

[0028] From the foregoing disclosure and detailed description of certain embodiments, it will be apparent that various modifications, additions and other alternative embodiments are possible without departing from the true scope of the invention. The embodiments discussed were chosen and described to provide the best illustration of the principles of the invention and its practical application to thereby enable one of ordinary skill in the art to use the invention in various embodiments and with various modifications as are suited to the particular use contemplated. All such modifications and variations are within the scope of the invention as determined by the appended claims when interpreted in accordance with the breadth to which they are fairly, legally, and equitably entitled.

CLAIMS

What is claimed is:

1. An air conditioning and mechanical ventilation system for providing conditioned air to a building, comprising, in combination:

an air handling unit adapted to receive fresh air and deliver the conditioned air to the building, and provided with a chilled fluid cooling coil and a heating coil;

a split dehumidification unit which generates heat;

a chiller adapted provide chilled fluid to the chilled fluid cooling coil of the air handling unit; and

a hot fluid pipe operatively connected between the split dehumidification unit and the heating coil, and adapted to transfer heat from the split dehumidification unit to the heating coil.

2. The air conditioning and mechanical ventilation system of Claim 1 further comprising a return hot fluid pipe operatively connected between the heating coil and the split dehumidification unit, and adapted to return fluid to the split dehumidification unit.

3. The air conditioning and mechanical ventilation system of Claim 1 further comprising a return air passageway adapted to rout air from the building back to the air handling unit.

4. The air conditioning and mechanical ventilation system of Claim 1 wherein the split dehumidification unit comprises a compressor, a condenser heat exchanger and an evaporator heat exchanger, wherein the hot fluid pipe and the return hot fluid pipe are in fluid connection with the condenser heat exchanger.

5. The air conditioning and mechanical ventilation system of Claim 2 wherein a maximum temperature of fluid in the hot fluid pipe is 45°C.

6. The air conditioning and mechanical ventilation system of Claim 4 further comprising:

a cooling fluid pipe operatively connected between the split dehumidification unit and the chiller, and adapted to deliver cooling fluid from the split dehumidification unit to the chiller; and

a return cooling fluid pipe operatively connected between the chiller and the split dehumidification unit, and adapted to return fluid to the split dehumidification unit.

7. The air conditioning and mechanical ventilation system of Claim 6, wherein the cooling fluid pipe and the return cooling fluid pipe are in fluid connection with the evaporator heat exchanger.

8. The air conditioning and mechanical ventilation system of Claim 6 wherein a temperature of fluid in the cooling fluid pipe is 7°C-10°C.

9. The air conditioning and mechanical ventilation system of Claim 5, further comprising an expansion valve positioned between the condenser heat exchanger and the evaporator heat exchanger.

10. The air conditioning and mechanical ventilation system of Claim 9, further comprising a first refrigerant line connecting the compressor and the condenser heat exchanger, a second refrigerant line connecting the condenser heat exchanger to the expansion valve, a third refrigerant line connecting the expansion valve to the evaporator heat exchanger, and a fourth refrigerant line connecting the evaporator heat exchanger back to the compressor to form a loop.

11. The air conditioning and mechanical ventilation system of Claim 7, further comprising:

a chiller fluid pipe operatively connected between the air handling unit and the chiller, and adapted to deliver chiller fluid from the chiller to the air handling unit; and

a return chiller fluid pipe operatively connected between the air handling unit and the chiller, and adapted to return chiller fluid to the chiller.

12. The air conditioning and mechanical ventilation system of Claim 11, further comprising:

a hot fluid pump operatively positioned on the return hot fluid pipe;

a cooling fluid pump operatively positioned on the return cooling fluid pipe; and

a chilled fluid pump operatively positioned on the return chiller fluid pipe.

13. The air conditioning and mechanical ventilation system of Claim 12, wherein:

the hot fluid pump is moveable from an open position allowing flow of a hot fluid through the return hot fluid pipe to a closed position restricting flow of the hot fluid through the return hot fluid pipe;

the cooling fluid pump is moveable from an open position allowing flow of a cooling fluid through the return cooling fluid pipe to a closed position restricting flow of the cooling fluid through the return cooling fluid pipe;

the chiller fluid pump is moveable from an open position allowing flow of a chiller fluid through the return chiller fluid pipe to a closed position restricting flow of the chiller fluid through the return chiller fluid pipe; and

a controller simultaneously controls a first position of the hot fluid pump, a second position of the cooling fluid pump, and a third position of the chiller fluid pump.

14. The air conditioning and mechanical ventilation system of Claim 11, wherein the cooling fluid line merges with the return chiller line to form a merged line which connects to the chiller.

15. The air conditioning and mechanical ventilation system of Claim 11, wherein the return chiller line has a split and the return cooling line begins at the split.

16. The air conditioning and mechanical ventilation system of Claim 15, wherein the cooling fluid line merges with the return chiller line between the chiller and the split.

17. An air conditioning and mechanical ventilation system for providing conditioned air to a building, comprising, in combination:

an air handling unit adapted to receive fresh air and deliver the conditioned air to the building, and provided with a chilled fluid cooling coil and a heating coil;

a split dehumidification unit which generates heat;

a chiller adapted provide chilled fluid to the chilled fluid cooling coil of the air handling unit; and

a cooling fluid pipe operatively connected between the split dehumidification unit and the chilled fluid cooling coil, and adapted to cool fresh air and reduce humidity of the fresh air at the chilled fluid cooling coil.

18. The air conditioning and mechanical ventilation system of Claim 17 further comprising:

a return cooling fluid pipe operatively connected between the chiller and the split dehumidification unit, and adapted to return fluid to the split dehumidification unit; and

the split dehumidification unit comprises an evaporator heat exchanger, and the cooling fluid pipe and the return cooling fluid pipe are in fluid connection with the evaporator heat exchanger.

19. The air conditioning and mechanical ventilation system of Claim 18 further comprising:

a chiller fluid pipe operatively connected between the air handling unit and the chiller, and adapted to deliver chiller fluid from the chiller to the air handling unit; and

a return chiller fluid pipe operatively connected between the air handling unit and the chiller, and adapted to return chiller fluid to the chiller;

wherein the cooling fluid line merges with the return chiller line to form a merged line which connects to the chiller, and the return chiller line has a split and the return cooling line begins at the split.