

## Mechanical Systems Existing Conditions

### Design Conditions

The entire Xanadu Sports Complex including the mechanical system was designed to comply with Building Officials and Code Administrators (BOCA) 1996. Chapter 28 of the BOCA 1996 code covers the provisions of a building's mechanical system. The mechanical section covers topics such as acceptable pipe material, insulation requirements, and plenum sizes; however, prescriptive methods for designing ventilation systems and acceptable comfort levels are not present in the code. It is evident that the BOCA 1996 code is nowhere near as detailed as the current International Mechanical Code (IMC) regulations.

The design outdoor conditions used for the load calculations and energy analysis were obtained using the ASHRAE Fundamentals Handbook 2005, and the weather data files were obtained from TRACE 700. The ASHRAE Handbook lists the closest city, Newark, New Jersey, as having a design summer temperature of 91°F DBT and a 73°F WBT. A winter design temperature of 14°F DBT was used and WBT was not used due to the fact that Trace assumes dry winter conditions for certain climate zones. Other weather factors assigned by Trace are clearness factors of 0.99 and a ground reflectance value of 0.2.

The indoor design conditions for the retail section of Building A were not available from the design engineer. For this reason an assumption was made, and the design dry bulb temperature was set at 72°F. While the retail design conditions were not available, the indoor ski resort's conditions were. In the Snowdome during normal day operation, temperatures must be maintained between 30°F and 32°F. However, at night fresh snow is made on a daily schedule, and temperatures must be cooled to approximately 24°F to ensure proper snow making.

As with many of the other design considerations, the design engineer was not available to provide information regarding design considerations; however, a look at the site reveals a problem with the introduction of uncontaminated air to the building. Figure 2 below provides an aerial photo of the site before construction began. The red silhouette represents Building A while the grey silhouette represents the rest of current construction. Figure 2 shows how close the complex is to the New Jersey Turnpike Interstate 95 and Route 120, which are both heavily trafficked on a daily basis. For this reason it is important to avoid introducing highly contaminated air through the building's ventilation system.

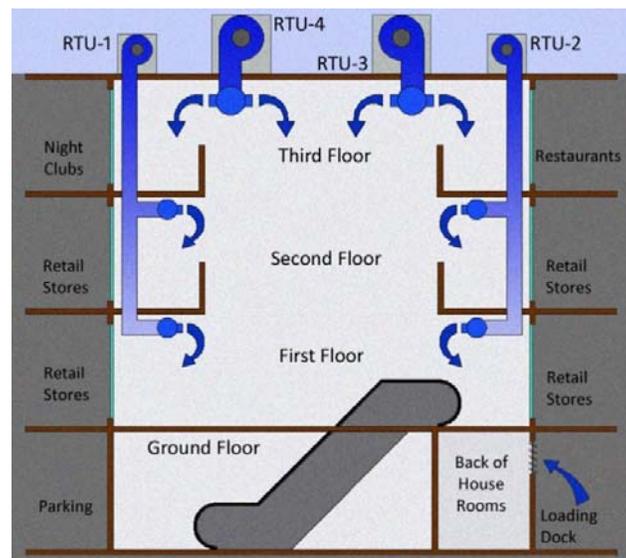


Figure 2: Aerial Photo of Complex Site Previous to Construction

### Retail Mechanical System

The air side mechanical system for the retail section of Building A uses four roof top air handling units that serve all the common areas of the building. In Building A common spaces are comprised of walkways to the different stores and restaurants, restrooms, back of house rooms, and a large central area that will create a large atrium for all the levels of shopping. All tenant spaces will not have any mechanical work done at this time and will be finished by the leaser towards the completion of the building. All four common area rooftop units are controlled by variable frequency drives with two running modes: occupied mode during normal operating hours and unoccupied mode during the nighttime. A programmable time clock will control when the occupied or unoccupied mode begins to run. A thermostat will control the cycling of the supply fan and energize the electric heating coil to maintain the nighttime setback temperature during the unoccupied mode. During the occupied mode the supply fan will operate continuously. The use of an economizer to maximize atmospheric cooling will also be implemented for all four of the rooftop units.

RTU-1 serves the first and second floor common areas on the east side of the building, and RTU-2 serves the first and second floor common areas on the west side of the building. Both units supply 16,100 cfm of air each with 1,496 cfm of that supply air being outside air. Each unit's cooling coil has a capacity of approximately 38 tons and an electric heating coil capacity of 150 kilowatts. RTU-3 and RTU-4 serve the third floor common areas. Both of these units supply 31,000 cfm of air each with 3,037 cfm of that supply air being outside air. Each unit's cooling coil has a capacity of approximately 78 tons and an electric heating coil capacity of 190 kilowatts. A graphical representation of the atrium's ventilation system can be seen in Figure 3.



*Figure 3: Retail Ventilation*

In addition to the rooftop units, wall mounted electric unit heaters are used in mechanical spaces, entrance vestibules, and exit stairways to maintain thermal comfort. To ensure fresh air enters the back of house rooms, exhaust fans are installed to negatively pressurize the rooms. With the use of exhaust fans, fresh air that has been supplied to the walkways on the floor will be drawn to the rooms with negative pressure. Small air condition units are also used in elevator machine rooms and the main ground floor entrance to supply cooling when needed.

### **Snowdome Mechanical System**

The challenge of an indoor ski resort is to ensure that snow can be maintained year round and to maintain a highly controlled environment. During normal day operation, temperatures must be maintained between 30°F and 32°F. However, at night fresh snow is made on a daily schedule, and temperatures must be cooled to approximately 24°F to ensure proper snow making. The Xanadu Snowdome plans to achieve ideal conditions by

using cooled supply air, under floor glycol piping, recirculation coolers, and snow guns to provide the best skiing conditions every day of the year.

The Snowdome ventilation system is comprised of a single 30,000 cfm air handling unit with 15,000 cfm of the supply air being outside air. The unit uses a main common intake system with one primary and two secondary cooling coils. The air is pre-cooled by means of a thermal wheel and then cooled down to above freezing by the primary cooling coil. The air is then cooled below freezing by the secondary coils which are fed by a cold glycol system. A hot glycol system line is also fed to the secondary coils and will only be used when the coils need to be defrosted. The system is fully variable in volume, achieved by using inverters on the fans, to suit the current occupancy.

Two 222 ton electric screw chillers operating at 1.5°F leaving glycol temperature provide the cold glycol to the air handling unit's coils, under floor piping matrix, recirculation coolers, and snow guns. Both chillers operate in conjunction with an evaporative condenser located on the roof of the Snowdome mechanical mezzanine which houses all the mechanical equipment.

Mounted along the ceiling of the Snowdome are recirculation coolers and snow guns. Both devices will be run using the cold glycol system during normal operation. However, when the devices need to be defrosted, the cold glycol system will be shut off, and the hot glycol system will be turned on for defrosting. The snow guns also require compressed air for the use of snow making; therefore, a compressed air line will be provided to each snow gun.

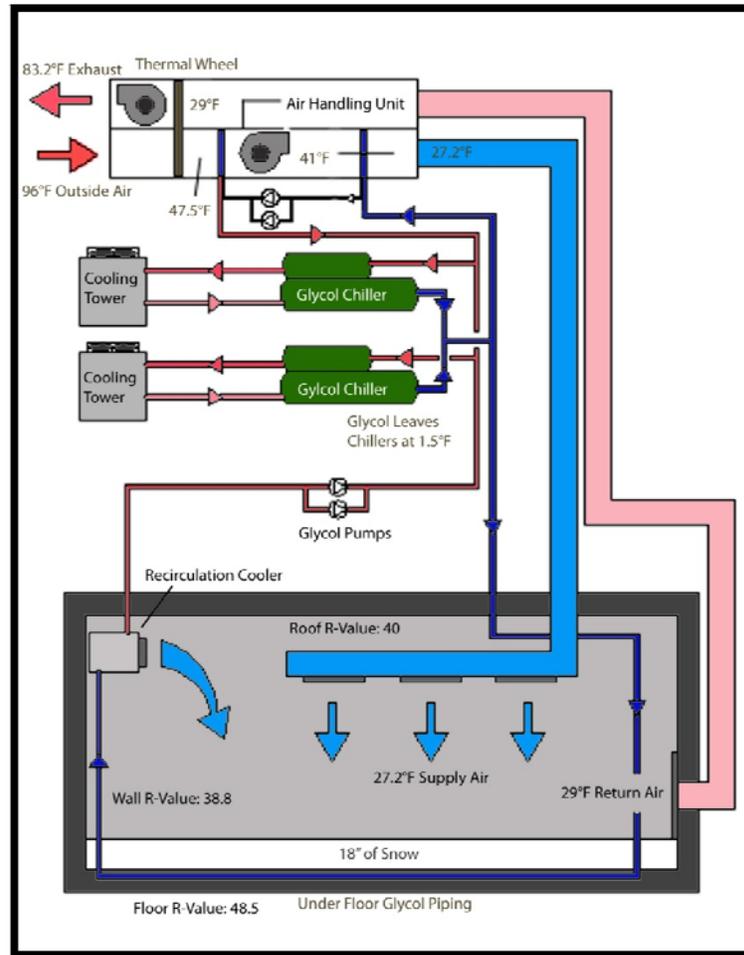


Figure 4: Snowdome Mechanical System

### Retail Rooftop Air Handling Units

The control logic for all four rooftop units serving the retail sections of Building A are the same. A programmable time clock will ensure the supply fan operates continuously during the hours the stores are open. The units have three set cycles: occupied, unoccupied, and morning warm-up.

During the occupied cycle the fan will operate continuously. When the outside air enthalpy sensor E1 reads a value less than the return air enthalpy sensor E2, dampers D1, D2, and D3 will modulate to maximize atmospheric cooling. The supply air temperature sensed by T3 will then be maintained to the design setpoint by modulating the electric heat coil EHC or energizing the direct expansion cooling coil DXCC. The supply air temperature will be set at 55°F, however, is adjustable. During the unoccupied cycle the fan and electric heating coil will maintain a setback temperature of 55°F. During morning warm-up dampers D1 and D3 will remain closed. Damper D2 will remain open, and the fan will

operate with the electric heating coil until temperature sensor T5 reaches 65°F. At this time the system will return to the occupied cycle. Figure 5 below provides a schematic for a typical retail rooftop unit.

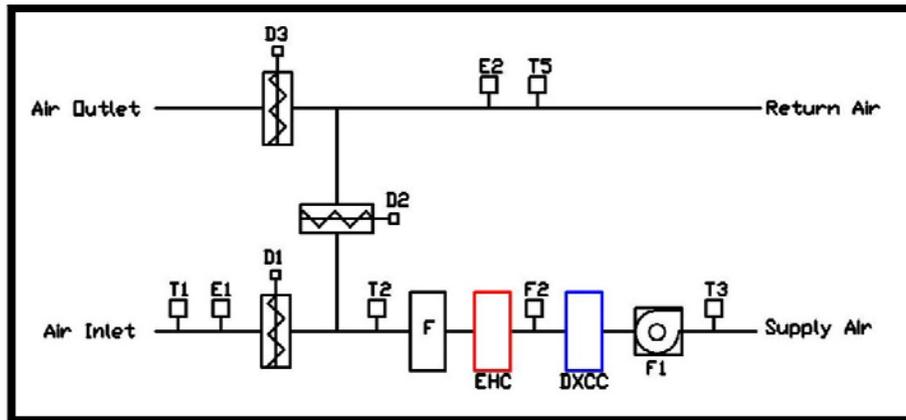


Figure 5: Schematic of a Typical Retail Rooftop Air Handling Unit

### Snowdome Air Handling Unit

The Snowdome's ventilation system is comprised of a main common intake system with one primary and two secondary cooling coils. The air is pre-cooled by means of a thermal wheel TW and then cooled to just above freezing by the primary cooling coil C1. The air is then cooled to below freezing temperatures by either one of the secondary coils C2a or C2b, which are fed by the main cold glycol system. The system is fully variable in volume to suit the occupancy which is achieved by inverters on the fans.

During normal operation the system will operate on a time control from the BAS and in conjunction with the occupancy of the Snowdome. The fresh air supply will be varied from a minimum set point which will be controlled by a carbon dioxide sensor. The system will ensure that the carbon dioxide level is maintained below 1000 parts per million. The signal from the sensor will be sequenced with the exhaust fan inverter to maintain the correct pressure. The unit will provide ventilation during regular operating hours and while the snow plows are grooming the snow at night. To ensure proper indoor air quality the unit is equipped with two sets of filters: a panel-type pre-filter PF and a main set of bag filters SF. The differential pressure transducers DPTs across the filters will indicate a dirty filter condition. Coil C2a will be used as a duty coil and will only shutdown for a defrosting cycle or if a problem arises with the coil, at which point coil C2b will take the cooling responsibility. The coil temperature sensor T4 will sense the coil temperature, and as long as it stays at its design temperature, dampers D1, D2, and D3 will remain open. However, if temperature sensor T4 detects a problem with coil C2a then dampers D1, D2, and D3 will close and dampers D4, D5, and D6 will open to allow the coil C2b to cool the air. At this

point the cold glycol valve MV3 will close to stop the glycol flow to coil C2a, and the valve MV5 will open to allow the cold glycol to flow into coil C2b.

Temperature sensor T3 will ensure that the temperature leaving the first coil is maintained at 41°F by modulating the temperature of the entering cold glycol. The glycol temperature sensor T10 will ensure that the glycol temperature never falls below 30°F. If T10 reads a temperature of 30°F, it will override the control of valve MV1 to allow the temperature to rise above 30°F. The off coil temperature of cooling coil C2a will be sensed by temperature sensor T6 which will control the modulation of the three-way valve MV2 on the primary cold glycol circuit.

Since coils C2a and C2b operate below freezing temperatures ice buildup will need to be addressed with a defrost cycle. The defrost cycle will be initiated through the use of a time channel within the BAS but will also be checked for loss of air flow through the DPT. Once it has been determined that the defrost cycle should be initiated, the cold glycol valves MV3 and MV4 will close along with dampers D1, D2, and D3. The heater ACH between dampers D2 and D3 will energize to prevent the freezing of the damper blades. At this point the hot glycol valves MV7 and MV8 will open. The cold and hot glycol valves will have end switches to provide a closed signal and will ensure that both valves are never open simultaneously. On the completion of the defrost cycle the hot glycol valves MV7 and MV8 will close, and the coil will remain switched off until required. Also the heater ACH will remain on until the coil is charged again. Figure 6 below provides a schematic for the Snowdome air handling unit while Figure 7 provides a schematic for the glycol connections to the unit's coils.

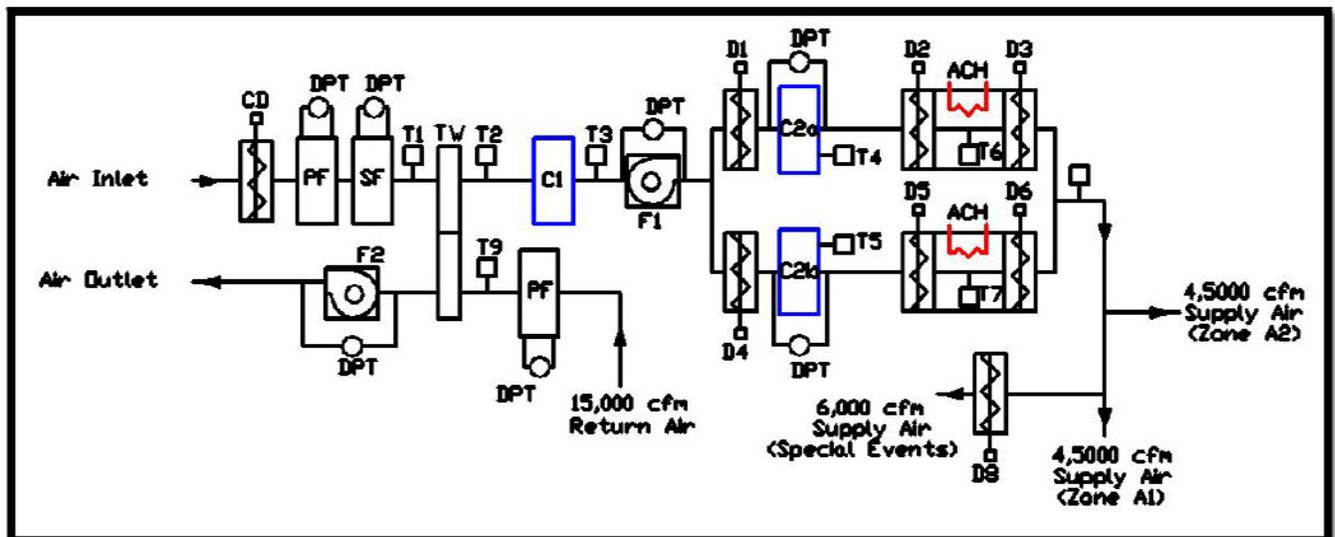


Figure 6: Schematic of the Snowdome Air Handling Unit

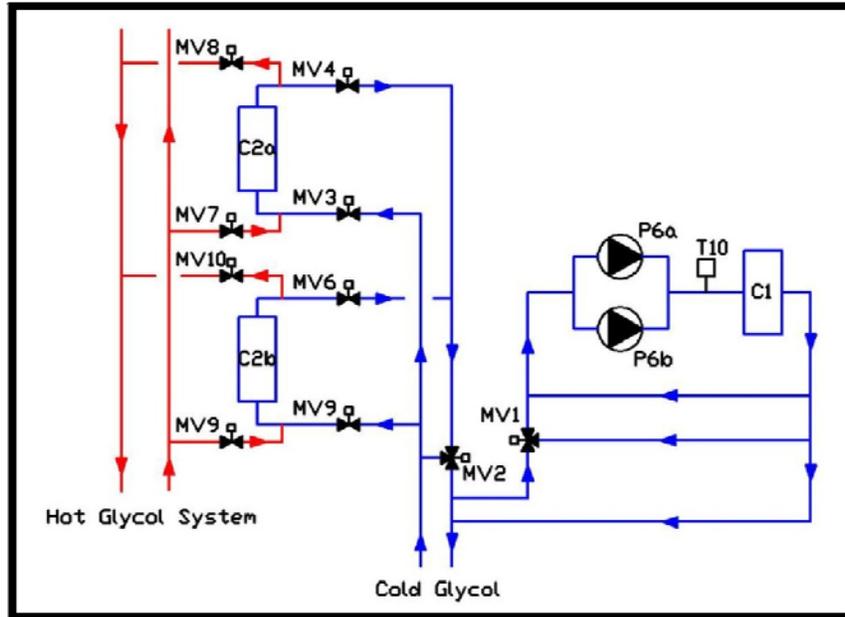


Figure 7: Schematic of the Snowdome Air Handling Unit Coil Connections

### Snowdome Chillers and Main Cold Glycol Pumps

The Snowdome Glycol Chillers provide cold glycol to all the recirculation coolers, snowguns, under floor piping matrix, air handling unit cooling coils, and snowmaking tank. The chiller system will be on at all times to ensure proper temperatures are maintained in the skiing area. The return glycol temperature sensor T1 will enable the number of chillers to be controlled at low load. A separate output to the chillers will change the chiller operating at set points required by the system for snow making. The main glycol pumps will run in a duty/standby operation. A differential pressure switch located across each pump will sound an alarm on sensing a no flow condition through the duty pump, and the standby pump will begin to run. The system will monitor the hours of operation of each pump and share operating time between them. A time delay between the switching of the duty pump will occur to ensure that the system does not shut down. As mentioned earlier, the chillers should never shut down. The only time of shut down will occur under a manual control or a power failure. In a manual shut down the duty pump will continue to run for a prescribed period of time; however, if the system loses pressure, the pumps will shut down immediately. If a power failure occurs, the compressors will automatically restart once the power is restored. Figure 8 below provides a schematic for the chillers and main glycol pumps.

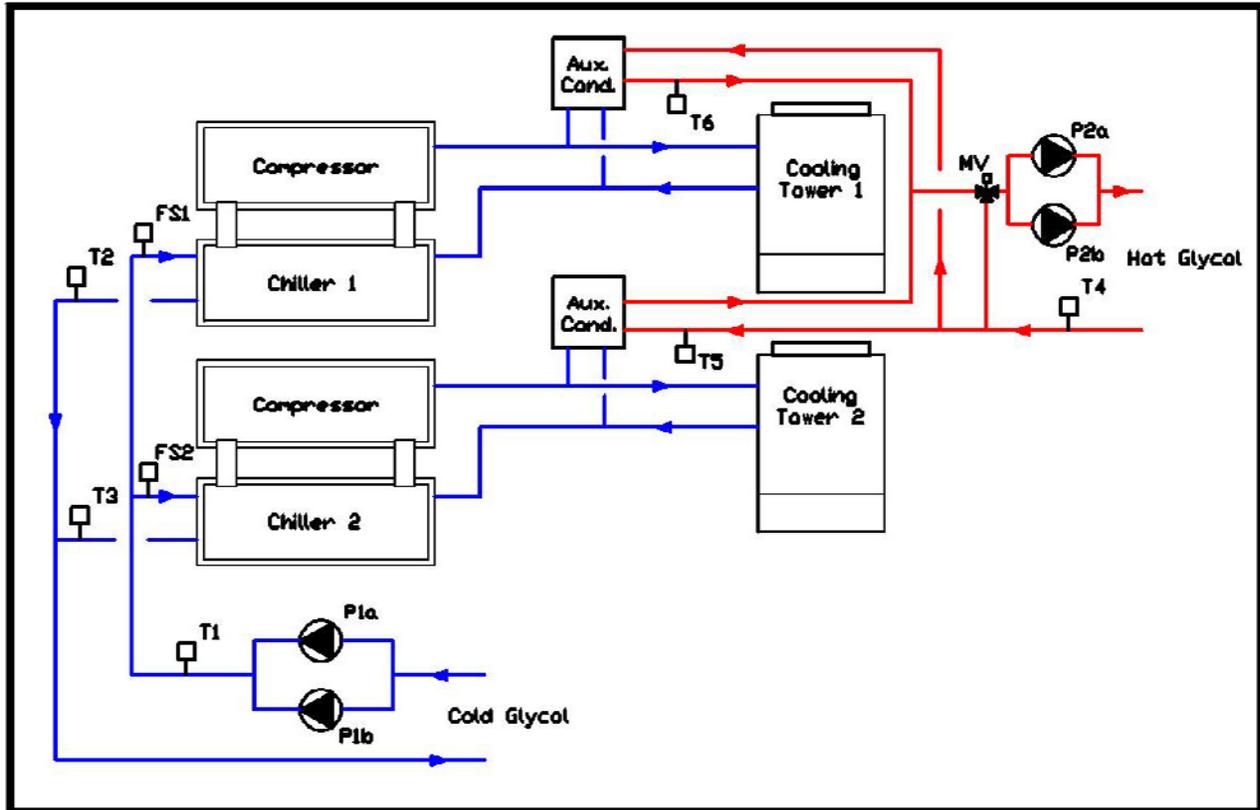


Figure 8: Schematic of Chillers and Main Glycol Pumps

### Snowdome Recirculation Coolers

Thirteen ceiling mounted recirculation coolers will help maintain skiing conditions year round. The cooler fans will operate normally at all times, however, will shut off during the defrosting process. The controls for the coolers will also provide a sleep function which will stop individual coolers if cooling is not required in the zone served by the cooler for a preset time. This will help provide power savings during periods of low ambient temperatures and low occupancy.

During normal operation the cooler fans will run at a low speed which is controlled by the fan inverter. The fan speed will be increased by a modulating control function if temperature sensor T1 reads that the return air temperature rises above 32°F to increase the cooling duty. When the temperature falls back within the limit, the fans will revert to the low speed. The output of the cooling coil will be controlled by modulating the cold glycol supply flow. The return air temperature sensor T1 will send a signal to the controller which will modulate the three-way valve MV1 to provide the supply air temperature. Along the cold glycol supply line are temperature sensors that ensure the proper glycol temperature is maintained. If one of these sensors determine that the main

cold glycol flow temperature has risen to high, all the recirculation cooler fans will shutdown in order to reduce the amount of heat produced.

At night during the snowmaking cycle, the cooler fans will run at full speed, and the return air set point will change to the lower 27°F air temperature. Also, since the system runs below freezing conditions a defrost cycle will periodically need to be run. This process is possible due to the hot glycol system. In order to defrost the coolers and still maintain skiing conditions, no more than three coolers will be defrosted at a time. In order to run the defrost cycle the cold glycol valve will close, and the fans will remain on to raise the temperature of the remaining glycol in the coil to room temperature. After a preset time the fans will shut down and the hot glycol valves MV2 and MV3 will open to allow the hot glycol into the coil. The coil temperature sensor T3 will read the coil temperature, and once the coil reaches a set temperature the defrost cycle will be shut off. Valves MV2 and MV3 will close and the cold glycol valve MV1 will open. Figure 9 below provides a schematic for the operation of a typical recirculation cooler.

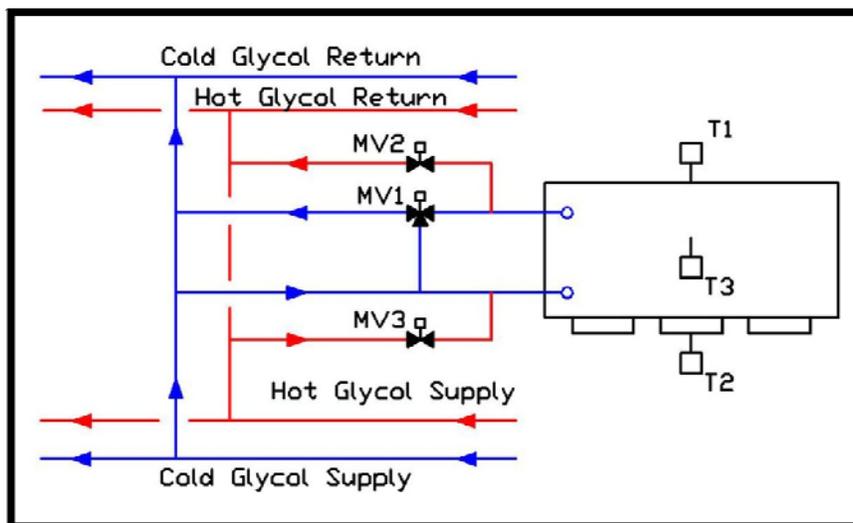


Figure 9: Schematic of a Typical Recirculation Cooler

### Snowdome Snowmaking Water Tank Cooling

The snowmaking water tank's function is to cool the water that will be used for snowmaking to a temperature near freezing in preparation for a phase change. The water temperature of the snowmaking water and the filling tank will operate under fully automatic controls to balance out the demand for cooling and the water supply.

During non snowmaking periods the water tank will be filled with the cold water supply via valve SV1. The supply water is cooled by a plate-type heat exchanger located in the bottom

of the tank. The heat exchange is fed with glycol from the main return glycol system. The cooling system is comprised of an injection design with the glycol flow being controlled by a three-way valve V3, and the glycol circulation is controlled by pump P4. The flow through V3 is controlled by the tank temperature sensor T1. The modulating of valve V3 will ensure that the water temperature in the snowmaking tank is to be maintained at the design temperature of 36°F. A second temperature sensor T2 will ensure that the glycol temperature never falls too low. To ensure proper snowmaking, ice is required on the plate heat exchanger. To provide consistent ice formation the tank is fitted with a compressed air blower which is connected to a sparge pipe under the plates which discharges air bubbles from the base of the tank. Figure 10 below provides a schematic for the operation of the snowmaking water tank.

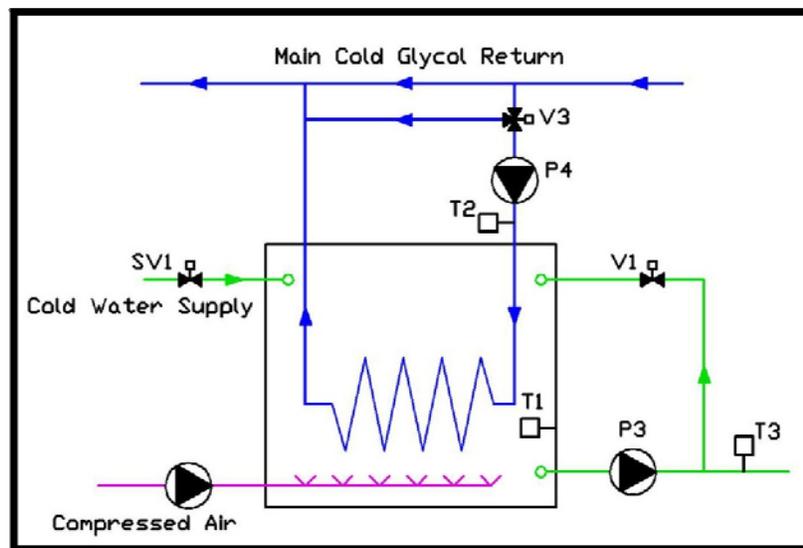


Figure 10: Schematic of the Snowmaking Water Tank

### Snowdome Snowmelting Pit

A snowmelting pit is located at the bottom of the ski slope to melt all unwanted snow. Every night before the snowmaking process begins plows will scrape the top two inches of old snow into the snow melting pits. After the snow is removed a fresh two inches of snow will be made to sit on top of the existing fourteen inches of old snow underneath.

The snowmelting pit uses the hot glycol recovery system to provide the heat to melt the waste snow. The melt pit is designed to retain an amount of water at all times, and the temperature of the water is monitored by temperature sensor T1. When snow is added to the pit, the temperature of the water will fall and this will be detected by T1, and the snowmelting process will be initiated. During this time the two-way hot glycol control

valve MV3 will open to allow hot glycol to circulate through the heat exchanger, and the drain valve MV2 will close, and the main valve MV1 will remain open. The spray pump P5 will start to circulate the water through the heat exchanger and discharge the warm water onto the snow via the spray nozzles. The level sensor will prevent operation of the spray pump in the event of a low level of water and will also control the water level within the pit. When the snow has melted, the water temperature sensed by T1 will rise, and the system will automatically shut down. The drain valve MV2 will open, and the main valve MV1 will close. The water will then be pumped to the drain until the preset level is reached. Also, at this time the hot glycol valve MV3 will close shutting off the flow to the heat exchanger. Figure 11 below provides a schematic for the operation of the snowmelting pit.

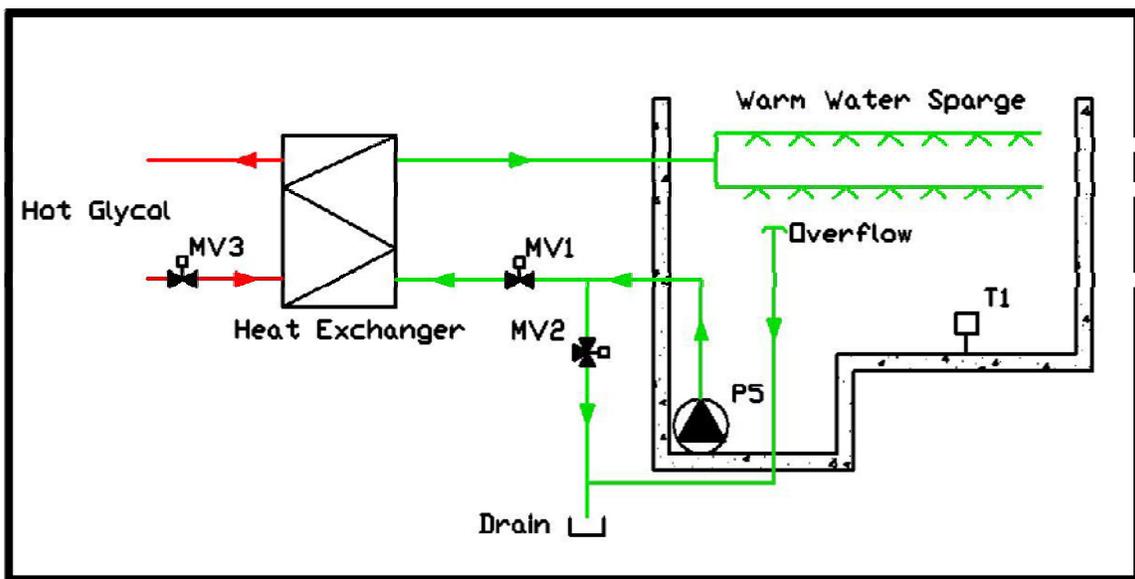


Figure 11: Schematic of the Snowmelting Pit

### Snowdome Snowguns

Ceiling mounted snowguns will be used at night time to create fresh snow. The snowguns will start from a main time clock control loop which will start the operation after the top two inches of old snow has been cleared. Once the snow making process has begun the recirculation coolers will step up to full load to lower the indoor temperature to 27°F. Once the indoor temperature setpoint has been reached the air compressor and water pumps will start. Once the compressed air is flowing valve V1 will open. After a preset time, the water valve V2 will open. At this point the snowgun will be fully operational. Once the snowmaking process is over the system will begin to shut down. During shutdown valves V1 and V2 will close, and the air compressor and water pumps will shut down. Figure 12 below provides a schematic for the operation of a typical snowgun.

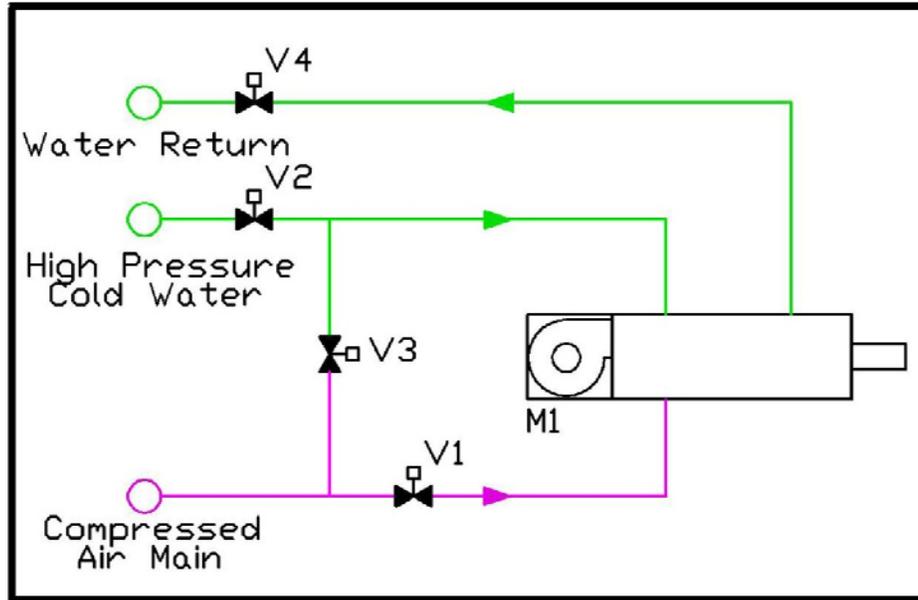


Figure 12: Schematic of a Typical Snowgun