AIR-CONDITIONERS CONDENSATE RECOVERY SYSTEM FOR BUILDINGS

Kelum Siriwardhena
Mercury International Electro-Mechanical LLC - UAE
Telephone: 00971507518423; Fax: 0097126270087
E-mail: Kelum.siriwardhena@mercury.ie; kal260@yahoo.co.uk
Subhashi Ranathunga
Mercury International Electro-Mechanical LLC - UAE
Telephone: 00971554796401; Fax: 0097126270087
E-mail: subhashirana@yahoo.com

Abstract

Most conventional cooling systems produce water as a byproduct, which can be recovered and put to good use. In order to product cool air from a compressed refrigerant, a set of coils allow a hot, high-pressured refrigerant to dissipate its heat and condense into a liquid. An expansion valve is then typically used to evaporate and cool the refrigerant. This cool gas then runs through a set of coils that allows it to absorb heat and cool the air, which is blown over the coils and into the inside of the building.

This process cools the warm coils, so when the warm air blowing past the coils reaches its dew point the moisture in the air condenses onto the coils, producing what is essentially distilled water. This byproduct of air conditioning units is called as Condensate drain water.

The quality of condensate created by Air Conditioners is typically very high, having low amounts of suspended solids, a neutral to slightly acidic pH, and low temperatures. These characteristics make the condensate adequate for several non-potable uses such as irrigation, cooling tower make-up or toilet flushing. In addition to quality water, high recovery capacity is a major benefit of these systems. Although the amount of condensate produced can vary greatly and depends on the size and operational load of the Air-conditioning system as well as the ambient temperature and humidity within a particular region.

A rule of thumb created by Karen Guz (Director of the Conservation Department for the San Antonio Water System, USA) is that 0.1 to 0.3 gallons of condensate per ton of air being chilled is produced every hour that the system is operating. Seizing this opportunity by replacing or supplementing potable water with the recovered condensate can considerably reduce a building's demand for potable water.

By implementing a condensate recovery system free, clean and unused water will be replacing costly, treated, high demand potable water. Decreasing the use of potable water within buildings plays a major role in conserving municipal sources.

Moreover following potential LEED credits can be achieved.

Water Efficient Landscaping

a. WE Credit 1.1
b. WE Credit 1.2

Key words: Condensate Recovery System, Potable water, LEED Water Efficient Landscaping

1.0 Introduction

In almost all modern buildings today, HVAC equipment is used to provide a conditioned indoor environment while using large amount of energy to cool, filter and dehumidify the air in these structures. This is especially true for buildings located in hot & humid climates around the world. International Engineering organizations, such as ASHRAE, have developed indoor air quality standards which stipulate substantial requirements for fresh outside air to be introduced into building's air conditioning system. Internal loads and additional outside ventilation air all generate considerable latent loads on these systems and exacerbate the already difficult moisture control problem. A manifestation of this load is the liquid water condensate that is typically drained away from the air conditioning equipment and routed to the nearest sanitary drain. This paper investigates the optimal methods of colleting the air conditioners condensates drain & re-use it for efficient ways to obtain potential LEED credits.

1.1 What is condensation

When water vapour in the air (often described as humidity) comes in contact with a colder surface, the water changes from a gas to a liquid and collects onto the cold surface. This is most often observed with an ice cold beverage container on a humid day, where water droplets collect on the outside surface of the glass full of iced tea or cold ale. The water vapour in the air that becomes liquid is referred to as condensate. While the condensate collected on a cold beverage is small and mostly considered a nuisance, the condensate that collects on refrigeration equipment is of significant volume and a potential alternate water source.

1.2 Condensate Water Quality & Uses

The quality of this condensate water is essentially the same as distilled water; mineral free and a Total Dissolved Solids (TDS) level of near zero. The water should never be used for human consumption as it may contain heavy metals from contact with the cooling coils and other HVAC equipment. The lack of minerals in the water (similar to distilled water) also makes it corrosive to most metals, especially steel and iron.

The water's low-mineral quality and lack of sanitizers (chlorine, chloromine, etc.) makes it excellent for the purposes of irrigation. In the residential sector, this water should be used similar to harvested rainwater; irrigation for plants not intended for human consumption. Although condensate water does not have the health risk of containing biological pollutants commonly found in rainwater (bird feces), there is a slight risk of lead contamination (from solder joints in the evaporative coils) building up to dangerous levels in soil continually irrigated with the water.

In non-residential sites, one of the best uses is make-up water for the cooling tower. For most cooling towers, a portion of cooling tower water is dumped several times each day to remove the build-up of minerals. The dumped water requires replacement in the system, and the replacement water is usually potable water from the local water utility. The amount of water removed and replaced is highly dependent on the level of minerals, measured as Total Dissolved Solids (TDS) contained in the potable water supply. The greater TDS level of the source water, the greater the water use of the cooling tower. Not only can condensate water be used instead of potable water (TDS levels of 150 to 800), the condensate water has virtually no minerals (TDS level of 0 to 25). This allows the cooling tower to dump water less often.

In commercial and industrial processes, there are a myriad of applications to use condensate. One should look beyond just irrigation and cooling towers. It may be possible to use condensate water for water cooled equipment, decorative fountains and water features, evaporative coolers, rinse water for washing vehicles and equipment, water for laundry operations, and industrial processes. Some newest generation of air-conditioners actually use the condensate to help cool the hot condenser coils of the Air-Conditioner itself. As water efficiency concerns increase, the variety of uses for condensate water will grow.

Below are the effective methods of condensate water uses in the modern buildings.

1. Use as Cooling Tower make-up water (after treatment)
2. Use as Water Closet flushing (after treatment)
3. Use for decorative fountains
4. Use as a cooling media
5. Industrial cleaning applications (after treatment)

Following table is given the condensate water quality and the acceptable range for each parameter to use for domestic purpose. Which indicates the water quality of condensate drain water would be acceptable for a domestic or industrial application and consumption with minimal treatment for biological contaminants.

Parameter	Condensate drain range	Acceptable range
Conductivity	60 – 100 µS/cm	0 – 400 µS/cm
Dissolved oxygen	5 – 8 mg/L	5 – 11 mg/L
Turbidity	0.4 – 0.7 NTU	0 – 1 NTU
Nitrates	0 – 1 mg/L	0 – 45 mg/L
Chlorides	1 – 3.2 mg/L	0 – 250 mg/L
pH	5.5 – 6.5	6.5 – 8.5

Table: 01

1.3 Design Considerations

Condensate water is distilled, pure water when it forms on the condensate coils of an air handler. However it can pick up bacterial contamination during formation and transport. As with any water stored in a tank, it must be considered unsafe for human contact without the addition of chlorine or ozone.

Chlorine injectors are relatively simple to add to tanks when the water will be used for fountains or aboveground irrigation systems. Treatment is not necessary if condensate water goes directly to cooling towers where biocide procedures will prevent a problem. Treatment is must if condensate water is using as alternative water resource for Water Closet (Toilet) flushing as it may contact human during operation.

An additional design consideration is that the condensate is more corrosive than ground or surface water because of its high purity. Materials that are used for steam condensate and other high purity water should be used in system components.

2.0 Design and Installation of Collection System

2.1 Project Introduction

The project comprises the construction of a hospital, clinic, energy centre and medical gas storage building. The scope of work also includes landscaping and internal design.

The complex has five floors, two levels of underground car parking. The 20,700 square meter hospital and the 9,000 square meter clinic are to be constructed on a 30,600 square meter podium. A key feature of the design is an architectural glazed structure to connect the buildings.

It will house three specialist healthcare facilities: Wooridul Spine Centre, the Abu Dhabi Knee and Sports Medicine Centre and a state-of-the-art Wellness and Diagnostic Centre developed by Mubadala in partnership with Singapore's AsiaMedic Group.

The sustainability target for this project is to achieve LEED Silver certification.

2.2 Condensate Drain Collection System

The air conditioning and ventilation for this building is supplied through 27 Air Handling Units, 354 Fan Coil Units and 5 Close Control Units. These units receive chilled water from the building chilled water plant located in basement level with 4 Water Cool Chillers (3 Duty 1 Stand by arrangement) 765 Cooling Tons each.

2.2.1 System Introduction

There are 187 Water Closets in this Hospital Buildings with dual flush mechanism to comply with LEED requirements. All condensate drains of Fan Coil Units & Air Handling Units (Except 2 Air Handling Units in Basement 2 level) are connected to common condensate drain piping system & collected to GRP Storage Tank (Condensate Drain Water Collection Tank) in Basement 1 level.

Collected Condensate drain water then transfer to GRP Flushing Water Storage tank through a duty stand-by transfer pump sets. Chemical Treatment process is taken place in suction & discharge of transfer pump. Collected water in Flushing Water Storage tank is then feeding to Water Closet piping system through a flushing water booster pump sets.

System description is presented in figure 01.

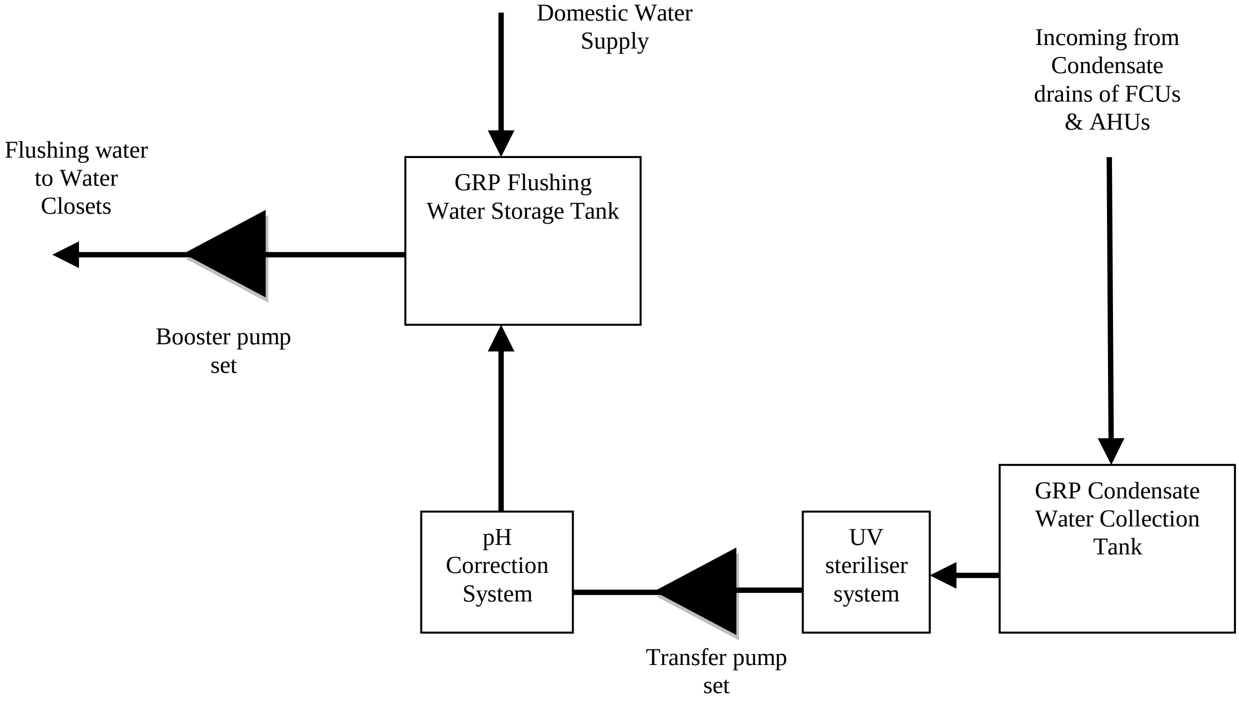

Figure 01.

Float type ball operated valves are installed in domestic water supply to Flushing Water storage tank to keep the tank full all the time. Further control valve (ON/OFF) installed in the domestic water line to flushing water storage tank, level sensors are installed in both tanks which are controlled through Building Management System (BMS). Control Philosophy is as below.

a. BMS is monitoring the level sensors (low, mid & high) feedback in GRP Condensate Water Collection tank.
b. Once the feedback is “mid” transfer pump switch on through its dedicated control panel which is controlling through BMS.
c. Same time the Control Valve in domestic water supply line to Flushing water storage tank will be commanded to CLOSE position.

d. Transfer pump will be commanded to switch off if “high” feedback is received from the level sensor in flushing water storage tank.
e. If the level sensor in the Condensate Water Collection tank gives a feedback of “low” transfer pump set will be commanded to OFF mode & the same time control valve in domestic water supply line to flushing water storage tank will be commanded to OPEN position.
f. Booster pump set is ramp up or down through its own Variable Frequency Drive (VFD) based on the feedback of the pressure sensors installed in the flushing water supply pipe work to Water Closets.
g. If “low” feedback is received from level sensor in flushing water collection tank during the transfer pump operation, control valve in domestic water supply line will be commanded to OPEN position.

Overflow pipe is installed in the Condensate water storage tank & connected to plant room floor drain.

2.2.2 Chemical Treatment

pH Control using Chemical Dosing System

pH Chemical dosing system provides chemical dosing to suction line to the transfer pump set from Condensate Water Collection Tank. It consists with following equipment and accessories.

a. A pH sensor installed in Condensate Water Storage Tank.
b. Chemical dosing tank
c. Dosing pump & piping

The pH sensor with controller checks the water pH and control the chemical dosage. Controller is a proportional dosing pump of the diaphragm type. The activation is by means of an electromagnet which is electronically controlled by 4-20 mA or pulse proportional signals. The capacity of each pulse is also manually adjustable in order to ensure the greatest precision in chemical dosing.

Disinfection using UV Steriliser system

UV steriliser is installed in the discharge line of the transfer pump set. Using special quartz glass material, UV lamps are able to generate the exact wavelengths of UV for disinfection. Specially designed power supplies and electronic controls operate and monitor these lamps for optimum performance.

2.3 Cost of Condensate Recovery

James Sewell of Beyer Mechanical in San Antonio, USA estimates that “Condensate recovery systems add approximately 3% to 5% to the total cost of mechanical engineering for a new building. For a building where a client is spending $100,000 to install their cooling, they will spend about $3000 – 5000 in additional costs if they are adding condensate drain recovery system.” Retrofit costs to add condensate recovery to existing buildings are somewhat higher, but still reasonable.

2.5 Summary

As a step towards water sustainability, collection of condensate water from air conditioning systems has tremendous potential. The key wording here is “captured from the condensate drains” in a building. It would be trivial to separate condensate piping (or combine in with gray water piping) in the plumbing and drainage systems during planning of the design phase of a project. Planning for storage and re-use of the collected water is also easier at the start of the design phase.

Existing buildings are more challenging, but creative solutions can always be developed given the sustainable potential of reusing the condensate. Through not a complete replacement for potable water needs in a modern commercial building, water conservation efforts would make this water to go quite a way towards meeting demand. Grey water use, irrigation of vegetation around the buildings or as flushing water for toilets are all proven uses of condensate water collection systems. In hot and humid regions the potential for generating significant amounts of water is available and should be pursued.

T. Boone Pickens recently stated that “Water is going to be the next Oil”. This is one technique that can help us do a better job managing a very precious and necessary resource.

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