PRECISION TEMPERATURE & HUMIDITY CONTROL

STULZ

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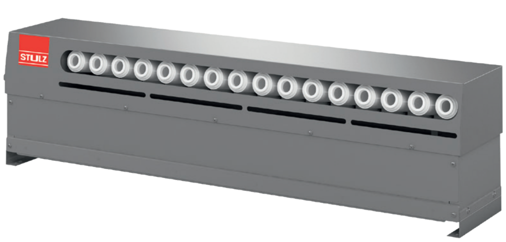
Precision Temperature & Humidity Control for the Medical Cannabis Industry

White Paper



Ultrasonic Humidifier

Grow Room Cooling Unit

Medical Cannabis Industry

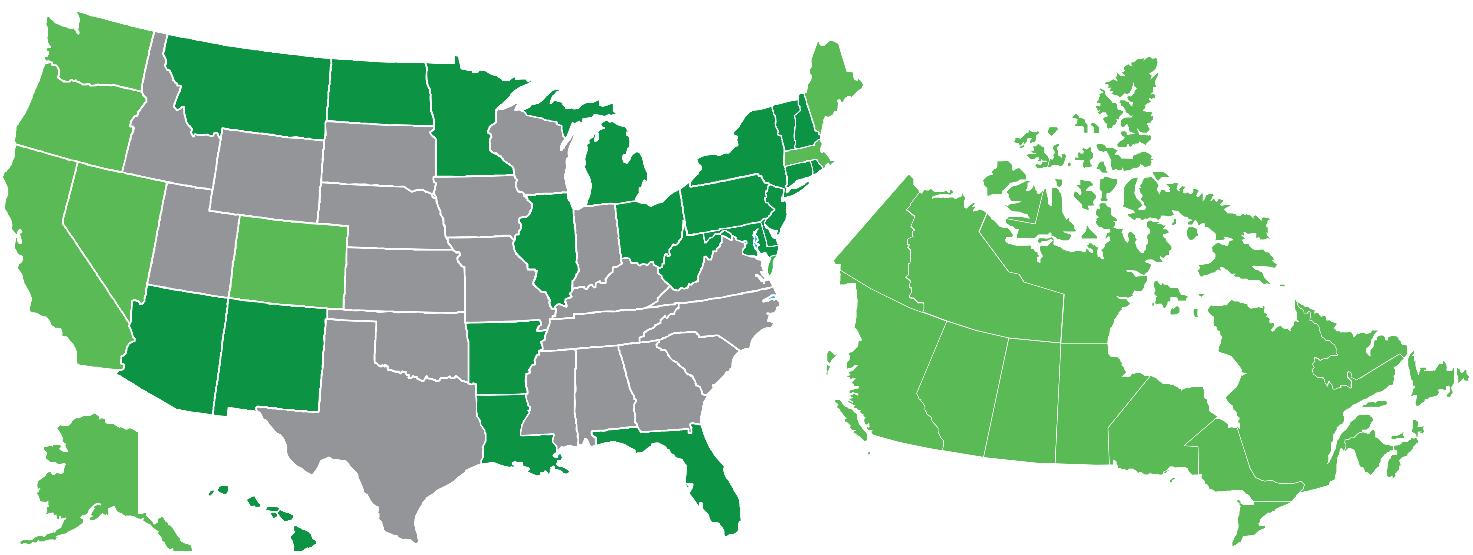
In October of 2016, Peter Judge writing for Data Center Dynamics asked the question "Why not diversify into dope?" The byline was meant to have shock value and thus the choice of words. Most folks today would use the word cannabis as opposed to some of the more colorful terms used for this particular plant. In his article Mr. Judge cited several similarities between the requirements for the environmental controls for data centers and those for cannabis grow facilities. He asked the important question: "Energy demand is high, and indoor cannabis farms also need cooling. Do we have the expertise to help?" He even cited some of the work that we here at STULZ USA have done in this growing industry.

As of this writing, 33 states and the District of Columbia have some form of legal cannabis, be it medical, recreational, or both. Medical cannabis has achieved wide acceptance in the medical community as a legitimate course of treatment for illnesses such as glaucoma, childhood seizures, bipolar disorder, schizophrenia, weight loss during chemotherapy, and many others. Cannabis is still federally prohibited as a Schedule I drug but in 2018 the first cannabis derived drug became available as a schedule 5 drug. That drug, Epidiolex™ has shown great promise in treating some rare forms of epilepsy.

The US government has stipulated that it shall receive all tax revenues it is owed from the sale of state legal cannabis and it has eased banking laws somewhat to shift the industry away from a cash-only to a more traditional commerce model. Though the government could change its stance on cannabis at any time (simply by enforcing current federal laws), the scale of the continued investment seems to indicate that the marketplace believes it will not.

In October 2018, Canada became the first major world economy to legalize recreational marijuana.

Marijuana Legalization Status



Medical Marijuana Legalized   Marijuana Legalized for Medical & Recreational Use   No Laws Legalizing Marijuana

How does this affect us as a producer and seller of precision HVAC products? Clearly it presents us with opportunities that were not there just a few years ago. The environmental control of the grow facility, with its required precision, is very similar to that of the data center with some glaring exceptions. The grow room has a large latent load not present in a typical data center application. This latent load comes from the large amounts of water that are fed to the plants on a daily basis. This water, which is removed primarily by the HVAC system, is produced through a biological mechanism known as "transpiration" (more on that later). In hydroponic grow operations where there is often standing water evapotranspiration must be considered (evaporation and transporation). To understand the latent load we need to understand a little about how the plant behaves at different times in its life cycle. This brings up another challenge, the grow space is dynamic, the conditions change based on plant behaviour and lighting conditions. Successful HVAC designs for the grow space must be able to quickly react to changing needs as well as being able to handle the worst case scenario in regards to the sensible and latent loads.

Plant Life Cycle and Conditions for Better Yield

The primary heat load is generated by high intensity grow lights. The type of lighting, and the lighting sequence used to manipulate the plants' life cycle, dictates the amount of load in the space. The types of lights primarily used in this industry include high-pressure sodium lights and full spectrum LED lights. In the modern indoor grow facility we typically see grow rooms, internal to a larger facility, where the plants are protected, conditioned, and manipulated as they go through their grow cycle such that they produce the greatest yield in the shortest period of time. The environmental conditions around the grow pods are kept close to grow room conditions to minimize the impact of infiltration and ex-filtration on the heat and moisture load in the grow space. In facilities that do not use the "room within a room" design philosophy , loads caused by infiltration, ex-filtration, and solar gains must be evaluated.

STULZ Precision Air Conditioners, deployed at Medicine Man Technologies, Inc. in Colorado

Mother Room

A logical starting place to discuss the grow process, and therefore the conditioning requirements, is with the mother plant in the mother room. To ensure consistency in the final product, the production plants are cloned from an existing mother plant. For this reason the health of the mother plants is critical to a successful grow operation. The mother room may have redundancy requirements for the HVAC equipment that the other grow rooms don't. Though each grower often has his or her own preferred environmental conditions for each individual grow room, common set points for this room are 75°F and 50% RH.

Clone Room

Cuttings are taken from the mother plant and moved to the clone room (often referred to as the nursery). Conditions in this space are also precisely maintained to ensure that the young plants have the greatest opportunity to develop a strong root system. The clone room is often kept slightly warmer than the other grow spaces and the clones prefer temperatures between 75°F - 80°F with moisture content between 40% RH and 70% RH. The clones are sensitive to temperature and lighting changes. For this reason the lights are often left on 24 hours a day during this part of the plants life-cycle. Small pests such a thrips and spider mites are always harmful to the cannabis plants, but especially so for immature plants. In some states regulations prohibit the use of chemical pesticides and therefore other approaches such as UV-C lighting coupled with oscillating fans are used to kill these micro pests. These eradication strategies can be used in all stages of the grow cycle.

Vegitative Room

Once the plants reach a certain height they are moved into the vegetative (Veg) room. The purpose of this room is to manipulate the plants to grow tall, strong, and develop a good root bulb. Several environmental control features are manipulated to achieve this "growth spurt." Oscillating fans are positioned throughout the various grow rooms to "exercise" the plants and make it more difficult for micro pests to land on them. Lights are typically turned on for 18 hours a day to imitate the long growing hours of summer. Temperature swings during the lights on/lights off cycle can stress the plants, which can result in low-yield hermaphrodite plants, so tight environment control during this cycle is required. Precision environmental control units such as computer room air conditioners (CRAC) are well suited to providing the tight control needed to limit these temperature swings. Environmental conditions in a vegetative room typically range from 60°F - 75°F and 40 - 50% RH.

Flowering Room

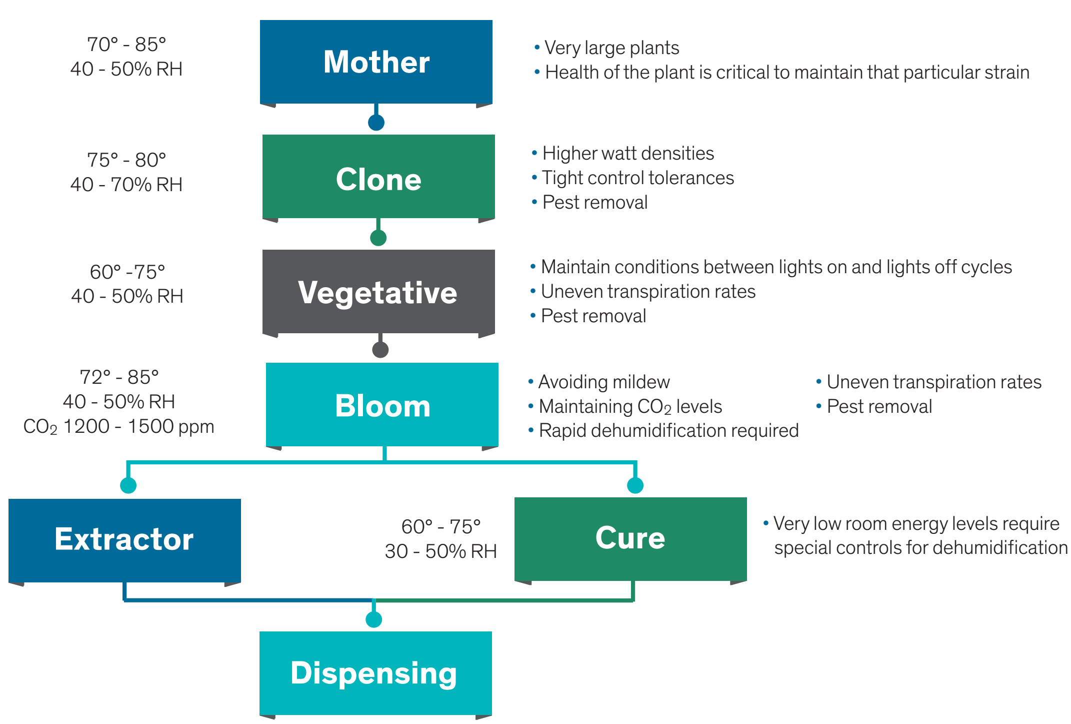
When the plants reach their optimal height they are moved to the flowering room (often referred to as the "bloom room"). The plants can be physically moved or the Veg room can become the flowering room by altering certain environmental parameters. Flowering buds are the part of the plant where many of the desirable cannabinoids are found. The goal of flowering room operations is to produce the largest flowering buds possible, as the higher the yield at this stage the more profitable an individual room will be. In the flowering room the lighting sequence is typically changed to 12 hours on and 12 off. This stimulates the plants to devote their resources to producing larger flowering buds. During the lights on cycle carbon dioxide (CO_2) is added to the room to stimulate the plants growth rate. The typical ambient CO_2 level may be around 300 PPM (parts per million), but by raising the CO_2 level to 1,200-1,500 PPM the growth rate of the plants can be almost doubled. The oscillating fans play a part in the CO_2 enrichment strategy as they help keep the slightly heavier CO_2 molecules from stratifying. This CO_2 enrichment strategy can be applied in other phases of the plants life cycle but many growers only use it in the flowering rooms due to cost. In the flowering room 72° to 85°F seems to be the target of most growers, with a relative humidity of 40% - 50%. Once optimal leaf growth is achieved the plants are harvested and sent either to the extractor or to a curing room. The extractor removes the cannabinoids for use in edibles, oral medications, and topical solutions; the curing room prepares product that is intended to be smoked.

Curing Room

The curing room is used for drying the cannabis in a controlled fashion to ensure the optimal final properties of the smokable end product. Curing is critically important in maintaining the quality of the plants and typically takes a week, but the duration is dependent on many variables. Curing breaks down chlorophyll and dramatically improves the flavor and smoothness of the smoke, reduces the chance of mold, mildew, or bacteria forming on the plants, and reduces odors associated with freshly cut plants.

There's much debate about the rate and conditions at which the plants should be dried. Specially designed air conditioners should be used that can maintain both the low temperature and low relative humidity that are the optimal conditions during this final phase. The environmental conditions in the Curing room often range from 60°F - 75°F and 30 - 50% RH.

Typical Values & Challenges



Sizing Environmental Control Units for Medical Cannabis Cultivation

Precision air conditioning is designed to maintain tight tolerances of both temperature and relative humidity (or dew point). To maintain this tight control the HVAC equipment must be properly sized. A high quality environmental control unit will be worthless if it is not sized correctly for the load. In most building heat loads are typically easy to calculate and when they change they typically change slowly. The grow space has some added challenges that must be addressed. These challenges are driven by the very nature of the cannabis plants. The plant, being a living organism, goes through many changes within a 24-hour period as it transpires, goes through photosynthesis, reacts to lighting changes, etc. Though the sizing of the HVAC equipment is a little more complicated than it is in a traditional building, it is not too difficult to determine if you keep three requirements in mind:

1. The maximum sensible load
2. The maximum latent load
3. The maximum required dehumidification re-heat

Let's start by looking at the maximum sensible loads that will be experienced in the grow room. To understand what needs to be done we should first define a few terms.

Sensible Cooling Load

The sensible cooling load refers to the transfer of heat energy out of the conditioned space to somewhere where it is not objectionable (i.e. outdoors). Sensible heat transfer results in the lowering of the dry bulb temperature of the space. For example, if a room is at 80° F and we provide cooling that does nothing to the room but lower the temperature to 75°F then we have provided sensible cooling.

Latent Cooling Load

The latent cooling load can be thought of in a couple different ways, but always results in a change to the amount of water that is held in the air or the grow space. Water evaporates by absorbing heat energy from the surrounding space and using that heat to change the water from a liquid to a vapor in the air. The removal of this heat energy cools the space while increasing the moisture content (humidification) of the air. To remove this moisture, we must reverse this process. We do so by removing the heat energy from the air water vapor mixture and return the water vapor from the vapor to its liquid form in a location that is not objectionable (dehumidification).

Reheat

Any system that puts sensible heat energy back into the space after we have over-cooled that space during the dehumidification process.

Determining the Maximum Sensible Load

In grow facilities where the grow space is inside another building and that building is conditioned very close to the desired conditions in the smaller grow room space, determining the maximum sensible load is pretty straight forward. This maximum load is encountered when we have the lights on and we are experiencing the smallest amount of latent cooling because we are experiencing the minimum amount of latent cooling to assist in offsetting the lighting heat load. The minimum evapotranspiration rate can be estimated using the Penman-Monteith equation or can be determined experimentally using one of the evaporative pan methods.

If the grow space is not in a controlled moisture and temperature envelope then such things as infiltration, ex-filtration, and solar heat load may need to be evaluated. For sites where infiltration/ex-filtration or solar loads may be present, contact an OEM HVAC manufacturer or a qualified consulting engineer to assist with the final HVAC sizing.

Maximum Latent Cooling Load

In grow facilities where the grow space is inside another building that is conditioned to approximately the desired moisture conditions in the space it is likewise relatively simple to determine the latent cooling required. The maximum latent load (dehumidification) will be experienced during the lights on period when the evapotranspiration rate is at its highest as the plants transpire to cool themselves. This can be calculated using the Penman-Monteith equation or through evaporation pan experimentation. If the maximum latent cooling load cannot be met, white mildew formation due to elevated moisture content in the grow space is possible.

Maximum Reheat Required

During the lights out phase (especially shortly after the lights have been turned off) the plants will continue to transpire for some time at a reduced rate, and the need for dehumidification still exists. The point when you have the maximum transpiration rate of the plant will determine the maximum amount of reheat required. The difficulty here is that during the lights out phase, you lose the significant heat load added by the lights, which would raise the temperature of the space back up to the desired set point. To remove the unwanted moisture, the HVAC equipment will chill the air to wring out the water, thus condensing the water vapor back into a liquid (where it flows off the cooling coil and into a drain for removal). This process is easy to visualize if you can imagine water forming on the sides of a cold can of soda on a humid day. The air that has now been dried flows back into the grow space and must be re-heated back to the setpoint temperature to prevent thermally shocking the plants. The air can be reheated through multiple means such as refrigerant hot gas, refrigerant liquid gas hybrid, hot water, low pressure steam, or electric reheat. Reheat should be sized and the type of reheat chosen wisely as the wrong choice can result in large power bills that will limit overall profitability.

Humidification in the Medical Cannabis Industry

We have already seen that controlling the moisture content in the grow space is critical to maintaining conditions conducive to healthy plants. Our biggest concern during the grow stage is too much moisture in the air. After harvesting the plants the concern becomes both too much and too little moisture in the air.

Cannabis curing rooms need controlled temperature, humidification, and dehumidification. The drying process is typically "ramped" to provide a higher quality product. By controlling the drying rate, greater consistency can be achieved from crop to crop. Humidification in the curing and storage rooms is especially important if the product is to be stored long term. Precise levels of humidity control prevent mildew or brittleness. Precision humidification in the curing room also ensures that the plants do not dry too quickly. If the plants dry too quickly, this can result in the chlorophyll failing to be converted which can lead to a poor tasting product that produces harsher smoke when inhaled. Adiabatic humidifiers such as ultrasonics provide precise control of the moisture content of the air, provide additional cooling, and use very little power, making them attractive to the growing community.

ABOUT THE AUTHOR

Dave Meadows is the Director of Industry, Standards, and Technology at STULZ USA. He has a Bachelor of Science degree in Mechanical Engineering from the University of Maryland, Baltimore County. He is a graduate of the US Navy Nuclear Power School and is an active participant on ASHRAE committees, AFCOM, and the Green Grid.

ABOUT STULZ USA

STULZ Air Technology Systems, Inc. (STULZ USA) is an ISO 9001 registered manufacturer of environmental control equipment and is responsible for product development, manufacturing, and distribution for the North American arm of the international STULZ Group. STULZ USA has provided environmental control equipment to some of the premier grow facilities in the United States.

ADDITIONAL GROW ROOM RESOURCES FROM STULZ USA

Website:
STULZ USA works directly with customers to provide purpose built solutions for many different industries that require reliability, efficiency and precision. Lean about these "User Driven, and Purpose Built" solutions for grow rooms and more at the STULZ USA website:
https://www.stulz-usa.com/en/vertical-farming-grow-room-cooling/

Online Hardware Selection for Grow Rooms:
Since many engineering firms are being asked to design a grow facility for the first time, STULZ USA has developed an online questionnaire that makes it easy for customers to submit details about their design conditions and begin working with a STULZ expert on the environmental controls selection process. This questionnaire is available online at:
https://info.stulz-usa.com/grow-room-selection

Grow Room Temperature & Humidity Control Solutions

STULZ offers unique design solutions that can be customized to suit your location and operations while ensuring the precise temperature and humidity control to prevent crop loss and maximize the return on your investment.

- **Maximize crop yield:**
  Advanced environmental control units maintain tight control of temperature and humidity in the grow space
- **Address relative humidity spikes during lights off cycles to prevent formation of white mildew:**
  Dehumidifier controls set coil temperatures low while reducing the air flow rate to maximize moisture removal
- **Pest control:**
  Ship loose UV-C lighting eliminates micro pests

Technical Data

Model	COS-060	COS-096	COS-120	CFU-053	CFU-070	CFU-105
NET DX COOLING CAPACITY - BTU/H, (includes standard DX evaporator motor heat @ std CFM & e.s.p. ratings)						
75°FDB/62.5°FWB, 50% RH						
Air Cooled						
Total	57,583	90,537	113,915	164,670	219,890	324,863
Sensible	50,938	82,801	94,319	152,846	184,490	283,016
Water Cooled						
Total	63,855	100,580	126,423	186,254	247,987	368,872
Sensible	53,049	86,188	98,966	161,149	195,729	300,357
Glycol Cooled						
Total	55,799	87,721	110,524	159,682	212,965	313,194
Sensible	50,347	81,663	93,220	150,953	181,770	278,499
Electric Reheat / Heat - Finned Tubular Heaters, (Standard) Performance Capacities Do Not Include Motor Heat						
Htr kW Rating (# of Stages)	9 kW (1-stg)	9 kW (1-stg)	9 kW (1-stg)	18 kW (2-stg)	18 kW (2-stg)	27 kW (3-stg)
Hot Gas Reheat - with 3-way Heat Reclaim Value (Optional)						
Total Capacity kW (MBH)	5.0 (17.2)	7.8 (26.6)	10.3 (35.1)	7.9 (26)	10.3 (35)	15.6 (53)
Evaporator Blower / Motor - Backward Curved, Direct-Drive, EC Plug Fan						
Horsepower	3.6 Hp, (1)	4.1 Hp, (1)	4.1 Hp, (1)	4.2 Hp	4.2 Hp	4.2 Hp
CFM @ ext. st. press.	2,700 @ 0.5”	4,400 @ 0.5”	4,800 @ 0.5”	9,000 @ 0.2”	10,000 @ 0.2”	15,750 @ 0.2”
Drive Method	Direct Driven	Direct Driven	Direct Driven	Direct Driven	Direct Driven	Direct Driven
Qty. of Fans	1	1	1	2	2	3
Dimensions (H” x W” x D”)	76×30.63×30.61	76×47.63×33.61	76×47.63×33.61	88.1×88.2×40.3	88.1×88.2×40.3	88.1×118.4×40.3
Approx. Weight	520 lbs	800 lbs	810 lbs	2,400 lbs	2,400 lbs	3,100 lbs
Advanced Dehumidification Mode (75°F and 60% RH)						
Latent Capacity (BTU/hr)	28,710	45,380	56,185	72,609	96,359	140,619
Rate of Moisture Removal (GPH*)	3.3	5.1	6.4	8.3	11.0	16.0
Rate of Moisture Removal (GPD**)	77.9	123.2	152.5	198.5	263.4	384.4
Dehumidification CFM	1,200	2,000	2,000	3,700	4,800	7,000

* Gallons Per Hour   ** Gallons Per Day

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For further information, please visit our website at **www.stulz-usa.com**

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STULZ AIR TECHNOLOGY SYSTEMS (STULZ USA), INC.
1572 Tilco Drive | Frederick, MD 21704
Tel. 301.620.2033 | Fax 301.662.5487
info@stulz-ats.com