Meeting Required DPT

DOAS Supply Air Conditions

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Dedicated outdoor air systems[1] (DOAS) supply the ventilation air required by ANSI/ASHRAE Standard 62.1-2007, *Ventilation for Acceptable Indoor Air Quality*, to the individual occupied spaces. The air is generally cooled and dehumidified to provide some portion of the terminal space sensible cooling and some to all of the space latent cooling requirements. Terminal equipment is required to accommodate the cooling loads not met by the DOAS. The variety of terminal equipment includes:

- Fan coil units (FCU);
- Heat pumps;
- Multisplit units;
- Emerging fan powered boxes;
- Constant or variable volume all-air systems;
- Active chilled beams, i.e., induction devices;
- Passive chilled beams; and
- Ceiling radiant cooling panels.

Supply Air (SA) Dew-Point Temperature (DPT)

Proper selection of the supply air dew-point temperature can avoid condensation and septic issues at the terminal equipment. For equipment with condensate pans, such as fan coil units, the SA DPT is not critical for condensation control, and can be around 55°F (13°C), eliminating most humidity problems. However, the likelihood exists that septic amplifier problems will occur.[2]

For equipment without condensate pans, such as chilled ceilings, the DPT conditions are important to avoid capacity loss, condensation formation, and related issues.[3]

Selecting the required SA DPT

If the DOAS SA is required to handle the space latent cooling load, it must be supplied at a DPT below that of the desired room DPT. The required SA DPT (or humidity ratio, W_{Supply}, gr /lbm$_{DA}$) is a function of the following three variables:

- space latent load, Q_L, Btu/h;
- the space DOAS SA flow rate, V, scfm; and
- desired space humidity ratio, W_{Room}, gr /lbm$_{DA}$.

The functional relationship between the variables is:

$$Q_L = 0.68 \cdot V \cdot (W_{Room} - W_{Supply})$$

To illustrate the use of the functional relationship, consider the following example:

- Room occupancy, 20 people;
- Occupant latent generation, 205 Btu/h;
- Additional latent transfer and generation, 400 Btu/h. Note, always keep the building pressurized to minimize this moisture transfer component;
- Standard 62.1 ventilation required, i.e., the DOAS SA flow rate, 400 scfm; and
- Design room humidity ratio, 64.9 gr /lbm$_{DA}$ (corresponds to 75°F [24°C] dry bulb temperature (DBT) and 50% RH).

Solving the functional relationship equation for W_{Supply}:

$$20 \cdot 205 + 400 = 0.68 \cdot 400 \cdot (64.9 - W_{Supply})$$

W_{Supply} = 48.4 gr/lbm$_{DA}$, or a DPT of 47.3°F (8.5°C)

If the DOAS SA flow rate were elevated by 30% (i.e., 120 scfm) above that required by Standard 62.1 to garner a LEED® green rating point, solving for W_{Supply} yields:

$$20 \cdot 205 + 400 = 0.68 \cdot 520 \cdot (64.9 - W_{Supply})$$

W_{Supply} = 52.2 gr/lbm$_{DA}$, or a DPT of 49.3°F (9.6°C)

If the SA DPTs in the example were achieved with mechanical refrigeration alone, assuming the coil leaving conditions to be near saturation, the DBTs would be below the conventional 55°F (13°C) SA DBTs. Obtaining the lower than normal DPTs without low SA DBTs is efficiently achieved with equipment currently on the market.

Impact of SA DPT

Sensible-only cooling terminal devices intended to operate on the heat transfer mechanisms of convection, radiation, or both lose their cooling capacity rapidly with elevated room DPTs since the entering cooling water temperatures must be above the space DPT to avoid condensation and septic amplification. For example, a radiant cooling panel heat removal capacity can decrease nearly linearly from about 32 Btu/h · ft^2 with a room DPT of 52°F (12°C)

Item No.	Description of Equipment in the SA Flow Path	CC Load, Tons	SA DBT, °F	Lost Sensible Cooling Refrigerant CC Alone, Tons	Total Cooling Plant Input, DOAS Plus Lost Terminal Coolng	Author Ranking
1	CC	9.7	44	0.0	9.7	6
2	CC w/ HGRH	9.7	44-70	0.0	9.7	7
3	EW + CC	5.2	44	0.0	5.2	1
4	EW + PCC+CC+RHC	3.7	61.4	1.6	5.3	1
5	EW+CC+SW	4	68	2.2	6.2	5
6	PDHC+CC	9.7	53.1	0.8	10.5	8
7	EW+CC+PDHC	4	63.3	1.7	5.7	1
8	EW+PDHC+CC+PDHC	5.2	53	0.8	6.0	4
9	CC+ADesW	6.8	88.5	4	10.8	9

Table Abbreviation Key

CC	Cooling Coil	RHC	Reheat Coil (the downstream part of a CC runaround system)
HGRH	Hot Gas Reheat, or tempering	SW	Sensible Wheel
EW	Enthalpy Wheel	PDHC	Passive Dehumidification Component
PCC	Precooling Coil (the upstream part of a CC runaround system)	ADesW	Active Desiccant Wheel

Table 1: Summary comparison of the major DOAS equipment on the market today when conditioning 1,000 scfm of OA at 85°F and 148 gr/lbm_{DA}.

and a DBT of 75°F (24°C) to just 15 Btu/h · ft^2 with a room DPT of 62°F (17°C) and a DBT of 75°F (24°C). This is a 53% loss in capacity over 10°F (6°C) change in the space DPT, or 5.3% reduction per degree Fahrenheit change in the space DPT. For each degree Fahrenheit in the space DPT, a 5.3% reduction in the first cost of the radiant cooling panel system is realized. In an effort to control the first cost of the terminal equipment, it is desirable to maintain a relatively low space DPT.

DOAS Equipment on the Market

Design engineers have an array of off-the-shelf equipment to select from.[4] The equipment can be categorized as:

- Cooling coil equipment (direct expansion or chilled water), with or without sensible energy recovery (generally wheels, heat pipes, runaround coils, or plates) or hot gas for central tempering.
- Cooling coil equipment that uses total energy recovery (generally enthalpy wheels or plate heat exchangers capable of sensible and latent energy transfer), with or without sensible energy recovery or hot gas for central tempering.
- Cooling coil equipment that uses total energy recovery and passive dehumidification wheels (thermodynamically, the Type III passive dehumidification wheels behave like an active desiccant wheel, but do not require high temperatures for reactivation, and generally rotate at about 1 rpm).
- Cooling coil equipment that uses active dehumidification wheels, generally without energy recovery (*Table 1*).

Selecting the Appropriate SA DBT

Based upon the DOAS equipment available, each of which is capable of delivering the required DPT, many options exist for SA DBT. Given that the required DPTs for the simple example discussed previously were below the ordinary SA DBT of 50°F to 55°F (10°C to 13°C), it is often thought that the SA must be tempered, even to a space neutral temperature.

Unfortunately, elevating the SA DBT causes the DOAS to lose some, or all, of its ability to do sensible cooling, placing more load onto the terminal equipment.

The advantages of using a SA DBT equal to the required DPT, i.e., no central tempering include:

- offsets a part of the terminal equipment's sensible cooling duty and first cost;
- first and operating costs associated with central tempering equipment are eliminated;
- simplifies controls; and
- reduces the total load on the cooling plant.

The disadvantage of using SA DBT equal to the required DPT, i.e., no central tempering, is terminal reheat may be needed at times. It is allowed by ANSI/ASHRAE/IESNA Standard 90.1, *Energy Standard for Buildings Except Low-Rise Residential Buildings*, when the flow rate does not exceed that required for ventilation. However, not all code jurisdictions allow terminal reheat. Terminal reheat can be minimized with either demand controlled ventilation or critical zone SA DBT reset.[5]

In addition to addressing the pros and cons of using some form of tempering or terminal reheat; the following items also must be considered when selecting the SA DBT:

- Diffuser selection is critical: dumping and condensation formation must be avoided;
- UFAD (under floor air distribution) cannot be used, since its SA DBT cannot be below 68°F (20°C); and
- If terminal equipment is placed in series[6] (never recommended), the low temperatures cause the terminal equipment to be derated. Series also requires the fan in the terminal equipment to handle all the air moving in the space.

Conclusions

Computing the required DOAS SA DPT has been illustrated. The industry has many fine pieces of equipment to meet the required DPT. Some operating at low CC temperatures, which can derate the cooling equipment. Others operate with passive dehumidification equipment that facilitates low DPTs with conventional 45°F (7°C) chilled water temperatures. Others operate with active desiccant wheels. Finally, in most cases, an EW is advised.

If low SA DBTs are acceptable, the author's first choice, based upon energy use and first cost, would be *Table 1* item 3; an enthalpy wheel with the cooling coil. If low SA DBTs are not acceptable, necessitating some central tempering with recovered energy, items 4 or 7 from *Table 1* are the author's first choices. Both item 4 and 7 place greater sensible load onto the terminal equipment, however item 7 is able to achieve the low DPTs with conventional 45°F (7°C) chilled water, an advantage in first cost of the cooling plant and its energy use.

Selecting the SA DPT and DBT involve making trade-offs between first cost, operating cost, and complexity. Terminal reheat avoidance is the most common concern when selecting the SA DBT, and can be minimized or eliminated.

References

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