

AIRSIDE COMPONENTS AND SYSTEMS

Ventilation: Outdoor air (OA) ventilation shall be introduced into each occupied building space in compliance with most current ASHRAE Standard 62. Adequate additional OA capability is needed to keep buildings under a typical positive pressure of 0.020" w.c. For reference, the most current ASHRAE 90.1 has requirements for building leakage.

System Architecture: Historically, we have pursued the installation of a limited number of large, high-quality, centralized air handling units, with N+1 redundancy for critical applications. The impetus for this approach is to maximize reliability while minimizing maintenance requirements. Recent energy conservation initiatives have challenged this approach. Yet it is still embraced and encouraged within these Standards to the degree that it can be accomplished without violation of most current ASHRAE Standard 90.1. At the same time, the current movement toward distributed air handling equipment is acknowledged and accommodated as deemed appropriate from a life cycle cost perspective.

Air Handling Unit (AHU) Equipment Scheduling: In order to provide consistency and to ensure that all scheduled information is provided, A/E's shall use the *Air Handling Unit Schedule Template* within these design guidelines.

AHU Subcomponent Locations: In order to provide good condensate drainage, AHU's should be designed such that cooling coils are located downstream of fans (blow-thru). Due to the highly saturated nature of the air stream leaving the cooling coils, DO NOT design any filtration media downstream of cooling coils. Rather, the preferred location of all filter media is upstream of all coils. The preferred location of humidifier grids is immediately upstream of cooling coils. The cooling coil will be inactive during humidification but the coil itself and associated drain pan provides good insurance against any moisture carryover. Follow the humidifier manufacturer's recommended minimum absorption distances when laying out the AHU's.

AHU Sizing Diversity: AHU's shall be sized at 100% diversity. In other words, whatever the room peak air flow sum is, is what the AHU design CFM will be. However there could be cases where it makes sense to size at some diversity level. Discuss with FP&CP Engineering early in the project.

AHU Coils:

General

- Face velocities shall not exceed 450 FPM
- Add 5% to the % building outside air (OA) component. As an example, an AHU that will need to handle 25% OA, shall be designed for 30%.
- Generally speaking, is preferred to have flat finned coils (is better to purchase more copper and aluminum, than to pay the penalty of added pressure drop thru the life of the AHU). However, in cases of cooling coils it is preferred to have rippled fins if need be to keep the coil to no greater than 8-rows.

Preheat Coils

- Design for 40% propylene glycol mixture with EWT of 130 Deg F.
- A poorly specified preheat coil can be troublesome to control at low loads on mild days (wide temperature swings). Provide dedicated circulating pump and two-way valve bypass arrangement (see *Drawing 23 21 02 - 01 Pumped Pre-Heat Water Coil Piping Schematic*). Design for a coil discharge temperature of 50 Deg F or slightly higher (do not design coil for 'building warmup', reheat coils will provide this). Additionally, coils for 100% OA usage shall be sized assuming -20 Deg F outside air temperatures, unless a heat recovery system is provided (no need to size PH coil for a failed heat recovery system condition).
- Preheat coils sized for tube velocity of 3-4 ft/sec at design flow. Preheat coils to be selected with minimal passes (minimum 2-row, maximum 3-row), this is to prevent/reduce left-to-right stratification. Lowering the coil GPM is desired via a higher waterside delta T (20-30+). Specify max GPM of coil, as this allows the coil recirc pump to be selected at same time.

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Chilled Water Coils

- See *Cooling Systems* narrative for waterside delta-T requirements.
- Coils isolated from campus chilled water via plate-and-frame heat exchangers shall be designed to use 30% propylene glycol.

Reheat Coils

- Design for 40% propylene glycol mixture with EWT of 130 Deg F, with an entering air temperature of 50 to 55 deg F (to allow for preheat coil temperature swing at low loads).

AHU Supply Fan(s): The use of fan arrays in larger air handling units is encouraged. Fan arrays provide more redundancy and better air distribution across the face of coils. They also take up less space than traditional fans. If fan arrays are not provided, plug fans are

AHU Return Fan(s): On systems that are equipped with economizer functionality, the use of return fans located within the same physical air handling unit as the supply fans(s) is preferred.

Stratification: AHU's shall take into consideration passive design to not allow outside air stratification to trip the freeze stats. While a pumped preheat coil helps, it will not prevent tripping a freeze stat. Single row high fan array, side OA entry are two passive ways to consider. As a last resort, air blenders can be added to the AHU.

AHU Fan Arrays Backdraft Dampers: Any fan array banks shall be supplied with zero or as-low-as-possible pressure drop non-motorized backdraft dampers.

AHU Pressure Relief Doors: Ductwork damage due to closed fire/smoke dampers while the AHU is running has been a recurring problem for us. Provide spring-loaded, pressure adjustable, relief doors on the discharge and inlet of all AHU's. Relief doors to be shown between AHU and any fire/smoke damper.

AHU Lights: Provide 4' LED marine strip light fixtures in the AHU sections, as this provides superior light. Connect to single light switch per AHU (so part of the AHU lights don't get accidentally left on, i.e. all lights on or all lights off).

Air Terminal Units: Size to provide full design airflow at 80% of rated capacity. Inlet velocity should not be less than 400 FPM at minimum flow. If these two conditions cannot be met, use the minimum flow, 400 FPM sizing criteria.

Air Terminal Unit Reheat Coils: All exterior spaces shall be served by 2-row coils at minimum. Where no perimeter heating is provided, design coils to provide 40 Deg F air temperature rise at 60% of design airflow using 130 Deg F heating hot water. Where perimeter heat is provided and for interior spaces, design coils to provide 25 Deg F air temperature rise at 60% design airflow using 130 Deg F heating hot water. Maximum air pressure drop at design airflow should be no greater than 1/2" w.g. Select and size coils based on the glycol content of the hydronic system.

Chilled Beam Systems: Coordinate with FP&CP Engineering.

Energy Recovery Systems: Coordinate with FP&CP Engineering.

Intake Location: It is generally preferred that outdoor air intake openings be located well above ground level to avoid typical lower level contaminants as well as any intentional harmful contamination. When a ground level installation cannot be avoided, the bottom of each intake opening shall be located a minimum of 3 ft. above the adjacent ground level. When an areaway is used as a means to provide outdoor air to below-grade equipment, compliance with the dimensional requirements set forth in the *Areaways and Window Wells* section within these *Design Guidelines* is mandatory. This includes a requirement that each areaway and/or window well be extended a minimum of 1 ft. above the adjacent grade level in order to minimize the entrance of leaves, debris

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and drifting snow. When locating outdoor air intake openings, it is essential that prevailing wind direction, building configuration, adjacencies and sources of odors/contaminants be considered. Vehicle exhausts from streets and loading dock areas as well as exhaust from emergency generators are common culprits for causing indoor air quality problems. The same is true of laboratory fume exhausts. In compliance with applicable codes and standards, minimum distances from various sources of contamination (e.g. sanitary vents, toilet exhausts, etc.) shall be maintained. Coordination is needed between designers who locate sources of contamination (i.e. Architect) and those who endeavor to minimize their effect (Engineer).

Intake Louvers: Outdoor air intake louvers shall be sized generously to prevent the carryover of rain and snow into associated ventilation systems. Light powdery snow is especially difficult to remove from the air stream regardless of the louver type. Thus, air velocity across the net free area of any intake louver shall not exceed 400 FPM. If, due to unalterable existing conditions, it is not possible to comply with this limitation, a louver that is rated for wind driven rain shall be used. If a horizontal wind driven rain louver is used in such cases the air velocity across the net free area shall not exceed 700 FPM. If a vertical wind driven rain louver is used the air velocity across the net free area shall not exceed 900 FPM. Bird screens shall be installed at each outdoor air intake louver. Intake louver or intake plenum shall have easily (with a 6' ladder) removable or broomable cottonwood screen (The Filter Shop) incorporated to prevent fine, wispy snow from entering the AHU's and wetting filters.

Outdoor Air Plenum: A plenum shall be provided inside each outdoor air intake louver to serve as a "stilling chamber" to remove entrained rain and snow from the air stream, *See Drawing 23 37 00-02 Louver Plenum Construction Detail*. Plenums associated with wall louvers shall be of adequate depth (in direction of airflow) to ensure that the air velocity profile is consistent across the full face of the louver. Inadequate depth results in localized areas of high velocity flow. Outdoor air ductwork connected to the plenum shall also be sized and configured to facilitate even air distribution at the louver. Each plenum shall include a piped floor drain connected to the building storm drainage system. An access door shall be provided at each plenum/duct to facilitate cleaning of the louver / bird screen and shall be as large as practical. Outdoor (and relief) air plenums, especially when partially formed from building elements (i.e. roofs, walls, or have penetrating elements like columns), need particular care given to forming a long-term airtight seal. If not, building pressurization and energy usage can be drastically affected.

Roof Intake: When an outdoor air intake hood or louvered penthouse is located at the roof level of a building it shall be installed in a manner that minimizes the potential for snow penetration. The lowest point at which air may enter the device shall not be less than 12" above the adjacent roof surface. In locations that are vulnerable to snow drifting this dimension shall be increased as appropriate. The air velocity across the total effective intake hood opening shall not exceed 300 FPM and the associated throat velocity shall not exceed 600 FPM. It should be noted that louvered penthouses are particularly vulnerable to rain and snow penetration due to increased wind velocity of wind at the roof level in conjunction a design that allows air to blow through the device horizontally. (i.e. air enters the windward side and exits the leeward side). For this reason, the use of louvered penthouses is generally discouraged. When these devices are used they shall incorporate wind driven rain louvers. Again, the throat velocity shall not exceed 600 FPM. Each vertical outdoor air duct or plenum shall include a basin at the bottom designed for collection and re-evaporation of snow and water. Where substantial entrance of snow or water is anticipated, a piped drain that directs water to an interior floor drain shall be provided. A hinged access door shall be provided to afford adequate access to the motorized outdoor air damper above and the collection basin below.

Relief Location: Each relief air opening shall be located, at an absolute minimum, 10 ft. from the nearest outdoor intake opening. Consideration shall be given to the prevailing wind direction, building configuration, intake and relief opening orientations, etc. when locating outdoor air and relief air openings to minimize the potential for recirculation of relief air back into the intake air stream. Such consideration will almost always dictate a separation distance that exceeds the

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minimum. Relief air shall be ducted directly to the outdoors rather than being discharged into a mechanical equipment room or other interior space. Relief (and outdoor) air plenums, especially when partially formed from building elements (i.e. roofs, walls, or have penetrating elements like columns), need particular care given to forming a long-term airtight seal. If not, building pressurization and energy usage can be drastically affected.

Relief/Exhaust Louvers: Requirements for intake louvers as listed above in the paragraph entitled *Intake Louvers* shall be applied to relief air and exhaust air louvers with the exception of the stated velocity limitations.

Economizer: Each air handling system with a capacity greater than 3,000 CFM shall have an air-side economizer in accordance with *ASHRAE Standard 90.1* unless the design of the air handling system precludes the use of an air-side economizer.

Air Stream Mixing: Inadequate mixing of return air and outdoor air streams at air handling units (AHUs) is a recurring problem on campus. Effective mixing of air streams is essential in preventing coil freeze-up problems and nuisance trip-outs of freeze protection thermostats. The mixing area upstream of each AHU shall be configured so as to ensure that air streams mix thoroughly prior to entering the unit. Thus, it is preferred that mixing occurs within the ductwork some distance upstream of the AHU. A design that ensures good mixing typically requires increased length of the AHU/duct assembly and, in turn, increased space requirements within the mechanical equipment room. The down-sizing of equipment rooms is the worst enemy of good mixing. A configuration that introduces return air beneath outdoor air as the two air streams move into the mixing area is preferred. Dynamic mixing of the two air streams is essential. Variable Air Volume (VAV) air handling units are especially susceptible to this problem. The use of special air blending devices located within air handling units or mixed air plenums is encouraged. However, the use of these devices shall be treated as a secondary rather than a primary means of achieving thorough mixing. In other words, they should be viewed as "insurance" rather than an essential component.

Filtration: Unless specific programmatic requirements dictate otherwise, supply airflow serving standard building environments shall be filtered by a minimum 24x24x4" MERV 8 (30% efficient) pre-filter followed by a minimum 24x24x12" MERV 13 (90% efficient) secondary filter.

Supply airflow serving special building environments (e.g. laboratories) shall be filtered by a minimum 24x24x4" MERV 8 (30% efficient) pre-filter followed by a minimum 24x24x12" MERV 14 (95% efficient) secondary filter. This more stringent level of filtration may also be required to comply with LEED requirements. (MERV Ratings are per *ASHRAE Standard 52.2*. Filter % efficiencies are dust spot efficiency ratings per *ASHRAE Standard 52.1*.)

All filters must be box type. Bag filters are not allowed. See Guide Specification 23 73 13 for more specific requirements.

Secondary or final filters shall always be installed upstream of any cooling coils (preferably right after the pre-filter). **Under no circumstances shall filters be installed downstream of any cooling coils.**

System Effect: When ductwork is attached to the outlet connection of a housed fan, a length of straight duct shall be provided prior to the first fitting or transition, thus minimizing "system effect". This maximizes efficiency and minimizes noise. The minimum length of this section of duct shall be calculated using the formulas provided within the chapter entitled *Duct Design* in the current edition of the *ASHRAE Fundamentals Handbook*, or by AMCA design standards/guidelines. Typically, the application of these formulas yield a minimum straight duct length that is equal to 2 to 3 times the diameter of the equivalent round fan outlet opening. Adequate space be must be provided within the mechanical equipment room to accommodate this configuration. System effect on the inlet side of fans shall also be minimized by ensuring that air enters fans uniformly. This applies to fans with either ducted or un-ducted inlets. Again, this requires that adequate space be provided within the equipment room.

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Vibration Control: All large fans shall be supported by properly selected spring type vibration isolators in order to minimize transmission of vibration into associated equipment and building structures. Such isolation is much more critical on upper levels of a building than on lower levels. Thus, our preference is that large rotating equipment be located in equipment rooms at the lowest level. Flexible duct connections shall be installed at all points of connection between fans and associated air distribution ductwork regardless of location in order to minimize transmission of vibration into and throughout duct systems. Exception: Flexible connections may not be required for small in-line fans, roof exhausters and some fume exhaust fan installations.

Sound Control: The use of sound attenuating devices within supply and/or return air duct systems is sometimes necessary. However, when the efficiency of air distribution systems is maximized noise becomes much less of an issue and sound attenuators are not required. This is accomplished via proper fan selection/sizing, duct design and terminal device selection/sizing (i.e. VAV boxes, diffusers and grilles). As stated elsewhere, the allowable HVAC-related background noise level for a given type of occupancy shall not exceed the guideline criteria provided within the chapter entitled Sound and Vibration Control in the ASHRAE HVAC Applications Handbook.

Under Floor Ductwork: Under floor ductwork below slab-on-grade construction is not allowed unless such ductwork is installed within an accessible tunnel.

SMACNA Duct Pressure Class Designation: All ductwork shall be given a SMACNA duct pressure class designation by the engineer and shall be noted on the plans or in the specifications.

SMACNA Duct Seal Class Designation: All ductwork shall be given a SMACNA duct seal class designation by the engineer and shall be noted on the plans or in the specifications.

Fibrous Lining: Fibrous lining shall not be installed within an air handling or air distribution systems. When duct liner is deemed necessary for its sound attenuation qualities, non-fibrous type duct liner should be used.

Air Velocity: For the purposes of this guideline, a medium pressure air distribution system is defined as a system with duct static pressure 2" w.c. or greater. A low pressure system is defined as a system with duct static pressure less than 2" w.c. Air velocity within medium pressure supply ducts shall not exceed 2,400 FPM. Air velocities within low pressure supply ducts including those located downstream of VAV and constant volume boxes shall not exceed 1,200 FPM. Branch run-outs to individual grilles and diffusers shall not exceed 600 FPM.

Flex duct: Flexible duct shall be used only in low pressure duct systems and only at final connections to diffusers and grilles. Flex duct shall not be used in a medium pressure duct system (e.g. at the inlet connection to a VAV box). Each segment of flex duct shall be limited to 3' maximum length. Flex duct shall be supported by devices designed specifically for this purpose. The use of wire, tie wraps, duct tape or fabric is not allowed. Where a change in orientation from horizontal to vertical is required (e.g. at a final connection to a diffuser or grille) a metal elbow shall be used. In no case shall flex duct be used for direction changes greater than 45 Deg.

Balancing Dampers: Each diffuser, register and grille shall have a balancing damper. Duct mounted dampers installed at take-offs are preferred in lieu of integral balancing dampers. "Air Scoop" type balancing dampers are not allowed.

Diffusers and Grilles: Supply air diffusers shall be carefully selected to prevent "dumping" of cold air at minimum flow conditions. For this reason, the use of perforated ceiling diffusers is not allowed. The use of sidewall supply grilles should also be avoided where possible. They are prone to cause uncomfortable drafts.

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In areas of potential high humidity (restrooms, locker rooms, vestibules, etc), diffusers & grilles to be aluminum construction (as steel may rust and blister with time).

Diffusers shall have built-in deflector plates or be able to have plates clipped on externally.

Ceiling diffusers to be provided with adjustable quadrant banks to allow for adjustment of airflow patterns.

Supply diffusers and grilles shall be selected and installed so as to direct a greater percentage of the supply airflow toward the source of the heating/cooling load (e.g. toward exterior walls). In exterior spaces where no perimeter heating unit(s) have been provided, slot diffusers (or equivalent) shall be provided near the exterior wall(s) to deliver supply air downward at high velocity to "reach the floor" with warm supply air in the heating mode.

In those areas served by return air plenums where noise travel is an issue, a duct sound boot on return air grilles is preferred.

"Air Scoop" type integral balancing dampers are not allowed.

Exterior Ductwork: The installation of exterior ductwork other than that conveying fume exhaust is disallowed. Non-insulated exterior ductwork (e.g. exhaust ductwork) shall be stainless steel construction.

Toilet Exhaust: Multiple toilets shall be served by a common exhaust system when feasible. When zoning such systems, consideration shall be given to coordinating exhaust zones with air supply zones. This approach allows supply and exhaust systems serving a common area to be cycled on and off together. Exhaust air from toilets shall be discharged in an appropriate manner at roof level to minimize potential for recirculation back into air intake opening(s).

Custodial Exhaust: Custodial exhaust fans may be combined with restroom exhaust fans provided chemicals located in custodial rooms do not require the system to run 24/7.