

Ventilation: Outdoor air ventilation shall be introduced into each occupied building space in compliance with *ASHRAE Standard 62*.

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. These were configured to serve far-reaching duct systems. The impetus for this approach was 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 *AHSRAE 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.

Dedicated Outdoor Air: The application of various dual path and dedicated outdoor air configurations for conditioning outdoor air separately from return air is encouraged and shall be *pursued as preferred system design options*.

Energy Recovery Systems: See the *Energy Recovery Systems* section within these *General Guidelines* for specific air distribution/exhaust system requirements related to energy recovery systems.

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 fourth in the *Areaways and Window Wells* section within these *General 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 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 500 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 screen shall be installed at each outdoor air intake opening. It shall be installed on the exterior of louvers as required by *ASHRAE Standard 62.1* in order to prevent the roosting and nesting of pigeons, which is a serious ongoing problem at numerous locations across campus. (See the *Bird and Pest Control* section within these *General Guidelines*.)

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. 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 louver 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. In our experience, plenum depth is often inadequate. This results in localized areas of high air velocity through the louver in the immediate area(s) of duct connection(s). Each 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. In cases where a wall louver is dedicated to a single outdoor air duct, it is preferred that a full size transition fitting be used in lieu of a "box plenum". In such cases the bottom of the transition fitting shall be pitched toward the louver such that water drains back outdoors. Proper configuration of the duct/louver connection is critical, particularly when mullions or other vertical members are involved. See *Drawing 23 37 00-1, Louver Installation Detail*. 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. Plenums shall have adequate structural strength to support the weight of service personnel who enter to perform maintenance/cleaning. See *Drawing 23 37 00-2, Plenum Construction Detail*.

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. Toward this end, the lowest point at which air may enter the device shall not be less than 2' above the adjacent roof surface. In locations that are vulnerable to snow drifting this dimension shall be increased as appropriate. When an intake hood is used the air velocity across the total effective intake 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 that which is required as a minimum. Relief air shall be ducted directly to the outdoors rather than being discharged into a mechanical equipment room or other interior space.

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.

Air Handling Units: Central air handling units shall typically be custom or "semi-custom" units.

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 the single greatest recurring problem we have experienced with air handling systems over the years. 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. Optimized control damper selection (parallel vs. opposed blade), sizing and orientation is helpful in this regard. Air handling units in variable air volume (VAV) systems 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: As a general rule, unless specific requirements dictate otherwise, supply airflow serving standard building environments shall be filtered by a MERV 8 (30% efficient) pre-filter followed by a MERV 11 (65% efficient) secondary filter. Supply airflow serving special building environments (e.g. laboratories where cleanliness is more critical) shall be filtered by a MERV 8 (30% efficient) prefilter followed by a MERV 14 (95% efficient) secondary filter. This more stringent level of filtration may also be required to comply with LEED requirements. Exception: A secondary filter is not required for air distribution systems of less than 3,000 CFM total capacity. It is acceptable to filter supply airflow through these smaller systems with a 30% efficient (MERV 8) filter with no additional secondary filtration. (MERV Ratings are per *ASHRAE Standard 52.2*. Filter % efficiencies are dust spot efficiency ratings per *ASHRAE Standard 52.1*.)

AHU Supply Fan: The use of housed fans and plenum fans is approved. At the time of this writing the use of fan arrays is being explored. It is anticipated that this technology will be embraced by the U of I but the jury is still out.

Return Fan: Each air distribution system that is equipped with an airside economizer shall incorporate a dedicated return air fan.

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*. 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 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.

Vibration Control: All sizable 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 often necessary. However, the best way to control noise is to not create it in the first place. When the efficiency of air distribution systems is maximized noise becomes much less of an issue. 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. With rooftop HVAC units of any size/type, sound and vibration problems abound. Supply ducts oriented vertically downward consistently create problems. As a result, the University strongly discourages the installation of rooftop units. In such cases when a rooftop unit is permitted, special steps shall be taken to prevent these sound and vibration problems from occurring.

Fibrous Lining: Fibrous lining shall not be installed within an air handling or air distribution system with the following exceptions:

- Within room-to-room and room-to-plenum return air transfer “boots”.
- Within other ductwork and system components (e.g. air handling units, attenuators, VAV terminal units, etc.) where the fibrous material is completely sealed within a “Tedlar” membrane and is separated from the air stream by a perforated metal barrier.

Additional conditional exception:

- With written permission from the Owner, fibrous lining may be installed within limited lengths of readily accessible sections of supply air ductwork downstream of terminal VAV or CAV units given that the lining incorporates a protective coating (e.g. neoprene) and is carefully sealed at joints to prevent any erosion of fibers. This exception will only be considered for systems serving spaces with very low allowable sound levels where adequate sound attenuation cannot be

achieved by the application of standard noise control measures.

Supply Air Velocity: For the purposes of this writing, 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.

Air Leakage: Excessive duct leakage has proven to be a recurring problem in U of I buildings. Thus, when designing air distribution systems special consideration shall be given to minimizing air leakage. All metal ductwork shall be SMACNA Seal Class A with all joints, seams and wall penetrations sealed. All rectangular ductwork shall be SMACNA Leakage Class 6 and all round metal ductwork shall be Leakage Class 3. All rectangular ductwork shall have Pittsburg type longitudinal seams to maintain seam integrity. Snaplock seams are not allowed.

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 6’ 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 lieu of a metal elbow flex duct may be used to “turn the corner” if a support saddle is provided to prevent kinking. The support saddle shall be pre-manufactured for this specific application.

Diffusers and Grilles: The use of sidewall supply grilles shall be avoided where possible. They are notorious for causing

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uncomfortable drafts. Properly sized and located ceiling diffusers are preferred. Supply air diffusers shall be carefully selected to prevent “dumping” of cold air at minimum flow conditions. The use of high performance diffusers shall be standard practice. 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.

Supply Plenums: Ceiling supply plenums shall not be used other than in clean rooms and similar research applications. In such cases they shall be carefully cleaned and sealed.

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.

Ducted vs. Plenum Return: In general, it is preferred that air from ventilated spaces be returned to associated air handling equipment via ductwork rather than through ceiling plenum(s). The use of return ductwork has the advantage of maintaining better return air cleanliness, being easier to balance, and allowing the use of standard products above ceilings rather than plenum rated products. The use of ductwork also ensures that return air passageways do not become obstructed as a result of the installation of other systems (e.g. supply ductwork, sprinkler piping, electrical conduit, cable tray, etc.)

Airflow Through Passageways: The use of an exit passageway, stair, ramp or other exit as a part of a supply, return, or exhaust air system serving other areas of a building is prohibited except as permitted by the *International Building Code* and the *International Mechanical Code*. Such prohibition applies to major renovations of existing buildings as well as to new

structures. Existing air distribution systems that utilize any of the exit elements of a building may not be altered in any way that reduces the level of life safety. Any alteration of an existing, non-compliant system must be approved by the Division of Safety and Compliance. Approval will not be given to any proposed alteration unless it is clearly demonstrated that such alteration will not result in a reduction in occupant safety. Note: For the purposes of this writing, a building will be considered to undergo a major renovation if either the existing air distribution system or the interior space arrangements and/or structure are modified to an extent that the renovation costs exceed 25 percent of the replacement cost of the distribution system or structure.

Makeup Air: Appropriately conditioned makeup air shall be delivered in a deliberate manner into each space from which air is exhausted. The makeup airflow rate shall be approximately equal to the exhaust airflow rate.

Toilet Exhaust: Multiple toilets shall be served by a common exhaust system. 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).