Basis of Design

This section applies to the design and installation of ductwork, air terminal boxes, air outlets and inlets, volume dampers, pressure relief dampers, smoke/fire dampers, and smoke/fire damper actuators.

Design Criteria

- Select duct velocities to meet N.C. requirements of each occupied space. NC level requirements shall be identified in the Basis of Design narrative. Coordinate required NC levels with University Project Manager and users.

Supply, Return and Non Fume Exhaust Ductwork

- Provide a 6-inch pressure rating for supply ductwork and plenums between the supply fan and the zone terminal boxes; for ductwork downstream of the terminal box, provide a 2-inch pressure rating. If pressure classes less than those given above are considered sufficient for a specific application, review with Engineering Services before specifying a lower rating.
- Use the ASHRAE Handbook of Fundamentals chapter on duct design to determine the allowable leakage rate (cfm/100 sq.ft.) at the specified test pressure for each type of ductwork on the project other than fume exhaust ductwork. Specify for each type of ductwork the duct pressure rating, the pressure to apply during the duct leakage test, and the allowable cfm/100 sq.ft. leakage rate at the test pressure.
- Minimize use of square elbows. Provide turning vanes in square elbows of supply ductwork. Do not use turning vanes in return or exhaust ductwork.
- To minimize noise levels in the space, specify balancing dampers in lieu of registers.
- Provide a balancing damper for each outlet and each inlet. Locate those balancing dampers adjacent to the connection to the main branch to minimize noise levels in the space.
- Do not use perforated plate ceiling diffusers in office or classroom applications. They cause dumping.
- Specify laminar flow diffusers in laboratory applications when required.
- Do not use nonmetal ductwork (i.e. fiberboard) without the approval of Engineering Services.
- Design ductwork to and from the HVAC equipment carefully so that stratified air will be mixed properly before entering branch ducts or downstream equipment.
- Limit flexible duct to no more than 6 feet and one elbow.
- On renovation and remodel projects, obtain the latest existing supply and exhaust air quantity information from the Owner and incorporate into the design. It may be necessary to procure the services of a balancer if existing information is not available.
- On renovation and remodel projects investigate the condition of existing ductliner, in particular at cooling coils. Test for mold and replace ductliner if warranted.

Dampers

- Install manually operated, opposed blade or single blade, quadrant-type volume dampers on all branch main and branch duct takeoffs from the main duct to control the amount of air entering or leaving the branch.
- Avoid register or diffuser-mounted dampers because they cannot reduce large volumes of air without causing objectionable air noise levels.
- Do not locate single blade volume dampers immediately behind diffusers and grilles. This application does not allow uniform airflow across the outlet face.
To minimize generated duct noise, locate volume dampers at least two duct diameters from a fitting and as far away as possible from the outlet or inlet.

Provide the necessary access space around components to allow the TAB technician to take proper readings. Allow adequate straight duct sections from fan outlets, elbows, or open duct ends to provide accurate duct traverse readings.

Pressure Relief Doors or Panels

- Smoke/fire dampers have the potential to damage ductwork if they close by accident, or even if they close when the fan is shut off but wheeling down during a power outage, fire test, or fire. Risk of damage to the ductwork is particularly serious if a single smoke/fire damper will arrest the full supply of air into or out of a large fan. Design the air distribution system so that the ducts won’t be damaged if the fans are run with the smoke fire dampers closed.

- The preferred means for protecting the ductwork against over-pressurization during smoke/fire damper closure is to select a duct pressure classification so the ducts will withstand sudden exposure to the maximum fan pressure. Provide accessible, well-sealed pressure relief doors or panels that can be closed after they open.

- Use pressure relief doors rather than pressure relief backdraft dampers.

Mounting

- For roof-mounted ductwork, fans and air handlers, see the Facilities Services Design Guide architectural standard drawing titled Mechanical Equipment Mounting for minimum mounting height. Coordinate with Architect to specify rooftop mounting under Architectural.

Renovation and Expansion Projects

- When adding or removing ductwork on an existing air distribution system, show on the mechanical drawings all existing ductwork and flow rates that will need to be rebalanced after construction.

- Review manufacturer’s fan data for existing fans to ensure these fans can operate at the new operating conditions. Review existing motor amperage and motor nameplate to determine whether a new fan motor should be specified.

- In the fan schedules, provide the existing and proposed fan airflow, fan static pressures, motor amperages and motor horsepower requirements for existing fans serving systems altered in renovation projects. The existing actual flows are needed for the design. Arrange with the University of Washington Project Manager for flow measurements as needed.

- On floor plans, show any new balancing dampers that should be added to the existing branch ductwork to facilitate balancing.

- Require measurements, prior to demolition, of any unknown airflows or static pressures that will need to be reestablished as part of testing, adjusting and balancing.

- If a small portion of an existing system is to be changed, avoid creating a new high pressure drop critical path to an existing system. Larger components should be selected to avoid significant increases in the fan discharge pressure requirements.

- Provide temporary means as necessary for dust control and lab safety while ductwork and fans are being removed and installed.

Fan-powered Zone Air Terminal Boxes

- For VAV air terminal box fans, specify the method of speed adjustment (e.g., continuous or 3-speed fan control) to be used during testing, adjusting and balancing. In reviewing manufacturer’s literature during design and during contractor equipment submittals, make
sure the selected air terminal boxes will operate at a speed range that doesn’t create excess noise or motor problems. Specify “extra-quiet” fan-powered VAV boxes.

- Specify maximum sound ratings (db level) for the air terminal boxes.
- To control sound transmission out of the secondary (plenum) air intake, include a lined intake boot that has at least one 90 degree elbow.
- On mechanical floor plans, indicate with dotted lines the horizontal access clearance requirements for maintenance of air terminal boxes.
- Connect fan powered air terminal boxes to the ductwork with flex connections.
- Connect fan powered air terminal boxes to structure with vibration isolators unless the fans are internally isolated.

Smoke/Fire Dampers

- The smoke/fire dampers and their actuators are to be covered under the ductwork specialties section of the project specifications (not under controls or the fire alarm system). Exception: The EP switch for smoke/fire damper pneumatic actuators will be specified under the fire alarm system. Coordinate with electrical and refer to Environmental Health & Safety Design Guide – Fire Alarm System section.
- The University strongly discourages use of engineered smoke control systems. Consult EH&S before designing one.
- Work with the Architect and EH&S to minimize the number of smoke/fire dampers through (1) coordination of duct layout with suite configuration, and (2) close attention to code “exceptions” to standard smoke/fire damper placement requirements.
- Use pneumatic actuators. Electric smoke/fire dampers shall only be used in retrofit projects where electric smoke/fire dampers are already installed.
- If electric smoke/fire dampers are to be used, discuss actuator application including noise with Engineering Services.
- Dampers shall be Class II, 250°F, with a minimum closure time of 7 seconds and a maximum closure time of 15 seconds.
- Fire damper actuating device shall be approximately 50°F above normal operating temperature within duct system. Rate for 286°F for smoke control systems.
- Use subducts in lieu of fire dampers in laboratory hood exhaust systems.
- Provide end switch for position verification.

Access Doors and Panels

- Coordinate with Architect to ensure there are access doors through walls and hard ceilings wherever necessary to reach access doors in the HVAC equipment.
- Access doors and panels should be a minimum of 24” x 24” unless the duct is too small to accommodate a larger door or the necessary access can be handled easily with a smaller door.
- Coordinate with Architect so that all access doors and panels in the ductwork are accessible in a manner that meets applicable safety standards. This includes access doors and panels located at the smoke/fire dampers.

Hospitals, Labs, and Animal Holding Facilities Pressure Relationships

- On hospital, lab, and animal holding facilities projects, discuss with EH&S and Engineering Services whether there are any special requirements for documentation and review of room pressure relationships.
• See EH&S Laboratory Safety Design Guide.

Design Evaluation

The following information is required to evaluate the design:

• **Programming Phase**: On retrofit projects, descriptions of existing systems to be altered. For all projects, provide design criteria for ventilation, heating and cooling and noise levels. Basic strategy for zoning air distribution system.

• **Schematic Design Phase**: Identify all systems; include single line system flow diagrams, outside air and exhaust outlet locations, shaft locations, and design calculations.

• **Design Development Phase**: Provide single line duct layouts, outside air intake calculations, updated single line flow diagrams, equipment schedules, design calculations, and outline specifications.

• **Construction Document Phase**: Provide fan curves that demonstrate the duct rating is high enough to withstand the deadhead fan pressure for the basis-of-design fan selections. Provide double line duct layouts, final single line system flow diagrams (Supply air, return air, and exhaust air), equipment schedules, design calculations, and final specifications.

Construction Submittals

• For smoke/fire damper submittals: Include the number of damper actuators in each damper bank, and an equipment list showing the manufacturer, model number, and amperage draw for the actuators in each damper bank (whether composed of a single or multiple dampers).

• Include manufacturer’s literature on the smoke/fire damper actuators.

• For projects with electric smoke/fire dampers, provide shop drawings that show electrical and mechanical coordination of smoke/fire dampers.

Products, Material and Equipment

**Accessories**

• Provide insulated drip pans for cooling coils.

• Damper position switches that contain mercury are not acceptable. Use cam action, lever, or proximity type damper position switches.

**Ductwork – Non Fume Exhaust**

• Provide an easily accessible lockable, handle for each balancing damper. Orient the handle parallel to the damper blade(s).

• Use aluminum sheet metal with watertight joints for exhaust ductwork from high humidity areas such as shower rooms. Slope ductwork back toward inlet.

**Fan-powered Zone Air Terminal Boxes**

• Internally isolate the fans in air terminal boxes.

• Line the air terminal boxes with at least 1 inch of fiberglass batt insulation. Cover liner with aluminum foil at least 0.001 inch thick to prevent entrainment of fibers into the air stream.

• Damper shafts shall have at least one flat facet at the point of connection to the actuator.

**Damper Shafts**
• Provide a grooved scribe running parallel to the blades on the end of each damper shaft, including but not limited to shafts on balancing, and smoke/fire dampers.

Fume Exhaust Ductwork
• Provide ducts that are round, non-combustible, inert to agents to be used, non-absorbent, and free of any organic impregnation.
• Provide liquid and airtight joints.
• Provide smooth, non-porous lining surfaces free of cracks, joints, or ledges.
• Use flexible connection sections of ductwork, such as hypalon or neoprene-coated glass fiber cloth, between the fan and its intake duct when such material is compatible with hood chemical use factors. Provide the transition joint from duct to fan of a seamless, constant diameter, inert, corrosion and ultraviolet-resistant material as approved by Owner. Provide the duct alignment within ½ inch at the hood collar and fan.
• Choose duct material based on the compatibility with the materials handled in the hood.
• On projects where general exhaust is combined with fume exhaust the all ductwork shall be the same material as the fume exhaust.

Buried Fiberglass Reinforced Plastic (FRP) Ductwork/Piping
• Submit design and calculations for buried FRP for review and approval.
• Construct FRP per industry standards and manufacturer’s recommendations.
• Buried FRP thickness to withstand bearing loads from soil and structure above, in addition to any applicable ductwork suction pressure.
• Provide counter weight and properly strap down buried FRP to resist buoyant force.
• Compact soil to an unyielding state. Provide minimum 6” thick pea gravel underlayment and compact to an unyielding state prior to installing the FRP.
• Ensure installing system free from unnecessary stresses.
• Slope ductwork and provide drainage as needed.

Smoke/Fire Damper Actuators
• Provide pneumatic actuators for the smoke/fire dampers unless the building doesn’t have other pneumatic controls. (The Facilities Services Design Guide requires pneumatic actuators for HVAC controls in mechanical rooms. See the Environmental Control Systems section.)
• Serve pneumatic actuators for smoke/fire dampers with pneumatic lines made out of hard drawn copper tubing that meets copper tubing specifications under Environmental Control Systems.
• Electric actuators shall have an end-switch or clutch to reduce force on the damper when it is being held open. Electric actuators shall not use stall-motors.

Access Doors
• Access doors shall be hinged, latched, and gasketed. Where located in insulated ductwork, access door shall be double walled and insulated to same level as duct in which they are located.
• Access panels shall open and close easily without damage to duct insulation, and reseal tightly on re-closure.

Installation, Fabrication and Construction

General
• Expose no raw fiberglass fibers to the air distribution system air stream or to occupied space.
• During storage, transport, and installation prior to start-up, cover the ductwork and air terminal boxes with plywood and/or plastic as necessary to keep them dry, clean, and protected from damage.
• At no extra cost to the Owner:
  1) Replace metal that is dented or has a damaged finish.
  2) Replace duct liner that is torn or wet.

Ductwork
• Specify to cover the ends of ductwork while they are in storage and after installation prior to start-up, so they are protected from accumulation of dirt.
• Thoroughly clean ductwork and plenums of debris and small particles of rubbish and dust before installing and making final duct connections.
• Locate plenums at least 4 inches AFF to protect them from water in case of mechanical room flooding. Provide adequate support.
• Provide each plenum area with a light. Include an "ON" pilot light on switch.

Fume Hood Ductwork
• Slope all horizontal ductwork down towards the fume hood. Low points or “bellies” in the ductwork run are unacceptable.
• Some retrofits may require to tie-into existing glazed ceramic ducts and vitrified clay tile ducts. Provide appropriate transition detail.
• Decontaminate fume hood ducts being removed as part of the project.
• Provide a flanged removable spool piece (minimum of 12 inches long) at each fume hood connection. Use spool sections for leak tests, inspection, and to facilitate removal of equipment. Install suitable gaskets at flanged joint connections.
• Provide adequate space and easy access to facilitate inspection, repair, or replacement of exhaust ducts.
• The target design velocity in each duct shall be in the range of 1200 to 1500 feet per minute (fpm) to prevent condensed fumes or particulates from adhering to the walls of the ducts, settling out onto horizontal surfaces, and to address acoustical issues. The actuated exhaust terminal unit needs to consider noise and prevention of product deposition in the ducts.

Fume Hood Exhaust Stacks
• See Environmental Health & Safety Laboratory Safety Design Guide for air flow study requirement.
• Terminate fume hood exhaust stacks at whichever is the greatest of the following: At least ten feet above the roof for workers safety or stack height as determined by the air flow study.
• Design discharge stack velocity to be at least 3000 fpm.
• Do not provide exhaust stacks with weather caps or louvers, which require the air to change direction or cause turbulence upon discharge. Provide means to drain rainwater from exhaust stacks.

Zone Fan-Powered Air Terminal Boxes
• Cover air inlet and discharge openings for air terminal boxes while they are in storage and after installation prior to start-up to prevent accumulation of dirt.
• Coordinate location of filters for easy access and replacement.
• Orient secondary air inlets either down or sideways, not toward the ceiling.
• Provide enough clearance between the secondary air inlet and the nearest surfaces to avoid restriction of air flow.

Access Doors
• Provide hinged access doors on rectangular ductwork, air handlers and plenums. On round and oval ductwork provide removable access panels.
• Provide access doors for all plenum areas. Provide latches operable from both inside and outside the plenum.
• Provide access doors that open against pressure, and are self-closing due to the direction of airflow and by pressure differential. No exceptions.
• Provide access panels upstream of all fire dampers, smoke/fire dampers, and coils, and elsewhere where occasional access is required. Provide access panels to both sides of turning vanes.

Smoke/Fire Damper Tests
• The Contractor shall demonstrate to an Owner's witness the full functionality of each smoke/fire damper by visual observation of the blades as it strokes "full open" and "full closed." All of the smoke/fire dampers shall pass the Owner-witnessed test before tests are witnessed by the Fire Department. To allow observation of the damper blades, access doors shall be opened by the Contractor before the test begins.

Fire Damper Tests
• The Contractor shall demonstrate to an Owner's witness that the fire dampers drop from the "full open" to the "full closed" position by gravity when the fusible link is removed. Perform tests for the Fire Department only after fire dampers have passed the Owner-witnessed test before tests are witnessed by the Fire Department. Open access doors to allow observation of the damper blades by the Contractor before the test begins.

END OF DESIGN GUIDE SECTION