## SECTION 00 50 00

## HVAC DESIGN GUIDELINES

**PART 0 PURPOSE**

A. Describe broad guidelines for design of schools.

B. Establish materials qualities and applications.

C. Describe materials and conditions which do not easily fit into specific specification sections.

D. See specific sections of Design of Construction Standards for additional requirements.

**PART 1 COMMON WORK RESULTS FOR HVAC**

A. Assume that buildings will be enlarged and modified in the future.

   1. Make provisions for future interconnections, upgrading, and expansion of mechanical systems.

B. Designs for plumbing shall not locate any plumbing in exterior walls.

C. DPS looks with concern on new and untried materials and equipment. We are opposed to experimentation on our projects. However, we look forward to preliminary evaluation of innovative designs.

D. For aesthetic reasons, locate or appropriately enclose large and unsightly exterior installations to be hidden from public view.

   1. Building elevation drawings must show mechanical installations, including installations projecting above parapet walls.

   2. If due consideration of aesthetics is not observed, the Owner will require redesign until an acceptable aesthetic design is achieved.

   3. Historic landmark structures require design coordination with the Denver Landmark Commission.

E. For security reasons, include enclosures and barriers to protect exterior and rooftop mechanical equipment from vandalism and unauthorized intrusion.

F. Equipment air intake locations:

   1. As high off the ground as possible to avoid vehicle exhaust and other biological contamination.

   2. As far away as possible from plumbing vents, kitchen exhaust vents, fume hood exhaust, and similar ventilating and exhaust units.

G. Design sufficient facilities and clearances for orderly arrangements, concealment, and optimal maintenance of equipment, piping, and conduit. Give special consideration to ceiling spaces.

H. Provide sufficient and safe access for maintenance of mechanical systems.

   1. Sufficient access implies the capability to replace major components with minor impact to the building.

   2. Clearly indicate sizes and locations of ceiling and wall access panels.

I. Provide curbed floor areas for storage of on-site water-treatment chemicals, following water-treatment consultant’s recommendations.

J. When renovating or retrofitting mechanical systems or spaces, review the need to remove asbestos-containing materials including, but not limited to, insulation.

K. Abandoned piping shall be removed in it’s entirety from existing walls or other locations. Existing valve to be removed when new replacement valve is installed.

   1. Contractor to remove all flushometers and faucets from demolished/removed plumbing fixtures and return to DPS.

L. Controls: Coordinate controls standards with the DPS and the DPS Controls Application Engineer.

M. Design temperatures for heating and air conditioning systems

1. Winter: 68-78 degrees F temperature difference between inside and outside conditions (-10 degrees F outside air temperature, 68 degrees F inside air temperature).

2. Summer: ASHRAE Summer .04% but 92°F db and 61°F wb outside conditions if air intake is above a roof, and 95°/59° for systems with high make-up air intake. 76°F db, 63°F wb inside conditions.

3. Consult with the DPS for temperature and humidity requirements for special areas such as computer rooms, etc.

N. Fan coil units and radiation will be required in specific areas to facilitate shut-down of major air handling units. Where necessary, the controls on these units shall be coordinated with the controls on the air handling units.

O. All air conditioning systems shall have air economizer cycles. Systems which have economizer cycles shall be capable of running the cooling equipment independent of the economizer cycle controls. Furthermore, the economizer control shall not revert to the minimum outside air damper position for cooling season unless mechanical cooling is available.

1. In order to take advantage of economizer cooling to the highest temperature possible, return air (RA) should be minimized. Therefore, RA dampers should be specified to be of outdoor sealing quality.

P. Air conditioning, heating, ventilating and exhaust systems shall be matched to the maximum required performance.

1. The use of variable volume supply and exhaust air systems is encouraged to compensate for diversities in loads and to reduce equipment sizes.

2. Space supply air outlets should be aspirating-type to prevent "dumping" of air into occupied spaces.

Q. Interior spaces requiring cooling the year around should be handled independently from perimeter areas requiring heating during the winter and cooling during summer.

1. Interior cooling only areas should be supplied from a variable volume cooling system utilizing an air economizer cycle.

2. Perimeter systems should use economizer cycles when cooling is required and minimum ventilation rates when heating is required.

R. Provide filters upstream of all air handling coils, including heat-recovery coils. All coils shall have access for cleaning, including re-heat coils in, for example, VAV terminals.

S. Outside air ventilation shall be per latest approved version of ASHRAE Standard 62.1 / IMC.

T. Direct evaporative cooling may be used in kitchens. Indirect evaporative cooling may be used in gymnasiums. Supply air temperature shall be controlled by the unit's DDC controller.

U. Pressure gauges are required across all AHU coils and filters.

V. Elevator shaft venting: In order to minimize drafts, heat loss and elevator door "whistling", it may be necessary to install a motorized damper where only a louver may be specified for elevator shaft venting. Review with current Elevator Code for minimum requirements.

W. Energy conservation:

1. The District is dedicated to the principle of conserving energy and will scrutinize proposed construction for means of reducing not only initial cost, but also long-range operating costs. Design new buildings and remodeling of existing buildings to make the most efficient use of building materials and energy sources available. The architect and engineers are required to work in close cooperation to design energy efficient buildings.

2. For new facilities, additions, and major remodeling projects, the design team may be directed to work with Xcel Energy and participate in Xcel's Energy Design Assistance (EDA) program.

3. In design of HVAC and electrical systems, give consideration to building use by planning for conservation of energy during summer and winter vacations and for other periods of minimum occupancy. Spaces

which might require vacation schedule operation or 24 hours/day operation must be serviced by systems separate from classroom systems.

4. The capability of using alternate sources of energy is of extreme importance.

5. Provide an updated energy budget. The budget shall show the estimated use of energy for the structure calculated on appropriate energy units per square foot per year basis.

   a. Consider constant volume HVAC systems with variable-air-volume outdoor make-up air in order to minimize the use of re-heat coils.

6. Occupied-unoccupied programming of systems should be initiated to shut off ventilation air, exhaust air, fan system, pumps, etc., wherever possible. Where shut-down of systems cannot be accomplished during unoccupied hours, heat recovery systems should be considered. Each application should be examined independently to determine any special sources for obtaining recovery of usable energy.

X. Vibration engineering:

1. Unless specifically rejected by the DPS project team during program planning, vibration analysis is required for buildings having: a reciprocating machine, or an air handling unit exceeding 5,000 CFM in buildings which may be used for other than storage where equipment or foot-fall vibration will affect the users.

2. The analysis shall be done by a firm capable of performing predictive dynamic modeling of building structures based on finite-element analysis, multi-modal structural dynamics, etc. It is typically necessary to use a “total system” approach wherein all of the vibratory components are included.

3. Criteria for vibration amplitudes and structural center-bay stiffness.

4. Classroom and office areas.

5. Amplitude: 300 to 900 micro-inches (peak to peak).

6. Stiffness: 100 to 300 KIPS/inch.

7. Bear in mind that each building is a unique combination of shape, structure, use and equipment. As such, each should be analyzed to determine what will meet its specific requirements.

Y. Heating systems:

1. Minimum two (2) hot water heating steel tube or copper tube boilers.

   a. Boilers may be forced draft; using modulating/condensing technology. Utilize highest efficiency possible.

   b. Boilers should be sized at: two at 65 +/-% or three at 35 to 45% of design heating load with boiler circulating pump (BCP) on each boiler.

2. The heating water pumping system shall be 100% redundant lead/lag stand-by system. If parallel pumping is used, then a stand-by pump shall be provided.

3. Heating water systems may be primary/secondary systems. The main distribution (secondary) pumps shall be redundant. Boiler circulation pumps (primary pumps) do not need to be redundant.

4. Do not design heating systems that utilize tertiary or circulation pumps located at the equipment. (Heating water systems shall be designed to utilize a glycol/water fluid to prevent freezing of the heating water).

5. Heating equipment shall be provided with control valves that fail to the ‘open’ position.

6. Heating systems shall be provided with automatic glycol/water mixture feed tanks. Do not connect the heating water system to directly to the domestic make-up water system.

7. Refer to specification sections Hydronic Piping and Specialties and 25 90 00 Control Sequence of Operation for additional heating system requirements.

Z. Cooling systems

1. Chilled water type systems
    a. Buildings under 75 tons of total cooling load: Air cooled chillers
    b. Buildings over 75 tons of total cooling load: Water cooled chillers.
2. Water cooled chiller systems between 75 and 300 tons: Minimum of one (1) chiller and one (1) one-cell cooling tower.
3. Water cooled chiller systems over 300 tons: Minimum of two (2) chillers and two (2) one-cell cooling towers.
4. Chilled water pumping systems may be primary/secondary type systems. However, the distribution system shall be 100% redundant lead/lag stand-by.
5. Provide one pump per cooling tower. Redundancy is not required for cooling tower pumps.
6. Design chilled water systems to supply 45°F chilled water and return water at 55°F.
7. Provide cooling equipment with control valves that fail to the ‘closed’ position.
8. Provide automatic glycol/water mixture feed tanks. Do not connect the chilled water system to directly to the domestic make-up water system.

AA. Meters

1. Unless otherwise indicated by DPS, all buildings shall be metered for all utilities including electricity, gas, water, etc.
    a. Provide sub-meters on cooling tower makeup, cooling tower bleed water, boiler makeup water, chiller/closed loop chill water makeup.
2. Meters may be connected to the IBAS for energy monitoring. Coordinate controls standards with the DPS and the DPS Controls Application Engineer.

## PART 2 MECHANICAL SOUND AND VIBRATION

A. For existing structures only, the A/E may specify mechanical equipment mounted on vibration isolators to prevent the transmission of vibration and mechanically-transmitted sound to the building structure.

B. New buildings shall have equipment directly anchored to floors, if approved by acoustic/vibration consultant.

C. Pump bases for split-case pumps shall include support for suction and discharge base ells.

D. Specify flexible connectors for all rotating and reciprocating equipment unless approved otherwise.

1. Exception: Not required for fan-coil units with internal isolation of fans.

E. Specify flexible connectors to the following:

1. To relieve pump flanges of strain.
2. To provide comparative freedom for floating equipment.
3. If installed horizontally, to relieve equipment of piping weight.

F. If needed, specify travel limiters for interconnected equipment.

G. Stainless steel flexible connectors are preferable in general.

H. Specify flexible stainless steel braided hoses for heating and ventilating unit connections that may be located away from the equipment room area.

I. Specify hoses on the equipment side of shutoff valves; require horizontal installation whenever possible.

J. Consider acoustic pipe riser anchors where interruptible water flows may cause vibrations in piping, such as variable condenser water flows to remote cooling tower sumps or cycled pumping.

K. Interior duct lining is allowed only in short, open-ended air transfer ducts. All other ducts shall be externally insulated.

## PART 3 IDENTIFICATION FOR HVAC

A. Assign unit identification numbers to operating units of equipment within a class or subclass during the design phase of new buildings, additions, or remodeling of existing structures.

1. In new structures, start the numbering system with 001, within a class or subclass
2. Numbers shall include building identification, system, type, sub-type and number compliant with the DPS Facility Information System and DPS project numbering system.
3. When new operating equipment is to be added to an existing structure, the numbering of new units of equipment shall fit in with the existing numbering scheme.
4. Drawings shall indicate unique numbers for all terminal units (e.g., VAV boxes). Specify that Contractor shall label the units accordingly, including the space being served.

B. Coordinate mechanical identification with painting standards. Refer to standard Section 09 91 00.

## PART 4 TESTING, ADJUSTING AND BALANCING

A. Performance Requirements

1. Comply with the applicable procedures in the chapter on testing, adjusting and balancing (TAB) in the latest ASHRAE edition of the Systems Handbook.
2. Comply with procedural standards for TAB of environmental systems as outlined in the latest edition of SMACNA, NEBB, and/or AABC procedural manuals.

B. Note to Specifier: consideration should be given to each project to determine whether it is desirable to allow the installing contractor to test, adjust and balance the systems per NEBB qualifications. If it is considered beneficial to the conditions of the project to do so, then add the following to the above paragraph: "or, under the direct supervision of a qualified testing, adjusting and balancing supervisor, possessing Certification from the National Environmental Balancing Bureau (NEBB)."

C. The key to the above paragraphs is the reference to "direct supervision" of a qualified mechanical engineer or certified personnel. This paragraph not only implies the necessary credentials needed to bid the work, but also addresses the critical area of supervision on the job. This will both help to pre-qualify prospective bidders and eliminate the practice of an engineer or contractor, remote from the job site, "rubber stamping" the balancing reports.

D. Note: in Submittals Section, specify that the balancing contractor shall review the contract documents and submittals for location and type of balancing devices being installed by the mechanical and sheet metal contractors, and shall issue a letter to the DPS that she/he is in agreement with them or shall identify deficiencies needing attention.

E. If the commissioning agent is not available, the mechancial rngineer of record shall be on site to verify the test and balance of the systems. The mechanical engineer shall be notified seven (7) days in advance of the test and balance.

## PART 5 HVAC INSULATION

A. Steam condensate and boiler feed water (Exception: When good engineering practice precludes insulation where cooling of condensate is desirable to avoid cavitation of condensate return pumps).

B. Specify adjustment, lock nuts, and tolerances for hangers.

C. Specify that the contractor shall reinstall cal-seals at time of pipe installation.

D. Specify removable insulation for chilled water pumps, flexible connectors, unions, etc.

E. Detail on the drawings removable insulation covers for equipment. For example, enclose chilled water pump bodies in insulated sheet metal split case housings to provide easy maintenance of pumps without damage to insulation.

## PART 6 COMMISSIONING FOR HVAC

A. Use of this Standard:

1. Due to the extent of detail provided in this standard, the A/E may choose to edit this standard and incorporate portions of this standard in the construction documents. To obtain an electronic copy of this standard in Microsoft Word format, contact the DPS.

B. Mechanical Contractor Requirements:

1. The commissioning responsibilities applicable to the mechanical Contractor, commissioning authority (CA), control system contractor, and others are outlined in Section 23 08 00 - Commissioning. This section covers the specific commissioning tasks for Division 23.
2. A/E shall edit this section to match the scope of the project.

## PART 7 NATURAL GAS PIPING

A. Design system in accordance with the following standards:

1. NSI B31.2 - Fuel Gas Piping.
2. NFPA 54 (ANSI Z223.1) - National Fuel Gas Code.
3. ANSI Z 223.1a - Supplement to National Fuel Gas Code.

B. A/E shall review all existing and new gas requirements to verify adequacy of gas supply (pressure, pipe size and meter size). A/E shall indicate design criteria in the construction documents.

## PART 8 HYDRONIC PIPING

A. Automatic pressure-compensating variable-orifice type regulating valves to balance flow are unacceptable as substitutes for manual balancing of hydronic systems.

B. In all hydronic systems the District requires an inhibited propylene glycol antifreeze solution. Refer to Specification Section 23 21 13 Water Treatment for additional requirements.

C. Automatic glycol/water feeder systems are required in DPS applications where antifreeze systems are used.

D. For glycol-filled systems, specify that all components exposed to propylene glycol shall be compatible with the specified glycol (especially the seals and gaskets).

## PART 9 HYDRONIC PUMPS

A. Pumping system design:

1. A primary-secondary pumping system is preferred. Redundant pipes are required for chillers and boilers.
2. Base friction head calculations on Hydraulic Institute Standards for:
   a) Chilled water systems: 15-year-old-pipe.
   b) Hot water systems: 15-year-old pipe.
   c) Steam condensate: 15-year-old pipe.
3. When pump redundancy is required, provide 100% stand-by pumping (with check valves) with automatic change-over.

B. Base-mounted water pumps:

1. For primary pumping applications, split case centrifugal pumps are preferred over end-suction pumps.

## PART 10 STEAM AND CONDENSATE PIPING

A. Piping System:

1. Locate and specify isolation valves for all zones, risers, branches and equipment.

2. Specify unions or flanges downstream of valves and at equipment and apparatus connections. Rating of flanges shall be 150 psi.
3. Piping systems designed with expansion loops and Z-bends to provide flexibility of pipe movement are preferred over systems designed with expansion joints.
4. Condensate return systems within buildings shall be gravity return to vented receivers. Lift from receiver to condensate return shall not exceed seven (7) feet. If lift from receiver to condensate return exceeds seven (7) feet, specify a high temperature vacuum or electric condensate pump.
5. Specify spiral-wound, non-paper flange gaskets.
6. Specify cast iron fittings instead of steel.

B. Condensate coolers:

1. Where design and energy conservation dictate, provide heat-recovery condensate coolers of sufficient capacity to reduce condensate from 200ºF to 120ºF using 40ºF water input and not to exceed 90ºF water output.

**PART 11 STEAM CONDENSATE PUMPS**

A. Pumping system design

1. A primary-secondary pumping system is preferred. Redundant pipes are required for chillers and boilers.
2. Select pumps to operate at optimum efficiency.
3. Base friction head calculations on Hydraulic Institute Standards for:
   a) Steam condensate: 15-year-old pipe.
4. When pump redundancy is required, provide 100% stand-by pumping (with check valves) with automatic change-over.
5. Select pump motor as non-overloading over the entire pump curve shown by the manufacturer. Consider option of pump operation reset based on reference temperature.
6. Specify pumps with separate pump and motor shafts and replaceable couplings for all but cartridge pumps.
7. Mechanical shaft seals shall be specified. Gland seals are not acceptable.

B. Electric steam-condensate return pumps

1. Specify packaged duplex pumps or steam-powered pumps.
2. Manual lead-lag alternator for duplex pumps.
3. Electrical float switch to bring on second pump if flow too great for one pump for duplex pumps.
4. Audible alarm activated when either pump fails (duplex pumps).
5. Specify deep sump type where adequate condensate cooling to avoid cavitation of pumps is not practical.
6. Provide a condensate cooler to avoid pump cavitation if condensate receiver is not big enough to achieve adequate cooling.

**PART 12 REFRIGERANT PIPING**

A. Design Requirements

1. Refrigerants
   a) This refrigerant piping guide section is written for the typical small project using Group I Refrigerants which are negligibly toxic and non-flammable. Use R-410a and R-134a.
2. Oil traps
   a) Ascertain that oil traps are not required, and design piping to avoid their use whenever possible.

## PART 13 HVAC POWER VENTILATORS

A. Placement within a mechanical room is required for all major mechanical equipment. Only small units may be roof-mounted, and shall be made as inconspicuous as possible by placing as far away as possible from edge of roof, painting, screening or a combination of these. DPS approval is required. Roof mounted air handling units shall be double walled insulated industrial quality units and shall be specified only with DPS specific approval.

B. Centrifugal, tubular centrifugal, axial and propeller fans may be used. The use of propeller fans shall be kept to a minimum.

C. Specify that centrifugal fans are required to have a continuously-welded housing (spot or tack-weld or lock-seam construction is not acceptable). Bearing life shall be stated to be L50 life of 200,000 hours at the maximum speed for the class of fan provided.

D. Fans, motors and drives shall be located for safe and easy access for periodic inspection and maintenance.

E. Systems selected for operation above 6 inches static pressure must be approved by the DPS. Specify that fan nameplate indicate maximum permissible fan RPM.

F. Before allowing or specifying synchronous drives such as the Gates Poly Chain, verify that all associated equipment (fan, motor, fan mountings, etc.) is designed to handle the stress of starting up with this type of drive where there is absolutely no slippage. Not recommended for across the line start.

## PART 14 HVAC DUCT AND CASINGS

A. Ductwork:

1. Fibrous glass ductwork and duct liner will not be allowed. Supply and return duct shall be externally wrapped with insulation. Duct liner shall be allowed for transfer ducts and sound boots ONLY.
2. Kitchen hood exhaust ductwork shall conform to NFPA 96 and the International Mechanical Code.
3. Ductwork for special exhaust systems shall conform to NFPA 91 and the International Mechanical Code.

B. Plenums:

1. All materials in plenums must be in full compliance with NFPA 90A and the International Mechanical Code.

C. Sound attenuation:

1. Refer to Section 23 05 48, Mechanical Sound and Vibration, for coordination of duct sound attenuators, acoustical duct and plenum linings and other acoustical treatment of ductwork systems.
2. Provide sound attenuators instead of duct liner for acoustical applications.

D. Volume Control Dampers:

1. Show on the drawings all required locations for volume control dampers in the ductwork where required for air balancing.

E. Take-offs:

1. Take-offs shall be conical with a manual damper if warranted.
2. Take-offs to VAV terminal units shall not have manual dampers.

F. Fire and Smoke Dampers:

1. Indicate all fire and smoke dampers on the drawings.
2. Drawing notes or specifications indicating fire damper or fire/smoke damper locations to be "Where Required by Code" are not acceptable. Drawings must indicate location and type of all dampers.
3. Fire and smoke dampers in small ducts (under 16” in height) shall have the damper blades out of the air stream.

## PART 15 SPECIAL EXHAUST SYSTEMS

A. Laboratory Ventilation and Hazardous Exhaust Systems:

1. Pre-design considerations:

   a) Laboratories shall be ventilated per ASHRAE Standard 62, NFPA 45, NFPA 91, ANSI/AIHA Z9.5.

   b) Early in the design process, the HVAC Design Engineer responsible for the fume hood exhaust system shall obtain a complete list of the chemicals and gases to be used and stored in the lab. This list shall be used to analyze fume hood exhaust for flammability, toxicity, corrosiveness, and explosion hazards. In selecting and analyzing fume hazard control techniques, the HVAC Design Engineer shall work closely with DPS and mechanical engineer. Reference the "Educational Specification" for this information.

   c) Other safety cabinets and enclosures for highly-reactive or toxic gases, and other specialized operations will have different and/or additional requirements than those listed above. In selecting and analyzing fume hazard control techniques, the HVAC Design Engineer shall work closely with the DPS and Mechanical Engineer. Chemical storage cabinets located in rooms designed with negative air pressure should not be ventilated unless required by code authorities. Where ventilation of storage cabinets is required by the local authorities, provide powered ventilation for these cabinets.

2. General design criteria:

   a) Laboratory modules in which hazardous chemicals are being used shall be maintained at an air pressure that is negative to the corridors or adjacent non-laboratory areas.

   b) Air containing hazardous chemicals shall be discharged through hood/duct systems maintained at a negative pressure relative to the pressure of normally occupied areas of the building. Air exhausted from laboratory modules shall not pass un-ducted through other areas.

   c) Paint booth hoods, range hoods and other hazardous materials exhaust hoods shall be equipped with individual exhaust fans and shall NOT be tied together into common exhaust systems, nor shall they be connected to any other system.

   d) Hazardous exhaust systems are not typically equipped with filters to capture contaminants. In some cases, however, pre-filters may be installed to protect heat exchange coils or other HVAC equipment from accumulating debris.

   e) Fume hoods should be located in close proximity to where chemicals are stored, and 10' minimum from exits or where interfering air currents and cross drafts from doorways, windows, high traffic areas, HVAC systems, or other apparatus, could adversely affect the proper function of the hood enclosure.

   f) Make-up air shall be provided to compensate for the air being exhausted. The location and volume of make-up air is critical to assuring proper fume hood operation. Air distribution around fume hoods shall be such that cross-drafts at the hood face are avoided, thereby minimizing the occurrence of back drafts that spill vapors into the hood operator's breathing space. Care shall be exercised in the selection and placement of air supply diffusion devices to avoid air currents that would adversely affect the performance of laboratory hoods, exhaust systems, and fire detection or extinguishing systems. Unless otherwise specified, supply air velocities shall be no more than 35 fpm at work stations and fume hoods.

3. Chemical fume hoods and storage cabinets:

   a) Chemical fume hoods must be capable of maintaining 120 fpm face velocity through the sash opening with the sash door at 13 inches, measured from the top of the air foil. Sash stops should be installed at 18 inches above the hood working surface. Constant face-velocity fume hoods shall be capable of maintaining 120 fpm at all sash heights below 18 inches. Special local exhaust systems, such as snorkels or "elephant trunks", shall have sufficient capture velocities to entrain the hazardous chemicals being released.

   b) Hoods must be equipped with audible and visual low-flow alarm which should be set at 75 fpm face velocity.

   c) Chemical fume hood ducts are generally not equipped with fire sprinklers or fire dampers, but wherever code requires, ducts shall be in fire-rated or fire-protected shafts. Where fume hood exhaust contains flammable vapor, DPS Standards require installation of automatic fire extinguishing systems in exhaust ducts. However, this requirement shall be carefully addressed on a case-by-case basis, since it may result in a variety of other potential hazards associated with fume hood operation.

d) Class I - Division I interior lighting and other electrical utilities are required where internal utilities are desired. Hazardous exhaust systems should be provided with emergency backup power and not shut down upon activation of any alarm; however, dedicated switches may be provided in the building fire alarm panel to allow capability for manual fan shutdown by the fire department.

e) Sinks inside fume hoods must have a raised rim or other design feature which prevents accidental chemical releases to the sanitary sewer.

f) Built-in ventilated chemical storage cabinets with spill-containment should be included in hood installations. Cabinets for flammable or hazardous chemicals should be located in close proximity to where the chemicals will be used, preferably under or adjacent to fume hoods. Chemical storage cabinets should be ventilated per the cabinet manufacturer's instructions to provide a minimum of ten (10) air changes per hour.

g) Flammable storage cabinets must be equipped with flame arrestors, but should not be vented unless required by local code authorities. PVC piping may be used to vent corrosive and other non-flammable storage cabinets. Chemical storage cabinets, whether they are free-standing or built-in under the hood, must be UL-listed for the materials that they contain and must comply with the applicable requirements of NFPA 30, 45 and 99. Separate cabinets must be used to segregate acids and oxidizers from flammables and organics. Cabinets must also be provided with spill-containment features or devices.

   1) Where vented cabinets are required by local authorities, provide power ventilation fans.

   2) Where vented cabinets are required by local authorities, coordinate with code enforcement agencies and the architect to assure that fire-rated chases are provided where needed.

   3) Where power ventilation fans are provided. Provide a current sensing relay to be connected to the DDC Controls System for fan status monitoring.

4. Ducts, fans and control systems

a) All chemical exhaust shall discharge through unobstructed, uncapped vertical stacks. The stacks shall terminate at least 10 feet above roof level, away from eddy currents, air intakes and openings. Discharge velocities should not be less than 3,000 fpm. Fan selection, stack height and discharge velocity determinations should give consideration to preventing the reentry of contaminants into buildings. A discharge-height exception may be made by DPS if he/she deems that adequate velocity and dilution will be achieved by the specified fan.

b) Controls and dampers, where required for balancing or control of the exhaust system, shall be of a type that, in event of failure, will fail open to assure continuous draft. If energy conservation devices are used, they shall not re-circulate laboratory exhaust air or otherwise compromise the safety of the building occupants.

c) Methods of providing emergency ventilation shall be considered, such as variable-speed fan systems, standby local exhaust systems, etc., to protect occupants against major chemical spills or similar hazards.

d) Ductwork should be installed with a minimum of elbows, using round ducts and sweep ells wherever possible. To further minimize friction loss and turbulence, the interior of ducts should be smooth and free from obstructions, especially at joints. Rectangular elbows shall not be used unless there is no other choice. If used, turning vanes and inspection doors upstream of the vanes shall be required.

e) Ducts for ventilating chemical fume hoods and flammable storage cabinets must be of galvanized steel or aluminum construction, or PVC-coated or stainless steel when used for corrosive or reactive chemicals.

f) Installation of ductwork must be in compliance with NFPA 91 and ANSI Z9.5, including provisions for properly sealing penetrations, grounding and sealing duct construction materials. Penetration of fire barriers should be avoided. If multiple hoods are on the same fan system, each should be equipped with a balancing damper.

1) Where ductwork penetrates fire barriers and/or adjacent floors, coordinate with code authorities and the design architect to assure that any required fire-rated shafts are constructed.

g) The fan housing and components shall be corrosion resistant and meet the AMCA standard for spark-resistant construction. The motor must be vapor-tight (Class I, Division I) if it is located in the air stream. All fans, ducts and power supplies should be clearly labeled to indicate exactly which areas they serve.

h) Ducts for ventilating flammable storage cabinets should separate from other hazardous and general exhaust systems.

i) Ducts for ventilating corrosive or reactive storage cabinets should be separate from other hazardous materials and general exhaust systems.

5. Testing, inspecting and certification

a) Testing, inspecting and certifying hazardous exhaust systems, fume hoods and chemical storage cabinets will be performed by DPS and mechanical engineer.

b) Testing procedures should conform to DPS Section 15890 and Sections 4.7, 4.8, 5 (excluding 5.5.4 and 5.5.5) and 6 of the ANSI/ASHRAE 110-1995 Standard: "Method of Testing Performance of Laboratory Fume Hoods" using calibrated air velocity measuring devices as specified in Chapter 9 of the ACGIH Industrial Ventilation manual. Environmental Health and Safety (EH&S) will use a calibrated, direct-reading air velocity measuring device for certification and inspection purposes. If a meter has not been calibrated for an elevation of 5,000 feet, a density-correction factor must be used when measuring air velocities.

B. Dust Collectors

1. Provide the following information on the Drawings.

a) Manufacturer's name and model number.

b) CFM at total pressure.

c) Horsepower and TEFC motor: 3,600 or 1,725 rpm.

d) Drive type: direct or belted.

e) Maximum footprint of the unit.

f) Overall maximum height of unit, including leg extensions and plenum silencer.

g) Capacity (in cubic feet) of storage hopper.

h) Length of legs to provide clearance under hopper without violating overall maximum height restriction of building space.

## PART 16 AIR THERMAL UNITS

A. VAV systems in general

1. Variable-volume air distribution systems should be used in office and common areas to vary the air flow rates as the cooling loads vary rather than falsely loading the system with reheat or mixing at the terminal units.

2. A simple system design using zoned-perimeter baseboard-to-finned-tube radiation (BBR) to offset the transmission heat loss through the walls and glass or other exposed components, and a separate VAV cooling system to balance the heat gain from solar, lights, equipment and people, is preferred, with each VAV zone interlocked with the corresponding BBR.

3. Since there are several types of VAV systems, manufacturers, and proprietary features, the design engineer shall review his proposed design and qualify manufacturers with DPS in a preliminary submittal for approval before finalizing design.

4. Proposed VAV cooling system should include the following features.

a) A 100 percent outside air economy cycle.

b) Maintenance or service requirements in the occupied space should be minimal.

c) All air filtering requirements should be accomplished in the central station equipment.

d) The amount of air balance required to make the system operate should be minimal.

e) Design for flexibility to revise zoning with only minimal changes in ductwork and controls.

f) Specify control provisions to open units to full ventilation volume if required for life safety smoke control.

B. VAV terminal units

1. Show terminal unit size and design air flow rate setting on each terminal unit on the drawings.

2. Insulation lining in accordance with NFPA Standard 90A requirements.

3. Units capable of handling minimum 5 inches static pressure.

4. Units independent of pressure variations and capable of operating satisfactorily throughout their range, from minimum to maximum air flow.

5. Volume control calibrated to identify air volume in increments of percent of maximum air flow.

6. VAV units shall be selected so required RC sound levels in various spaces are not exceeded at 1-½” wg inlet pressure. Both unit casing radiated sound levels (as attenuated by ceilings when present) and discharge sound levels shall be considered in terminal unit selection.

**PART 17 DIFFUSERS, REGISTERS AND GRILLES**

A. General:

1. Provisions for balancing air flow from outlets or into inlets shall be included in the specifications as well as indicated on the drawings.

2. Air quantities and distribution pattern shall be shown on the drawings.

3. Identify outlet and inlet types on drawings using the following basic codes:

a) Supply (S)

b) Exhaust (E)

c) Return (R)

d) Transfer (T)

e) Diffuser (D) for air pattern control (include damper for volume control)

f) Grille (G) no volume control, inlet or outlet

g) When more than one type is used, add a schedule item reference number after the code name, i.e. SD-1, ER-2, etc.

4. Do not specify perforated type grilles or diffusers. Specify rectangular or square louvered diffusers and fit in the ceiling grid.

B. Intakes and Relief:

1. Design fresh air intakes protected from the prevailing winds.

2. Locate unprotected vertical plane intake louvers on the south or east.

3. Specify storm-type louvers and provide sufficient distance or directional change of fresh air between the outside air intake louver, the dampers and the filters to eliminate (or at least minimize) snow and rain being carried to the air filters. Do not exceed manufacturer’s recommended inlet velocities to help minimize snow and rain.

4. Roof-type intakes or relief are to be minimized and are only acceptable where no other solution is possible. Where the design solution requires roof-type intakes or reliefs, design and specify hoods with hinges and quick-release fasteners for ease of access to dampers.
   a) Locate roof intakes 30 feet, minimum, from plumbing vents and exhaust outlets and 20 feet, minimum, from operable windows.
5. Place intake louvers on penthouses to minimize re-circulation of exhausted air (short circuiting).
   a) Place intake and exhaust louvers 30 feet apart, minimum.

## PART 18 COMMERCIAL-KITCHEN HOODS

A. The kitchen hood fire control panel is intended to provide additional safety in the operation of the kitchen range hood. This panel interfaces between the kitchen hood exhaust fan start controls, the make-up air fan, the kitchen fire suppression panel (Ansul Panel), under-hood power, under hood lights, electric gas valve(s), gas reset buttons, the building fire alarm system and the kitchen exhaust hood and make-up air systems. The kitchen hood fire control panel is field-wired.

B. The kitchen hood is furnished and installed by the contractor.

C. The kitchen hood will be a dry hood.

D. Ladder Diagram: See DPS standard drawing at the end of the section. The diagram is for reference and may have to be modified depending on the equipment being controlled. Additional contactors, voltage changes, etc. may be necessary to coordinate with other equipment. The electrical engineer shall coordinate the equipment and the panel and shall show a completed panel design on the 100% CD drawings.

E. Locate the kitchen exhaust hood fan starter and make-up air starter next to the kitchen hood fire control panel, which should be near the kitchen, but does not have to be in the kitchen.

F. Locate EC-1 and EC-2 contactor above ceiling in kitchen or nearby.

## PART 19 HVAC AIR CLEANING DEVICES

A. In general, air filtration systems shall utilize replaceable media, 100 percent non-woven polyester synthetic fibers, 1-½” thick blend of variable polyester fibers, permanently bonded, pre-crimped fibers in laminates, each graduating down in diameter. The media shall be white on the air-inlet side and colored on the air-outlet side. The downstream section shall be uniformly impregnated with a non-drying, non-migratory tackifier to assure dust retention. Media specification:
   1. Media shall be at least UL-Class II.
   2. Minimum media performance and particle efficiency shall be:
      a) Weight: 11.0 oz. per sq. yd.
      b) Minimum performance (24” x 24” x 1-1/2” media):
         1) 0.21” w.c. resistance at 300 fpm.
         2) 30 percent ASHRAE efficiency
         3) 92 percent average weight arrestance
         4) 221 gm. dust-holding capacity at 1.0” w.c.
      c) Minimum particle efficiency:
         1) 46.1 percent at 1 to 5 microns
         2) 86.1 percent at 5 to 10 microns
         3) 89.3 percent over 10 microns

B. Built-up filter frames shall be specified to accommodate replaceable media in plastic filter frames as provided by the equipment manufacturers.

C. Plastic Filter Frames

1. Shall be permanent-style designed for replaceable media.
2. Frames shall be constructed of PVC channel shaped perimeter with 14-gauge 2” x 2” galvanized welded wire back guard.
3. Frame construction shall provide a competent seal of the filter media in order to minimize air flow bypass.

D. Media shall be supported to minimize flexing during start-stop fan cycles.

E. Firing Ranges

1. Provide electronic ionization filtration for firing ranges.
2. The range shall be 100% exhausted.

**PART 20 HEATING BOILERS**

A. Natural Gas:

1. The properties of the natural gas available : each unit to be supplied with 936 B.T.U.H. per C.F.H. natural gas at 7"-11" W.G., and 14” W.G. for forced-draft boilers. The boiler/burner units to be complete and factory tested.

B. The designers shall review the type of Boiler used with the DPS for new construction and retofit projects.

C. Controls: all equipment controllers and system controllers must use BACnet protocol to integrate into the building automation system. Provide all necessary hardware and software to interface control panels or controllers to the Integrated Building Automation System.

**PART 21 HEAT EXCHANGERS FOR HVAC**

A. Shell and tube-type heat exchangers

1. Use steam in shell and water in tubes to convert steam heat to hot water for Hydronic heating systems.
2. Specify fouling factor for tubes and shell as required.
3. Allow for glycol in water.
4. Specify the appropriate construction for heat exchangers, including pressure and temperature ratings.

B. Condensate coolers

1. Where design dictates, provide steam condensate coolers of sufficient capacity to reduce condensate from 200ºF to 120ºF using 40ºF water input and not to exceed 90ºF water output. For energy conservation when feasible, use condensate cooler to preheat domestic hot water.

**PART 22 COOLING TOWERS**

A. Review with DPS the equipment-mounted gauges desired for diagnosis and service.

B. Provide Refrigeration Room Ventialtion in accordance with the current IMC and ASHRAE Standard 15.

C. Specifically, DO NOT require that self-contained breathing apparatus (SCBA) to be provided. ASHRAE Standard 15-2001 does not require SCBA.

D. Provide low ambient controls and crankcase heaters for air cooled chillers.

E. DX Condensers:

1. For units requiring operation down to -30ºF, provide low ambient control package to allow start-up and positive head pressure control.

F. Controls: all equipment controllers and system controllers must use BACnet protocol to integrate into the building automation system. Provide all necessary hardware and software to connect control panels or controllers to DPS Integrated Building Automation System.

## PART 23 INDOOR CENTRAL STATION AIR HANDLING UNITS

A. General:

1. Medium and high velocity draw-through and built-up systems shall have transitions to achieve velocity energy recovery.
2. Specify maximum sound levels at the discharge, return and from casing.

B. Variable Volume:

1. Variable speed drive control of air flows and static pressure in harmony with budget and energy conservation requirements for project.

C. Casings:

1. Specify access doors that are easily opened and removable for inspection and access to internal parts.
2. Specify access door handles to be safety latch type. Thumb screws are not acceptable.
3. Specify stainless steel drain pans for cooling coils and humidifiers to be extensive enough to catch condensate leaving coil at highest catalogued face velocity. Bottom shall be designed to slope to drain to minimize standing water.
4. Condensate lines from drain pan must have deep traps to prevent either draw or blow through conditions. Specify proper depth dimension.
5. Specify lights with wire guards in accessible sections, factory-wired to one switch mounted on casing exterior. Switch shall have pilot light in handle.
6. Downstream of evaporative or humidifier sections, specify marine lights with sealed wire-and-glass.
7. Specify windows in access doors in evaporative-pad, filter, fan, damper and humidifier sections.
8. Specify insulation to meet NFPA-90A flame spread and smoke generation requirements.

D. Fan Section:

1. The use of a two-fan wheel housing assembly in a common section can be a cause for shaft flexing due to length, and should be evaluated before specifying.
2. Fans selected for operation above six (6) inches static pressure must be approved by DPS.
3. Original drive sheaves shall be changed when required by balancing.
4. Specify solid steel fan shafts less than 1 ½” diameter. Shafts larger than 1 ½” may be hollow with solid ends reduced to 1 ½”.
5. Specify self-aligning, pillow block re-greaseable ball type fan bearings for an average life of 200,000 hours at design operating conditions, per ANSI Code B3.15.
6. Specify externally-accessible fittings for lubrication.

E. Vibration Isolation (only if required after consultation with the DPS):

1. Specify entire fan, motor and drive assembly to be internally spring mounted at the factory, together with fan discharge flexible connection and thrust restraint springs.
2. Internal factory-selected and installed vibration isolation is preferred over an alternate design requiring external field installed deflection springs, pipe and duct flexible connections, thrust restraint springs and spring type pipe hangers on all pipes direct connected to the unit per Section 23 05 48, Mechanical Sound and Vibration Control.

F. Coil Sections:

1. Provide for removal of coils and space coils to allow for cleaning them without removal. Clearance shall be 18”, minimum.
2. Specify differential pressure gauge across coils.

3. All other coils shall be in accordance with Section 15790, Air Coils.
4. Steam coils shall not exceed six (6) feet in width.
5. Provide access section between heating and cooling coils to allow for cleaning of temperature sensors.

G. Damper Sections:

1. Bronze or nylon bearings.
2. Blades mechanically secured to control rods.
3. Blades with neoprene gaskets to seal against entire stop.

H. Filter Sections:

1. Capable of accepting rechargeable media metal frame or rigid plastic frame filters. Provide the filters in accordance with Section 23 40 00 HVAC Air Cleaning Devices.
2. Provide hinged access doors on both sides for filter replacement.
3. Required upstream of all coils, including heat recovery.

I. Casing section lengths:

1. Indicate minimum lengths for access to filters, coils and dampers.

J. Mixing Boxes:

1. Provide equal sized flanged openings capable of handling full air flow.

K. Spray Coil Assemblies:

1. Not acceptable.

L. Indirect Evaporative Cooling:

1. Is encouraged, either where direct evaporative cooling is being designed or in conjunction with backup/complementary "mechanical air-chilling" coil.
2. Chilled water from an absorption chilled-water source may be considered an indirect-cooling coil equivalent when used in conjunction with direct evaporative cooling, and chilled water temperature is controlled by supply air temperature.

M. Humidifiers:

1. When required, specify steam grid type to inject steam into air stream. Do not use steam from boiler plant.

## PART 24 PACKAGED ROOFTOP HEATING AND COOLING EQUIPMENT

A. General:

1. Take special care to minimize sound and vibration transmissions to structure by locating units symmetrically over columns and beams.
2. Provide adequate clearances for servicing filters and unit components.
3. Specify a 115-volt convenience outlet on unit sized to handle a small power load or service light.
4. On large units, specify lights with wire guards in accessible sections, factory wired to switch mounted on exterior of casing.
5. Coordinate Painting Section 09 91 00 to include painting HVAC rooftop units a harmonizing color if units are to be exposed to view.
6. Specify painting of AHU per DPS color criteria.

## PART 25 COMPUTER ROOM AIR CONDITIONING

A. General:

1. Depending on location and user condition, designer may use any of the following types of heat rejection.
    a) DX with air-cooled condenser.
    b) DX with water-cooled condenser for specific centralized computer rooms only. DPS shall approve use of these types of systems
    c) DX with glycol-cooled condenser for specific centralized computer rooms only. DPS shall approve use of these types of systems
2. Easily removable panels on all units for maintenance access to equipment. Compressor shall be serviceable out of airstream.
3. Solid-state electronic control systems, easily accessible with plug-in modules, out of main electrical panel.

B. Humidifiers:

1. Humidifiers shall be provided for specific centralized computer rooms only. DPS shall approve use of these types of systems.
2. Any of the following:
    a) Electric immersion heaters (preferred).
    b) Lattice electrode steam type.
    c) Infrared-type consisting of high-intensity quartz lamps mounted above and out of the water supply (least desired).
3. Evaporator pans arranged to be serviceable for cleaning without disconnecting water supply lines, drain lines or electrical connections.
4. Lattice electrodes enclosed within disposable plastic cylinder and which shall not require periodic cleaning.
5. Automatic flush cycle.

C. Condensate Pumps:

1. Provide as an accessory inside cabinets for upflow condensate drain systems.

D. Filters:

1. Disposable media type in accordance with Section 23 40 00 HVAC Air Cleaning Devices.

E. Floor Stands:

1. Isolate air conditioning units from raised floors with adjustable floor stands mounted on vibration isolation pads.

F. Air-cooled Condensers:

1. Low-profile, slow speed, multiple direct-drive propeller fan type.
2. Provide low ambient control package to allow start-up and positive head pressure control with ambient temperature as low as -30°F.
3. Outdoor design temperature: 105°F if on roof.

G. Water-cooled Condensers:

1. Cleanable, shell and tube, counter-flow type with removable heads.

H. Glycol Systems:

1. Glycol-cooled condenser cleanable, shell and tube, counter-flow type with removable heads.
2. Dry cooler, low profile, slow speed, multiple direct-drive propeller fan type.
3. Provide dual pump package with automatic start of standby pump upon failure of lead pump.

4. Consider glycol "free cooling" economizer coil and all controls necessary to provide winter cooling without compressor operation.

5. Outdoor design temperature: 105°F if on roof.

I. Controls:

1. During preliminary design meetings, review with the DPS which controls are required before submitting final design documents.

2. Connect to Integrated Building Automation System.

J. Ceiling Recessed Units (last choice):

1. Factory assembled, completely packaged for horizontal ceiling mounting and sized to fit a 2’ x 4’ opening of a standard "T-Bar" ceiling.

2. Air-cooled types shall have the condenser air (outside air) taken from and discharged to the outside by means of a remote blower pack suitable for duct mounting and having a low limit outside ambient control to operate the unit down to -30°F.

3. Use of ceiling cavity to reject heat of compression is unacceptable.

K. Compressors:

1. Semi-hermetic for 5 ton units and up.

L. Water-dumping Units:

1. Water-cooled types that utilize tap water for condensation, after which the water is disposed of in a drain, will not be permitted.

**PART 26 AIR COILS**

A. General:

1. Except where special design requirements might dictate, coils shall have copper tubes with aluminum fins, permanently bonded.

2. Provide access areas on inlet and discharge sides of coils for maintenance purposes.

3. Provide for coil pull space and specify full-track support for easy installation and service.

4. Specify all water coils to be drainable type.

5. Provide drain piping and air venting at all water coils.

6. Specify all coil ratings to be ARI Standard 410 certified.

7. Specify fin spacing to be 12 fins per inch or less, unless otherwise indicated.

8. As a measure to improve indoor air quality per ASHRAE 62-1989, coil drain pans and drip troughs at the bottom of coils should be designed to slope to drain to minimize standing water in the air handling unit, plenum, etc. (Stagnant water is prime habitat for microorganisms.)

9. Specify working pressures and temperatures for coils. Be sure to allow for static head due to the height of the building.

10. Specify type and percent of glycol in water.

11. Provide good mixing of return and outside air streams upstream of coil to minimize stratification and possible coil freeze-up.

12. Provide flexibility in piping where connected to the coil if the coil is not isolated from fans or other vibrating equipment.

B. Chilled water coils:

1. Design for full counter-flow of water and air with water inlet at the bottom of the supply header and outlet at the top of the return header.

C. Direct-expansion refrigerant coils:

1. Direct expansion coils may be used on small systems and shall be piped and installed in accordance with factory recommendations.
2. Additional design precautions shall be taken, or a field refinement procedure shall be included in the specifications, on those installations not covered by the manufacturer's guide.
3. Specify full-face active coils in applications involving variable airflow through the coils, such as multi-zone or VAV systems.
4. Specify face-split coils for constant volume or where humidity control is required.

D. Hot water coils:

1. Constant full-flow water coils are preferred by using face-and-bypass dampers.

E. Steam coils:

1. U-bend single-tube coils acceptable for booster coils in ductwork.
2. Specify double-tube steam distributing type for all other applications where sub-freezing air enters the air handling apparatus, or where uniformity of leaving air temperature is required.
3. Specify vacuum breakers and steam air vents.

F. Where coils are exposed to all outside air:

1. Provide full-flow coil circulating pumps.
2. Design the system so that the volume of heating medium supplied to the coil will not be modulated.

G. Coils in built-up plenums:

1. When cooling coils are stacked one above the other, design and specify drip troughs on the downstream side of each of the upper coils to eliminate drip into the air stream of the bottom coil. Drip troughs shall slope to drain as noted above.
2. Condensate drain piping should incorporate a P-trap with the height of its water seal correctly sized to prevent trap from being sucked or blown dry by the static pressure differential between the inside and outside of air handling unit.

## PART 27 UNIT VENTILATORS

A. General:

1. Baseboard radiation is preferred for heating the exterior wall of all perimeter rooms. Use radiant ceiling panels only as a last choice. Use of radiant ceiling panels shall be with the approval of the DPS.
2. Use convectors where architectural features cause greater capacity requirements than baseboard radiation can provide in the available space.
3. Use cabinet unit heaters at building entrances, where greater capacity and quick response is necessary to adequately handle rapid changes in space temperature.
4. Select cabinet unit heaters and unit heaters on low-speed capacity (of three speeds) to provide quiet operation under normal conditions and have extra capacity at higher speeds for extreme conditions.
5. For all the product types listed in this Standard, specify the appropriate pressure and temperature ratings.
6. When providing any of the product types listed in this Standard, allow for thermal expansion and contraction as required.

## PART 28 INTEGRATED AUTOMATION

A. Introduction:

1. The purpose of this document is to provide the A/E with DPS requirements for use in the design. Not all design details necessary for properly specifying a controls system are described here. The detailed design and specifications are the responsibility of and shall be developed by the A/E.
2. Controls provided with equipment (e.g., a chiller, RTU, etc.) are referred to as "equipment controls" in this document.
3. Other building controls systems (e.g., fire alarm) or controls associated with other systems to which the DDC System or IBAS is interfaced are referred to as "Subsystems" in this document.

B. Design Requirements:

1. The controls shall be provided and installed by a factory authorized dealer. The controls system shall be Johnson Controls as installed by the Denver (JCI branch) or Johnson Controls as installed by Centennial Controls Inc. (CCI); or Tridium/KMC as installed by Long Building Technologies (Long).
2. The DDC system shall also be provided with a full-featured operator inteface (PC and software) for on-site system testing, operation prior to completion of the IBAS functions and during the warranty period, and for system service capabilities (i.e., configuration programming) not available via the IBAS.
   a) The software may not need to be provided if previously provided for another DPS project.
   b) The A/E shall specify the level of operator interface graphic screens needed.
   c) Consult with the DPS Controls Application Engineer regarding the above issues.
   d) See Parts 2 and 3 for more information.
3. Manual timer overrides are no longer permitted. Manual overrides will be handled through a software function. If manual override timers exist in the Facility Managers office, they shall be removed as part of the project to install the DDC System.
4. IP communications wiring for shall be installed by the telecom contractor. Mechanical engineer shall coordinate with the electrical engineer to locate IP wiring drops needed within the building.
5. Control drawings (i.e., system schematics with all controls field devices) and points lists (if not shown on the drawings) shall be included in the design.
6. All mechanical equipment shall be DDC controlled unless otherwise approved by the DPS Controls Application Engineer.
7. The A/E shall provide a schedule for the Controls Contractor listing the available pressure drop to be used for the sizing for each control valve in the project, unless it is a reverse-return system. It is not acceptable to list a single pressure drop to be used for all valves. For a piping system in which modulated two-way valves are used, for example, the valves nearest the pump will have a larger available pressure drop than those farther away from the pump.
8. The A/E shall clearly define the division of responsibility concerning the supply, installation and control of fire/smoke dampers and elevator shaft ventilation dampers. This information shall be covered both here and in the other relevant sections/drawings.
9. The A/E shall properly select the specific flow sensor type for each application, if any are used on the project, and locate it on the drawings so that manuacturer-recommended installation requirements can be met.
10. For school building addition projects:
    a) When a school already has a DDC system – Install controls to match existing DDC system manufacturer, however, comply with the requirements in this. Remove and replace existing Automated Logic (ALC) controls when necessary. ALC controls shall not be expanded upon nor re-used for any project. Integrating via BacNet to ALC controllers is acceptable.
    b) When a school already has a pneumatic system – Do not extend existing pneumatic system. Install new DDC controls for all new systems, per this document.

c) When a school has no existing controls system - Install new DDC controls with electronic actuaion for all new systems, per this document.

11. For new school projects:

    a) Install new DDC controls with electronic actuation for all new systems, per this document.

12. For mechanical system renovations (e.g. EMS replacement, boiler burner replacement, etc.):

    a) When a school already has a DDC system – Install controls to match existing DDC system component manufacturer, however, comply with the requirements in this document. Remove and replace existing Automated Logic (ALC) controls when necessary. ALC controls shall not be expanded upon nor re-used for any project. Integrating via BacNet to ALC controllers is acceptable.

    b) When a school already has a pneumatic system – Do not extend existing pneumatic system. Install new DDC controls for all new systems, per this document.

    c) When a school has no existing controls system - Install new DDC controls with electronic actuation for all new systems, per this document.

13. Equipment Controls and Subsystem Integration:

    a) All equipment controls shall be connected to the DDC system via digital communications.

    b) Subsystems that do not communicate via BACnet/IP shall be interfaced to the DDC System.

    c) It is the A/E's responsibility to coordinate the designs of the Equipment Controls, Subsystems and DDC System so that:

    d) Each equipment controller or Subsystem uses a communications protocol/interface that is compatible with the DDC System, and that this protocol/interface is defined for the Controls Contractor.

    e) They provide the points/data and functions required by the IBAS.

14. The A/E shall select basis of design equipment controls and Subsystems, determine the type of interfaces available, specify (in the equipment controls and Subsystem specification) interface to be used, and specify the process for providing DDC System communications should an alternate equipment control or Subsystem with differing communications requirements be selected.

15. Testing: The A/E shall coordinate the testing requirements in Part 3 with the relevant equipment controls and Subsystems specifications.

16. Commissioning - The A/E shall modify the testing requirements in Part 3 to properly coordinate with and/or define any testing requirements by the Commissioning specification.

## PART 29 INTELLIGENT BUILDING AUTOMATION SYSTEM

A. Introduction:

1. The purpose of this document is to provide the A/E an overview of the IBAS and guidance on the IBAS design tasks needed for the project.

2. Refer to the schematic diagrams at end of this section for information to supplement the text of this section.

3. The 25 50 00 Controls system, equipment controls (e.g., a chiller) or other systems (e.g., fire alarm) to which the IBAS is interfaced are referred to as "Subsystems" in this document.

    a) The term DDC (Direct Digital Control) System is used in this document to only refer to the 25 50 00 Controls system.

4. Acceptable Contractors:

    a) Centennial Controls (FX Server), Johnson Controls (ADX Server) and Long Building Technologies (AX Server).

    b) The work may be undertaken by DPS staff or another approved contractor with the permission of the DPS Controls Application Engineer.

c) Consult with the DPS Controls Application Engineer concerning the above issues.

B. IBAS Overview:

1. The IBAS is an existing software/hardware system consisting of individual servers dedicaticated to AX, ADX and FX building automation systems.

2. The IBAS provides a universal operator interface to all district DDC Systems regardless the manufacturer of the system. The only requirement needed to provide this function is that the DDC System needs to be BTL-listed for BACnet/IP communications.

3. The IBAS also provides operator interface functions to other Subsystems such as fire alarm, lighting control, etc. Again the requirement for this interface is BACnet/IP.

4. The operator interface functions that the IBAS provides includes:

   a) Graphical representation of Subsystems with associated points/data.

   b) Scheduling of Subsystems start/stop schedules where applicable.

   c) Alarming and historical trending of points/data.

5. The operator interface functions that the IBAS does not provide includes:

   a) Programming and other configuration tasks that requires proprietary software (i.e., the data cannot be created/modified via BACnet).

   b) Access to any data not available via BACnet/IP.

   c) Data mapping/communications between the DDC System and any other HVAC equipment (e.g., chillers, RTU's with factory controls, etc.). The A/E shall cover all HVAC integration under the 25 50 00 system design.

6. The IBAS does not have any point interface capabilities. All point connections are to the DDC System or other building Subsystems (e.g., the fire alarm system).

7. The IBAS does not execute any control sequences. All control sequences are executed by the Subsystems.

8. The IBAS uses communications wiring, routers, gateways, switches, etc. specified/installed under other section. Unless otherwise determined no hardware or software products/installation, (e.g., routers, gateways, communications wiring/devices) are required in this section for IBAS operation.

C. IBAS Scope Of Work Summary:

1. The scope of work includes:

   a) Coordination with the Subsystems' contractors concerning set up of the Subsystems' communications and data to be used in operator interface (i.e., point and other object naming/addressing, start/stop scheduling, alarms, trends, etc.).

   b) Mapping of this data into the IBAS.

   c) Development of all operator interface screens (i.e., color-graphics, etc.).

   d) Setup of the start/stop scheduling, alarm and trending functions.

   e) Any other IBAS modifications/additions for representing/controlling data from the Subsystems.

2. The A/E shall edit the 25 50 00 point/data list to match the specific point/data types and quantities provided by the Subsystems, and shall confirm that the Subsystems are capable of communicating the required points/data.

3. Unless otherwise noted, no hardware and/or software products are to be provided. Consult with the DPS Controls Application Engineer to determine if any IBAS hardware/software upgrades are to be includes in this project.

4. No communications wiring is included in this section's scope of work.

5. Provide complete IBAS functions for all Subsystems and the Point/Data lists in 25 50 00, on the drawings, and/or in the Subsystems' specifications..

    a) Software programming including fully configured database, graphics, reports, alarm/events, schedules, and trending to integrate all Subsystems as well as create graphical user interfaces (GUIs) for the building that will appear on the IBAS.

    b) The integration of Subsystems that may be be identified as add alternates include (consult with the DPS Controls Applications Engineer):

        1) The Security cameras and/or security system.

        2) The irrigation T.

        3) Utility monitoring.

D. Coordination:

1. General:

    a) The preferred method of Subsystem communications with the IBAS shall be BACnet/IP.

        1) When BACnet/IP communications is not available the Subsystem shall be interfaced to the DDC System.

            - For existing DDC Systems N1 may be acceptable – consult with the DPS Controls Application Engineer.

        2) It is the A/E's responsibility to select and specify the DDC System interface when BACnet/IP communications is not available.

    b) Other Division 22, 23, and 25 sections of this document contain coordination information for and/or references to the IBAS. However, all information is not necessarily shown and/or duplicated in all sections involved. Therefore, it is the A/E's responsibility to review all sections involved and include requirements in the design to cover the requirements of the IBAS.

        1) For example, Subsystems that require a gateway for communications to the IBAS (e.g., the fire alarm system, etc.) shall have the gateway specified in that Subsystem's specification (the gateway is manufactured/provided by the Subsystem manufacturer).

        2) It is the A/E's responsibility to select a Subsystem basis of design, determine the availability of a BACnet/IP communications, and to specify (in each Subsystem specification) the path for IBAS communications should an alternate Subsystem without BACnet/IP communications be selected.

    c) Each Subsystem shall be set up to communicate all the required data to the IBAS.

        1) Where a Subsystem is BTL-listed "communicate" means two way communications with BACnet alarm and event messages being sent by the Subsystem to the IBAS and all other messaging (status, file upload, backup, time synch, etc.) being initiated by the IBAS (e.g., a BACnet Read Property service). Where possible the integration shall not depend solely on so-called "polling" of the Subsystems by the IBAS.

    d) Specify that each Subsystem contractor coordinate with the IBAS Contractor concerning all data that must be communicated to/from the IBAS.

    e) Specify that the IBAS Contractor review all Subsystem sections to determine the complete scope of communicated data and operator interface functions for the DDC System.

    f) The DPS intranet shall be used for communications between the building and the IBAS.

        1) It is the A/E's responsibility to coordinate the locations of all Ethernet/IP drops needed with the Telecom designers.

        2) The final Ethernet/IP wiring from Subsystems to the drops shall be provided by Subsystems' contractors

3) Subsystems that do not use BACnet/IP communications shall be wired to the DDC System by the DDC System contractor.

4) Subsystem communications addressing (networks, devices, objects) shall be set up per the direction of the DPS Controls Application Engineer.

g) See Part 3 of this section for more information.

2. The IBAS supplements the DDC System, but is not a substitute for that system nor does it replace any functions that are normally performed by and/or provided with the system. In particular:

   a) Full operator interface capabilities for the DDC System shall be provided with that system. These capabilities are required for system setup, testing, commissioning and warranty operation until the IBAS's capabilities are fully operational.

   b) Integration between the DDC System and any other HVAC equipment needed for execution of the 25 50 00 Sequence of Operation shall be included in the DDC System design.

3. IBAS Integration to non-HVAC Subsystems

   a) The scope of integration to fire alarm, lighting control, irrigation, security, etc. systems is determined on a project-by-project basis. Consult with the DPS Controls Application Engineer.

   b) It is the A/E's responsibility to coordinate the design requirements for this integration with all disciplines involved (i.e., mechanical, electrical and division 17) and to ensure that the integration requirements are covered by the Subsystem designs.

4. Setup of Alarms, Schedules and Trends

   a) Subsystems that are BTL-listed and/or support certain BACnet objects/services shall have alarms, schedules and/or trends set up in the Subsystem (not the IBAS).

   b) It is the A/E's responsibility to determine the BTL-listing and BACnet capabilities of each Subsystem and to specify where alarms, schedules and/or trends are to be set up.

   c) See Part 3 for more information.

5. Testing – The A/E shall coordinate the testing requirements in Part 3 with the relevant equipment controls and Subsystems specifications.

6. Commissioning - The A/E shall modify the testing requirements in Part 3 to properly coordinate with and/or define any testing requirements by the Commissioning specification.

**PART 30 INTEGRATED AUTO CONTROL SEQUENCES FOR FACILITY**

A. Design Requirements:

1. General:

   a) The intent of this Design Guide Section is to provide the A/E with representative control sequences and point/data lists that the District has found satisfactory to use as an example in the final design of typical projects.

   b) The typical systems described are simple solutions to typical control designs. Before using them, be sure the control design for the project system is typical. Be aware that the final design is the responsibility of the Design Consultant.

   c) The District requires functional performance testing of the complete control system prior to Owner acceptance.

2. Kitchen suites with Make-up Units:

   a) Make-up air for kitchen hoods shall be controlled in sequence with the kitchen exhaust hood. (See Division 16 for hood and make-up unit controls).

   b) Make-up unit will run only when kitchen hood is on.

c) Supplemental heat shall be provided via baseboard radiation units located at all rooms with exterior exposures. The radiation units shall be controlled by a separate thermostat.

**END OF SECTION 00 50 00**