ALBUQUERQUE PUBLIC SCHOOLS

Facility Design & Construction / Maintenance & Operations

MECHANICAL SYSTEMS DESIGN STANDARDS

Including:

HVAC
Controls
Plumbing
Fire Protection

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September 12, 2013

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4.0 OVERVIEW

These Design Standards are intended to provide detailed procedures, design processes, approvals, and materials criteria for the design, specification, installation, and performance of Heating, Ventilating & Air Conditioning (HVAC) systems, Controls, Plumbing systems, and Fire Protection (FP) systems in buildings throughout the Albuquerque Public School District. The Standards apply to all new construction projects. They also guide decisions for repair/replacement/upgrade of systems in existing buildings.

4.1 INTRODUCTION

The Facilities Design and Construction (FD&C) Department, in cooperation with the Maintenance and Operations (M&O) Department and other consultants, has prepared these Mechanical Design Standards to ensure that APS receives the most appropriate mechanical systems for every application. The goal is an optimal balance of the following factors:

- Safety and Code Compliance
- Effectiveness and Reliability
- Energy Efficiency
- Low Operational and Maintenance Costs
- Reasonable Capital Cost

Each of these factors is in service of our overriding mission:

"…to create an environment conducive to student achievement and success by providing safe, clean, comfortable, aesthetic, and purposeful indoor and outdoor learning spaces throughout the District in meeting the needs of the education process."

These Standards reflect APS' real-life experience with systems, as well as lessons learned about Best Practices. While they are not intended to be rigid and inflexible, they are expected to be followed on every project. Of course, ultimate responsibility for a given design rests with the Mechanical Engineer whose stamp is on the drawings. Any disagreements with or departures from these Mechanical Design Standards must be presented in writing to representatives from both FD&C and M&O *before* being incorporated into a design.

4.2 TASKS & RESPONSIBILITIES OF DESIGN MECHANICAL ENGINEER

The tasks listed below are required of the Mechanical Engineering firm. Additional responsibilities are discussed throughout this document.

- **CONTACT PERSON:** Assign an Engineer from the Mechanical Engineering firm's office who will be the contact person for the project, and formally introduce them to the FD&C Project Manager. This contact person must be in attendance at the Conceptual Design meeting, the 50% Construction Documents meeting, and the 95% Construction Documents meeting as outlined below.

- **CONCEPTUAL NARRATIVE:** Create a narrative for the Conceptual Design submittal which includes the following:
  - **Project Description.** Basic description of the project, with a statement of the purpose, need or problem the project addresses.
  - **Existing Conditions** (if applicable - for renovation projects, additions, etc.)**.** Description of the age and square footage of the facility, type and condition of the existing HVAC system, sketch of the facility, etc.
  - **Design Options.** Discussion of the mechanical design options that were considered and rationale behind the option(s) selected. Include zone control strategy. Also include discussions of operational costs (utilities, maintenance and service life) for the various design options. Under maintenance concerns, consider the following: seasonal switch over requirements; control sequences; automatic versus manual operation. Include a discussion of Life Cycle Cost (LCC) for the various options (formal LCC analysis not required). Some systems may require the use of private sector maintenance contracts; include this impact in LCC discussions.
  - **Selected Systems.** If firmly decided prior to this narrative submittal, list: 1) type of system; 2) number and location of zones and units; and 3) equipment placement.

- **CONCEPTUAL DESIGN MEETING:** Meet with the FD&C Project Manager, the APS HVAC Project Manager and the M&O Mechanical Manager early in the design phase to discuss project scope and the design option(s) being considered. This meeting shall occur before the Design Development submittal goes to the Board of Education (or on projects that are not submitted to the Board, before Construction Documents begin). The areas of HVAC, plumbing, fire protection, controls, and building energy management systems must be addressed in this meeting. Document any major concerns and/or decisions, and copy FD&C and M&O. **See Appendix B for sign-off sheet to be completed before proceeding to 50%.**

Items to be Addressed in the Conceptual Meeting:

- ✓ project scope
- ✓ site conditions
- ✓ available utilities
- ✓ conceptual design of mechanical, plumbing, building energy management controls, and fire protection
- ✓ cost and budget
- ✓ schedule.

- **50% CONSTRUCTION DOCUMENTS SUBMITTAL.** This submittal should include the following:
  - **Drawings.** Major system layouts, zone locations, mechanical room layouts and equipment schedule(s).
  - **Written Sequence of Operations.**
  - **Technical Specifications.** Outline of specification sections using CSI's MasterFormat.
  - **Loads Summary.** Brief (1 or 2 page) summary of the load and equipment sizing calculations performed specifically for this project. Include heating and cooling loads, BTUH/SF, CFM/SF, etc., as well as a description of how the loads were calculated.
  - Initial Energy Star / Target Finder calculations (See section 4.4).

- **95% CONSTRUCTION DOCUMENT SUBMITTAL.** This submittal should include the following:
  - **Drawings.** All mechanical and plumbing sheets substantially complete, including notes, control diagrams / point schedule, and final Sequence of Operations.
  - **Technical Specifications.** Complete specifications including those outlining how coordination with electrical trades and commissioning will occur.
  - Revised Energy Star / Target finder calculations (See section 4.4).

- **FD&C STAFF INVOLVEMENT.** As part of their project management responsibilities, FD&C staff will be available to meet during design activities, and should be consulted regularly as design develops.
- **BIDDING SUBSTITUTIONS.** Notify FD&C of any substitution requests. Identify FD&C-approved substitutes in an addendum. Follow published project manual requirements for substitutions. Any such request must note whether a local parts and servicing vendor is available for the proposed product.
- **COORDINATION.** Coordinate with the Electrical Engineer for correct equipment power voltages, and to ensure that mechanical control requirements are reflected on electrical ladder diagrams. The Architect and each discipline shall verify that their respective work is properly coordinated.

- **DETAILS.** All details in the drawings must be referenced. Include specific details for the installation of new equipment and for coordination of architectural and electrical work. (For example: “Duct penetrations thru 2-hour fire wall.”)
- **REFERENCES TO OTHER DISCIPLINES.** When referencing the drawings of other disciplines (e.g., Mechanical sheets referencing Electrical sheets), verify that the referenced information actually exists and is correct; inform the Architect and Owner if it isn’t.
- **OPERABLE WINDOWS.** For ventilation in case of equipment failure, verify that operable windows are shown on the architectural drawings and that their operators are accessible to occupants. Notify FD&C if they are not. (See Operable Window requirements in APS Architectural Design Standards.)
- **REFLECTED CEILING PLAN.** Coordinate with the Architect and Electrical Engineer on all HVAC air distribution items and all above-ceiling equipment locations.
- **MAINTAINABILITY.** Maintainability is a primary consideration in the selection of mechanical systems for our buildings, and APS’ maintenance resources are limited. Always incorporate simplicity, ease of maintenance, equipment accessibility, parts availability, standardization, thorough & consistent labeling, etc., in mechanical designs.
- **PLAN REVIEW MEETING MINUTES.** The Engineer is responsible for documenting concerns and decisions discussed at plan review meetings and making sure that these items are addressed in subsequent design documents. When distributing minutes, copy all parties who attend the meeting.
- **CONSTRUCTION ADMINISTRATION.** *[NOTE: On new construction projects, the designated Design Professional (normally the Architect) is the responsible party, and may assign various Construction Administration duties from this list. On mechanical renovation projects that do not involve a Design Architect, the Design Mechanical Engineer may specifically be hired by APS to act as Construction Administrator.]* The Design Mechanical Engineer is always responsible for proper interpretation of their construction documents. Sufficient conversations, team meetings and field inspections will be made to verify all key phases of mechanical system installation, including:
    - **Submittal Review.** Assemble and route mechanical submittals for review and/or comment. Send to the APS HVAC Project Manager, Contractor and M&O Mechanical Manager. Also send to the project’s Electrical Engineer (if any) for review and comment regarding the electrical aspects of the design.
    - **Documents for On-Site Inspections.** During construction, provide relevant documents for inspection, including current drawings, specifications, control submittals, punch lists, etc.
    - **Construction Progress Meetings.** Attend and document all construction progress meetings. Copies of meeting minutes shall be sent to FD&C, the Contractor, M&O, and the school’s representative.
    - **Progress Payments / Request for Payment.** Advise the designated Design Professional what percentage of completion the mechanical / plumbing subcontractors have reached for each month’s pay application review.

Special Note for On-Call Contractor Invoices: When the Design Mechanical Engineer is the acting Construction Administrator on a renovation project, all hourly time-and-materials original invoices from On-Call Contractor(s) will be sent directly to the ME for review. Originals are then returned to the HVAC Project Manager with written comments and recommendations. The Design Engineer's review shall include the following:

- ✓ completeness of billed work
- ✓ verification of work quality
- ✓ whether the work is done according to plan
- ✓ whether the hours are reasonable
- ✓ correct hourly rate
- ✓ billed materials installed or on-hand
- ✓ correct mark-up on billed materials
- ✓ legible back-up for billed materials
- ✓ comparison of total billed-to-date versus contract total.

Copies of relevant APS On-Call contracts will be provided to Construction Administrators overseeing On-Call Contractors.

- **Test and Balance Reports.**
  - Promptly review each TAB report.
  - In conjunction with the Owner's representative, decide which items in the report need to be addressed.
  - Develop a set of recommendations based on the report's findings.
  - Resolve any identified design issues.
  - Work with the Contractor to resolve all construction issues that affect the performance of the mechanical systems.
- **Building Commissioning (Cx)** – *as applicable***.** It is Albuquerque Public School's policy to have any project (new construction or renovation) involving substantial changes or additions to HVAC and/or lighting to be commissioned and functionally tested by an independent third party. Although the Cx firm is normally hired directly by APS, the Design Mechanical Engineer must themselves participate in, and make the project team aware of, the required Cx process. They must also include commissioning cooperation language in the contract documents (drawings and specifications).
- **Final Acceptance and Training.** The Design Mechanical Engineer and Contractor will conduct an on-site final acceptance / training review of the HVAC systems to include:

  - ✓ system operation
  - ✓ trouble-shooting procedures
  - ✓ time clock/EMS operation
  - ✓ O&M Manual use
  - ✓ system component description.

  Coordinate with the FD&C Project Manager to identify required attendees. FD&C Project Manager is responsible for notifying all APS personnel of the training. Training will be verified and documented by the Commissioning

Agent (CxA). Confirm training requirements with the FD&C Project Manager and CxA. Systems/equipment that are new or unfamiliar to the District may require more in depth training, including participation by a certified manufacturer's representative.

- **Warranty Period.** One-year warranty period begins when the entire project is substantially complete. If a functional problem arises during the warranty period, the Mechanical Engineer will be notified by FD&C staff. The ME is expected to take ownership of the problem's resolution. If the problem involves the total lack of heating or cooling, the ME should be prepared to go on site every morning to check on the current resolution status, and follow-up with daily reports to the school administration, FD&C and M&O mechanical department until solved.

- **OTHER RESPONSIBILITIES.** See other sections of these Standards for additional responsibilities of the Mechanical Engineer.

- **REQUIRED COMPLIANCE WITH TASKS.** Failure to follow design and review tasks in this document and elsewhere may result in FD&C prohibiting the project from going to bid, as well as holding pay requests until all items are completed.

4.3 REQUIREMENTS FOR TECHNICAL SPECIFICATIONS

In this section, specific requirements concerning the technical specifications and how they are implemented by the Contractor are described. *Specifications shall follow the Construction Specifications Institute (CSI) Masterformat 2004 numbering system.*

- **SCOPE OF WORK.** Include a narrative description of the project in Section 23 0500. Whether this amounts to a single paragraph or several pages, it should give the reader a general understanding of the scope and intent of the mechanical portions of the project.

- **UTILITIES SPOT.** Make sure that utilities are spotted as necessary to identify any underground utilities that could potentially be damaged in the course of the project.

- **MAINTENANCE ACCESSIBILITY.** All equipment shall be located in accordance with applicable codes and as approved by APS representatives. Locations shall be convenient, safe and serviceable.

- **APS EQUIPMENT IDENTIFICATION.** Check with the FD&C Project Manager regarding APS Equipment Identification tags. APS may supply inventory tags for the Contractor to install on equipment in a visible location. For exterior equipment, this is normally the northeast side of the device.

- **PIPING LABELS.** Labels for piping shall be taped circumferentially around the piping insulation, at each end of the label. Use self-adhesive tape, color-coded the same as the label.

- **TRACER TAPE.** For buried piping, set tracer tape 12" above the pipe location during backfilling. For trenches with multiple piping runs, set one tracer tape and marker tapes for other types of pipes using wire taped to the piping above the ground on the riser. For all non-metallic piping use 14 ga. copper tracer tape.

- **EXTRA COOLER PUMP.** For evaporative systems, instruct the Contractor to include in their bid at least one extra pump (or two, for large jobs) as well as extra belts and fuses. These items shall be turned over to M&O at the end of the warranty period. This ensures that APS can obtain replacement pumps in a timely manner during warranty.
- **PRIOR APPROVAL.** If the Contractor wishes to substitute equipment in place of that specified, they must comply with the requirements for substitutions described in the Project Manual and obtain prior approval from APS. This requirement will be enforced.
- **EQUIPMENT SUPPLIER RESPONSIBILITIES.** Include in the specification the following note: "Equipment suppliers shall be responsible for certifying that equipment is installed properly and shall submit written reports on equipment installation and performance if so requested by the A/E. In addition, suppliers shall be responsible for furnishing qualified personnel at the job site as requested by the A/E or FD&C Project Manager during construction or warranty periods."
- **ROOFING.** In general, use four-sided curbs for rooftop equipment supports and ductwork penetrations. Obtain FD&C approval for any pipe or conduit penetrations. For duct supports, do not use pitch pans, but use a 4" x 4" sheet metal foot over a 6" x 6" piece of 90# roofing. For clarification, see the APS Roofing Standards.
- **SECURITY REQUIREMENTS.** For on-site inspections, anyone who has keys to school buildings and might enter or leave buildings during non-standard hours is required to provide name and last four digits of social security number on the APS Facilities Access Form, signed by the facility principal and forwarded to APS School Police via email or fax, with a copy to the FD&C Project Manager. Anyone entering or leaving school buildings during non-standard hours must phone in to the APS Police Department: 243-7712.
- **PROTECTION OF SPECIAL SYSTEMS.** Include in the text or notes the following instructions:
    - The Contractor shall be responsible for making a concerted effort to protect and avoid damage to existing Special System components in the area(s) involved in the construction process. These Special Systems include fire alarm devices, security systems, smoke sensing and detection circuits, temperature sensors, emergency lighting, exit lights, temperature controls, telephone and communication equipment (including cabling and wiring), and electric wiring and cabling that may be located in above-ceiling spaces, partitions, and similar areas.
    - All of these systems are affected by the construction process. Sensitive devices, such as smoke detectors and temperature sensors, must be protected from damage and surface dust. These devices are delicate and expensive to replace. Smoke detectors should be secured in plastic and either located in a ceiling space out of the way of the construction, or disconnected and removed to avoid damage. If any devices are found to be defective at the time they are covered or removed, notify the FD&C Project Manager. APS will furnish (or pay for) replacement devices. Any re-installation will be done by the Contractor as part of their original contract price.
    - Discuss with the APS representative a proposed method of protection for any Special Systems components that will be in the construction area. It is best for

the components to be left in their present locations and wrapped or in some way enclosed to protect them from construction activity.

- Items that are stored, removed, or bagged need to be identified and labeled. It is best to indicate the date and time they were deactivated.
- Certain systems or portions of systems need to be disconnected at various times during the construction phase. For example, security alarm detection devices are often disconnected while construction work is going on. Smoke detectors that are affected by accumulation of dust and debris are another example of devices that should be disconnected or contained during construction.
- Deactivation of Special Systems devices must be coordinated with APS Police and documented in writing. Requests must include the date(s) that the systems are to be deactivated and the scheduled date when they will be restored to active status upon completion of construction. This is particularly important for critical systems, such as security devices and fire and smoke alarm systems. The APS Police representative to contact with deactivation requests is David Grega: 263-9950 (direct line) or 243-7712 (APS Police Department main line). If Mr. Grega is not available, ask for Steve Gallegos or Steve Tellez.

- **TEST AND BALANCE BY OWNER.** Test and Balance (T&B) will be provided by the Owner (APS) and should not be included in the Contractor's bid. Contractor shall request commencement of the T&B work through the Mechanical Engineer. Note in Sections 23 0500 and 23 0593 that, if the Contractor calls for T&B and the systems are not ready, the Contractor is responsible to pay for the visit. "Ready" means simply that **a)** the equipment is in place (including ductwork, diffusers, piping, electrical power, controls, etc.) and **b)** the equipment operates when turned on. Include in the contract documents a form for the Contractor to sign, such as the form in Appendix B of this document, "Contractor Request for Test and Balance." NOTE: It is not the Owner's responsibility to pay hourly for the T&B firm to perform start-up of equipment or address the Contractor's punch list.
- **BUILDING COMMISSIONING (Cx).** APS requires commissioning on any project (new construction or renovation) involving substantial changes or additions to HVAC and/or lighting. The Cx firm is normally hired directly by APS. Include commissioning cooperation language in the following specification sections:
  - ✓ 01_9100 General Cx Requirements
  - ✓ 23_0800 Mechanical Cx Requirements
  - ✓ 26_0800 Electrical Cx Requirements
- **OPERATIONS AND MAINTENANCE (O&M) MANUALS.** The Contractor shall provide APS with two (2) hard copies and four (4) electronic copies of the O&M Manuals. These shall include the controls as-built drawings and the T&B report, bound in with the other documentation. O&M Manuals shall identify pieces of equipment by manufacturer and model number as well as by the codes used on the drawings. The name, address, and phone number of local supplier for equipment and equipment parts shall be included in the manuals.
- **WARRANTIES.** Warranty period for equipment shall be one (1) year beginning with substantial completion of work. Warranty period for controls labor and devices shall be two (2) years.

- **WARRANTY SERVICE CALLS.** Instruct Contractors to include in their bids the cost of three (3) service calls during the warranty period for services that are unrelated to warranty items (i.e., for operational or maintenance items). Any such visits by the Contractor shall be documented by email to all parties, including the FD&C Project Manager, M&O and the school administration, on the same day as the warranty call.

4.4 SUSTAINABILITY

- **General Comments.** Sustainability is an increasingly important element of responsible design. APS is committed to implementing sustainable features wherever feasible and cost-effective in the building of new schools and the renovation of existing facilities. We have had an ongoing energy conservation program for decades, which has included both system/equipment modifications and behavioral adjustments.
- **LEED Policy.** It is APS' policy that all new stand-alone buildings achieve LEED Certification at the Silver level or higher. In selecting LEED credit targets, top priority will be placed on Optimizing Energy Performance (EA Cr1). Independent LEED Consultants and Commissioning Agents will be hired directly by APS.
- **Energy Conservation and Renewable Energy Rebates.** The District will pursue all available energy conservation and renewable energy rebates from utilities such as the Public Service Company of New Mexico (PNM), the New Mexico Gas Company, and other entities. The A/E team is expected to assist the District as needed with rebate submissions related to their construction projects.
- **Monitoring.** Monitoring the performance of new schools, new additions, and existing building renovations is a fundamental part of operating and evaluating our sustainable facilities. In addition to tracking overall energy performance (consumption and demand), on given projects APS may choose to monitor: lighting performance; HVAC performance; renewable energy performance; occupant comfort and satisfaction; noise/sound levels; air quality; other environmental factors. The A/E team must be prepared to incorporate monitoring strategies into their design, and accommodate them in the construction schedule. Installed sub-meters must be integrated with the building's Facility Management System (FMS). Due to staffing limitations, APS may rely on outside entities to perform monitoring and/or analysis of the various elements.
- **Measurement and Verification (M&V).** M&V is the formal process used to determine if a building is performing as predicted by energy modeling. The process involves three steps:

  1) drafting an M&V Plan that outlines the systems/ attributes to be measured, the frequency and manner in which measurements will be collected, and producing an initial energy model of the project;

  2) implementing the M&V Plan, which includes designing and installing any required metering equipment and collecting the data over a prescribed period of time;

  3) verifying the design's performance by analyzing the collected data to determine how it compares to the initial energy model and/or the list of

attempted Energy Conservation Measures (ECMs). This third step may include producing a new "calibrated" energy model.

Following the above steps can earn the project LEED points under EA Cr5 *Measurement & Verification*. The A/E team's scope may include any or all of these tasks.

- **Commissioning.** Commissioning is currently being implemented on any APS project (new construction or renovation) involving substantial changes or additions to HVAC and/or lighting. Commissioning ensures that systems are installed and operating as designed when they are turned over to the Owner. Fundamental Commissioning is a LEED Prerequisite; Enhanced Commissioning and Building Envelope Commissioning can earn additional LEED points. The entire Project Team is responsible for accommodating commissioning in their respective scopes of work and schedules.
- **Life Cycle Cost Analysis.** Though Life Cycle Cost (LCC) analysis is not required on every APS project, it is a valuable way to quantify sustainability approaches, and a useful tool for comparing two or more proposed HVAC systems for a given project.
- **Energy Star / Portfolio Manager.** The District requests that each project be entered into EPA's Portfolio Manager, beginning with the first year of energy use. In addition, APS asks for updated Energy Star/Target Finder calculations at each milestone (50% CDs, 95% CDs and project completion). This is currently being required on most educational facility construction projects in New Mexico. The A/E team is responsible for seeing that these steps are implemented.
- **Renewable Energy.** APS welcomes the use of renewable energy in projects. When evaluating, consider first cost, energy savings, maintenance requirements, rebates and grants. (Remember that the A/E team may be asked to assist APS in pursuing rebates and grants.) Renewable energy system performance must be verified, and, if on a LEED project, formally commissioned. Include thorough training of APS personnel as needed, including M&O and school staff. If feasible, connect renewable system monitors to the APS network for use in education.

4.5 HVAC SYSTEMS

GENERAL GUIDELINES:

- **Individual Room Control.** It is usually desirable to have temperature control for each room. This can increase comfort, reduce maintenance calls, and save energy. In addition, Leadership in Energy and Environmental Design (LEED) allows an IEQ credit for individual room control.
- **Ventilation Requirements.** Do not specify excessive ventilation. While codes and standards must be complied with, remember that K-12 school spaces are usually exterior-load dominated. Occupants are in the spaces for shorter periods of time than is typical for most commercial buildings, and hallways and operable windows help supplement ventilation. Specify only the cfm required to meet the particular needs of each space.
- **System Consistency.** For additions, priority should be given to maintaining similar or identical mechanical systems throughout a given campus. This helps with equipment maintenance, spare parts, trouble-shooting, etc.
- **Performance/Design Expectations.** Great effort and expense is put into quality designs for APS buildings. It is very important to verify that performance expectations are met upon occupancy and throughout the warranty period. If performance falls short of design, be prepared to work with APS to determine causes and come up with a strategy for correcting problems.
- **Roof Issues.** Leaky roofs, roof maintenance, and re-roofing projects are major issues for APS. In general, no new mechanical equipment should be placed on roofs. In cases where it is unavoidable, written approval to do so must be obtained from the Director of FD&C. Utilize ground-mounted and indoor mechanical rooms whenever possible.
- **Information Technology Rooms.** IDF/MDF rooms (IT 'computer' rooms) shall have separate DX split systems and shall not be connected to building central heating/cooling systems. (NOTE: This rule does not apply to computer lab classrooms.)

HVAC SYSTEM TYPES:

All the system types shown below currently exist in APS schools. While none of them is inherently 'good' or 'bad' (as all approaches have advantages and disadvantages), the District is attempting to minimize the variety of systems used, by standardizing on those that best meet our design criteria and performance requirements. This approach is intended to streamline training, maintenance, acquisition of parts, and system management. It should even extend the life span of systems through proper maintenance, care and understanding of functionality.

Our number one priority is to provide the most appropriate system for each application. There are always multiple factors to consider when designing – and a certain degree of 'give-and-take'. **Please see APPENDIX A: Recommended HVAC Systems by Type of Space** for specific guidance.

Whichever system you propose, be sure to verify APS' experience with existing installations of that system before making your final decision. While we welcome your insight into recent improvements in existing systems as well as new innovations, it is imperative that the chosen system(s) be serviceable, sustainable and maintainable by APS occupants and staff from the day they are installed.

1. **Large Air Washer / Hot Water System.** This is a prevalent system within the District. It includes: a central hot water boiler with circulation pumps (one primary and one standby) and duct coils; air handler(s) located in an indoor mechanical room or on the roof, with air washer(s) to provide cold weather air circulation and warm weather ventilation and cooling; exhaust fans for relief air; pneumatic or electronic controls.
2. **Small Evaporative Cooler / Hot Water System.** This system is the same as the system above except that there is an individual evaporative cooler for each classroom, and heating is typically provided by means of wall convectors. In recent years, the individual coolers have been small residential-sized air washers, but there are numerous existing installations that have traditional evaporative coolers with aspen pad media.
3. **Small Evaporative Cooler / Furnace System.** This system is most commonly found in existing portable classroom buildings. The difference between it and the system described above is that heating is provided by furnaces, usually one per classroom. This system is also common in small additions, such as kindergarten classroom buildings, elementary school libraries, and small gymnasium buildings. Components include: gas-fired furnace, located inside a furnace closet, for heating. [The furnace should not be located not on the roof. Certain exceptions apply.]; evaporative cooler or air washer -- with separate ductwork -- for cooling; exhaust fan, if needed.
4. **Rooftop Units.** These are gas heat and DX cooling units integrated with a supply fan. They can be pre-engineered ("package units") or custom designed. Conditioned air is distributed to the spaces through duct-mounted diffusers.
5. **Central Chilled Water / Hot Water with Variable Air Volume.** This is one of the more common systems in newer buildings. It typically includes air handlers with variable frequency drives, a central hot water system with duct coils, a central chilled water system, and variable air volume terminal units (VAVs).
6. **Water Source Heat Pump System.** This simple system utilizes individual terminal units that extract heat from, or reject heat into the water source. It is reliable, but has limitations when outdoor air temperatures drop below 40^{o} F.
7. **Ground Source Heat Pump System.** Also called a 'Geo-Thermal' or 'Ground-Coupled' system, this features a geothermal well field for heat exchange, individual heat pumps for classrooms, and a central air handling system that provides ventilation air, often with some sort of heat recovery. Supplemental heating and/or cooling may be necessary in some cases.
8. **Variable Refrigerant Flow.** This is one of the newest systems APS has used. It basically consists of individual Fan Coil Units (FCUs) in each space, connected to a refrigerant line served by an outdoor condensing unit. Temperature control is achieved through variation of refrigerant volume flow. The system typically includes a central air handler that provides ventilation air and heat recovery (ERV).
9. **Hybrid System.** This system combines direct/indirect evaporative and refrigerated cooling elements. The outside air is pre-cooled with an indirect heat recovery unit; air washers provide direct evaporative cooling for normal conditions; refrigerated air (DX) is introduced when the air washer is unable to achieve set point, either due to high humidity or extreme temperatures. Heating is provided by gas or hot water.

4.6 EQUIPMENT REQUIREMENTS

The following guidelines apply to HVAC equipment:

- **BOILERS.** Provide redundant boilers and size each for two-thirds the heating load. Provide a separate gas pressure regulator for each boiler. Provide at least one (1) spare gas valve and burner controller for each boiler room. Allow adequate space in boiler rooms to walk completely around boilers, with 18" clearance on all sides. Refer to latest approved and adopted version of the National Boiler Code. Preferred boiler manufacturers: Lochinvar, Laars, Airco.
- **HEATING HOT WATER PUMPS**. Use base-mounted, flexibly-coupled pumps, sized for full heating load. Install redundant pump for standby.
- **AIR HANDLERS**. Specify double-wall construction, min. 2" thick, with 2" fiberglass insulation. Supply and return duct openings shall be at ends or sides of units, not bottom. Insulate supply ductwork. Ductwork shall include flex connection, with sun shield on top and sides. Bird screens required on all roof units or ductwork where birds might find refuge underneath (generally clearances of 18" or less).

  Use floor-mounted, double width, double inlet, centrifugal fans. Size fans generously to not exceed 1000 to 1200 RPM. Motor(s) shall feature variable frequency drive (VFD) capability. Provide separate minimum outside air damper, with adjustment capability (e.g., manual damper with locking quadrant or gradual switch in pneumatic line). Use high quality dampers such as aluminum air-foil type with rubber edge seals. Specify full air-side economizer ventilation cycle with outside air and return air dampers. Engineer shall perform load calculations.
- **EXHAUST/RELIEF FANS.** Use two single-speed exhaust fans per air handler. Direct drive preferred unless APS M&O approves belt-driven. 4000 FPM maximum tip speed.
- **AIR WASHERS.** Maximum unit size 8,500 CFM; maximum motor size 7½ HP. Use FD&C approved mounting detail, coordinating design with APS Architectural and Roofing Standards. All air washers shall have stainless steel pans. Specify 12" thick cellulose media. Use copper distribution for air washer makeup water. Include both a ball valve and a fixed flow control device in air washer riser. Use adjustable fan motors (two-speed or VFD). Provide means of draining water supply line. At pump discharge connection, install a 6-8 inch section of heavy-duty 5-ply hose for convenient pump replacement.

  Engineer shall perform load calculations; we have found that 2.5 CFM per square foot is adequate for most classroom areas. (Due to the relatively small "delta T" produced by these coolers, delivery CFMs and saturation efficiencies are sometimes overstated.) Provide cooling ductwork separate from heating ductwork. Provide override switch with twist timer in space for after-hours cooling.
- **FURNACES.** Use upflow gas-fired furnaces. Rooftop furnaces may be allowed in high ceiling areas such as gyms. Specify Energy Star Certified units. Provide heating ductwork separate from evaporative cooling system. Include fan "AUTO-ON" control on thermostat. Provide twist-and-hold timer and night setback controls.

- **AUXILIARY CONTACTS.** If motor starters are specified, verify adequate auxiliary contacts are available to provide interlocks, lock-outs, etc. Auxiliary contacts are preferred over relays.
- **FILTERS.** Equipment requiring air filters shall use standard-sized filters warehoused by APS. The most common are 12”x24”x2”; 16”x20”x2”; 16”x25”x2”; 20”x20”x2”; 20”x24”x2”, 20”x25”x2”; and 24”x24”x2”. Contact APS M&O for approval of other filter sizes: 505-765-5950.

4.7 HVAC COMPONENT DETAILS

The Mechanical Engineer shall design HVAC systems as follows:

- **Ductwork.** Comply with SMACNA ductwork standards. Relief air through operable windows should not exceed 500 FPM. Seal all joints and seams.
- **Smoke Detectors in HVAC Duct Work.** These must be properly wired into a separate zone in the fire alarm panel. Duct smoke detectors shall accommodate an ionization sensor that provides continuous monitoring and alarm verification from the fire alarm control panel. The sensor will be wired so that disconnection of the power to the HVAC unit feeding the ductwork will not alarm the unit unless smoke is present.
- **Spin-in Dampers and Locking Devices.** Specify manufacturer and model for spin-in dampers and locking devices.
- **Balancing Dampers.** Include an adequate number of balancing dampers in ductwork. As a minimum, include one damper for each reheat coil zone, and one damper for each diffuser. Locate dampers well upstream of diffusers, in order to reduce noise.
- **Fire/Smoke Dampers.** Fire/smoke dampers require access doors large enough for effective service and inspection. Access shall be verified prior to occupancy.
- **Access to Coils.** Include access door in ductwork both upstream and downstream of each hot water coil to provide access for cleaning and maintenance of coils.
- **Diffusers.** Use high volume, step-down diffusers. Do not use perforated-face diffusers.
- **Manual Air Vents.** All manual air vents are to have petcock and ¼” copper discharge tubing, turned down. If manual air vent cannot be reached using a 12’ step ladder, install remote bleed station in a location reachable by a 12’ ladder and approved by M&O.
- **Drain Piping.** Drain on chemical make-up tank and drain from boiler are to be piped separately. Separate lines help identify which line is leaking.
- **Hot Water Piping.** Heating hot water piping shall be black steel or copper (type “L”). Discuss with APS HVAC Project Manager acceptable types of pipe joints. No plastic piping will be allowed. For heating hot water systems, include valves, gauges and strainers. Provide thermometers on all three sides of main 3-way valve in boiler room: supply, return, and mixed.

- **Isolation Valves.** Include an adequate number of isolation valves (ball, globe or gate valve) in the main heating hot water lines so that work can be performed on part of the system without having to drain the entire system.
- **Relief Valves.** All pressure and temperature relief valves are to have unions and lines run separately to the floor drain. Select pressure and temperature relief valves are to be at least 12 PSIG above maximum operating pressure.
- **Three-way Valves.** Provide adequate three-way valves at coils at ends of piping runs. The purpose is to reduce supply piping pressures and maintain minimum flow in the system when all or most of the two-way valves close under light load conditions. Do not use pressure-operated bypass valves. Locate three-way valves in accordance with applicable codes and as approved by APS HVAC Project Manager. Locations shall be convenient and safe.
- **Coil Piping, Water Balance.** All heating coil piping arrangements are to have: isolation valves; drain valve (hose bibb); manual air vent (gooseneck); and some means of providing water balance. Contact APS HVAC Project Manager to discuss what type of balancing device to use at coils. Provide "circuit-setter" type balancing valves at main branch lines only.
- **Location of Coils and Terminal Units.** Whenever possible, locate heating hot water duct coils and other terminal unit components where they can be serviced from hallways/corridors adjacent to the classrooms, for ease of access, ease of locating, and minimal disruption of school activities during maintenance activities.
- **Location of Freeze-Stat.** Typically locate freeze-stats in main duct at the first branch take off, within 3 feet of coil.
- **Boiler Headers.** The ends of the headers on the boilers shall have nipples and caps instead of plugs.
- **Support of Air Handlers.** The location of equipment must be coordinated with the Structural Engineer and the Architect. Consideration should be given to structural strength, vibration, noise, roof drainage, sight lines, etc.
- **Dampers for Winter.** For air washers, it is not necessary to provide external winterizing panels. Provide multi-blade damper with locking quadrant in supply duct. Slot the damper shaft in the direction of air flow, so that the position of the damper can be readily determined.
- **VFD's.** Air handler / air washer systems should have variable frequency drive (VFD) fan motors. (Two-speed motors acceptable in some applications; consult with APS HVAC Project Manager.)
- **Chemical Feeder.** Chemical feeder for heating hot water, chilled water, or steam systems shall be accessible and separately valved. It shall be no higher than 36" above finished floor (AFF). Coordinate design with M&O to make sure it is up to date and serviceable. Meet with M&O's current water treatment provider to ensure it meets their requirements, as well.
- **Furnace Fan Control.** Include fan "AUTO-ON" sub base for gas-fired furnace thermostats.
- **Cooler Control.** Control for evaporative coolers shall be wall switch (Fan "ON-OFF", fan "HIGH-LOW', and pump "ON-OFF"). Include a 4-hour, "no-hold" spring-wound timer switch before control circuit, to prevent cooler from being left on when the space is unoccupied.

- **Other Information.** See section 4.9 *Controls Requirements* for information on locations and types of thermostats.

4.8 INSULATION REQUIREMENTS

Provide insulation on supply air ductwork, return air ductwork, heating hot water piping, domestic hot water piping, etc., to meet IECC 2009 (unless noted otherwise) as follows:

- **Heating Hot Water Piping.** Use minimum 1-inch fiberglass, with fire retardant, vapor barrier jacket. Larger pipe sizes require thicker insulation per IECC 2009.
- **Domestic Hot Water Piping.** Same as heating hot water piping.
- **Supply and Return Air Ductwork Above the Roof.** 1-inch rigid insulation, treated and sealed to be watertight, covered with corrugated aluminum jacketing, lapped, sealed to be watertight, attached with screws, joints painted, etc.
- **Supply Ductwork Directly Within The Spaces Served.** No insulation required under typical conditions.
- **Supply Ductwork Above Ceilings, In Chases, Etc.** 1-inch fiberglass blanket with a fire retardant, 3-ply vapor barrier, lapped, sealed, stapled, etc.
- **Return and Relief Air Ductwork Inside.** Line with 1-inch, 3-pound minimum density acoustic liner where necessary for sound control.
- **Protection of Insulated Piping.** All insulated piping subject to physical injury shall be protected by a smooth aluminum jacket .015” minimum thickness, banded at joints.

4.9 CONTROLS REQUIREMENTS

It is APS' intention to incorporate Direct Digital Control (DDC) whenever possible into new construction and renovation projects. In cases where limited equipment is being added to an existing campus that has no installed DDC, the preference for system consistency will override this requirement. (Contact APS HVAC Project Manager for pneumatic control requirements if needed for a project: tony.sparks@aps.edu.)

- **DIRECT DIGITAL CONTROL (DDC)**
  - Preferred DDC Systems: Alerton, Automated Logic, Trane Summit.
  - System must be BacNet compatible.
  - All control wiring to be in blue 'low voltage' conduit.
  - Thermostats and room sensors must be coordinated during design to avoid conflicting commands, and to ensure they are associated with the correct space(s).
  - Supply tamper-proof covers for control components in all unsupervised spaces. Coordinate special spaces during design.
  - Preferred control valves: Belimo or Siemens
  - Projects shall include an on-site control system PC desktop or laptop, integrated into the APS mechanical server.
  - Locate this system in a secure area or an IDF / MDF room.
  - Every new or re-modeled PC station shall be provided with two data drops at the location. Separate buildings will have separate data drops and PC stations.
  - Provide on-site battery back up to the control system data.
  - Upload Sequence of Operations onto the laptop/PC, and provide a wall-mounted, protected copy of the control sequence in a visible location for maintenance personnel use.
- **GENERAL REQUIREMENTS**
  - **Thermostat Location.** Locate room thermostats at 5'-0" above finished floor (AFF) or as required by code. In hallways, toilet rooms, or other unsupervised areas, locate thermostats at least 7'-0" AFF, and provide sturdy metal protective enclosure. Provide thermostats with temperature control readily operable by occupants, and visible room temperature display.
  - **Ceiling Indicators.** Contractor shall indicate locations of heating coils and heating hot water control valves in the buildings by means of a red self-adhesive dot, ½" to 1" in diameter, located on the cross-bar of the dropped ceiling. Contractor shall indicate locations of unit freeze stats and low-limit discharge air controllers in the buildings by means of a blue self-adhesive dot, ½" to 1" in diameter, located on the cross-bar of the dropped ceiling.
  - **H-O-A Switches.** Provide "HAND-OFF-AUTO" switches for relief fans. Locate in same room as central air handler control panel.
  - **Kill Switch.** Provide a mushroom head 'kill switch' for boiler at boiler room exit labeled "Emergency Boiler Power Off."

PLUMBING REQUIREMENTS

- **PIPING – DOMESTIC WATER & SEWER**
  - **Sanitary Sewer**: EXTERIOR: Bell and spigot cast iron; PVC or other code-approved plastics; acid resistant (for science labs). Approved type(s) to be identified at APS design review meetings. INTERIOR: Bell and spigot cast iron underground; PVC or other code-approved plastics; no-hub acceptable above floor (if accessible). 4-band couplings preferred. Alternate materials may be considered upon prior written approval by M&O.
  - **Roof Drains:** INTERIOR: Same as sanitary sewer. Copper (type "L") or steel acceptable for small diameter. Roof drain lines must be run above grade.
  - **Domestic Water:** SITE / BUILDING EXTERIOR: Galvanized steel (installed per code); copper (type "L"); plastic/non-metallic piping with tracer wire (16-12 ga.) *and* foil tape. Approved type(s) to be identified at APS design review meetings. Ductile iron also allowed for large diameter (4" or greater). INTERIOR: Copper (type "L") or code-approved plastic.

- **PIPING – GAS**
  - **Natural Gas:** BELOW GRADE: Coated black steel or plastic/non-metallic piping with tracer wire (16-12 ga.) *and* foil tape. Approved type(s) to be identified at APS design review meeting. ABOVE GRADE: Black pipe or corrugated stainless steel only, no plastic. ALL LOCATIONS: All elevated pressure piping shall be welded. Wherever possible, route gas lines outside of the building. Consult with Gas Company for latest sizing tables and pressure standards. Generally, no building gas pressure over 2 psi.
  - **Boiler Regulator**. Provide gas pressure regulator at each boiler and at each piece of gas-fired equipment. Provide 18" clearance in front of boiler regulator. To be vented with ½" diameter or larger rigid piping to the outside, or as required by code. Open end of vent to be protected by downturned elbow and screen. Installation and vent pipe routing shall be in accordance with instructions of City of Albuquerque boiler inspector, APS Mechanical Department, or other entity having jurisdiction.
  - **Gas Shut-off Valves**. Gas shut-off valves shall be located at equipment and shall be accessible. Gas regulators should have a gas stop immediately ahead of the regulator, and test ports on both sides of the regulator. Gas cocks shall be looped above ground; underground gas cocks are not allowed. Valves shall have test port on the inlet side.
  - **Protection of Gas Meters**. Provide chain-link fence or cage around gas meters. Use concrete-filled 4" steel pipe posts to protect meter from vehicles. Fencing shall be designed & installed such that it cannot be used by vandals as a 'ladder' to access roofs, etc.
  - **Gas Pipe on Roof**. All roof-mounted gas piping shall be painted safety yellow.

- **Portables.** Always coordinate gas line installation for portables with input from APS Portables Manager**,** Sal War: 842-4537.
  - **Expansion Planning.** As the very purpose of utilizing portable buildings is flexibility, design gas feeds for portables with potential additions/expansions in mind.
  - **Manifolds.** For large or multi-row portable campuses, consider a manifold configuration to preserve gas pressure and facilitate additions, removals and maintenance of units.
  - **Gas Pipe on Roof**. Due to the structure of roofs on portable buildings, avoid roof-mounted gas piping whenever possible. Any roof-mounted gas piping shall be painted safety yellow.
  - **Di-Electric Unions**. Provide di-electric unions on gas lines to portable classrooms.
  - **Isolation Valves.** Wherever possible, provide separate gas line isolation valves for each portable.

- **PIPING – FIRE PROTECTION**
  - **Fire Protection Piping.** SITE / BUILDING EXTERIOR: Use ductile iron. Steel is acceptable on small diameter pipes (less than 4"). Comply with NFPA.
  - **Fire Protection Piping.** INTERIOR: Use steel. Comply with NFPA and City fire protection codes.

- **PLUMBING – GENERAL**
  - **Cross Connection Prevention.** Conform to all requirements of the City of Albuquerque "Cross Connection Prevention and Control Ordinance." APS systems shall have a Reduced Pressure Backflow Assembly (RPBA) located outdoors in a suitable protective enclosure. Enclosure and its location shall be approved by both APS and the City of Albuquerque. (See City of Albuquerque drawings No. 2394 and No. 2385 for specific installation requirements.) RPBA enclosure must be protected against vandalism and freezing, provide for convenient service access, and include a City-approved drain to daylight.
  - **Other Backflow Prevention.** Use USC approved, reduced-pressure backflow preventers (RPBP). Acceptable manufacturers are Wilkins, Febco, and Watts. No exceptions allowed. Double check-valve backflow preventers are not allowed. Location must be discussed and approved by M&O. Backflow preventers shall not have bypasses. Provide flapper on catastrophic drains and splash blocks around test drains.
  - **Location of Backflow Preventers and Pressure Reducing Valves (PRVs).** Wherever possible, locate backflow preventers and PRVs outdoors to prevent possible flooding. 2" diameter and larger backflow preventers must be installed outside of the building and in a "hot box" to prevent freezing in cold weather. Backflow preventers for boilers must be 3-5' AFF and at least 12" from wall to allow access to RPBPs and drains for testing. All backflow preventers and relief-

valves shall be piped to adequately-sized drains (2” minimum diameter for boilers). All PRVs must be readily accessible.

- **Other Protected Spaces.** Provide separate backflow prevention (vacuum breakers) for cafeterias and custodial closets.
- **Chemical Treatment Systems.** Provide individual plumbing feeds for chemical feed / chemical clean systems.
- **Plumbing Chases**. On new construction, plumbing chases shall have 3’-0” min. interior width and 18" min. walking clearance between piping. Piping will be configured and supported to allow reasonable movement of personnel in the chase for maintenance. Each chase shall have an access door that is 18” min. width and 6’-8” min. height.
- **Isolation Valves for Water**. Provide isolation valves for each toilet room, for both cold water and hot water. Also provide isolation valves throughout building for each group of fixtures. Provide access doors for any valves located behind walls, above hard ceilings, etc. At plumbing chases, install isolation valves immediately inside entrance door.
- **Access to Valves.** Provide adequately-sized access doors for any valves located behind wall, above hard ceilings etc. Access doors shall be 12” x 12” min. Any valves larger than 2” diam. shall be in a chase or in a mechanical room with 24” min. access clearance.
- **Ceiling Indicator**. Isolation valves and other valves that are located above lay-in ceilings must be labeled permanently and visibly on the grid crossbar. Proper labeling method shall be discussed with M&O. (e.g.: “HT-coil”, “Frz- stat”, “Dom H2o valve”.)
- **Cooler Make-up and Bleed.** For make-up water piping to evaporative systems, use copper piping interior, galvanized (only) exterior. Do not use water softening systems. Provide drain down station with pressure reducing valve (PRV), gauge, make-up water valve, and drain down valve. Pipe the cooler drain to an indirect drain. For air washer systems, run bleed to janitor sink or other indirect drain inside the building.
- **Roof Stands.** Piping located on the roof shall be mounted on proper roof stands approximately 18 inches above the roof. No wood allowed. See the Architectural Design Standards for more information.
- **Flush Valves.** Pressure-assisted toilets are not allowed. STUDENT TOILET ROOMS: Provide toilets and urinals with manual flush valves. STAFF TOILET ROOMS & HEALTH OFFICE TOILET ROOMS: Provide toilets and urinals with manual or sensor flush valves. NOTE: Any automatic diaphragm sensor flush valves must be powered by hard-wired power supply; battery-powered flush valves are not allowed.
- **Mounting of Toilets**. NEW CONSTRUCTION: For all schools, toilets shall be floor-mounted. Do not specify toilets that are floor-mounted *and* back-discharged. Pressure-assisted toilets are not allowed. RENOVATIONS: In certain cases where existing toilets are floor-mounted and back-discharged, it may not be practical to change sewer elevations to allow downward discharge. In these cases, with APS approval, replacement toilets may be wall-mounted.

- **Water Closet Piping.** The stub-up piping to water closet flanges must be flush with the installed closet flange. Carefully coordinate piping with actual fixtures. Offset flanges are not allowed.
- **Lavatories.** Provide individual lavatories; no wash fountains are allowed. All wall-mounted lavatories shall have carriers. With APS permission, multiple-sink lavatories may be allowed if each wash station is served by an individually controlled faucet. STUDENT AND STAFF TOILET ROOMS: Provide manual metered faucets. HEALTH OFFICE LAVATORIES: Provide manual faucets. No long wrist blades shall be used on accessible handles.
- **Classroom Sinks:** Provide manual faucets. No automatic sensor faucets are allowed and no metered-flow-duration faucets are allowed in classrooms. No long wrist blades shall be used on accessible handles.
- **Manufacturers.** Pre-approved plumbing fixture manufacturers are: American Standard, Moen, Sloan, T&S and Zurn. Other manufacturers will be considered with a substitution request.
- **Floor Drains.** Provide all floor drains with trap guards. If and only if required by the building official, also equip these drains with trap primers. Where provided, trap primers shall be located on branch fixture lines so that pressure changes will be sufficient to activate the primers. Deep floor sinks in mechanical rooms shall be served by 4" min. diameter drain pipes.
- **Drinking Fountains**. No refrigerated drinking fountains will be used. Projecting drinking fountains shall be located within alcoves or between wing walls to protect from accidental impact. No exterior drinking fountains are allowed.
- **Kitchen Dishwashers.** Include chemical treatment for dishwashers. Provide individual vacuum breakers to isolate dishwasher water supply.
- **Water Heaters.** All water heaters shall be Energy Star rated, sized below 200,000 BTU's. Provide separate water heaters for kitchen vs. non-kitchen uses to reduce scalding hazard. (Provide this separation even where thermostatic mixing valves are required by code.)

4.11 FIRE PROTECTION REQUIREMENTS

- **Piping Requirements.** See fire protection pipe specification above under 4.10 *Plumbing Requirements*.
- **Automatic Wet Pipe System Required.** The entire building or addition shall be provided with a complete, automatic wet pipe fire protection sprinkler system. Non-heated spaces and food freezers require dry head sprinklers.
- **Compliance with Codes.** Design and installation shall conform to the latest editions of NFPA 13, 101, and the Universal Building Code (UBC).
- **Piping Above Ceiling.** In areas with ceilings, all piping shall be concealed.
- **Exposed Piping.** In areas where piping is exposed, all pipe fittings and hangers shall be painted, color as selected by the Architect. All exposed piping shall be run as high as possible and shall be coordinated with structure, ductwork, roof openings, and lighting to be as inconspicuous as possible.
- **Degree of Protection.** Degree of protection shall be "Light (Low) Hazard" per NFPA.
- **Approvals.** Fire protection layout shall be submitted for approval to:
  - ✓ Albuquerque Fire Department
  - ✓ State of New Mexico
  - ✓ City of Albuquerque Building and Inspection Department
  - ✓ Architect.

  All required approvals shall be obtained before ordering materials or beginning fabrication.
- **Sprinkler Heads.** All heads shall be chrome plated. Temperature ratings shall be as follows:
  - ✓ 165°F normal spaces
  - ✓ 212°F mechanical rooms
  - ✓ 286°F near hot water piping and/or as required by NFPA 13.

  Direct-mount or rigid drops only; NO flexible drops. As a best practice when renovating an existing building, provide all new sprinkler heads in the area of renovation.
- **Routing of Piping.** Whenever possible, route sprinkler mains above ceiling spaces. Due to limited ceiling space, coordinate with other trades prior to any piping installations. If the Fire Protection Contractor fails to properly coordinate piping with other trades, relocation of sprinkler piping, etc. may be at their own expense, as determined by the Architect and/or Engineer.
- **Shop Drawings.** Sprinkler shop drawings shall show, as much as practical, all ductwork, diffuser locations, lights, buss ducts, other piping mains, etc. requiring coordination with sprinkler mains, sprinkler heads, etc.
- **Location of Switches.** Fire Protection Contractor shall coordinate locations of monitor switch(es), pressure switch(es), and/or flow switch(es) with Electrical

Contractor, and pay for all required electrical connections back to main fire alarm panel from these devices.

- **Flow Switch Alarm.** For all school buildings, if the school has an automatic water sprinkler system, the tamper/flow switch located on the fire sprinkler riser must be connected to the fire alarm panel as well as a zone punch point in the SALCO control panel for the school's security system. (This connection satisfies the Fire Code requirement for monitored fire protection service in schools with fire sprinkler systems.)
- **Possible Job Requirements.** Consider other possible job requirements. Examples are: include provisions for design, calculations, and installation of alternates, even if they are not accepted; relocate inspector's test points and auxiliary drains from present location.
- **Space in Building.** Fire Protection Contractor shall verify with the Architect that there is enough space in the building for the fire protection equipment.
- **Catastrophic drains.** Provide a solid flapper on all catastrophic drains.
- **Test Points.** Test valves shall be in a suspended area accessible at floor level, with a splash block at the point of discharge. Whenever possible, drains shall discharge outdoors.

APPENDIX A: RECOMMENDED HVAC SYSTEMS BY TYPE OF SPACE

A. GENERAL

1. The District has a number of different HVAC systems installed which may be considered for various applications as suggested below. (See ***MECHANICAL SYSTEMS DESIGN STANDARDS - Section 4.5 HVAC Systems*** for more detailed descriptions.) We ask the Design Engineer to carefully evaluate the advantages and disadvantages of using their approach and research APS' history with it before proposing a given system to the project team. Possible systems include the following:

    a. Hot water heating, air washer cooling
    b. Furnace heating, air washer cooling
    c. Package units (gas heating, DX cooling)
    d. Hot water heating, chilled water cooling (VAV system)
    e. Ground-source heat pumps
    f. Variable refrigerant flow system w/ ERV ventilation
    g. Hybrid system: gas or hot water heating, both air washer and refrigerated air cooling (air washers used for most cooling conditions and refrigerated air for high temperature and/or humidity conditions).

2. Beyond safety and code compliance, important considerations in HVAC system selection include the following:

    a. Comfort/Controllability
    b. Maintenance/Durability
    c. Energy consumption
    d. Water consumption
    e. Potential for roof leaks.

3. For a large space with continuous high ventilation requirements, such as cafeteria or gymnasium:
    - ✓ Provide peak cooling with one or more air washers.
    - ✓ Down-size the main air handler accordingly.
    - ✓ Design each large space to be cooled and ventilated at maximum occupancy load.

4. For a special space such as kitchen, locker room, or shop area that has higher ventilation requirements during certain parts of the day, design as follows:
    - ✓ Use hot water unit heaters or convectors for the primary source of heat.
    - ✓ For make-up air, transfer air from adjacent large space (e.g. cafeteria, gym).
    - ✓ Each space should have a separate manually switched power exhaust. Some areas can be grouped together on one exhaust system, depending on floor plan (e.g., locker room, shower area, toilet area, coach's office, etc.).
    - ✓ Do not use hot water coils in rooftop units, as it presents a freeze hazard.
    - ✓ Do not use gas-fired units where hot water is available.
    - ✓ For cooling special use spaces, use individual evaporative coolers with separate ductwork.

B. CLASSROOM. Refer to appropriate system(s) under square footage categories below.

1. **Cooling:** Central air washer system, central chiller, Variable Refrigerant Volume (VRV), package units, or DX system.
2. **Heating:** Hot water with duct coils or VRV.
3. **Ventilation:** Operable windows plus exhaust fan(s) or ERV.

C. ADMINISTRATION. Always at high schools and whenever practical at other facilities, provide a system separate from the main building system to accommodate unique occupancy schedules.

1. **Zoning:** Designer is expected to establish at least eight (8) distinct controllable zones in Administrative areas.
2. **Cooling:** Single air washer located in a mechanical room with thermostatically controlled zone control, chilled water with staged compressors and controls, or Variable Refrigerant Volume (VRV) system.
3. **Heating:** Gas furnace, air handling unit with hot water duct coils, or VRV.
4. **Ventilation:** Air handling unit.

D. LIBRARY / MEDIA CENTER

1. **Zoning:** Provide separate unit for Workroom, if anticipated heat loads warrant.
2. **Cooling:** Refrigerated air or a different system decided at the conceptual design meeting. System choice must address humidity control.
3. **Heating:** Furnace (inside) or air handling unit with hot water duct coils
4. **Ventilation:** Air handler associated with heating and cooling equipment. Exhaust fans with operable windows.

E. COMMONS AREA

1. **Cooling:** Centrally located air washer; chilled water if building has chilled water system.
2. **Heating:** Use main building heating system; hot water system if building has boiler.
3. **Ventilation:** Use air handling unit that supplies heating and cooling above.

F. CAFETERIA / KITCHEN

1. **Zoning:** Provide separate cooling unit for kitchen.
2. **Cooling:** Air washer in kitchen. For cafeteria, consider the same system as the other buildings on campus.
3. **Heating:** Hot water or gas unit heater in kitchen. For cafeteria, consider the same system as the other buildings on campus.
4. **Ventilation:** Kitchen should be negatively pressurized with respect to cafeteria. Provide means of make-up air for kitchen hood. Interlock hood and make-up air source. For cafeteria, consider the same system as the other buildings on campus. Provide detailed Sequence or Operation for interaction/control of kitchen/cafeteria HVAC components.

G. HIGH SCHOOL GYMNASIUM

1. **Cooling:** Central air washer.
2. **Heating:** Hot water system if building has boiler. If not, use rooftop furnace. DO NOT run hot water piping above wood floor.
3. **Ventilation:** Air handling unit that supplies heating and cooling above.

H. AUXILIARY OR MIDDLE SCHOOL GYMNASIUM

1. **Cooling:** Central air washer.
2. **Heating:** Hot water system or gas-fired furnace (located on mezzanine).
3. **Ventilation:** Air handling unit that supplies heating and cooling above.

I. MINI-GYM

1. **Cooling:** Air washer, central unit in a mechanical room, or DX package unit with exterior door sensor cut off switch and demand controlled ventilation.
2. **Heating:** Gas furnace or boiler.
3. **Ventilation:** Exhaust/relief fans. Include operable window(s) in coach's office.

J. MECHANICAL / BOILER ROOM

1. **Cooling:** Cooling is generally not required in these spaces.
2. **Heating:** Gas or electric furnace. Do not use HW heat generated in the same room being protected by this furnace, as it presents a freeze hazard if the boiler goes down.
3. **Ventilation:** Exhaust fan(s).

K. IDF/MDF (IT ROOM) OR TELECOM ROOM

1. **Cooling/Heating:** Individual DX Split System not tied to central heating/cooling equipment.
2. **Ventilation:** Exhaust fan, sized for highest exchange rate during unoccupied periods in auditorium.

L. PERFORMING ARTS CENTER (PAC). Provide a system separate from the one serving the main building, in order to accommodate special scheduling needs of PACs.

Provide separate systems for the following five (5) functional areas:

a. Main Auditorium
   - **Cooling:** Package unit with economizer, minimum two-stage. Always separate from other zones.
   - **Heating:** Package unit, or package unit used as air handler with hot water from main system.
   - **Ventilation:** Package unit.

b. Backstage
   - **Cooling/Heating/Ventilation:** Defer to overall system type used at the school. Or, if PAC is free-standing, refer to appropriate system(s) under square footage categories below.

c. Classroom and Office
   - **Zoning:** Use the same unit for Classroom and Office in PAC.
   - **Cooling/Heating/Ventilation:** Defer to overall system type used at the school. Or, if PAC is free-standing, refer to appropriate system(s) under square footage categories below.

d. Stage
   - **Cooling:** Package unit.
   - **Heating:** Package unit or package unit used as air handler with hot water from main system.

- **Ventilation:** Package unit.

e. Sound/Control Room
   - **Cooling/Heating:** Individual DX Split System not tied to auditorium heating/cooling equipment.
   - **Ventilation:** Exhaust fan, sized for highest exchange rate during unoccupied periods in auditorium.

M. PORTABLE BUILDING

1. **Cooling:** New portables use an end-mounted combination DX/furnace unit. For portable building renovations: evaluated case-by-case, based on existing cooling system.
2. **Heating:** Interior gas furnace.

N. SMALL ADDITION – LESS THAN 5,000 GROSS SQUARE FEET

A typical building in this category is classroom, kindergarten, or special needs addition.

1. **Cooling:** Central air washer in mechanical room or on ground outside, separate split systems (one per classroom), or Variable Refrigerant Volume (VRV) system.
2. **Heating:** Gas furnace, split system, or VRV.
3. **Ventilation:** Exhaust fans with operable windows or ERV.

O. MEDIUM ADDITION – BETWEEN 5,000 AND 15,000 GROSS SQUARE FEET

1. **Cooling:** Central air washer system, central chiller, Variable Refrigerant Volume (VRV), package units, or DX system.
2. **Heating:** Hot water with duct coils or VRV.
3. **Ventilation:** Exhaust fans with operable windows or ERV.

P. LARGE ADDITION – GREATER THAN 15,000 GROSS SQUARE FEET

1. **Cooling:** Chilled water, ground source system, Variable Refrigerant Volume (VRV) or hybrid system.
2. **Heating:** Hot water with duct coils (or campus primary heating system).
3. **Ventilation:** Exhaust fans with operable windows. For heat pump systems, provide a separate ventilation system, and consider including heat recovery with it (ERV).

APPENDIX B. SIGN-OFFS AT CRITICAL PROJECT DESIGN MILESTONES

PRE-DESIGN CONCEPTUAL MEETING (OK to proceed to 50% CD) DATE_____

_____ Design Architect
_____ Design Mechanical Engineer
_____ M&O Mechanical Representative
_____ APS Staff Architect
_____ APS HVAC Project Manager

50% REVIEW MEETING (OK to proceed to 95% CD) DATE_____

_____ Design Architect
_____ Design Mechanical Engineer
_____ M&O Mechanical Representative
_____ APS Staff Architect
_____ APS HVAC Project Manager

95% REVIEW MEETING (OK to proceed to Final Bid Documents) DATE_____

_____ Design Architect
_____ Design Mechanical Engineer
_____ M&O Mechanical Representative
_____ APS Staff Architect
_____ APS HVAC Project Manager

PRE-CONSTRUCTION CONFERENCE (OK to proceed to Construction) DATE_____

_____ Design Architect
_____ Design Mechanical Engineer
_____ M&O Mechanical Representative
_____ APS Staff Architect
_____ APS HVAC Project Manager

APPENDIX C. CONTRACTOR REQUEST FOR TEST AND BALANCE

I, the undersigned Contractor, certify that the HVAC systems in this project are ready for Testing and Balancing as of the date indicated below, and I hereby request that T&B services be provided. “Ready” means that all HVAC equipment is installed and operational per the contract documents, including power/gas/water connections and installation/programming of controls.

I agree to provide – at my expense – personnel to accompany the Test and Balance firm in order to locate, identify, operate, adjust and service HVAC equipment as necessary. The name and phone number of the responsible party with whom to coordinate this equipment access is listed below.

If the HVAC systems are found to not be “ready” at the time the T&B firm is mobilized with this request form, I agree to pay any costs incurred for attempted Test and Balance services on this project until such time as the HVAC systems are made fully ready.

Date: _____

Location: _____

General Contractor Company: _____

Mechanical Subcontractor Company: _____

Responsible Party to Accompany T&B: _____

Responsible Party Phone Number: _____

Signature of Requester: _____

Requester’s Name (printed): _____

Notes: _____

_____