230000 – HVAC

I. DESIGN

A. A/E Coordination

1. Per Fairfax County 2021 Operational Energy Strategy, for new construction and major renovations, design Net-Zero Energy (NZE) structures to incorporate best practice energy-efficient design, using electricity-based space and water heating.

2. For design of Clinical Facilities with Negative Pressure Rooms refer to Appendix A.

3. For design of Evidence or Forensic Rooms in Law Enforcement or Public Safety Facilities refer to Police Station Design Manual.

4. Mechanical Room General Design Criteria:
   a. Mechanical equipment shall be located on the ground floor and provided with double doors, or doors sized to be able to remove the largest piece of mechanical equipment. When conditions require roof mounted mechanical equipment, units shall be mounted on 18" high curbs and never placed directly on roof. Additional clear height is required for larger equipment and shall be in accordance with the recommendations of the American Roofing Contractors Associations latest reference manual. Fans ventilating kitchen hoods: At least 24 inches (610 mm), or more if required to place discharge of fan 40 inches (1016 mm) above roof surface. In addition, all roof mounted mechanical equipment required to be screened (refer to Division 010000) shall be designed to allow required access and airflow.

   b. Paved access for maintenance vehicles shall be as close as possible to the mechanical room access.

   c. Rooms shall be of sufficient size for all required clearances and all proposed piping and duct layouts and must accommodate replacement of each piece of equipment without removing any other piece of equipment or any part of the building Sufficient space shall be shown on the plans and designated in the room by striping, for the replacement of the largest piece of equipment in the room to allow assembly and testing of the replacement piece of equipment prior to switch over and removal of the piece of equipment being replaced.

   d. Travel paths shall be clearly indicated which present no to minimal obstacles for equipment replacement and servicing.

e. Where it is not practical to design equipment rooms on the ground floor level, the room design, and if necessary adjacent spaces, shall incorporate clearly defined provisions for equipment replacement and servicing. Necessary adjacent spaces shall not include spaces critical to the operation of the building function.

f. Mechanical rooms that serve as air plenums shall be designed according to prevailing code, shall be void of combustible materials, and shall not permit untreated outside air delivery into the room.

g. Mechanical room floors shall be painted or otherwise treated with an industrial grade, slip resistant, water-proof type coating of a light gray color and curbs and equipment pads painted/trimmed out in yellow color slip resistant, industrial grade treatment.

h. Rooms shall have proper drainage depending on the type of equipment housed.

i. Where there is equipment to be cleaned, etc., there shall be a ¾" hose bib with backflow protection.

j. Noise attenuation measures shall be incorporated into the design of the mechanical room(s). Provide an NC of 35 for office spaces. A lower value of NC-30 is appropriate for classrooms and sleeping rooms.

Noise Criterion	Octave Band Center Frequency (Hz)							
	63	125	250	500	1000	2000	4000	8000
	Sound Pressure Levels (dB)							
NC-30	57	48	41	35	31	29	28	27
NC-35	60	52	45	40	36	34	33	32
NC-40	64	56	50	45	41	39	38	37

k. Equipment rooms must be weatherproofed and have secured locking hardware.

l. A/E must clearly show HVAC equipment and screening located on the roof and/or on the site on all renderings and elevations to show accurate representation on the overall design.

5. Roof Guards:
   a. Refer to the Mechanical Code for requirements to provide guardrails at the edge of roof areas adjacent to rooftop equipment that require maintenance access at the roof level.

b. If guard rails are unavoidable, the A/E is to indicate and specify railing that is compatible with the building's structure and aesthetics.

6. Roof Access to HVAC Equipment:

   a. All roof levels shall be accessible for maintenance – no exceptions. Provide OSHA approved safety tie-off/anchor points on all roofs without code minimum railing /parapet wall.

   b. Roof walkways must be provided in all expected travel areas and around roof mounted equipment.

   c. Provide platforms around cooling towers and other HVAC units elevated above roof surface. Provide permanent ladders to access platforms.

   d. Ladders must be provided to all roof levels and interior ladders are preferred where practical. Provide a ship's ladder with straight steps (no alternating treads) to the main roof levels.

   e. Refer to Accessibility and Maintainability section (I.E.2) for detailed access criteria.

   f. Kitchen exhaust fans must be provided with proper access in accordance with NFPA 96 8.1.1.3

7. Ceiling Access to HVAC Equipment:
   a. In ceiling areas where HVAC equipment, such as VAV boxes, need to be located, A/E shall provide appropriate ceiling space such that equipment, dampers, valves, etc., can be easily accessed for maintenance. Where access to equipment is required maximum ceiling height shall be 9'-0".

   b. Ceiling access shall be accessed no greater than that required from 8' step ladder. For ceiling spaces only requiring junction boxes, cabling and other miscellaneous items the ceilings can be up to 10'-0".
   If there is nothing (including junction boxes) in the ceiling requiring service/maintenance, ceilings can be higher in special areas but shall be specifically requested to FMD in writing no later than the design development submission and the design must illustrate that access above such higher ceilings is not required. VAV boxes and similar equipment can be located in lower ceiling areas (9'-0"), if need be, to allow for limited higher ceiling areas, but specific parameters for this accommodation must be detailed on the drawings.

c. For inaccessible ceilings, the A/E shall indicate and specify compatible access panels of sufficient size (20" x 20" minimum) that have been coordinated with the Engineering layout and requirements.

d. It is permissible to specify cable operated volume dampers for individual air devices where access panels may be less desirable.

e. Equipment shall be a minimum of 3'- 6" from a wall.
NEC requires 42" to grounded sources from live electrical components.
NEC defines walls, ceiling grids, sprinkler piping etc. as grounded source.

f. Where built-in systems (furniture and/or shelving) are planned and basic layout can be determined, VAV boxes/AC equipment shall be located above the walkways and not directly over furnishings that cannot be easily moved.

8. Return Air Paths:
   a. Buildings with tall, vaulted attic spaces require close coordination between Architect and Engineer.

   b. Use of attic space as an air plenum is not permissible.

   c. Design and specify ducted supply/return systems where ductwork must traverse through an attic space or within vaulted elements. Ducts shall be insulated as required by the Energy Code for exterior ductwork in all unconditioned spaces.

   d. For "flat" ceiling applications, plenum returns are preferred unless there are compelling reasons for ducting back to the air mover(s). Extreme caution must be taken when creating a return air plenum in an existing building as all materials within the plenum must be confirmed by the design team in advance of issuance of the design documents to be safe and plenum rated as required by code. This requires observation and testing, and complete removal of materials not allowed per code for plenum use. Do not make it the responsibility of the contractor to determine the suitability of the above ceiling area to meet the code requirements related to return air plenum.

   e. Where ceiling return air plenums are utilized, coordinate the design intent and use of return air light fixtures and other architectural return air measures with the BDCD Project Manager. Ensure replacement light fixtures are equipped with equal return air capacity of the fixtures being replaced (this is particularly important with LED fixtures which are much more compact and do not always have as much room in the housing for return air openings). Add appropriate sizes and quantities of return air grilles if replacement light fixtures reduce the net opening for return air flow.

f. The A/E shall coordinate all full height walls, obstructions, and prevailing code requirements such that the return air plenum is viable. Provide transfer ducts or openings where necessary with appropriate fire dampers and/or smoke dampers. If the full height wall/partition is sound attenuated, then "Z" or "U" type sound-lined transfer air ducts as appropriate shall be provided.

9. Cooling tower emergency drain down and water treatment drains shall drain to sanitary sewer and not to storm drain.

B. Submission Requirements

1. The A/E shall send building load letters and plans to the electric and gas companies with copy to BDCD Project Manager at appropriate times during design.

2. A/E shall submit cut sheets for the major equipment components which form the basis for design, at the Design Development phase. The cut sheets must identify equipment dimensions. The construction drawings shall include detailed part plans and section views (1/4" = 1' or larger scale) dimensioned to show the major equipment, duct work, and piping located within the mechanical spaces. Detailed plans must reflect that adequate space and clearances are provided for inspection, maintenance and replacement access, and all major mechanical equipment. These clearances, along with those required by code, NEC etc., shall be indicated by light dashed lines on all plans for all equipment.

3. A/E shall use eQuest, Trane Trace, DOE-2 or other pre-approved equivalent building simulation programs to conduct energy modeling to aid in preparing a life-cycle cost analysis for mechanical system selection, optimized building orientation, architectural shading methods, building envelope characteristics, and day lighting options during the Schematic/ Design Development phases. The BDCD Project Manager and A/E shall meet with the Using Agency to determine actual building operations plan and schedule and what options shall be evaluated and to review costs/benefits of various design alternatives. The A/E shall provide the Owner an annual energy budget model based upon the computer simulation. Report shall include the program outputs and list of input assumptions.

4. A/E shall conduct a Life Cycle Cost Analysis of alternate HVAC systems at Schematic Design Phase. Submit brief description of proposed system options for County approval prior to performing LCCA. Owner's final selection shall be subject to County approval, based on considerations such as reliability, energy consumption, maintenance cost, etc. For maintenance costs, A/E shall request to BDCD Project Manager for FMD to complete applicable equipment maintenance

costs in Exhibit 230000-A. Where specific costs are unavailable, RS Means cost data shall be used. Life cycle cost analysis shall consider installation costs and energy cost reductions associated with renewable energy systems for each mechanical system option. Final system selection must achieve County energy goals which may not be the option with the lowest life cycle cost. The following parameters shall be used for evaluating life-cycle cost analysis.

a. 5% discount factor for capital costs.

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b. Current utility rates should be confirmed with BDCD Project Manager (OEEC provides) and the escalation rate should be discussed at the time of the study as they can vary widely and have a big impact on life cycle analysis. 3% escalation rate has been used recently.

c. Study period shall be for 30 years. Use the following for life cycles for replacement for the below listed equipment:

- Packaged roof top equipment – 15 years
- Boilers – 15 years for condensing
- DX equipment – 15 years.
- Air handling units with water coils – 17 years.
- Control Systems – 10 years
- Piping – 30 years
- Ductwork - 30 years

d. All life cycle costs shall be in "Present Worth" format.

5. The A/E shall confirm design conditions early in the project and submit all heating and cooling load calculations for review by the end of Design Development. Revised load calculations shall be resubmitted to the Owner as required to reflect revised loads based on Owner & HVAC Peer Reviewer comments.

6. Provide a points list and sequence of operations for each project.

   a. Within the Sequence of Operations, the A/E shall clearly separate the sequences between those performed by the Energy Management System and those performed by packaged equipment controllers.

   b. Where there is communication between the Building Automation System (BAS) and packaged equipment the hard wire points shall be specified and a separate list of points provided for all BACnet mapped points.

   c. Sequences shall be provided at the DD phase.

7. Show true North arrow on all Mechanical plan sheets for all submissions. Provide graphic scales on all sheets including scaled drawings.

8. For building footprints too large to fit on a single plan sheet, provide a key plan on all plan sheets. Provide a key plan on any sheet where partial plans are utilized and indicate in a light hatch pattern for the area(s) of work. Where feasible, maintain same building orientation for all plans and include column lines even on key plans, as applicable.

9. Provide outside air calculations to the BDCD Project Manager by no later than the Design Development review. Calculations to be performed in accordance with the Virginia Mechanical Code, ASHRAE 62.1 and ASRAE 90.1. A-E shall verify any additional requirements from LEED. Fairfax County LDS provides a spreadsheet for Mechanical Ventilation which shall be submitted with each set of permit application drawings.

10. Equipment schedules for major equipment shall contain capacities required by load calculations and capacities of proposed equipment. This applies for heating and cooling BTUH's and GPM. This will allow the county to more easily verify that equipment has not been oversized (requirement of IECC) and facilitate future equipment replacements based on actual required capacities instead of what was installed.

C. Main Fuel Tank, Day Tank & Piping for Diesel Generators (Applicable only when natural gas fired generator is not selected)

1. Engineer shall evaluate if a day tank is required based on the generator mounted fuel pump (available Net Positive Suction Head). A day tank is only to be supplied if the main fuel tank is not located immediately adjacent to the generator and there is not sufficient head.

2. Main fuel tank or day tank shall not be located or mounted on the same frame as the emergency generator. Packaged units with main fuel tanks, sub-base fuel tanks, belly tanks, on-board tanks or rail mounted tanks are not acceptable. The Day Tank (when required) shall be mounted on a slab on grade, independent of the emergency generator. Simplex Day and Pryco Day Tanks are reference suppliers of the day tank.

3. The main fuel tank can either be an Underground Storage Tank (UST) or an Aboveground Storage Tank (AST) mounted on a slab independent of the generator in accordance with UL listing. An AST is preferred over an UST. The AST shall be securely bolted to the slab and properly grounded. AST's, UST's,

and Day Tanks (when provided) shall be double wall. AST and Day Tanks shall comply with UL-2085.

4. Above ground Fuel Storage Tanks shall be located at or near grade and shall be easily accessible for ease of maintenance, repair or replacement. There shall be no obstacles to accessing the generator with dollies and 55-gallon drums. Underground tanks shall be located away from structures to not interfere with the structure during replacement.

5. The fuel system shall be sized to support the generator for a period of 96 hours at full load capacity. The main tank shall be sized to be full at 3/4 capacity. When serving dual systems (such as heating equipment), the generator fuel quantity for required Life Safety loads must be clearly identified on the exterior of the tank.

6. The A/E shall include in the specifications that the contractor is required to provide a 4-hour step load bank test and that the contractor is responsible for providing a minimum of half tank (Main Tank) of fuel at the time of generator startup.

7. All fuel piping and fuel tank designs should be approved by the system manufacturer of the generator set.

8. Fuel oil return piping must be provided from the generator to the the Main Fuel Tank or to the Day Tank (if provided) and from the Day Tank to the Main Fuel tank.

9. A remote fill line shall be supplied on the Main Fuel Tank with an overfill protection valve in the tank. A spill containment box shall be supplied. Morrison Brothers and Fairfield Industries are reference suppliers.

10. Provide level indication on the tank.

11. Fuel system piping shall be black pipe and painted with Corrosion-resistant black paint. Copper piping is not to be used for fuel supply or return.

12. Fuel return line piping must be properly sized as per manufacturer's recommendations. Generally, the return line will be equal to or one size larger than the supply line.

13. The fuel piping and the electrical conduit between the generator and the Day Tank and fuel piping between the Day Tank and the Main Fuel Storage Tank shall be routed to allow easy access around these items without conflict.

14. In the event the supply line fuel piping is elevated, provide an anti-siphon valve on top of the tank. An anti-siphon valve will prevent the free flow of oil from the storage tank through a break in the fuel piping.

15. A foot valve is to be installed on the suction line drop tube to maintain a prime if the fuel level can drop below the elevation of the pump suction. The use of a check valve close to the pump set is an alternative to the foot valve.

16. Operations will need to treat the diesel in the tank. Provide connections to circulate the diesel (the fill line can be used to return the fuel).

17. When a Day Tank is not required, provide a hand pump on the supply line to the return line near the generator to prime the supply line from the tank.

18. Day Tanks (when required):

    a. Day tank shall be sized for a minimum of 4 hours of continuous operation of the generator at full load.

    b. A duplex fuel pump system shall be provided to fill the Day Tank from the Main Fuel Tank. The pump shall be capable of filling the day tank at a minimum rate of 4 times the generator fuel usage rate at full load. This pump system may be supplied as an integral part of Day Tank.

    c. A hand pump shall be specified to pump from the main tank to the day tank as a backup to the electric pumps.

    d. A duplex fuel pump shall be provided with a return line from the Day Tank to the Main Fuel Tank. The function is to drain the day tank for maintenance. This pump may be supplied as an integral part of Day Tank.

    e. The day tank piping shall be provided with unions so that the Day Tank may be isolated and replaced without redoing the piping. The return line shall have no valves, as required by code.

19. Main fuel tank, Day tank and fuel lines shall be installed by a certified contractor in accordance with manufacturer's installation requirements and the requirements of the NFPA, IBC, NEC. The main fuel tank and Day Tank may be painted with the same color as that of the generator.

20. Provide fuel leak detection system. It shall be located next to the Remote Generator Annunciator Panel (RGAP) or in another location as determined by specific needs of the facility. The International Fire Code (IFC) Paragraph 3404.2.7.10 requires there be immediate reporting to the fire department, code official and other AHJ's. Underground double walled tanks are required to have an approved method of leak detection per IFC 3404.2.11.5.2.

21. AE shall include in the specifications that training for the leak detection system (Veeder Root) (for the tanks supplying the emergency generator only) is to be included in the training/demonstration specified under specification 017900 Equipment Demonstration / Instruction when FMD is present.

1 22. The leak detection system (Veeder Root) monitoring the tank(s) supplying the emergency generator only (not vehicle fueling systems) shall be connected to the BAS displaying only that the system is in alarm.

D. Heating, Ventilation and Air Conditioning System Selection (Refer to Energy Efficiency section I.E.1 for additional information)

1. The A/E shall coordinate with DPWES and FMD prior to selection of the mechanical system.

2. Where building size and use (generally greater than 100,000 sf and of a Government Center or other major function) require complex multi-zone comfort systems, central plant configurations are preferred. In such cases, the basis of the heating and cooling system shall incorporate the following:

   a. Centrifugal chillers above 120 tons and scroll or screw type chillers below 120 tons supplying chilled water, with VAV air handling units are strongly preferred.

   b. A four-pipe system is preferred.

1 c. Heat pump chillers or other electric powered heat source supplying hot water to perimeter baseboard or VAV terminal mounted heaters and air handlers (use hot water coils for morning warm-up) should be used for the heating system. For VAV systems, the decision to use terminal unit electric reheat will be made on a case by case basis.

1 d. If the County approves an exception to use natural gas heating in lieu of all electric heat source, the use of condensing boilers is preferred for new installations. For retrofits, the use of condensing vs. non-condensing boilers will be made on a case by case basis. Multiple boilers should be incorporated for redundancy and shall use cascading controls between the boilers. A minimum of two boilers shall be used and each sized such that when a boiler is out of service, remaining capacity shall produce a minimum of 75% of the total heating load.

   e. Temperature controls shall be Direct Digital Control (DDC).

   f. Chillers should be located in an enclosed mechanical room. Avoid locating chilled water units above the roof line. Specify glycol and for piping to enter the unit directly below the unit, when no other acceptable options are available. Provide refrigerant monitoring, detection, alarms, and ventilation as required to meet Mechanical Code requirements and ASHRAE standards. Smaller chillers that use scroll compressors can be packaged units located outdoors but must be

designed to include glycol to prevent freeze-ups and/or the need to drain/fill the system seasonally. Glycol feeders shall be included for such systems instead of make-up water connections. Heat tracing of the exterior piping shall be included, and the heat tracing shall be monitored through the BAS. CFC and HCFC refrigerants are not to be used in mechanical equipment on County projects. The County goal is to achieve the LEED Enhanced Refrigerant Management Credit, and the use of HFC refrigerants is strongly encouraged.

g. AHUs located in mechanical rooms are the owner's preference to achieve extended AHU life cycle. Mechanical rooms shall be sized such that replacement units can be assembled adjacent to the existing operating unit and readily ducted into the existing duct system to allow minimal down times for systems replacements. These added costs shall be accounted for in the Life Cycle Cost Analysis (LCCA).

h. Avoid designs that require heating plant operation in the summer, which are not typically run during the summer months.

i. Avoid designs that require chiller operation during the winter. Any space that requires 24/7 cooling should use a DX system. County chillers typically, are not run during the winter months.

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3. In small, less complex buildings, VAV or constant volume roof top units with fully modulating natural gas heat and DX cooling are preferred as they minimize floor space required for mechanical rooms. *(By exception only, requires PM approval)*

4. Hot water systems designed to be outside the building envelope are not permitted.

5. Where commercially available, DX units shall have at least one inverter driven fully variable compressor to ensure that humidity is controlled in low load, high OA humidity conditions and to avoid excessive cycling of compressor(s).

6. VAV systems are preferred for indoor comfort control (humidity). Variable volume and temperature (VVT) systems are not permitted. Constant and variable air volume systems shall utilize modulating hot gas reheat for humidity control. In single zone spaces a space humidity sensor may be used. In multiple zones, a return humidity control system shall be integral with the unit controls.

   a. Ensure that discharge temperature (DAT) reset is coordinated with the hot gas reheat (HGRH) so that the reset is lowered to the point required to maintain humidity levels and minimize any heating required at the VAV boxes; i.e. it shall not automatically set back to the lowest DAT when dehumidification mode is enabled if a higher DAT will dehumidify

sufficiently. This will prevent/at least minimize using new energy to reheat any zones that become overcooled.

b. For conference rooms and other high cooling load spaces, the VAV box(s) serving these spaces and their air distribution system shall be sized for a DAT reset condition of 62 degrees F. vs. the typical peak cooling day DAT (+/- 55 degrees F).
c. Where constant volume systems are deemed appropriate, design and implementation of a "single zone VAV" approach is preferred.

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~~7. Where natural gas is not available, packaged air to air heat pump units with 100% electric back up are acceptable.~~

8. If the motor operated damper is in series with a gravity damper, it can be in two positions (open/close). Packaged equipment shall only be specified with a motor operated damper or a barometric backdraft damper, not both.

10. Supply air shall be directed away from thermostat/sensors. Thermostat/sensor locations must be shown on the drawings. Before locating, coordinate thermostat/sensor locations with loose and fixed furniture plans to avoid conflicts and poor sensing capabilities. For exterior zones, avoid locating thermostat/sensor too far from the exterior wall.

11. Interlock exhaust fans with associated AHU to assure they are included in controls package and don't run continuously. This will also save control points.

12. Provide telecom and elevator machine rooms with independent split system units where appropriate to the facility's operations. The unit shall be wall mounted, located above the door to maximize wall space available for the intended use of the room.

13. An evaluation of the building criticality shall be completed to determine required redundancy of the heating system. Criteria such as the need for continual occupancy and risk of pipes freezing in event of an equipment failure shall be considered. The system shall be designed to address these concerns.

E. Heating, Ventilation and Air Conditioning Design Criteria

Optimal design will emphasize energy efficiency, accessibility, and maintainability.

1. Energy Efficiency

a. The HVAC system shall meet all building code requirements for heating and cooling loads and shall be designed to meet project target for LEED. The use of VRF or equivalent type systems may not be considered. Refer to section

010000 General Design Requirements. Building envelope components shall be designed for energy efficiency in compliance with ASHRAE, IMC, and other applicable building and energy codes. Special attention shall be paid to the International Energy Conservation Code requirements for equipment sizing criteria.

b. The HVAC designer shall pay close attention to actual building occupant load patterns and anticipated actual building loads to ensure that the system efficiently meets these requirements. Fairfax County has had problems with systems that meet the code requirements but do not effectively heat, cool or dehumidify the building in actual loading conditions. A/E shall:

   i. Use all code approved methods to reduce occupant loads to match actual conditions and to reduce fresh air quantities to lowest possible levels

   ii. In buildings with fixed shelving and stacks, such as libraries, such shelving and stack floor areas, must be deducted from the net square foot calculations.

   iii. Use occupant averaging, room volume, transfer air techniques or other approved code methods to reduce fresh air requirements. This is mandatory for all meeting rooms, conference rooms, or other assembly areas. Use LDS occupancy load program to calculate outside air quantity reductions for variable and intermittent occupancies where possible. Coordinate with the BDCD Project Manager or contact Building Plan Review in County's Land Development Services to obtain the most current copy.

   iv. In renovation projects, ensure the remaining portions of any mechanical systems that are to be reused are coordinated with the new/planned use of the building. This shall include a detailed evaluation of the exhaust systems to ensure they are not oversized for the new/planned use. Otherwise oversized exhaust systems will often dictate an increase in the amount of fresh air required (buildings overall must be designed to be positive) and drastically affect energy use and potentially humidity levels.

   v. Size cooling equipment to match actual building occupant load conditions.

   vi. HVAC loads shall be based on actual lighting loads wherever possible. If actual lighting loads are not available at the time HVAC loads are calculated, lighting load shall be estimated by maximum lighting power density permitted by space type according to IECC. Do not use 2 W/SF as standard lighting load for all spaces.

   vii. Central plant equipment shall be sized for the building peak, not the sum of the zone peaks.

viii. If packaged DX equipment is used, they shall have multiple/variable cooling and heating stages to meet part load conditions for proper humidity control. Design CFM range for DX equipment that serves occupied spaces shall be in the range of 340-360 CFM/Ton. Design CFM/ton for equipment that primarily serves equipment such as server rooms shall be at the equipment manufacturer's rate to adhere to the cataloged cooling capacity.

ix. HVAC systems shall be designed to limit indoor humidity levels in the cooling mode to an average 50% with an upper limit maximum of 55% per OSHA requirements and recommendations, as levels above 60% promote and support mold growth.

x. Variable speed compressors, hot gas reheat, dedicated outside air units and other active humidity control systems shall be used. New energy reheat shall not be used.

c. Provide HVAC zones for different functional areas and to allow for night use in appropriate areas.

i. Where design loads for a space may vary significantly from actual loads, the system shall be designed with capacity reduction capability.

ii. CO_2 sensors shall be provided to control amount of fresh outside air intake.

Effort should be made to properly design the outside air intake boundaries so that the equipment is not oversized. Outside air (OA) quantity when CO2 is below setpoint shall be half the calculated code required ventilation. When CO2 exceeds setpoint, OA shall increase to the calculated code required ventilation rate. If upper and lower limits for OA intake are included, it will allow the TAB contractor to properly setup the outdoor air control on AJ+HU's and RTU's. The OA lower limit needs to be calculated based on the amount of exhaust to always keep the building positive. The maximum OA should be the calculated code minimum as it is typically more as it based on the calculated occupancy rather than the actual occupancy.

d. Systems designed shall maintain the following temperature settings:

Type of Area	**Summer Range Occupied [1,2]**	**Summer Range Unoccupied [1,2]**	**Winter Range Occupied[1,5,2]**
General Office	72-75	85	72 - 75

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Type of Area	Summer Range Occupied [1,2]	Summer Range Unoccupied [1,2]	Winter Range Occupied [1,5,2]
Sleeping Areas (Fire Stations)	69-74		69-74
Corridors	75		72
Building Lobbies[6]	75		72
Toilets	75		73
Locker Rooms	73		74
Electrical Closets	78		55
Mech. Spaces	95 [3]		55
Elec. Switchgear	95 [3]		55
Elevator Mach. Room[6]	78		55
Emerg. Gen. Room	95[3,4]	95[3,4]	55
Transformer Vaults	95 [3]		
Stairwells	(none)		65
Comm./Tel. Frame Room	75	45	72
Storage Room	74		65
Conference Room[7]	72-75		72-75
Auditorium[6]	72-75		72-75
Kitchen[6]	72-75		72-75
Dining[6]	74		76
Cafeteria[6]	74		76
Courtrooms	72-75		72-75
Data Center[6, 2]	65-72		65-72
Data/Security Equipment Closet[2]	77		77
Specialty Rooms & Labs[6,8]	TBD[8]	TBD[8]	TBD[8]
Apparatus Bays	Heat Exhaust		56

1. Temperatures are degrees Fahrenheit and shall be adjustable within the provided range.
2. Maximum permissible relative humidity is 50 percent in conditioned areas. Data Centers and data closets adjustable range shall be 40%-45%.
3. Maximum temperature. Space to be mechanically cooled if necessary.
4. Room must not exceed temperature with generator running.
5. Minimum temperature in a building and all associated spaces to include mechanical must be 55 °F even when unoccupied.
6. System shall be designed for process cooling. Cooling system shall be a dedicated independent system.
7. Provide independent temperature control.
8. To be determined by end user and certification/licensing requirements

e. Outside Air Design Parameters (temperatures) for General Building Areas.

Winter	13ºF
Summer	95/ 75ºF

(Verify design temperatures with ASHRAE Standards.)

f. The building thermal envelope shall be maximized as these items are static and the added thermal performance does not add maintenance and directly saves energy no matter the efficiency of the HVAC system. In any case, the minimum values shall be per the Energy Code or as listed below, whichever is more stringent:

Window U-Factor Metal Frame	0.50 Max
Window U-Factor Nonmetal Frame	0.40 Max
Window Solar Heat Gain Factor	0.40 Max
Mass Wall U Factor	0.104 Max (R9.5 c.i.)
Steel-Framed U Value	0.064 Max (R-13 + R-7.5 c.i.)
Metal Building	0.084 (R-19)
Soffit/Floors U-Factor	0.10 Max
Roof Insulation entirely above Deck	0.048 (R-20 c.i.)
Roof Metal Building	0.055 (R-13 + R-13)
Roof Attic and Other	0.027

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g. Warehouses, garages and Fire Station Apparatus Bays should be provided with ~~infrared tube~~ in slab radiant heating systems (where feasible) and should not be air-conditioned. For retrofit projects or other exceptions approved by the County, gas infrared heat systems which have more than five burners shall be "Co-Ray-Vac" Class I serpentine infrared system manufactured by Roberts Gordon or approved equal. Infrared heat systems with less than five burners can be specified as a Class II, open to several manufacturers. Whenever possible, eliminate or reduce the use of make-up air heaters. Use single bulb temperature sensors (Accustat) set at 65 degrees in lieu of factory controls. Bring in un-tempered air at the ceiling level, with the infrared systems sized for the additional load. Exhaust systems shall be automatically controlled by exhaust gas sensors. For maintenance garages, provide ceiling mounted commercial grade propeller fans for summer ventilation. For all bay doors provide BAS interlock to shutdown conditioning system in bay area(s) when a bay door is open and to re-energize heat when the space is in danger of freezing if doors remain open and initiate BAS or local alarm. Provide local temperature controls with BAS monitoring and override controls.

h. Energy recovery shall be used whenever possible to reduce energy use. The use of air to air heat exchangers should be used when airstreams cannot be mixed, otherwise energy recovery wheels shall be used. Energy recovery devices can be integral to air handling equipment or be separate units to pretreat the outside air. Generally separate energy recovery units are preferred.

i. All air handling units/cooling equipment (including DOAU/energy recovery units) with outdoor air intake greater than 20% of the supply air volume shall be sized to meet both the peak cooling on a 0.4% day and the peak dehumidification on a 0.4% day. Each of these required capacities shall be included on the equipment schedules.

j. All control dampers critical to emergency systems operation shall fail to the position required to allow this system to operate (fail safe operation).

2. Accessibility and Maintainability

a. Planning and coordination are required during design and construction to assure accessibility to new mechanical equipment. The long-term equipment maintenance requirements must be evaluated so that reliable, sustainable, maintainable and replaceable mechanical systems are installed. This will help the systems operate efficiently and safely throughout the life of the building.

b. Design shall provide for adequate access and work space to all HVAC equipment for maintenance, inspections, repairs, cleaning and replacement. Clearances shall be sufficient so that any piece of equipment can be replaced without the removal of any other equipment. Designate an area on the plans needed for laydown of the existing and new rooftop equipment so that the area it is not taken by solar panels or other equipment.

c. Mechanical rooms shall, to the degree possible, be located on the ground level, at an outside wall with maintenance vehicle parking spaces and loading zone immediately adjacent to the mechanical room door. All major HVAC equipment shall be located in the mechanical room(s).

d. Maintenance, repair, and replacement requirements must be carefully considered and evaluated, during the design phase, for all equipment mounted on the roof or located in the attic to assure reasonable and appropriate access.

e. All HVAC equipment located in the ceiling such as VAV boxes shall have unimpeded access from an 8’step ladder and the bottom elevation of the equipment shall be designed to be at 9’- 4” AFF. Maximum ceiling height shall be 9’-0” in areas with equipment above the ceilings.

f. All HVAC equipment shall have accessibility details noted on the mechanical and architectural plans and specifications, including, but not limited to: walk-ways, cat-walks, access doors, maintenance areas, electrical disconnects, electrical control panels, VAV box maintenance areas, equipment coil, filter and belt access locations.

g. The manufacturer's minimum clearance requirements shall be provided. At least 42 inches of clearance is required for maintenance around all mechanical equipment, unless otherwise recommended by the manufacturer, and allowed by NEC.

h. Avoid locating ceiling mounted HVAC equipment over areas that would be adversely affected by daytime service, such as a kitchen or other equipment and furnishing or office cubicles.

i. Air conditioning condensate drain piping shall discharge to a storm drain or directly outdoors by gravity. Liquid combustion byproducts from fuel fired boilers and furnaces shall discharge to an approved location in accordance with the appliance manufacturer's instructions. All condensate piping shall discharge to a location where it will not cause a nuisance. Piping shall be properly anchored. Condensate drains from rooftop equipment shall terminate directly at roof drain and be supported by premanufactured piping supports compatible and suitable with the roofing. Provide drainable P-traps for systems subject to freezing.

j. All HVAC condensate drains shall be equipped with a shunt trip to shut-down the unit off upon detection of water and interlocked to annunciate and alarm at the BAS.

k. Non-curb mechanical equipment shall be supported by platforms with pipe columns with umbrella flashings where applicable. Height of column should be a minimum of 8" above roof membrane. Additional clear height is required for larger equipment and shall be in accordance with the recommendations of the American Roofing Contractors Associations latest reference manual.

l. If roof mounted A/C units are used, provide a power receptacle, an interior stepladder with handrails, steps 12" apart and top step no more than 15" from opening of roof hatch.

F. Heating, Ventilation and Air Conditioning Specifications

1. Boilers (County Approved Exception) - The specifications shall include:

a. Outside Air Reset - For non-condensing units, provide hot water reset based on outside air temperature by the use of a three-way mixing valve.

b. Combustion Efficiency Test - Burner shall be tuned up for maximum performance, including correct nozzle size, flame shape, and air damper adjustment for minimum excess air. Performance shall be verified via written results of an instrumented combustion efficiency test, including test data net stack temperature, percentage CO_2 or O_2 oil smoke spot or percentage CO, and total combustion efficiency percentage.

c. Boiler Water Flow - Consider boiler re-circulation pumps or injector pumps for boilers to maintain water flow. Re-circulation pumps shall maintain minimum flow in the boilers as recommended by boiler manufacturer. The water flow can be a problem where three-way valves are used for outside air reset at warmer OA air temperature when most water is by-passed, and the boilers have very low flow. Systems shall also be designed to avoid thermal shock to boilers at start-up.

2. Where removable printed circuit boards are provided, an extra set shall be furnished including description, manufacturer, and source of supply identified.

3. Provide spare relays for A/C units and identify manufacturer and source of supply (include in Operations and Maintenance Manual).

4. Specify direct drive fans when possible as they are more efficient and require less maintenance/adjusting and replacement of belts.

5. Provide one extra set of belts for each belt driven unit including axial HVAC fans, centrifugal HVAC fans, and/or HVAC power ventilators.

6. In designs where the number of similar sized VFD units exceeds 10 units, provide a spare VFD to minimize spare parts and to obtain parts and service from one source and provide with communication between VFDs similar to Smartlink.

7. Use of lining for ductwork shall be limited and will be determined on a case by case basis and all ductwork lining shall include perforated metal liner. ~~If possible~~, where required for acoustics, use perforated metal liner for inner wall or sound attenuator.

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8. ~~Provide two extra changes for each type filter, 2" pleated are preferred.~~ Install new filters at Substantial Completion ~~in addition to supplying the two spare sets for attic stock~~.

9. Provide proper set of any non-standard test tools/equipment and appropriate training for installed equipment. Avoid specifying non-standard test tools/equipment, as applicable.

10. The temperature control system and the energy management control system shall be provided by one manufacturer.

11. An instructional session shall be held after systems are functional to familiarize Fairfax County staff (FMD) mechanics with the design and construction of the system. Time shall be set up during the warranty period for "shake down" meetings as needed. Total instructional and "shake down" time provided by the design engineer and installing Contractor shall be coordinated with the Owner prior to bidding but shall not be less than six hours. Contractor shall video record all instructional sessions and provide the DVD to the Owner.

12. The specifications shall provide for a full one-year warranty period for all HVAC systems equipment and associated controls, in addition to more extensive standard warranties carried by the specified systems and equipment. Require a minimum 10-year warranty of gas fired heat exchangers. Additional special or extended warranties must be evaluated and approved by the Owner during the design process. Include a separate consolidated list of all warranties including duration, vendor and contact information in the O&M Manual and in the Mechanical room framed under glass.

13. Provide wall mounted control diagrams in all boiler and mechanical rooms. The diagrams shall be framed and covered with Plexiglas or laminated.

14. Provide engraved equipment labels for the newly installed HVAC equipment. Lettering on labels shall be ¾" tall for equipment designation and 1/2" tall for the installation date (mm/dd/yy format), warranty, and contact information. Plastic laminated engraved labels shall be black with white lettering and be permanently affixed in a conspicuous location approved by the BDCD Project Manager. Provide label submittal with full scale drawing(s) of labels for review prior to fabricating/ordering.

15. All valves shall be numbered with brass tags and referenced to operational instructions.

16. Provisions shall be made for metering of heating fuel oil consumption. Provide back flow preventers in fuel lines, as required. Exposed exterior fuel lines must be insulated/heated.

17. Coordinate with DPWES to notify FMD staff when system balancing is scheduled so FMD HVAC mechanics can observe the procedure.

18. Access panels or doors must be provided for any equipment located in all wall or ceiling spaces that may require maintenance, repairs, or modifications.

19. All equipment, smoke detectors, heat detectors, etc., HVAC equipment which are located above a suspended ceiling must be clearly labeled at the appropriate location on the ceiling.

20. CFC and HCFC refrigerants are not to be used in mechanical equipment on County projects. The County goal is to achieve the LEED Enhanced Refrigerant Management Credit. Use of HFC refrigerants is strongly encouraged.

21. In DX units that have multiple compressors, cooling coils shall be intertwined.

22. All motors are to be NEMA Premium efficiency.

23. A minimum of three-foot- six inches (42") clearance is required at electrical elements at VAV boxes, fan coil units, etc. per National Electric Code (NEC.)

24. All ductwork and piping that will gain or lose energy to/from the surrounding atmosphere, or may cause condensation, shall be properly insulated per ASHRAE 90.1 2010 to minimize energy costs and condensation. All duct and pipe insulation joints must be properly sealed. Insulation shall be continuous through hangers, supports, and building construction elements such as walls, floors and ceilings.

    a. Exterior ductwork shall be completely sealed and waterproofed and tapered insulation used on any surface, which shall be installed and shall prevent water from collecting. The entire duct system shall be covered with an approved weatherproof cladding with overlapping seams, on the underside of the duct only.

    b. Specification shall include requirement for the contractor to request a pre close-in inspection and sign-off by Owner-M/E/P consultant for duct and pipe insulation for walls and ceilings.

25. All hydronic piping shall be run in conditioned space to avoid freezing. Where it is unavoidable to run in spaces subject to freezing, thermostatically controlled electric heat tape shall be provided on piping. In cases where emergency generators are specified, the electronic heat tape shall be connected to the emergency generator. All heat tape shall be monitored by the EMCS and an alarm sent when a failure is detected.

26. Provide Aegis grounding rings for all motors controlled by a VFD.

27. Fire dampers shall be type B (out of the air-stream) and are to be dynamic type and shall be mounted in accordance with their UL Listing and per SMACNA.

28. VAV Systems

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~~a. VAV systems are the preferred systems in buildings of any significant size depending on the size and building layout they can either be chilled & hot water central air handlers or gas-fired/DX roof-top units.~~

b. For smaller buildings gas fired single zone RTUs are acceptable.

29. Deleted VRF Systems Specifications

30. For design of Clinical Facilities with Negative Pressure Rooms refer to Appendix A.

31. For design of Evidence or Forensic Rooms in Law Enforcement or Public Safety Facilities refer to Police Station Design Manual.

32. Specifications shall include prohibition of crimped connections and process tubes used for the evacuation and charging of the refrigerant cycle: Assemblies for HVAC cooling system components such as RTU's and modular air handing units charged with refrigerant shall not include process tubes or other direct connections to refrigerant piping closed at the factory or in the field by crimping. The presence of crimped tubes or piping in these systems shall be considered a Contract non-conformance to be corrected by the Contractor without delay and at no cost to the Owner. Correction of this condition by the Owner following a seven (7) day notice period shall not void or shorten any warranty.

G. Building Automation Systems (BAS)

1. In all buildings, a DDC Building Automation System (BAS) shall be installed. Refer to Division 260000 Electrical, Section I.I for additional design requirements of the BAS system.

2. The Building Automation System shall control HVAC operations and conditions, alarm abnormal conditions and index control modes and provide AHU optimized start/stop operations, AHU/RTU fan optimization options, and provide reporting and trend logs. The specific system requirements shall be reviewed with the County during design.

3. The plans and specifications for the mechanical system must include a detailed points list showing all monitor and control points and must also include a sequence of operations for all equipment and systems.

4. The BAS must be capable of performing the following functions:
   The details and requirements of how the BAS should monitor and control equipment including custom program load shedding interface with third-party devices, shall be elaborated in the specifications based on the specific building/system requirements. There are differences between hardwire points and mapping points through BACnet.

   a. Monitor and Alarm Selected Conditions: Temperature; Pressure; Flow; On/Off, Start/Stop Status; Safety Control Status (Fire, Freeze, Smoke); all critical applications.

   b. Initiate Selected Control Sequences: AHU/Chiller/boiler/pump; Start/Stop; Occupied/unoccupied modes; Optimized Equipment Start/Stop operation, unoccupied night set-back/set-up, monitor total building electric usage and provide demand limiting routines as determined by Owner. The A/E should note that if required, the sequence of operations should include keeping the DOAH HW valve open at all outside air temperatures in order to allow the freeze protection pump to run continuously.

5. Metering: Natural Gas shall be metered either through a separate meter or through the utility company's meter and integrate with the building's BAS and FMD's Central Energy Meter System (BuildingLogix – BDX). Where at all possible, tenant utilities should be directly connected to the utility provider. If this is not practical due to installation costs, a utility grade submeter must be installed to allow Fairfax to bill tenants for actual utility consumption and demand. Refer to Guideline 220000 Plumbing for additional information for water metering and 260000 Electrical for electrical metering.

6. BAS Graphic Template Requirements
   a. Graphical User Interface (GUI) Screen Design - The system GUI refers to the browser-based mechanical system flow diagram served by the B-OWS or the B-BC. Provide a single flow diagram populated with dynamic display of all points for each mechanical system. All inputs, outputs, Set Points (SP), and logical mode values are to be displayed at the system GUI. All SPs are to be adjustable at the system GUI. All alarms are to be annunciated at the system GUI and have a color code in table -1. All schedules are to be adjustable at the system GUI.

   b. Graphics shall have tab pages for all rooftop units, exhaust fans, electrical meters, split system, make up air units, fan power VAV boxes, chillers, pumps

and for all control sequences of operation. All graphics shall be approved by FFX County FMD before system is uploaded.

c. Graphics for VAV boxes shall have the CFM setpoints, heating and cooling output, damper position, operating mode, temperature setpoints, and CO2 readings.

d. Graphics for air handlers and rooftop units shall have supply air temperature, outside air temperature, outside air CFM percentage, cooling and heating percentage, damper positions, fan percentage, and duct pressure.

e. Floor graphics shall have 3D mechanical layout, VAV box number as on the mechanical drawings, control address, CO2/NO2 sensor layout, duct static sensor location, room layout and room numbers used in the building.

Table 1 - Alarm Color Codes

Alarm	Color
High	RED
Low	BLUE
Sensor failure	BLACK
Dirty filters	Flash RED
Pump, fan, Etc.	Flash RED

7. System Requirements

a. Operator Interface:

i. Controllers shall communicate using BACnet protocol. Control network backbone shall communicate using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing as specified in ANSI/ASHRAE 135, BACnet Annex J.

ii. Operating system shall meet or exceed the DDC System manufacturer's minimum requirements for their software. Acceptable systems include, but not limited to latest FFX County Windows enterprise SQL Server.

b. System Graphics:

i. The operator interface software shall be graphically accurately based and shall represent the physical layout of the systems equipment, sensors, pipping and floor layouts to include at least one graphic per piece of

equipment or occupied zone, graphics for each chilled water and hot water system, and graphics that summarize conditions on each floor of the building.

ii. Functionality. Graphics shall allow operator to monitor system status, to view a summary of the most important data for each controlled zone or piece of equipment, to use point-and-click navigation between zones or equipment, and to edit set points and other specified parameters.

iii. Animation. Graphics shall be able to animate by displaying different image files for changed object status.

iv. There shall be a tab page for each part of the system and the sequences of operation.

v. Alarm Indication. Indicate areas or equipment in an alarm condition using color or other visual indicator.

vi. Format. Graphics shall be saved in an industry-standard format. Web-based system graphics shall be viewable on browsers compatible with browser standards. Web graphic format shall require no plug-in.

vii. Custom Graphics. Custom graphic files shall be created with the use of a graphics generation package furnished with the system. The graphics generation package shall be a graphically based system that uses the mouse to create and modify graphics that are saved in the same formats as are used for system graphics.

viii. Graphics Library. Furnish a complete library of standard HVAC equipment graphics such as chillers, boilers, air handlers, terminals, fan coils, and unit ventilators. This library also shall include standard symbols for other equipment including fans, pumps, coils, valves, piping, dampers, and ductwork. The library shall be furnished in a file format compatible with the graphics generation package program. A backup of the graphics package must be installed on Fairfax County network.

8. System Applications
   a. System shall provide the following functionality to authorized operators as an integral part of the operator interface or as stand-alone software programs. If furnished as part of the interface, the tool shall be available from web browser interface Automatic System Database Configuration. All third-party devices and software need to be approved by FFX County DIT.

9. BAS Associated Hardware Requirements
    a. The main BAS system controller, IP Patch Panel (12 Port) and the BAS UPS shall be wall mounted in a designated location in the main mechanical room or as otherwise designated on the Contract Documents. The system controller and the BAS UPS shall be mounted in NEMA 3R enclosures. The UPS shall be sized for the required load of the BAS controller, also have status feedback from the UPS and integrated into the BAS to show alarming of UPS and conditions of power.
10. Set-up trending at 15-minute intervals for all BAS points.

H. Commissioning

1. Requirements for the HVAC system commissioning process shall be included in the construction contract. An independent Commissioning Authority may be hired by the Owner through the Architect's contract. ASHRAE Guideline 0, or other industry recognized guidelines for commissioning shall serve as the basis for all HVAC commissioning and the guidelines will be tailored to the specific requirements of the project.

2. The Architect and Mechanical Engineer and Commissioning Authority will perform reviews of the HVAC system design from a commissioning perspective at all review phases of the design process and will cooperate fully with the Owner's Commissioning Authority throughout the design review process as applicable.

3. The contract specifications must clearly spell out the responsibilities of the General Contractor and all appropriate subcontractors relative to commissioning and shall also define the role of the Commissioning Authority.

4. The Architect and Mechanical Engineer shall coordinate and cooperate fully with the Owner's Commissioning Agent and with DPWES representatives throughout the actual HVAC system commissioning process prior and subsequent to, system acceptance. The Architect and Mechanical Engineer shall provide all design and or system information that is requested by the commissioning team members and respond to all comments from the Commissioning Authority from design through system acceptance.

5. The Architect and Mechanical Engineering team shall review the Commissioning Report to confirm that the full scope of the Commissioning scope as required by the Contract Documents has been completed before it is deemed to be "Final".

6. The Architect or BDCD Construction Manager shall include the final commissioning reports and documents provided by the Commissioning Agent in

the Operations and Maintenance Manuals supplied by the Contractor. This shall include the final Testing and Balancing Report for the air and water of the entire HVAC system , and the final control drawings and sequences.

II. PRODUCTS

A. Mechanical Equipment Preferences

1. Below are listed preferred equipment brands for which supply of repair parts exist (specifications shall include at least three acceptable equipment options for competitive bidding, unless a limited source procurement is approved in advance by the owner):

   a. Chillers: Trane, Airstack by Multistack (air cooled) or Carrier (coordinate with the Owner for the most recent updates) (No Equals or Substitutions) Provide modular chillers with factory accessories to allow individual modules to be isolated for servicing and cleaning, both on the water side and electrically, all while the other modules remain in full service.

   b. Cooling Towers — Baltimore Aircoil, Evapco, or Approved Equal

   c. Pumps: — Bell & Gossett, Taco, Goulds, or Approved Equal

   1 ~~d. Non-Condensing Boilers: Natural gas/#2 oil Fired Burnham 4F or Approved Equal~~

   1 e. Condensing Boilers: — Lochinvar, Veissmann; or Approved Equals presented by the A/E during the design phase (based on technical specs including turndown ratio and cascading abilities) (Use by exception only for high-capacity requirements)

   f. Air Handlers: — Trane, Carrier, Air Enterprises (AEI), Liebert, Valent, Daiken or Aaon

   g. VAV Boxes: — Titus, Trane, Nailor, or Approved Equal (Electronically controlled)

   h. BAS: — 1. Trane

2. Siemens
3. Automated Logic
4. Delta
(No Equals or Substitutions)

i. Rooftop Units: Trane, Carrier, Valent, Air Enterprises (AEI), AAON, Innovent, and Daiken (No Equals or Substitutions)

~~j.~~ Variable Frequency Drives: Yashikawa, Danfoss ABB, or Square-D

k. Baseboard Heaters: Trane without Dampers, or Approved Equal

l. Underground Storage Tanks: Double wall, urethane coated steel. Act 100U, Type II, and approved by U.L.58 for underground storage of motor fuel. Double wall welded steel with a primary (internal) tank and a secondary (external) tank; as manufactured by (Highland, General Industries or Approved Equal). UST shall include quick release filler neck; 9 watertight raised access to filler neck; and shall support accessory equipment including drop tubes, two tank sumps, and submersible removable pumps. UST design shall allow for continuous monitoring of the interstitial spaces between the two walls and the two manways.

m. Fuel Storage Monitoring and Leak Detection System: Veeder Root Model TLS-450PLUS (No Equals or Substitutions)

n. Submersible Fuel Pump: Redjacket (submerged turbine); or Approved Equal

o. Fuel Dispensers: Gas Boy (No Equals or Substitutions)

p. UST Fill Caps and Overflow Devices: Ohio Pipe Works (OPW) Model 2100 overfill containment basin (5 gallon); or Approved Equal

1 q. Fire Station Diesel Exhaust Extraction System: Refer to Fire Station Manual

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r. Gas Fired Infrared Heaters: Superior Radiant Product "Co-Ray-Vac" Class I or II by Roberts Gordon. (By exception only. For new applications, use alternate heat source)

s. Airflow Measuring Stations: Ebtron or Kele (No Equals or Substitutions).

t. Gas Sub-Metering: Onicon with flow conditioner

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EXHIBIT 230000-A
FAIRFAX COUNTY MAINTENANCE COST
FOR
LIFE CYCLE COST ANALYSIS

Notes:

1. BDCD Project Manager to coordinate with Facilities Management Department (FMD) to provide the current staff rates.
2. BDCD Project Manager to coordinate with Facilities Management Department (FMD) to confirm the Parts Cost are current.
3. Maintenance costs are per year.

Equipment	Staff Rate *Note 1*	Hours	Total	Parts	Parts Cost (2018 Costs) *Note 2*
Air Cooled Chiller <40T	*$90.00*	12	$1080	Coil cleaner, contactors, MISC	$100.00
Air Cooled Chiller >40T	*$90.00*	15	$1350	Coil cleaner, contactors, MISC	$100.00
Water Cooled Chiller	*$160.00*	18	$2880	Contactors, MISC,	$300.00
Cooling Tower	*$90.00*	18	$1620		
Water Treatment - Single Closed Loop	*$65.00*	14	$910	chemicals	$1,500.00
Water Treatment - Single Open Loop	*$65.00*	14	$910		
Condensing Boiler	*$120.00*	12	$1440	Break down kit for winter service	$1,200.00
Inline Pump	*$90.00*	2	$180	oil, grease	$30.00
Base Mounted Pump	*$90.00*	3	$270	coupling, grease	$50.00
Rooftop Packaged RTU DX Gas Fired <10T	*$90.00*	12	$1080	Filters	$400.00
Rooftop Packaged RTU DX Gas Fired >10T	*$90.00*	12	$1080	Filters	$400.00
rooftop Packaged RTU Heat Pump <10T	*$90.00*	10	$900	Filters	$400.00
rooftop Packaged RTU Heat Pump >10T	*$90.00*	10	$900	Filters	$400.00

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Equipment	Staff Rate *Note 1*	Hours	Total	Parts	Parts Cost (2018 Costs) *Note 2*
Indoor AHU - Chilled/hot water	*$90.00*	8	$720	Filters	$400.00
Kitchen Make-up-Air Units Gas Fired	*$90.00*	4	$360	Filters, heating parts	$100.00
DOAS units - Flat Plate HX	*$90.00*	4	$360	Filters	$600.00
DOAS units - Heat Wheel	*$90.00*	4	$1620	Filters	$600.00
Outdoor Condensing Units >10 T	*$90.00*	8	$720	Coil cleaner, contactor	$200.00
Split System AC Units	*$90.00*	3	$270	Coil cleaner, contactor	$75.00
Split System Heat Pumps	*$90.00*	3	$270	Coil cleaner, contactor	$75.00
VAV terminal - Shut-off, Electric	*$90.00*	2	$180		
VAV terminal - Fan Powered, Electric	*$90.00*	2	$180	Filters	$20.00
VAV terminal - Shut-off, Hydronic	*$90.00*	2	$180		
VAV terminal - Fan Powered, Hydronic	*$90.00*	2	$180	Filters	$20.00
Fan Coil Unit - 2 Pipe Floor Mounted	*$90.00*	1	$90	Filters	$20.00
Fan Coil Unit - 4 Pipe Floor Mounted	*$90.00*	1	$90	Filters	$20.00
Fan Coil Unit - 2 Pipe Above Ceiling	*$90.00*	2	$180	Filters	$20.00
Fan Coil Unit - 4 Pipe Above Ceiling	*$90.00*	2	$180	Filters	$20.00
Exhaust Fan - Roof Mounted	*$90.00*	3	$270	belts, grease	$20.00
Exhaust Fan - Inline above ceiling	*$90.00*	1	$90		
VFD - Wall Mounted, separate from packaged equipment	*$90.00*	2	$180		
DDC Controls ($/SF) Yearly Service contract value $850,000	*$0.00*	360		This is divided between 4 contractors on 5 BAS systems	

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Equipment	Staff Rate *Note 1*	Hours	Total	Parts	Parts Cost (2018 Costs) *Note 2*
DDC Controls ($/SF) FMD staff	*$0.00*	12		FMD staff make sure the panels are clean and check alarms	