TVHS Energy Requirements and Design Guide

TVHS Energy Design Guide
Revised: 9-30-14

Introduction: This Design Guide is intended for the Architect - Engineer (henceforth referred to as the A - E), Design-Build Contractors, Controls Contractors, General Contractor and others engaged in design, construction or renovation of projects at TVHS Nashville or Murfreesboro VAMC facilities. The guide focus is energy savings and operational concerns. The intent is to ensure performance, quality control and uniformity in design and construction practices and procedures.

In addition, the below standards are intended to supplement the project Statement of Work, VA Master Spec sections, project specific specs and drawings for this project. If this is an A-E design project, the A-E shall use these energy saving techniques and standards as a starting point to design the Architectural, Mechanical, Electrical & Plumbing (MEP) systems of this project. Adjustments should be made, as necessary, to fit the specific design requirement of the space or area being served. If this is a General contractor construction projects, the general contractor and it's sub-contractors shall us these requirements to supplement Architectural, Mechanical, Electrical & Plumbing (MEP) requirements of this project.

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1. Part 1, Architectural, Mechanical, Electrical & Plumbing (MEP) Energy Saving Requirements and Design General Intent:

A. Energy Efficient Project Design: Energy efficient designs and specifications will be used for new construction and for construction alterations and retrofits. A-E's shall comply with the following energy requirements on all projects:

1) Pre-design energy planning requirements: A-E design team members shall be aware of the importance of energy conservation and that energy usage should be a critical consideration in all aspects of the design process.

2) Project Design Reviews: At each stage of the design review process, A-E shall provide a review set of drawings and specifications to the Energy Manager for energy conservation reviews and to ensure that energy usage has been considered. Projects that involve significant additions or modifications to the complex systems (such as HVAC, Boilers, chillers, electrical, medical gases, major equipment) shall use commissioning to optimize and verify performance of the systems. Other design considerations include:

a. Use Energy Star Building Upgrade Manual

b. High-energy efficiency levels shall be specified for new equipment.

c. Low water-use levels shall be specified for new fixtures.

d. Heating and cooling system control modifications (including night-setback, skip-hour/day shutdown, duty cycling, tamper-proof preset, and area/zone demand).

e. Reduction of heating and cooling system losses (including insulation, equipment modification/replacement).

f. Exhaust air reduction, shall be set to values specified in VA HVAC Design Guide. Use CFM setback for unoccupied spaces. New bathroom rooms and bathroom renovation projects shall include occupancy sensing for supply and exhaust CFM setback. Also, see ASHRAE 62.1 Ventilation for Acceptable Indoor Air Quality.

g. Lighting level adjustment and control modifications.

h. Operating equipment control modifications (including skip-hour/day shutdown, and duty cycling).

i. Re-commissioning shall be performed on major systems that undergo significant additions or modifications.

j. Utilize Sustainable, LEED, and Green Buildings guidance and evaluate building elements with life cycle costing.

B. Design to meet intent of LEED Health Care (HC) energy saving requirements. If project is new construction, design to meet Guiding Principles Checklist for Green Globes-New Construction, May 6, 2014 or Guiding Principles Checklist for LEED-New Construction, May 6, 2014

C. Design to meet requirements in VA Sustainable Design Manual – May 6, 2014 or latest revision. See VA Technical Information Library, http://www.cfm.va.gov/til/sustain/sustain.pdf Also see VA Alert 003 Sustainable Design Third-Party Rating of Healthcare Facilities. http://www.cfm.va.gov/til/alert.asp

D. Procedures for Energy Star*, Energy Saving Performance Contracts and Energy Efficient Equipment Procurement:

1) Executive Order 15514, Federal Leadership in Environmental, Energy and Economic Performance, requires the federal government to purchase energy-using equipment which meets "EPA Energy Star" requirements for energy efficiency. These products should be procured when available and practical.

2) If an Energy Star* product is not available, there is still the requirement to save energy. The use of products that are in the upper 25% of energy efficiency for all similar products or products that are at least 10% more efficient than the minimum level that meets Federal Standards will be purchased whenever practical.

3) Items that consume power in a standby mode should meet Federal Energy Management Program (FEMP) recommendations for standby power wattage. If FEMP has listed a product without a corresponding wattage recommendation, purchase items that use no more than one watt in their standby power consuming mode. When it is impracticable to meet the one-watt requirement, purchase items with the lowest standby wattage practicable.

4) When available, use EPA's WaterSense labeled products or other water conserving products.

5) Reference Energy Star Building Upgrade Manual, at http://www.energystar.gov/index.cfm?c=business.bus_upgrade_manual.

E. For renovation projects, reduce energy use by 20% compared to the baseline performance rating per ASHRAE 90.1 2007 Appendix G. Also reference ASHRAE Advanced Energy Design Guide (AEDG) for Large Hospitals, download the AEDG for Large Hospitals from ASHRAE.

F. For all new buildings and/or additions to existing buildings entering design on or after July 9th, 2014, must be designed to meet the minimum requirements of ASHRAE 90.1-2010. In addition, if lifecycle cost-effective, reduce site energy use by 30 percent compared to the baseline building performance rating per AHSRAE 90.1-2010, Appendix G, excluding plug and process loads. If a lifecycle cost effective design cannot be achieved that meets the 30 percent reduction requirement, select the most efficient design that meets or exceeds the minimum requirements and is lifecycle cost-effective. No design shall be less than 30 percent more efficient than ASHRAE 90.1-2007, excluding plug and process loads. Also reference ASHRAE Advanced Energy Design Guide for Large Hospitals at ASHRAE.org AEDG downloads.

G. Commissioning: When required in the SOW, meet requirements of EISA 2007, section 432, VA Master Spec requirements and intent of VA Standard Alert, Sustainable Design Commissioning (see VA Standard Alert 004 located in the TIL, http://www.cfm.va.gov/til/sAlert/sAlert004.pdf

H. See current VA Design Alerts at http://www.cfm.va.gov/til/Alert.asp . Pay special attention to A/E Quality Alerts for HVAC, Electrical and Plumbing Engineering. Also comply with relevant items from the following VA Alerts, located in TIL, (check for currency and latest version), to include:

a. SA-005 Sustainable Design Renewable Energy Requirements,

b. SA-006 Energy Efficient Design of Major Renovations,

c. SA-007 Life Cycle Cost Effective Renewable Energy,

I. Window Improvements: When required, replace windows with energy efficient high performance glazing, with energy star designation. Consider sun shading/light shelves, skylights, etc. Also see VA Sustainable Design & Energy Reduction Manual.

J. Envelope Improvements: When applicable, investigate installation of insulation on exterior walls and at roof deck. Address improvements to the space continuous air barrier system. Reference ASHRAE 90.1 Addendum Z for information on standards for air barriers. Special attention to be given to improving the thermal performance of the envelope from eliminating thermal bridging and reducing the degree of air infiltration through the façade. See VA Sustainable Design & Energy Reduction Manual.

a. On projects that have a SOW that notes moisture and mode issues, the A-E shall perform a Dew Point Analysis and plans to remediate moisture infiltration of the building materials and interior spaces.

b. Also reference ASHRAE Advanced Energy Design Guide for Large Hospitals at ASHRAE.org AEDG downloads. Components addressed in the recommendations include insulation and solar reflectance index (SRI).

c. Joints and other openings in the building envelop that are potential sources of air leakage shall be corrected and sealed.

K. HVAC and Controls General Energy Saving Requirements:

1) All HVAC systems (including AHU's, VAV's, return fans, heat exchangers, chillers, boilers, exhaust fans, etc), shall be commissioned, tested, adjusted, and balanced to meet the design intent and design quantities.

2) Maximize recirculation air to the extent permissible per ASHRAE Std 62.1 procedures and subject to VA HVAC Design Manual minimum Outside Air requirements.

3) All areas that are modified or constructed (i.e. renovated spaces) shall include retrofitting existing VAV boxes with DDC controls or installing new VAV with DDC controls. All DDC controls shall be integrated with the DDC/ECC frontend system, see Controls spec and related parts of this document for more detail.

4) When required, replace steam and chill water pipe insulation on related Air Handling Unit's and related equipment. To meet energy saving requirements, consider installing heat recovery system(s) on AHU's and major exhaust fans.

5) When required in project SOW, replace related steam traps. Include wireless monitoring of steam traps. See Steam Trap Monitoring System VA Design Alert at http://www.cfm.va.gov/til/alertDesign.asp .

6) Provide Direct Digital Controls (DDC) for all HVAC equipment consistent with facility standards. Connect to Engineering Control Center. Connect new DDC controls to the current DDC/Energy Management System or replace DDC frontend. Include functional graphic diagrams of each new component in system. All programmable points in the space

should be programmed into the existing system and programmed (a complete points list will be provided by controls contractor). Utilize native BACNET protocol. Provide remote monitoring and control of all HVAC equipment. See VA master Spec and TVHS modified spec 23-09-23.

7) Utilize NEMA MG-1, high energy efficient motors (NEMA premium efficiency) for all fans.

8) Do not use by-pass or 3-way valves. Use pressure independent valves on AHU Chill Water valves. Exception to the no by-pass valves policy will be considered in select situations, for example, a bypass valves may be needed at the end of select chill water runs. A-E to recommend when required and coordinate location with Energy Engineer.

9) See VA TIL HVAC Alerts at http://www.cfm.va.gov/til/alertDesign.asp#hvac

10) See VA Sustainable Design & Energy Reduction Manual.

K. Lighting, General Energy Saving Requirements: See Part 11 Lighting and Controls.

L. Plumbing Considerations:

1) EPA's WaterSense labeled products or other water conserving products.
2) Do not use single pass cooling of equipment (i.e. ice makers, cold room systems) with domestic water. Single pass with chilled water is OK if it is returned through the chilled water return system.
3) Toilets shall be low flow and/or dual flush
4) Toilets shall have automatic control valves
5) Sinks shall be laminar flow
6) Sinks shall incorporate sensors for automatic tempered water flow for hand washing
7) Use hot water recirculation where possible

M. Utilize the relevant items in Checklist at Appendix B, C, D and E.

N. The following design baseline requirement (Part 2 to Part 8) shall be utilized on this project. During the design phase, the A-E shall recommend adjustments to these requirements for unique project objectives. If this is not an A-E design project, the controls contractor shall use this document as a project requirement document and apply the content of this document to this project.

O. Include the following GEMS and Energy related spec sections in Division 1 of all construction project specs:

- Spec Section, 01 81 11, TVHS Sustainable Design Requirements
- Spec Section 01 74 19 Construction Waste Management

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2. Part 2, HVAC and DDC Requirements and Standards:

A. The following includes general requirements for HVAC systems and Controls systems. It includes general notes on equipment selection, control points that tie into controls system, and operational initiatives that can save energy and operational dollars, with no negative impact of patient and staff comfort. Also see VA Sustainable Design & Energy Reduction Manual.

B. Use Native BACNET on all DDC and HVAC controls. All information, programming and data related to the DDC controls shall be open source. See VA TIL spec sections and related sections of this document.

C. Centrifugal chillers are the most efficient form of cooling currently on the market, therefore it is required that centrifugal chillers be used for all new installations.

D. For cooling systems in the range of 145 – 290 tons, where standard centrifugal chillers are not available, frictionless centrifugal chillers should be used. New frictionless centrifugal chillers are available as small as 30 tons (a centrifugal chiller with VFD drive and magnetic bearings). Micro centrifugal chillers can have part load efficiencies as low as 0.33 kW per ton.

E. Full commissioning is required on all AHU's and any new or modified HVAC system. Commissioning should verify the proper operation of each element of the HVAC system, including but not limited to chiller(s), air handler(s), control devices, sensors, thermostats and VAV boxes.

F. Motors shall be National Electrical Manufacturer's Association (NEMA) Premium Efficiency rated. Use Ultra Efficiency on lager motors. Motor shall not be purchased unless they meet the NEMA Premium Efficiency rating. Also, see Part 7 of this document, VFD Requirements and Design Intent.

G. Building humidification: Reference TIL Design Manual and Guides. Also see VA Design Alert for Building Humidification, at http://www.cfm.va.gov/til/alertDesign.asp#hvac .

H. DDC Controls and Graphical Standards: The below standards is intended to supplement the DDC Controls and graphic requirements, that are detailed in project drawings and spec section 23 09 23. A-E's shall use this standard as a starting point to design the HVAC, Controls system (or Energy Management System) and mechanical requirements of this project.

I. The General contractor, Controls contractor and A-E shall comply with the requirements listed below and elsewhere in this document. The Controls Systems Operator Interfaces shall be user friendly, readily understood and shall make maximum use of colors, graphics, icons, embedded images, animation, text based information and data visualization techniques to enhance and simplify the use and understanding of the displays by authorized users at the ECC. Also the graphical user interface software, shall minimize the use of keyboard operations through the use of the mouse and "point and click" approach to menu selection. See Appendix A of this document for frontend user interface details:

    1) Valve and damper positions shall be indicated as percent open: i.e. 0% equals fully closed and 100% equals fully open. This may not apply to select items, such as linked economizer dampers.

    2) Use 3D graphics, when feasible.

    3) Use constant ID's on DDC values: CHWS, CHWR, CWS, CWR, see existing frontend for

examples.

4) Filter Status: Use CLN for clean and DIRT for dirty?
5) Always include unit type for each value displayed on graphic screens: (F, %, CFM, FPM, psi, GPM, hrs, KBTUs, % RH, " WC, etc)
6) Always show (by label ID or color) if a value is a setpoint that is changeable under normal operation conditions (white font on gray background) or actual/status value (blue font on gray background).
7) To enhance usability, use animation to show rotation, temperatures or moving mechanical components. For example, temp of coils, louvers position, valves are open/closed/partially open, temp of fluids, steam release from Humidifier, Air arrows, etc. See AHU-22 on the BACNET system.
8) Show start/stop command and actual fan run status. VFD info, on/off/hand, percent, alarm, etc. For all actuators, controls and valves that have status capability; show command value (white font on gray background) on top and the status value on the bottom of the blocks (blue font on gray background) on the graphic pages.
9) On AHU graphic floor plan, include "Area Served:" for each AHU.
10) Controls contractor to provide complete BACNET points list that shows all BACNET devices (valves, controls, sensors, etc). Controls contractor to provide complete schedule list of a devices.
11) All controls contractors shall expose all data info and make all info discoverable on the frontend system.

J. Energy Recovery Systems: Each AHU shall be designed to maximize energy recovery. 100% outside air units shall only be used when required by the VA HVAC Design Manual. Energy recovery shall use the most efficient method for the specific ductwork and AHU layout. Use the following Energy Recovery methods (highest efficiency methods are at top of the list and lowest are at bottom of list):

1) Return air system
2) Energy Wheel
3) Air to Air Heat Exchanger, see Part 9 for set point info
4) Heat Pipe method
5) Wrap Around heat recovery coil with Glycol

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3. **Part 3, AHU With DDC Controlled VAV's, Design Intent:** The following design requirements shall be utilized on this projects AHU design:

A. All projects that rebuild, replace or install new AHU's, shall utilize DDC controls on AHU's.

B. See VA Design Alert 134, VA Adoption of Plenum Fans for Air Handling Units Application.

C. 100% outside air unit AHU's shall be limited to those listed in the VA HVAC Design Manual (SPD, Wet Labs, etc)

D. For 100% outside air AHU's, include a Thermal/Heat Recover method (Glycol Loop, Plate & Frame Heat Exchanger, etc)

E. Heat Recover on General Exhaust: Heat Wheel or Desiccant Heat Wheel should be considered for Admin spaces (not to be used in patient areas).

F. Insure proper insulation thickness on duct work and AHU enclosures. Pay special attention to AHU's and duct work in attics or hot/humid Mech Rms. Utilize modern ductwork design and insulation standards and develop insulation/ductwork design that save the most energy. Minimum insulation thickness should be 2 inches on interior HVAC supply lines. The duct work leakage objective is to obtain ASHRAE Standard 90.1, Seal Class A on major supply lines and Seal Class B on return and exhaust lines.

G. Use NEMA premium efficiency motors

H. Use 480V on larger motors and VFD's.

I. Controls and Interface for AHU's with DDC Controlled VAV's, shall include:

1) Reset Supply Air Temp (SAT) based on worst-case-zones (selectable) Air Terminal Unit's average load demand from poling VAV/ATU damper position percent. Also allow select ATU's to be ignored in the poling. Per ASHRAE Standard 90.1, The SAT (to VAV's with reheat) shall be reset higher by 5 degrees under minimum cooling load conditions. SA Temp should have a max and min temp control limits. The SAT StPt should be adjusted within these limits. Use a default SAT StPt and then adjust (inc/decrease by temp value and reset delay time) based on VAV/ATU damper position. Also see example screen shots from a typical VAMC at Appendix H. Also see VA Sustainable Design & Energy Reduction Manual, section 2, "Warmest Supply Temp Reset".

a. Night Setback Schedule for Night/Weekend/Holiday unoccupied setback shall be used to the maximum extent practical for non-patient spaces that will not negatively impact patent safety. Use AHU temp and Static Pressure/CFM for AHU's that serve VAV's with override capability. Insure night setback override in each space from terminal unit/VAV at all T-stats. See Part 6 of this document for VAV Requirements and Design Intent.

b. Use optimized setback start/stop programming

2) Economizers: Reset with outside enthalpy Vs Return Air Enthalpy. Example: Enthalpy controls – The systems designer should describe how to treat the relationships between Outside Air (OA) and Return Air (RA) and how that relationship will be utilized to generate the Mixed Air (MA) mass that is the least costly to condition.

a. When RA is the lowest cost air mass to condition, the sequence of operation should specify that the system will utilize the minim amount of OA as possible while remaining compliant with ASHRAE requirements for OA content.

b. When OA is the lowest cost air mass to condition, the sequence of operation should specify that the system will utilize the maximum amount of OA possible by exhausting as much RA as necessary to generate the desired MA temp.

c. The BMS should then modulate the OA damper, the EA damper and the MA damper is such a manner as to mix the OA and RA air masses generating the desired conditions in you MA air mass. In this fashion the BMS system will minimize the energy required to condition the space.

d. Unoccupied Mode – During unoccupied mode, the system shall have the ability (selectable mode) to run in 100% re-circulatory mode, with the outdoor air damper fully closed, to maintain night setback temperature, See VA HVAC Design Manual.

3) Static Pressure and CFM Reset: Based on worst case zone VAV's. See EnergyStar.gov "Modify Controls" document. AHU Static Pressure adjustments, can be implemented as explained in the below VA sequence of operations logic:

   a. The following reset method and values are examples; A-E to evaluated and recommend actual method and values for each project. Reset the static pressure setpoint using a Trim and Respond logic within the range of 0.5" WG to 1.5" WG. When the fan is started the setpoint should be 1.0" and the setpoint trimmed by 0.04" every two minutes of if there are two or fewer zones pressure requests. If there are more than two zone pressure request, respond by increasing the setpoint by 0.06". A zone pressure request is generated when a VAV damper is greater than 95% open until it drops to 80% open. All set points shall be adjustable through the operator workstation.

   b. For non-patient areas, also utilize night setback (Summer & Winter mode) Static Pressure setback. Setback shall not reduce CFM more than 50% of design occupied CFM, see VA HVAC System and Control; Design Considerations General Guidance.

   c. To assist with air volume setback, include Carbon Dioxide sensors in space/return air.

   d. AHU Return Fans should track the Supply fan reset changes or use a CFM offset adjustment that is also based on a trend and respond reset method, see examples at Appendix H.

   e. Include discharge air temp vs discharge air temp stpt graph on each AHU graphic page.

   f. Show AHU static pressure sensor location on DDC floor plans. Display Static Pressure SetPt and actual value in inches.

   g. Also see VA Sustainable Design & Energy Reduction Manual, section 2 for other info on variable ventilation rate methods and 50% CRM setback. Also see HVAC Design Guide for info on 50% CFM reduction during unoccupied mode.

4) For each AHU, show VAV Summary page that displays VAV unit #, Occupied/Unoccupied status, space temp, space StPt, Reheat Valve Pos, discharge air temp (DAT), CFM StPt, CFM actual and Damper position. Also include color on Space Temp to indicate over/under temp conditions. See example at Appendix H for VAV/ATU summary page and see Appendix A for color and temp limits for each color.

5) Possible starting point of SAT Reset (tune reset parameters based on observed performance and to maintain space comfort). This is used, only if reset cannot be accomplished with Return Air Enthalpy.

OAT	SAT
95	55
60	60

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4. Part 4, AHU (**without DDC Controlled VAV's**) Requirements and Design Intent: For existing AHU's without DDC controlled VAV's, comply with the above Part 3 requirements, except for the following design requirements:

A. Reset Supply Air Temp (SAT) based on outside air enthalpy or Outside Air Temp (OAT). SAT would be proportionally adjusted between two points.

B. Economizers: Reset with outside enthalpy Vs Return Air Enthalpy.

C. Unoccupied Mode – During unoccupied mode, the system shall have the ability to run in 100% re-circulatory mode, with the outdoor air damper fully closed, to maintain night setback temperature, See VA HVAC Design Manual.

D. Static Pressure Reset: (for admin areas) based on night setback, Summer or Winter modes. Objective is to reduce flow to 50 % (adjustable) of winter heating CFM requirement or min cooling CFM (whichever is less). Show AHU static pressure sensor location on DDC floor plans, with SP SetPt and actual Setpoint reading displayed.

E. Possible starting points for SAT reset (Tune the reset parameters based on observed performance and to maintain space comfort). This is used, only if reset cannot be accomplished with Return Air Enthalpy.

OAT	SAT
75	55
60	60

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5. Part 5, Exhaust Fan Requirement and Design Intent: The following design requirements shall be utilized on this project's Exhaust Fan design:

A. Utilize energy efficient Cogged Synchronous drive belts and use NEMA premium efficiency motors.

B. Larger EF' s (over 3 HP) should be 480V.

C. See VFD checklist design intent.

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6. Part 6, VAV Requirements and Design Intent: The following design requirements shall be utilized on this project's terminal unit's and VAV's:

A. Each VAV box shall be programmed with a max and min set point for each thermostat independent of the thermostat setting. The DDC system shall set a dead-band range and this will prevent occupants from setting values outside of this range.

B. Space Temp & CFM Setback: All VAV's shall have temp set points and CFM occupied/unoccupied capability for nights/weekends/holiday setback. This capability is important, ever if the current use of this feature is not utilized, the set point values would be set the same in each mode. This will allow the facility to save a significant amount of energy and money. Eliminating or reducing the air flow through VAV boxes will allow fan motors to utilize their VFD drives and reduce speed and energy use. With less air flow across the heating and/or cooling coils, less energy is removed from your heating/cooling system which in turn allows your hot water heaters or boilers or chillers to slow down saving additional energy. With less air flow, the system will require less humidification which saves additional water and energy. [See AHU-22 graphics]

C. Use Space Temp & CFM setpoints that are easy to understand (i.e. heating stpt, cooling stpt, stpt adjust by +/-, space t-stat stpt) and show controlling method (system or space wall sensor/T-stat). System should have a programmed range for each VAV box where no matter where the occupant sets their desired temp, the space will never get colder than the preset minimum nor will it get hotter than your preset maximum. Night setback shall be used on all administrative space and any clinical spaces where use of night setback will not negatively impact patient safety.

   1) During unoccupied mode, the CFM flowing into the space shall be reduced to a preset CFM valve (adjustable). Some areas may need no or very little flow, as long as the temperature is maintained within the dead-band range. Based on the type of space, consideration shall be given to odor control and flushing the space to prevent order buildup. Other areas, such as Surgical Suite and Spinal Cord Injury/Disorders Center, set back to 50% of the designed occupied air flow is allowed, see VA HVAC Design Manual for details.

   2) Temperatures shall be allowed to fluctuate over a wider range (selectable). The loop shall be expanded to at least twice the normal operating range allowing for both warmer and colder temps than are allowable during occupied hours.

   3) Night setback shall have a simple override that allows both the room occupants (via the wall t-stat control) and controls operator to add periods of occupied time (i.e. 30 min or 1 hour, selectable a DDC frontend) to the room occupied time, after which the room would revert back to the original Night Setback schedule. For after-hours use of the space, the space occupiants shall be able to push a button on the wall T-stat and override the unoccupied mode for X minutes/hours.

   4) Program with optimize start/stop

   5) Time Schedules for occupied and unoccupied modes individual, zone and global. Use a graphical display of an occupied/unoccupied temp range. see example at appendix.

D. Include space temp vs space temp stpt graph on each VAV.

E. Appendix H has a VAV screen example from another VAMC that meets the above requirements.

F. DDC graphic floor plans shall include “Area Served:” for each VAV, location of the VAV box, supply/return grills and location of wall T-stat.

G. For each VAV, include info on a VAV Summary page, see AHU Design Intent section above.

H. See VA Sustainable Design Manual, for other info on variable ventilation rate methods and CFM setback. Also see HVAC Design Guide for info on unoccupied mode, and CFM reduction during unoccupied mode.

I. VAV & TU Reheat: Reset the Reheat temp based on OAT.

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7. **Part 7, VFD Requirements and Design Intent:** The following design requirements shall be utilized on this project’s VFD design. .

A. VFD’s shall be installed on all new or modified AHU’s, large Return Fans, Large Exhaust Fans and Fume/Bio-Safety Exhaust Fans. By requiring a VFD drive on the supply and return air fan motors the facility will save energy in two ways. First, the VFD drive will always have the motor operating at peak efficiency. A motor that is oversized for its task will use a disproportionate amount of energy as motors are less efficient when they are not fully loaded. Installing VFD drives on these fan motors for a continuous air system also makes it easier to re-configure this system to a variable air volume (VAV) system in the future.

B. VFD’s shall interface with the ECC frontend and as a minimum include the following:

1) Status, start/stop
2) Status, speed
3) On-off command
4) Belt break alarm
5) VFD alarm
6) Graphics on ECC
7) Mode status, Hand-Auto-Off
8) Energy usage KW and KWH used by fan/drive
9) Etc.

C. VFD’s should be 480V, Dan Foss (or approved equal) units (this is site standard, due to patient safety and Hospital mission).

D. Individual motors serving variable flow devices and having a motor speed exceeding 3 HP shall use variable speed controls that result in pump motor demand of no more than 30% of design watage at 50% of design flow.

8. Part 8, Unused at this time.

9.

10. Part 9, Air-to-Air Plate & Frame Heat Exchanger (HX) Requirements and Design Intent:

A. Air-to-Air Plate & Frame Heat Exchanger shall be used on 100 % outside air AHU's and on large exhaust fan systems when practical. Typical set points, all shall be adjustable and tuned as required. A-E to investigate and recommend optimal design configuration and settings:

1) OAT < 55, Operate HX, maintain CFM set point. If exhaust air leaving HX is below 35 degrees, face & bypass damper shall modulate until discharge air temp raises above 36 degrees.
2) 55 < OAT < 75, Shut down HX.
3) OAT>75, Operate HX to maintain CFM set point.

11. Part 10, Boilers and Steam Systems:

A. See VA TIL Steam Generation Design Guides, Steam Distribution and VA Alerts at http://www.cfm.va.gov/til/dManual.asp and http://www.cfm.va.gov/til/alert.asp

B. See VA TIL for Design Alerts, such as "Steam Trap Monitoring System, Alert #117" at http://www.cfm.va.gov/til/alertDesign.asp#hvac

C. Steam Traps: Per the above Design Alert #117, Orifice Steam Traps should not be used. Inverted bucket traps with thermal vent buckets should be used for steam line drip service. Closed float-thermostatic traps should be used for heat exchangers which have modulating steam control valves.

D.

E. Boilers shall have stack economizers.

F. Boilers shall have automatic blow down.

G. New Boilers shall have combustion air fans on VFD drive.

H. Only the highest efficiency boilers should be considered for new plants.

I. Boilers shall have automated oxygen trim controls

J. The following info is for general engineering reference and design considerations, this is not for project requirements:

Steam system improvements: http://www1.eere.energy.gov/manufacturing/tech_assistance/pdfs/steamsourcebook.pdf

Mechanical Insulation Design Guide, at *www.wbdg.org/midg* for more on steam system insulation

For more information on insulation, refer to Steam Tip Sheets #2 and #17, *Insulate Steam Distribution and Condensate Return Lines and Install Removable Insulation on Uninsulated Valves and Fittings* at: *manufacturing.energy.gov*
http://www1.eere.energy.gov/manufacturing/tech_assistance/pdfs/steam2_insulate.pdf

http://www1.eere.energy.gov/manufacturing/tech_assistance/pdfs/steam17_valves_fittings.pdf

Steam System Survey Guide:
http://www1.eere.energy.gov/manufacturing/tech_assistance/pdfs/steam_survey_guide.pdf

Condensing Boiler Economizer in:
http://www1.eere.energy.gov/manufacturing/tech_assistance/pdfs/steam26a_condensing.pdf
http://www1.eere.energy.gov/manufacturing/tech_assistance/pdfs/steam26b_condensing.pdf

Steam Trap Inspection and Repair info:
http://www1.eere.energy.gov/manufacturing/tech_assistance/pdfs/steam1_traps.pdf

Part 11, Lighting and Lighting Controls:

All building spaces that are renovated shall include upgrade of existing lighting to energy efficient lighting systems.

Lighting, General Energy Saving Requirements:

A. Lighting shall be in compliance with ASHRAE 90.1- 2010 – Part 2, Lighting Controls and VA Design Manual, Chapter 6.

B. Design shall be for energy efficient lighting. For example, building energy efficiency will be increased by using T-8 lighting with programmed electronic ballasts, LED lighting, CFL's, etc. See Energy Star Building Upgrade Manual, Chapter 6 for more detail on lighting, at the following link; http://www.energystar.gov/index.cfm?c=business.EPA_BUM_CH6_Lighting

   1) Electronic Ballast: electronic programmed start ballasts shall be used on all fluorescent fixtures, unless another type is required for unique applications.

C. Include infrared (IR) and ultrasonic (US) or dual technology (IR & US) occupancy sensor lighting controls in offices, class rooms, store rooms, warehouses, restrooms, day rooms, and conference rooms, select exam rooms, non-inpatient hallways and similar spaces. See Energy Star Building Upgrade Manual, Chapter 6 for more detail on lighting, at the following link; http://www.energystar.gov/index.cfm?c=business.EPA_BUM_CH6_Lighting .

D. All Occupancy Sensors shall be from the same manufacture. Occupancy sensors should use manual DIP switches or dials to adjust functions; such as timeout, range, operating mode, ambient light level, override, etc. Select sensor Coverage Area based on the actual space SF and layout. Based on the lighting layout, utilize Line-Voltage or Low-Voltage sensors. After installation of the occupancy sensors, contractor to coordinate with VA COR and follow manufactures suggestions to set optimal operating modes and sensor settings based on the actual space conditions.

E. During low use or unoccupied periods, such as during evenings, nights, and weekends, corridor light levels will be reduced. Emergency lighting circuits in corridors and other spaces shall always remain on (lighted) and provide a minimum egress lighting level (see NFPA 101 and VA Lighting Design Guide for details) for low-use periods. Any areas of reduced lighting may have lighting levels raised in support of specific clinical needs or in order to carry out specific activities (e.g., intermittent use, cleaning activities, etc.), however, lights will be reduced back to low use or unoccupied level at the completion of activity requiring higher level of light.

F. Stairway lighting shall be designed with occupancy sensors to allow reduced (50%, adjustable or to min fc level for security and safety) lighting levels during unoccupied periods.

G. Patient areas will be maintained at lighting levels appropriate to patient care as determined by the clinical staff and VA Design Guide requirements.

H. Lighting levels and control in animal care areas will be as recommended by research staff and VA Design Guide requirements.

I. Design should optimize natural light. Also investigate use of *Daylight Harvesting,* in which electric lights are dimmed or turned off in response to the presence of daylight.

J. Generally, interior finishes having good light reflectance will be utilized.

K. Investigate integrating lighting controls with HVAC DDC controls for HVAC ventilation rate setback on select spaces.

L. See Appendix C of this document Office Lighting Checklist and Appendix G, Initial Settings for occupancy/motion sensors in New or Renovated Space of this document.

Appendix A, DDC Frontend User Interface, Example from Recent Nashville VAMC projects:

General Graphical Objectives: The workstation shall allow the operator to access various system schematics and floor plans via a graphical penetration scheme, menu selection, or text based commands. Graphic software shall permit the importing of AutoCAD or scanned pictures in the industry standard format (such as PCX, BMP, GIF, and JPEG) for use in the system.

System Graphics shall be project specific and schematically correct for each system. (ie: coils, fans, dampers located per equipment supplied with project.) Standard system graphics that do not match equipment or system configurations are not acceptable. Operator shall have capability to manually operate the entire system from each graphic screen at the ECC. Each system graphic shall include a button/tab to a display of the applicable sequence of operation.

Dynamic temperature values, humidity values, flow rates, and status indication shall be shown in their locations and shall automatically update to represent current conditions without operator intervention and without pre-defined screen refresh values.

Color shall be used to indicate status and change in status of the equipment. The state of colors shall be user definable.

Graphic Floor Plan Requirements: The following items shall be listed on the floor plan graphical drawing for each floor or section of a floor. The items shall be shown as an icon (or text ID) on the floor plan that will bring up another level of graphical and text details. Include floor plans for related spaces, such as Mech rooms. Floor plan graphics shall show heating and cooling zones throughout the floors in a range of colors, which provide a visual display of temperature relative to their respective setpoints. The colors shall be updated dynamically as a zone's actual temperature to setpoint changes:

Floor plan backgrounds shall include walls (as single lines),zones (as double lines), stairs and room numbers. If the floor plan is to busy, then divide up the floor plan into different sections. Consider using the ability to fade the floor plan itself into the background, i.e. fade it out so that it can be seen, but faintly. And then have the important data in the foreground, so it stands out.

Show locations of key space sensors: T-stat, static pressure station (with reading) and humidistat. In addition to showing AHU Static Pressure sensor location on floor plan, show Static Pressure Set Point and actual value in inches.

Show each VAV or box that serves each area and show the limits of that space boundary. If the graphics are too busy, then divide up into different sections.

Use colors and icons to distinguish different equipment items.

Floor plans to be vector based to allow for zooming in and out of floor plans.

Special Controllers and Special Rooms: Show locations with icons or text on the drawing for Bio-Safety

Cabinets, Fume hoods, Differential Pressure, Tissue Culture, Open Lab, Microscopy, and Animal Procedure areas. Selecting the item shall bring up a screen with status details for that space/equipment. The following spaces have special equipment and controls: Bio-Safety Cabinets, Fume hoods, Tissue Culture, Open Lab, Microscopy, Instrument, and Animal Procedure areas. Selecting these rooms (or equipment) on the Floor level drawing should bring up a screen with specific details for that space/equipment. This detail screen should include:

1) Graphics showing the inter-relationship of the space and major equipment items, shall include:
   - a) Lab enclosure/boundary lines,
   - b) Hoods,
   - c) Show associated exhaust fans for each Lab area or Hood. If needed show icon/fan number outside of floor footprint with connection line to the related space or hood for the following:
     - i) Dedicated fumehood exhaust fan,
     - ii) Exhaust valve (CV),
     - iii) General exhaust,
   - d) Supply/makeup air valve,
   - e) Differential Pressure/Offset Controller
   - f) Related VFD’s, etc.

2) Readings/monitoring points should include:
   - a) Alarms,
   - b) CFM’s,
   - c) Balance,
   - d) Hood face velocity,
   - e) Show air flow direction,
   - f) Mode,
   - g) Start/stop and fan motor run status (if available)
   - h) VFD info, on/off/hand, percent, alarm, etc.
   - i) Flow tracking/monitoring,
   - j) Temps (discharge air, space),
   - k) Damper min & max,
   - l) Pressures, etc. (see spec section 23-0923, para 2.8 for Special Controllers)

Show associated exhaust fans for each major area on each floor plan. If necessary show icon/fan numbers outside of floor footprint with connection line to the related space.

Show fire/smoke damper locations and status (open/closed).

Set-point adjustment and color band displays should be provided at the room level screen.

The floor plan maps shall show heating and cooling zones throughout the building space in a range of colors which provide a visual display of temperature relative to their respective setpoint.

Colors shall be updated dynamically. Each space shall show (via colors that are user definable) the operational status of the space temp, for example:

- Light Gray - Unoccupied
- Non-Gray color - Occupied, see below colors
- Light Yellow - Space temp is less than 3-deg F above set
- point
- Dark Yellow - Space temp is 3-deg F or more above set point
- limits
- Light Blue - Space temp is less than 3-deg F below set point
- Dark Blue - Space temp is 3-deg F or more below set point,
- Red – Space temp is more than 5-deg F above or below set point
- limits, includes alarm.
- Pink - Communications failure

Click on any of the data displays for related AHU (i.e. DAT) and operator is taken to AHU graphic. Click on HWS temp to go to heating system equipment, etc.

Screen Information Outside of Floor Plan: On each floor plan screen, include the following (outside of the floor footprint): Show associated AHU's serving the selected floor as an icon (with alarm status color and AHU #). Click on icon to display AHU details in a pop-up window.
AHU's screens: Mechanical system graphics shall show the type of mechanical system components serving any zone through the use of a pictorial representation of components. Selected I/O points being controlled or monitored for each piece of equipment shall be displayed with the appropriate engineering units.

Animation shall be used for rotation or moving mechanical components to enhance usability, such as to show if louvers/valves are open, closed or partially open, temp of fluids, etc.
Use animation to show fans are running. Also show start/stop command and actual fan run status. VFD info, on/off/hand, percent, alarm, actual load in KW, belt break alarm, etc.

Show discharge air static pressure.

Insure AHU controls has capability for auto restart after AC power failure.

Exhaust Fan Summary page for, example is the "ACRE Building Exhaust Fans": Show location reference for each exhaust fan.

Clicking on room or VAV number would take you to VAV graphic and details.

The VAV list screen shall show all VAV's associated with that floor plan screen. The VAV list should also show Room number, VAV #, Zone temp, air flow required, air flow actual, DAT for VAV, SP for space temp and position of reheat.

Trend reports shall be generated on demand or pre-defined schedule and directed to monitor display, printers or disk. As a minimum, the system shall allow the operator to easily obtain the following types of reports:

1. A general list of all selected points in the network.

2. List of all points in the alarm.
3. List of all points in the override status.
4. List of all disabled points.
5. List of all points currently locked out.
6. List of user accounts and password access levels.
7. List of weekly schedules.
8. List of holiday programming.
9. List of limits and dead bands.
10. Custom reports.
11. System diagnostic reports, including, list of digital controllers on the network.
12. List of programs.

Scheduling and Override: Provide a calendar type format for time-of-day scheduling and overrides of building control systems. Schedules reside in the ECC. The workstation, digital controllers shall ensure equipment time scheduling when the ECC is off-line. The ECC shall not be required to execute time scheduling. Provide the following spreadsheet graphics as a minimum:

a. Weekly schedules.
b. Zone schedules, minimum of 100 zones.
c. Scheduling up to 365 days in advance.
d. Scheduled reports to print at workstation.

Collection and Analysis of Historical Data: Provide trending capabilities that will allow the operator to monitor and store records of system activity over an extended period of time. Points may be trended automatically on time based intervals or change of value, both of which shall be user definable.

Appendix B, HVAC Energy Checklist

The following was developed with input from the National Renewable Energy Laboratory. A-E designers should use the below checklist to ensure relevant HVAC Energy items have been implemented and proper design considerations have been investigated.

____ **Reduce Ventilation Rates**

One of the largest energy wasting items is having 100% outside air (OA) ventilation for areas that don't require it. Common areas that require 100% OSA are OR's, SPD, Lab, and Research Labs, all other areas should be examined to make sure that proper ventilation rates are being used. Consider installing variable frequency drives on OA and EA fans to reduce speed/flow rates during unoccupied times.

____ **Eliminate Duct Leakage**

Periodically trace main HVAC duct runs and listen for air leaks in both the duct system and in the compressed air system, if you have one. Confirm that your duct static pressure set point is within the pressure class of the installed ductwork before repairing your leaks.

____ **Investigate Duct Static Pressure**

For VAV systems, review your duct static pressure set points and adjust them as low as possible while keeping all VAV dampers below 90% open. If you have VAV dampers at 100% open, don't reduce your SP set point, but look at why the space is calling for so much cooling. Can heat load be removed from the space?

____ **Check the Function of Heating & Cooling Valves**

Check all heating and cooling valves for proper operation. Check the heating valve in the winter by shutting off the valve and checking the air handler mixed air and discharge temperatures. If the valve is closed but the air is still getting warmed up by the coil then your valve isn't closing entirely and you would still be heating the air in summer time when the valve is supposed to be closed. Do the same procedure for your cooling valve in the summer time.

____ **Verify the Correct Operation Air Handler Dampers**

Confirm that all AHU dampers are operating correctly. Have an operator force all dampers open and closed and visually confirm that they are closing and opening properly. Also have the operator open the dampers to about 50% to make sure they are varying position correctly. Now confirm that the damper position is following the economizer schedule laid out in the sequence of operations by viewing their positions at different outside air temps.

____ **Chilled Water Coil Valve Configuration**

Check that your chilled water coils have two way valves instead of three way valves. Your secondary chilled water loop should have VFD's on the pumps and two way valves on all coils except for the coil that is furthest away from the pumps. Once you confirm your valve configuration is correct, check that the static pressure set point controlling your pump VFD's isn't set so high that you are short circuiting past your primary chilled water loop. You can check this by looking at your chilled water temp leaving your chillers and comparing that to chilled water temperature going out on your secondary loop. If you secondary loop chilled water supply temperature is much higher than your primary loop then you may be having issues with this.

____ **Use an HVAC System Night Setback Schedule**

For all HVAC systems that serve non 24/7 areas make sure that night setback controls have been implemented. Work with staff to find out operational hours. Some areas may contain equipment that cannot get too hot or cold, so make sure your unoccupied high & low temp set points are not outside the acceptable limits of all the equipment in the space.

____ **Track HVAC Setback**

Setup trend-logs of your HVAC systems to collect data on whether your systems are actually going into night set back mode. If your system is coming on during the night to either warm up or cool down spaces, look at the unoccupied temperature range of the space to see if it can be adjusted. Also check to see if there is something going on in the space causing the temperature to go out of range.

____ **Exhaust Fan Control**

Make sure for areas that you are using night setbacks that your exhaust fans are shutting down with your other HVAC equipment. If you leave your exhaust fans for bathrooms and other direct exhaust spaces running, you will be drawing in air directly from the outside and that will increase the amount of time and energy it will take for your HVAC system to bring you back to your occupied set points.

____ **Replace Inefficient Motors**

Consider all motors for replacement with NEMA premium efficiency motors. Convenient replacement times include, all new installations, when purchasing equipment packages, instead of rewinding older standard efficiency motors, when doing preventative maintenance or energy conservation programs. Also consider replacing single speed motors with dual speed motors. Consider adding variable frequency drives to any AC motors that could be ramped up or down for different load requirements. If fan speed is reduced to ½ of full load speed, power usage is reduced to 1/8 of full load.

____ **Check Motor Belts**

Checking motor belts for proper tension and alignment can greatly deteriorate the efficiency of power transmission. Replacing standard v-belts with cogged v-belts can increase the efficiency of the power transfer by 2% due to reduced bending resistance. Cogged v-belts can use the same pulleys as standard v-belts. Replacing standard v-belts with synchronous v-belts can increase the efficiency of the power transfer by 3%. The use of synchronous v-belts requires the installation of mating toothed-drive sprockets.

____ **Deploy Operation & Maintenance Programs**

O & M programs targeting energy efficiency can save between 5%-20% on energy bills. In these programs, there are things that can be done in order to be sure that the system is operating efficiently. Some of these items include, calibrating system sensors, air filter replacement, coil cleaning, periodically retro-commissioning equipment, leak detection, oil level monitoring, and verifying the operation of system components.

____ **Install Programmable Thermostats**

Set up thermostat to adjust the space temperature according to the 7 day occupancy schedule. These thermostats should have manual override settings for uncharacteristic weather conditions and off schedule occupancy. The thermostats should be checked periodically to verify the correct settings are in place. This is also a good time to revise thermostat set points. Just lowering the temperature by a few degrees in the winter and raising it by a few degrees in the summer can have a large impact on energy usage.

____ **Replace Pneumatic Sensors with Electronic Sensors**

All room humidistats should be replaced with electronic humidistats that can be tied to into the DDC system. All VAV damper actuators should also be tied into the DDC system, rather than being controlled by pneumatic thermostat. With electronic sensors, all components can be monitored with the DDC system.

____ **Enable Air Side Enthalpy Economizer**

Economizers operate by using OA for cooling when the OA conditions are sufficient to cool the space. In order to determine when to use this strategy, temperature and humidity sensors must be in place outside, in the return air duct, and in the space.

____ **Replace Old Cooling System Components**

Consider replacing old cooling system equipment with new high efficiency equipment, look for equipment that has higher coefficient of performance (COP) than the existing equipment. All air cooled chillers over 100 tons should be replaced with water cooled chillers. In addition to higher efficiency components, add variable frequency drives to the existing pump and fan motors.

____ **Adjust Cooling System Set Points**

Adjust the set point temperatures of the chiller and condenser depending on the OA conditions. When the temperature and humidity are changing outdoors, the chiller and condenser temperatures can be adjusted to conserve energy while achieving the same results. This requires the use of temperature and humidity sensors.

____ **Replace Redundant Systems**

Replace secondary chilled water systems with variable flow primary systems. This idea can be applied to other HVAC systems throughout a building in addition to the chilled water system. Variable flow primary water cooled systems are the most efficient design currently available.

____ **Install a Desiccant Dehumidification System**

Moisture can be removed from conditioned air through the use of desiccants such as LiBr. Desiccants enable independent control of temperature and humidity, improving HVAC efficiency. Desiccant components can be powered by waste hear from a local onsite producer.

____ **Replace Existing DHW Components with High Efficiency Equipment**

Installing new high efficiency domestic hot water (DHW) can greatly reduce energy bills. There are several options available, including EnergyStar, heat pump, and on demand systems. There are also ways to improve the efficiency of the existing equipment. Adding additional insulation to the storage tank of a water heater can reduce stand by losses. Putting insulation on hot water pipes can save money and reduce the amount of wait time for hot water to arrive at the faucet.

____ **Lower the DHW Temperature Set Point**

Reducing the temperature set point will reduce the amount of energy that is lost due to storage. Do not drop the temperature below 120 F to ensure that all water born infections are killed.

____ **Use Effective Boiler Management Techniques**

Operating on high fire settings or installing small boilers can save over 7% of a typical facility's total energy use. Doing comprehensive tune-ups and correcting excessive air losses, high stack temperatures, and excessive smoking can result in fuel savings of up to 20%. Installing insulation on all hot water and steam pipes over 120 F will ensure that excessive heat is not lost in transmission.

____ **Set a Maintenance Schedule for the Boiler**

Periodic maintenance of a boiler should be set in place to ensure that the boiler is operating at the peak efficiency. The peak efficiency can be achieved can be achieved by optimizing the air-to-fuel ratio by using an oxygen trimming system. It is also important to clean the fire side of the boiler and the water side of the boiler, to make sure that there is no buildup of slag and scale to inhibit the transfer of heat. Checking the water quality is also important to limit the buildup of scale.

____ **Install Automatic Steam Trap Monitors**

Malfunctioning steam traps can cause much energy to be lost. By having an automatic monitor up to 16 steam traps can be monitored for malfunction, allowing them to be repaired before a large amount of energy is lost.

____ **Consider Using a Solar Ventilation Preheat for Combustion Air**

Using solar ventilation preheat will decrease the amount of energy needed to heat up combustion air. The solar preheat requires no maintenance and has a quick payback (6-7 years in some cases).

Appendix C, Office Lighting Checklist

Developed with input from the National Renewable Energy Laboratory

____ Replace T-12 Lamps and Magnetic Ballasts with Low Wattage T-8 Lamps and Electronic Ballasts

Spectrally enhanced low wattage T-8 lamps use less energy and produce better quality light than standard T-12 lighting systems. Electronic ballasts with low ballast factors (BF<0.85) can reduce lighting system energy use by as much as 40% and improve light quality. All T-12 lamps and magnetic ballasts should be replaced with spectrally enhanced low wattage T-8 lamps and low ballast factor electronic program ballasts.

____ Replace Standard T-8 Lamps with Low Wattage T-8 Lamps and Low Ballast Factor Ballasts

Spectrally enhanced low wattage T-8 lamps use less energy and produce better quality light than standard T-8 lamps and ballasts. Electronic ballasts with low ballast factors (BF<0.85) can reduce lighting system energy use by as much as 30% and improve light quality. Standard T-8 lamps should be considered for replacement with spectrally enhanced low wattage T-8 lamps and low ballast factor electronic ballasts.

____ Install Perimeter Dimming Ballasts

Dimming electric lights in locations where daylight is sufficient for working purposes can significantly reduce energy use. All lamps and ballast within 10-20ft of the perimeter envelope should be capable of dimming (continuous from 100% to 10%) and connected to a daylight sensor.

____ Install Low Wattage Screw-in Lamps

Compact fluorescent lamps (CFL) and low wattage halogen lamps use significantly less energy for similar light outputs compared to standard incandescent lamps. All incandescent and standard halogen lamps should be replaced with CFL's and low wattage halogen lamps.

____ Optimized Interior Security Lighting

Interior security lighting should be maintained at a minimum of 5 fc during unoccupied times in hallways, and turned off in traditional office space during normal business hours. Non-security fixtures should be controlled by occupancy sensors.

____ Replace Exit Signs with LED Exit Signs

LED exit signs typically use 5 Watts or less, and can save significant amounts of energy when compared to standard incandescent exit signs. All incandescent exit signs should be replaced with LED exit signs which meet building and fire code requirements.

____ Replace HPS/HID Garage Lighting with LED lighting

LED garage lighting can reduce the energy usage of standard garage lighting up to 50%. All HPS/HID garage lighting should be replaced with low wattage LED lighting.

____ Replace Incandescent Recessed Can Fixtures with LED Lighting

LED lighting uses less energy and has dimmable capability and are good retrofit options for recessed can fixtures. All incandescent recessed can fixtures should be replaced with LED lighting.

____ Replace Incandescent Cooler/Freezer Lights with LED Lighting

LED lighting uses less energy and has dimmable capability when compared to standard incandescent lights. All incandescent lamps in coolers/freezers should be replaced with LED lighting.

____ Replace/Install under Cabinet and Task Lighting

Task lighting can reduce the general area lighting requirements and significantly reduce energy consumption. Under cabinet and task lighting should be installed in conjunction with an appropriate reduction in general area lighting.

____ Replace Outdoor Parking and Street Lights

Current LED technologies can reduce outdoor parking/street lights energy consumption by up to 60%. All HPS or HID lamps with magnetic ballasts should be replaced with a low wattage LED lighting system.

____ Install Occupancy Sensors in Bathrooms, Conference Rooms, and Private Offices

Occupancy sensors can significantly reduce light usage during unoccupied times. Occupancy sensors should be installed in all bathrooms, conference rooms, private offices, and other appropriate spaces.

____ Install Central Lighting Controls

Central lighting controls can significantly reduce the operating time of current lighting circuits. Central lighting controls should be installed and commissioned according to the various occupancy schedules.

____ Replace HID Magnetic Ballasts with Electronic Ballasts

Electronic ballasts provide better lumen and color maintenance than magnetic ballasts, and have dimmable capabilities for energy savings. All HID fixtures that currently use magnetic ballasts should be retrofit with lower wattage lamps and electronic ballasts.

____ Reduce Lighting Levels on Over-lit Spaces

Maintain code recommended lighting levels in all spaces. If some areas are over-lit, de-lamp fixtures to reduce the lighting levels and conserve energy.

____ Replace Linear Fluorescent ‘Milky White’ lens with Clear Acrylic Prismatic Lens

Clear acrylic prismatic lens allows more light to pass through with a more even distribution of light. Replace all linear fluorescent ‘milky white’ lens’ with clear acrylic prismatic lens’.

Super T-8 Fluorescent Lamps

Super T-8 Fluorescent Lamps have the same light output as standard T-8 lamps, but they use less energy, last longer, and have improved color rendering. The only disadvantage of Super T-8 lamps over standard T-8 lamps is that they are slightly more expensive.

Appendix D, Building Envelope Checklist

Developed with input from the National Renewable Energy Laboratory

____ Install Additional Insulation in Exterior Walls

Adding insulation to exterior walls can reduce the heat gain or loss through the building envelope and save energy on maintaining comfortable conditions inside of the building. EIFS can be used for exterior insulation. Loose-fill can be used for enclosed existing wall, and hard to reach places. Rigid fibrous insulation is good for ducts in unconditioned spaces or other places requiring insulation that can withstand high temperatures. Sprayed foam and foamed-in-place insulation can be used in enclosed existing wall. Energy savings can be modeled in eQUEST.

____ Seal Areas of Infiltration in Exterior Walls

Using caulk or weather-stripping to seal areas of infiltration can reduce the amount of unconditioned air that enters the building, and save significant amounts of energy. Energy savings can be modeled in eQUEST.

____ Fix Rain Leaks in Exterior Walls

Rain leaks are indications of improper installation of siding material, poor-quality flashing, and weather-stripping or caulking around exterior joints. This can cause a drainage-plane within the wall system f the building and significantly damage the building envelope.

____ Install Solar Shading Features on South-Facing Facades

Installing high-quality fenestration and shading features such as landscape (trees, hedge rows), overhangs or fins, lightshelves, and blinds can save heating/cooling energy as well as save on electrical lighting if designed properly. Shading features should be installed on all South-facing facades. Energy savings can be modeled in eQUEST.

____ Replace Old or Single-Pane Windows

New window technologies can save significant amounts of energy. Old and metal window frames should be replaced with non-metal insulating frames. Old or single-pane windows should be replaced with double or triple-pane glass with insulating gas (argon or krypton). Also, the new glass should be specified based on climate with tints, heat reflective coatings (low-e), or laminates. Energy savings can be modeled in eQUEST.

____ Add Film to Old or Single-Pane Windows

New window film technology can significantly save energy by reducing solar heat gain into the building. Old or single-pane windows should be retrofitted with low-e products or blue/green tints that combine low SHGC with high VLT. Energy savings can be modeled in eQUEST.

____ Install Revolving Doors

Revolving doors reduce the amount of unconditioned air entering the building by a factor of 8, when compared to standard swinging doors. This reduction in infiltration will significantly reduce the energy required for heating and cooling loads. Revolving doors should replace swinging doors where applicable. Energy savings can be modeled in eQUEST.

____ **Create Entrance Vestibule with Two Doors**
Entrance vestibules reduce the amount of unconditioned air that enters the building, and reduces the energy required for heating and cooling loads. Single door entrances should be replaced with two door entrance vestibules. Energy savings can be modeled in eQuest.

____ **Install Weather-Stripping Around Loading Dock Doors**
The irregular surfaces and mounting hardware of rolling doors require heavy duty weather-stripping (vinyl or wood pile, neoprene bulb, neoprene baffle). All loading dock doors should be insulated to reduce heat transfer through the building envelope and reduce energy. Energy savings can be modeled in eQUEST.

____ **Increase Roof Insulation**
Increasing the amount of roof insulation will reduce heat transfer through the building envelope and reduce energy demands. Loose-fill, sprayed foam, or foamed-in-place insulation can be used in unfinished attic floors. Batt or roll insulation can be used in unfinished attic walls and ceilings. Energy savings can be modeled in eQUEST.

____ **Retrofit Existing Roof with Green Roof or Cool Roof**
Retrofitting an Old roof with a green roof or cool roof can save significant amounts of energy. Energy savings can be modeled in eQuest. The following websites can be useful for calculating savings and searching for products:
http://www.ornl.gov/sci/roofs+walls/facts/CoolCalcEnergy.htm
http://www.energystar.gov/index.cfm?c=roof_prods.pr_roof_products
http://www.roofcalc.com/RoofCalcBuildingInput.aspx

Appendix E, Water Conservation Checklist

Developed with input from the National Renewable Energy Laboratory

____ Retrofit Existing Toilets

There are several low cost options for reducing water consumption in toilets. These options include displacement devices, toilet dams, early closure devices, and dual flush adapters. Using these methods, 0.5-2 gallons of water can be saved per flush. Some of these options can be user installed, while others require the assistance of a plumber.

____Replace Toilets

Replace the existing toilets with low-flow (<1.6 gpf) or high-efficiency toilets (<1.28 gpf). Look for the WaterSense classification.

____Retrofit Existing Urinals

- Siphonic jet retrofits – fit flushometer valves with water-conserving parts, and use a timer to stop the flow of water when the building is not occupied.
- Washout/washdown retrofits – add infared or ultrasound sensor activated controls that automatically flush after the urinal is used.
- Blowout retrofits – install timers or sensors to operate the urinals only when the building is occupied.

____Replace Urinals

Replace the existing urinals with low-flow (<1.0 gpf), high-efficiency (<0.5 gpf), or waterless urinals. Look for the WaterSense classification.

____ Retrofit Existing Showerheads

Incorporating flow restrictors, is the most cost effective option available. However, this can result in poor water pressure in some showerheads. The addition of a temporary cutoff valve can be used in order to stop the flow of water during soap application or shampooing. Water is reactivated at the previous temperature.

____ Replace Existing Showerheads

Replace the existing showerheads with low-flow showerheads (<2.2 gpm). This can be achieved with Atomizing, Pulsating, or Aerating showerheads.

____ Retrofit Existing Faucets

Adding flow restrictors, or aerators in the form of a disk or head at the faucet head can greatly reduce the flow rate through the faucet. These are good options for faucets primarily used for washing.

____ Replace Existing Faucets

Replace or repair any faucets that leak. Even slow leaks add up to substantial water usage each year. Several new styles of faucets are available to limit the amount of water usage.

- Metered Valves – deliver a preset amount of water, then shut off

- Self Closing – spring loaded to stay on for a short time only
- Infrared and Ultrasonic Sensors – sensors in the faucet head turn on the flow of water only when an individual is present

____ **Employ Water Efficient Appliances**

Incorporate EnergyStar Water-Consuming appliances whenever possible. Dishwashers and clothes washers are the appliances that use the most water in many cases. Use a dishwasher that reuses water for multiple stages, this not only saves water, but also detergent and rinse additives. Typically, front loading clothes washers use less water than standard upright washers.

____ **Eliminate Single Pass Cooling Systems**

Single pass cooling systems use water to cool equipment, with the water being circulated only once before being dumped. If possible, modify these systems to be closed-loop. If that is not possible, make sure the cooling system is only running during the machine operation. Instruct the machine operators on ways to reduce the machine run time, and look for an additional use for the waste water (i.e. landscape irrigation, cooling tower make-up). When the opportunity arises replace the water cooled equipment with air-cooled equipment.

____ **Reduce Water Consumption from Cooling Towers**

Reducing blow-down is the main way to save water with a cooling tower. This can be achieved by installing covers to block sunlight penetration, treat the water with ultraviolet light, do an acid treatment to control scale build up, filter the sediments from the water using a sidestream, or use ozonation to control scale, corrosion, and biological growth.

____ **Minimize Irrigation Water Use**

Reducing the amount of water used by irrigation systems can save large quantities of water. This can be done by watering only in the early mornings, watering deeply once a week instead of watering lightly each day, adjusting sprinklers to water only landscape (not sidewalks and parking lots), and use a soil moisture sensor (tensiometer) to avoid over-watering.

____ **Select Proper Landscaping**

In addition to minimizing water use, some foresight when designing the landscape can also help reduce water usage. When landscaping one should select climate appropriate plants, reduce turf areas, monitor soil quality, incorporate mulching beds, and setup a proper irrigation system maintenance schedule to check for leaks and broken components.

____ **Procure Irrigation Water from Alternate Water Sources**

Instead of using clean drinking grade water for irrigation, consider getting water from alternative sources such as municipal water reclaim programs, recycled gray water, rainwater harvesting, single pass cooling, condensate, or RO reject water.

____ **Install Efficient Irrigation Systems**

In addition to the previous methods outlined, there are several water efficient irrigation systems that are available that can further reduce the quantity of water consumed. A few of these include the low-volume drip system, sub-surface drip system, and the weather based irrigation system.

Appendix F, Emerging Technologies Checklist

Developed with input from the National Renewable Energy Laboratory

____ LED Lighting

LED lighting is robust (shock resistance), use little energy, have a long life (50,000 hours), are fully dimmable, turn on instantly, and have no infrared or ultraviolet components. Although LED lights are still relatively expensive, the price is expected to go down. There are many applications where LED lighting is applicable, so consideration should be given to LED lighting.

____ Plasma Lighting

Using plasma lighting has many advantages that make it a good fit for a variety of lighting applications. Plasma light bulbs use all benign materials in their constructing, have high efficacy, have a long life (20k – 60k hours), have constant light output over the life of the bulb, had have excellent color rendering. The lights give off a considerable amount of heat, requiring that they be cooled, but take only 20 seconds to heat up.

____Super T-8 Fluorescent Lamps

Super T-8 Fluorescent Lamps have the same light output as standard T-8 lamps, but they use less energy, last longer, and have improved color rendering. The only disadvantage of Super T-8 lamps over standard T-8 lamps is that they are slightly more expensive.

____Scotopic Lighting

Scotopic lighting uses a slightly more blue light than traditional lights to stimulate the eye's photoreceptors in order to make the pupils contract and increase visual acuity. This allows the light levels in a building to be reduced while allowing people to see better.

____Task-Ambient Lighting Design

Task-ambient lighting uses direct-indirect lighting with lower ambient light levels an localized task lights to illuminate a work surface. This method saves energy and also improves occupant comfort. This approach takes experienced designers to be correctly implemented.

____Intelligent Lighting Design Scheme

Intelligent lighting uses a combination of workstation-specific direct-indirect lighting with personal controls where the indirect portion is constant and the direct portion is controlled by the occupant and occupancy sensors.

____Variable Refrigerant Flow System

Variable Refrigerant Flow systems control the amount of refrigerant flow to multiple evaporators throughout a building. Not only does this system save energy, it also improves occupant comfort control, is easy to install, and allows for simultaneous heating and cooling. This technology is beneficial when there are diverse zones that require individual control. Some downsides of the technology include, a relatively high first cost, and poor performance in cold climates.

____Sensible and Latent Energy Recovery Ventilators

Sensible and Latent energy recovery ventilators use heat exchangers between the exhaust and incoming ventilation air in order to precondition the sensible and latent portion of the ventilation air. By using both a heat exchanger and desiccants, a large amount of energy can be recovered from exhausting air.

____Heat Recovery Chillers

Heat recovery chillers are water cooled chillers with condenser water leaving at a temperature in the range of 130 F that can be used for hot water heating applications. This system can be used in any building that has simultaneous hot water heating and cooling.

____Liquid Desiccants with Solar Thermal

This system uses solar thermal energy as the input energy for a liquid desiccant cooling system. The system can be used for both cooling and dehumidification. This system has very low operating costs due to the energy for the desiccant cycle coming from evacuated tube solar collectors, potentially reducing the operating cost to near zero.

____Desuperheater

Implementing a desuperheater can use waste heat from a cooling cycle to heat domestic hot water. This device offers a twofold advantage of improving the cooling efficiency and reducing the amount of auxiliary energy needed to heat hot water.

____Fuel Cells

Fuel cells can be highly advantages for storing electricity that can be used in cases when uninterrupted power is required. With a long life of 40,000 hours, fuels cells are clean, quite, and reliable. Two drawbacks of fuel cells include high initial cost ($3,000-$4,000 / kW) and efficiencies only falling between 40-50%.

____Power-Spar Concentrating Solar

Power-Spar is a parabolic trough solar concentrator that can be used for electricity, heating, cooling, and lighting applications. The main benefit of the system is its versatility. It can be ground mounted, roof mounted, have two axis or bi-directional tracking.

____Power Panel

The Power Panel system is a solar collector that has both a photovoltaic component for producing electricity and a solar thermal component for producing hot water. This is advantageous because the water is used to cool the PV panels, increasing their efficiency while producing hot water. These systems are beneficial to use when there are space constraints on solar collector area.

____Concentrating PV

Concentrating PV uses optics to concentrate sunlight on a small area of solar cells. Most concentrating PV systems use either single or dual axis tracking. These systems are advantageous over traditional solar panels because of higher efficiencies and lower costs associated with them. The market for concentrating PV is still in the developing phase, and there are some reliability issues associated with tracking, but these systems have great potential for growth.

Appendix G, Initial Settings for occupancy/motion sensors in New or Renovated Space

Below are recommended settings for new or renovated areas. The objectives are to initially set up this space to be very user friendly (i.e. minimum false-offs) and to save energy by automatically turning off lights in un-occupied spaces. The below initial settings should help achieve these objectives, but additional adjustments may be needed. A-E or contractor shall submit suggested settings and procedures for review by the VA Energy Engineer. The settings shall be specific to the actual sensors to be installed and to achieve the objectives. VA Energy Engineer will review and provide approval prior to the initial setup of occupancy sensors. Once all spaces are complete and the agreed settings/adjustments are optimized, contact the TVHS Energy Engineer, via the project COR for testing and approval of sensors.

Offices, Conference Rooms, Exam Rooms, etc Ceiling or Wall Switch Occupancy Sensors (Dual Tech) :

- Time: Set to 30 min time-out setting.
- Range: Start by setting at mid-point of range, adjust range as required, based on proximity to supply vents, size of room or other heat type items.
- Light: Set to turn on when ever motion is detected, even in full day light. However, if room is on South face of building, consider use of day light sensing to control lighting. (i.e. if there is enough ambient light, then turn off the lighting.
- US and PIR sensitivity: Set at medium ultrasonic sensitivity, with PIR enabled. Adjust as needed
- Adjust blinders, if needed.

Bathrooms, Ceiling or Wall Switch Occupancy Sensors (PIR): Use non-adapting mode with fixed time-out.

- Time: Set to approx 10 min for time-out. List specific instructions for procedures.
- Range: Start by setting at mid-point of range. Adjust as required, based on proximity to supply vents, toilet location, size of room or other heat type items.
- Light: Set to turn on when ever motion is detected, even in full day light.
- Adjust blinders, if needed for door opening?

Storage Rooms and Clean Utility Room, Ceiling or Wall Switch Occupancy Sensors (PIR only): Use adapting mode.

- Time: Set to 5 minute time-out. Adjust as required, based on proximity to supply vents, size of room or other heat type items.
- Range: Set at min level, adjust as required,
- Light: Set to turn on when ever motion is detected, even in full day light.
- Adjust blinders, if needed.

Larger Admin Spaces, Ceiling Mounted (Dual Tech):

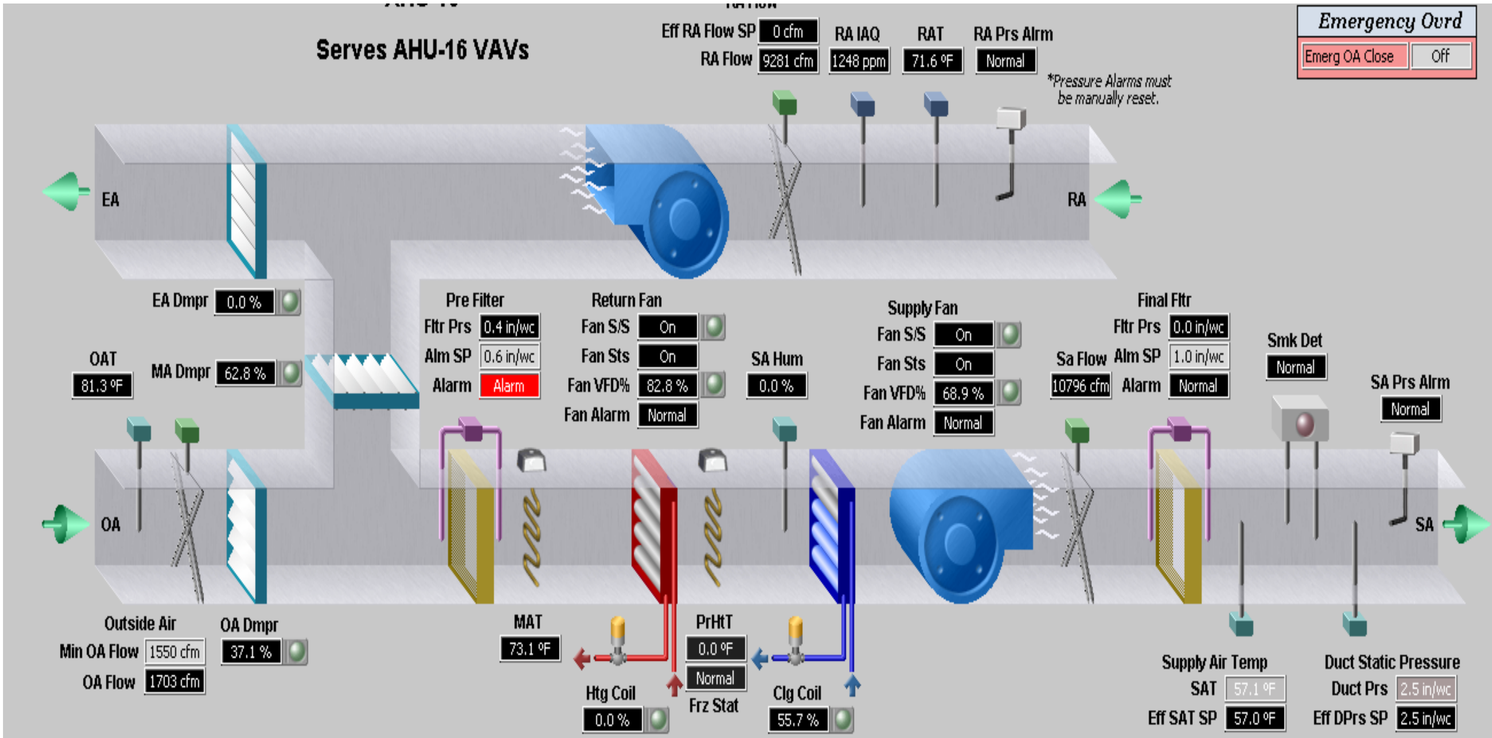
- Ultra Sonic (US) Range: Start with factory default 50%, adjust based on size, layout of space and testing of sensor.
- IR Range setting: Start with factory default 75%, Adjust based on size, layout of space and testing of sensor.
- Delayed off-time, Set at 30 minutes.
- Ambient Light Override: Set to no ambient light override. However, if room is on South face of building, consider use of day light sensing to control lighting. (i.e. if there is enough ambient light, then turn off lighting.
- DIP Switch Settings: Based on specific sensor. Submit for review.

Corridors and Lobby Areas: Ceiling Mounted heads (Single or Dual Tech):

- Design, install and adjust angle of sensors to optimize view of corridor and minimize interference from other areas. Adjust so that foot traffic in other unrelated corridors/areas does not cause lights to come on. Comply with VA Lighting Design Guide and NFPA 101 requirements for emergency egress lighting levels. Also, design and install lighting and sensors to ensure security and egress lighting remain on 100% of time. All others can reduce lighting level or turnoff fixture.
- Ultra Sonic (US) Range: Start with factory default 50%, adjust based on size, layout of space and testing of sensor.
- IR Range setting: Start with factory default 75%, Adjust based on size, layout of space and testing of sensor.
- Delayed off-time: Initial setting of 15 minutes. Adjust as needed.
- Ambient Light Override: no ambient light override.
- DIP Switch Settings: Based on specific sensor. Submit for review.

Stairways: Use LED or T-8 bi-level fixtures. Design, install and adjust angle of sensors to optimize view of stairway and landings and minimize interference from other areas. Adjust so that foot traffic in other unrelated corridors/areas does not cause lights to come on. Design and install lighting and sensors to ensure security and egress lighting remain on 100% of time. All others can reduce to lower light levels.

Appendix H, Example AHU Controls and Graphics



Unit Schedule

Schedule	Occupied
OSS Next Time	12:00 AM
Unoccupied Enable	Off
Last Start	null
Last Stop	null

Unit Status

Supply Fan S/S	On
Supply Fan Sts	On
Supply Fan VFD Speed	68.9 %
Supply Fan Alarm	Normal
MA Damper	62.8 %
OA Damper	37.1 %
EA Damper	0.0 %
CHWV	55.7 %
HWV	0.0 %
Smoke Detector	Normal
Freeze Stat	Normal
Static Prs Hi Limit	Normal

Min OA Control

OA Flow	1703 cfm
Min OA Flow SP	1550 cfm
OA Damper	37.1 %

Economizer Control

Economizer Enable	Off
Econ Enable DB	0.0 ºF
OAT	81.3 ºF
RAT	71.6 ºF
MAT	73.1 ºF
Economizer Signal	0.0 %
OAT Econ Lockout SP	40.0 ºF
Econ Lockout Time	30 min

SA Temp Control

Supply Air Temp	57.1 ºF
Eff SA Temp SP	57.0 ºF
SA Temp Max SP	75.0 ºF
SA Temp Default SP	60.0 ºF
SA Temp Min SP	55.0 ºF
SA Temp Inc/Dec Value	0.0 ºF
SA Temp Reset Delay	5 min
Terminal Load (Max)	-70.2 %
Inc SA Temp @ VAV%	75.0 %
Dec SA Temp @ VAV%	100.0 %
SFan Spd Inc/Dec SP	70.0 %
PreHeat SP	50.0 ºF

Power Fail Mode

Setpoint Pwr Fail Mode	Use Last

*Upon startup resettable setpoints will go to last setpoint or default setpoints

Duct Static Control

Duct Pressure	2.5 in/wc
Eff Duct Static SP	2.5 in/wc
Duct Static Max SP	2.5 in/wc
Duct Static Default SP	1.0 in/wc
Duct Static Min SP	0.5 in/wc
Duct St Inc/Dec Value	0.1 in/wc
Duct Static Reset Delay	5 min
Damper Position (Max)	98.6 %
Dmpr Pos Inc DPrs SP	0.0 %
Dmpr Pos Dec DPrs SP	0.0 %

SF VFD Status

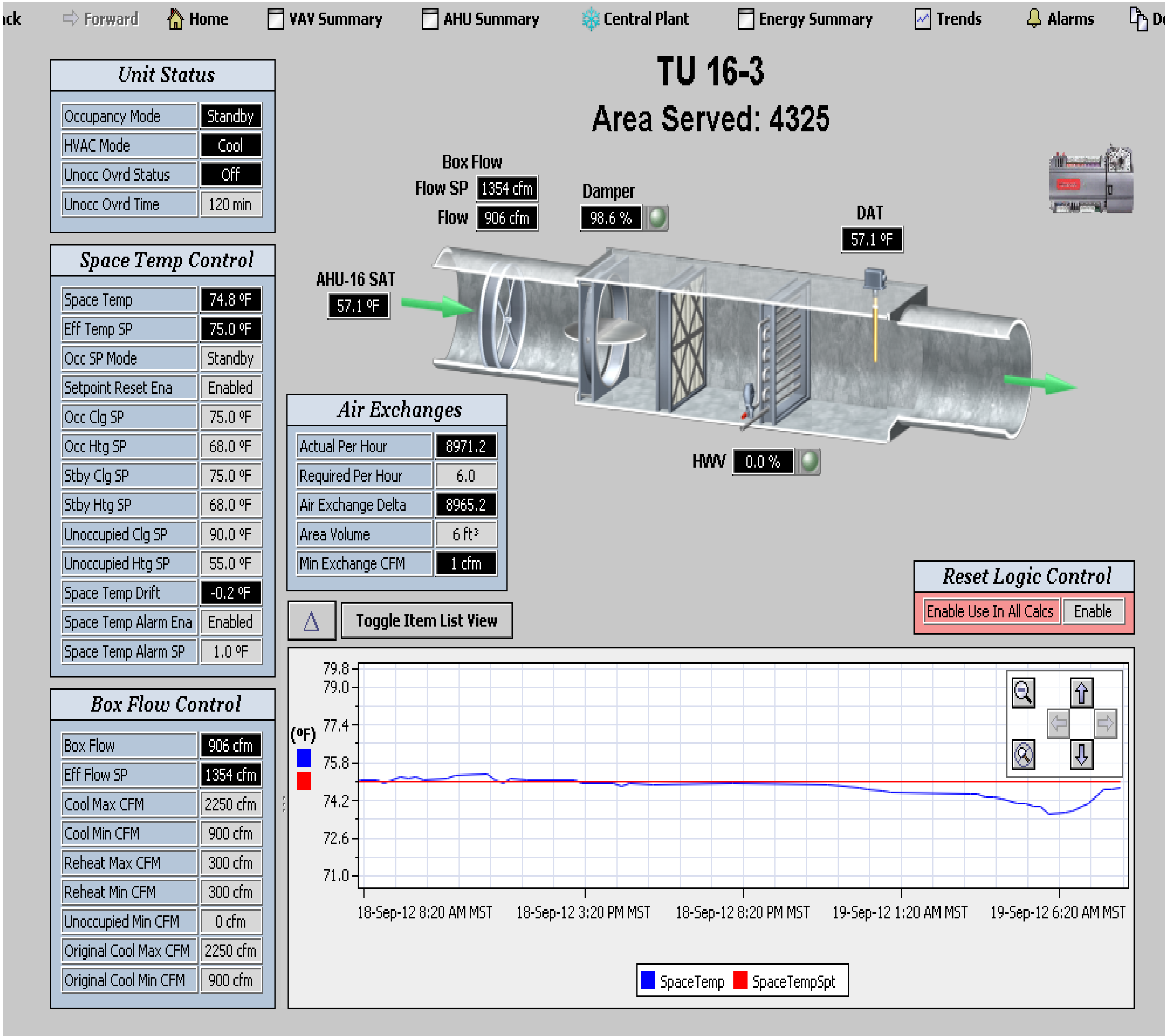
Hand/Auto	AUTO
Current	0.0 A
Current Power	0.0 kW
Total Power	0.0 kW-hr
Alarm	Normal

Return Fan Control

SA Flow	10796 cfm
RA Flow	9281 cfm
Eff RA Flow SP	0 cfm
Eff Offset SP	1550 cfm
Offset Max SP	1550 cfm
Offset Dfault SP	1550 cfm
Offset Min SP	1550 cfm
Offset Inc/Dec Value	500 cfm
Offset Reset Delay	5 min
Bldg Prs	0.02 in/wc
Bldg Prs SP	0.05 in/wc

RF VFD Status

Hand/Auto	AUTO
Current	0.0 A
Current Power	0.0 kW
Total Power	0.0 kW-hr
Alarm	Normal


ck
Forward
Home
VAV Summary
AHU Summary
Central Plant
Energy Summary
Trends
Alarms
Do
TU 16-3
Area Served: 4325
Unit Status
Occupancy Mode Standby
HVAC Mode Cool
Unocc Ovrd Status Off
Unocc Ovrd Time 120 min
Space Temp Control
Space Temp 74.8 ºF
Eff Temp SP 75.0 ºF
Occ SP Mode Standby
Setpoint Reset Ena Enabled
Occ Clg SP 75.0 ºF
Occ Htg SP 68.0 ºF
Stby Clg SP 75.0 ºF
Stby Htg SP 68.0 ºF
Unoccupied Clg SP 90.0 ºF
Unoccupied Htg SP 55.0 ºF
Space Temp Drift -0.2 ºF
Space Temp Alarm Ena Enabled
Space Temp Alarm SP 1.0 ºF
Box Flow Control
Box Flow 906 cfm
Eff Flow SP 1354 cfm
Cool Max CFM 2250 cfm
Cool Min CFM 900 cfm
Reheat Max CFM 300 cfm
Reheat Min CFM 300 cfm
Unoccupied Min CFM 0 cfm
Original Cool Max CFM 2250 cfm
Original Cool Min CFM 900 cfm
Box Flow
Flow SP 1354 cfm
Flow 906 cfm
Damper 98.6 %
DAT 57.1 ºF
AHU-16 SAT 57.1 ºF
HWV 0.0 %
Air Exchanges
Actual Per Hour 8971.2
Required Per Hour 6.0
Air Exchange Delta 8965.2
Area Volume 6 ft³
Min Exchange CFM 1 cfm
Toggle Item List View
Reset Logic Control
Enable Use In All Calcs Enable
(ºF)
79.8
79.0
77.4
75.8
74.2
72.6
71.0
18-Sep-12 8:20 AM MST
18-Sep-12 3:20 PM MST
18-Sep-12 8:20 PM MST
19-Sep-12 1:20 AM MST
19-Sep-12 6:20 AM MST
SpaceTemp
SpaceTempSpt