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Small/Medium-Sized Commercial Building Re-tuning Training

Identifying and Implementing Re-tuning Measures

A PRESCRIPTIVE APPROACH TO RE-TUNING SMALL/ MEDIUM-SIZED COMMERCIAL BUILDINGS

PNNL-SA-92685 4/24/2013 Version 1.1

Small/Medium-Sized Commercial Building Re-tuning: Implementation Phase

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- Based on the findings from the building walk-down prepare an implementation plan for each of the major focus areas. It should:
  - Highlight the current condition and proposed changes to address the current condition
  - Indicate if proposed changes require additional cost to implement the measure
- The following sections will provide the trainer with several “What’s Wrong” slides that provide students the opportunity to interact with the training to come up with solutions to real problems.

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Building Envelope: Implementation

APPLYING PRESCRIPTIVE MEASURES TO THE OUTSIDE OF THE BUILDING

Building Envelope: What's Wrong?

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- What solution do you recommend?

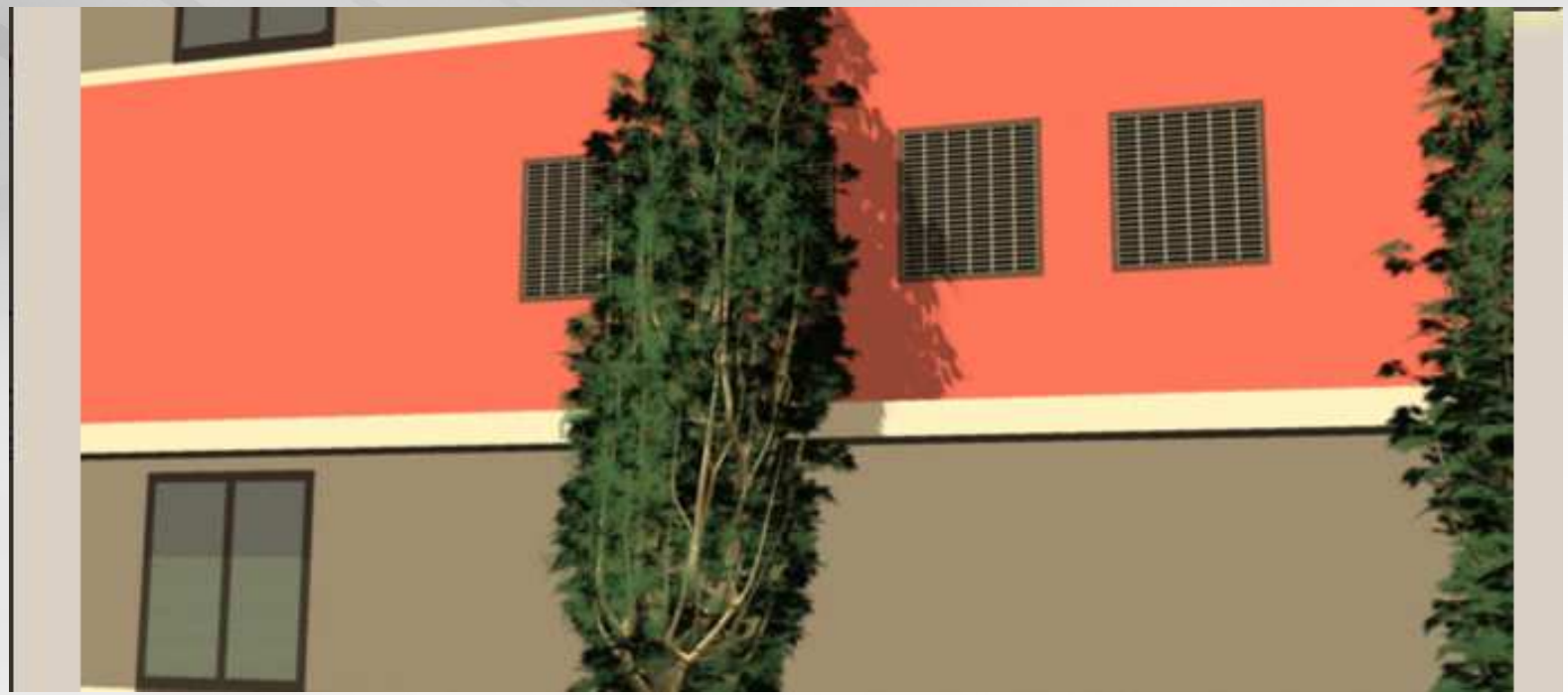
- Solution: Remove and replace the door seal weather stripping!

Building Walk Down: Roll-Up Doors – What's Wrong?

- What's solution do you recommend?

- Solution: The door opening can be integrated to the HVAC system, so if it is open for more than a few minutes, the HVAC unit is turned off
- Make sure the exterior lighting control is working (photocell, timer, etc.)

Building Envelope: What's Wrong?



- What solution would you recommend?
- If it were a building exhaust, would your recommendation be different?

Ans. Trim the bushes or trees away from the grills

Ans. No

Implementation: Exterior Penetrations

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Properly seal any penetrations created by piping (water, gas, electrical, etc.)

Implementation: Exterior Penetrations

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Not properly sealed piping penetrations (water, gas, electrical, etc.) can lead to problems

Implementation: Exterior Wall Penetrations

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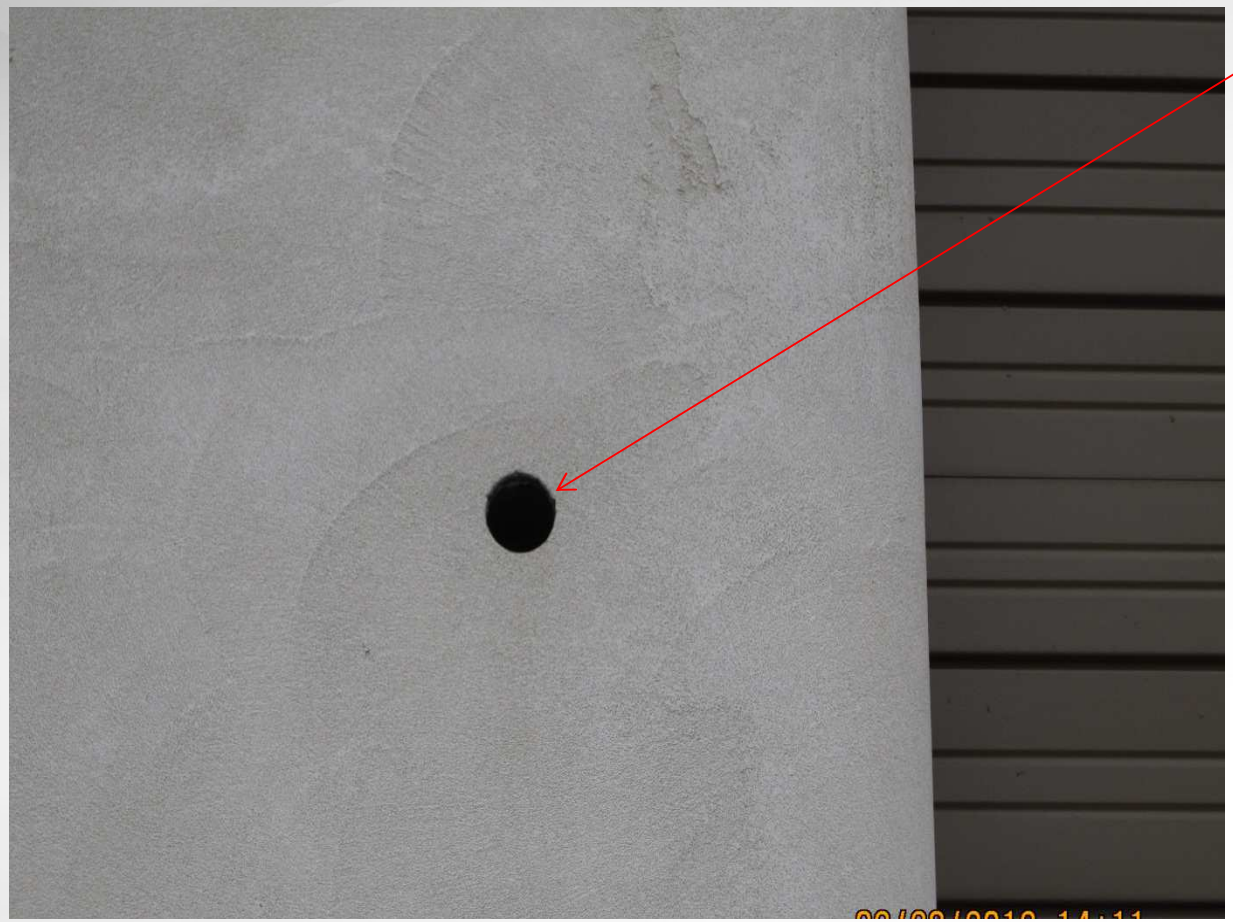
Penetrations created by removal of piping that are not sealed properly will allow air to infiltrate



Piping removal without sealing creates wall opening that allows unwanted outside air to enter into the building

Implementation : Exterior Penetrations

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Penetrations created by installation of new piping that are not sealed properly will allow air to infiltrate

PIPE CHASES FOR PIPING SHOULD BE SEALED ON THE INSIDE OR OUTSIDE (OR BOTH).

Implementation: Exterior Wall Penetrations

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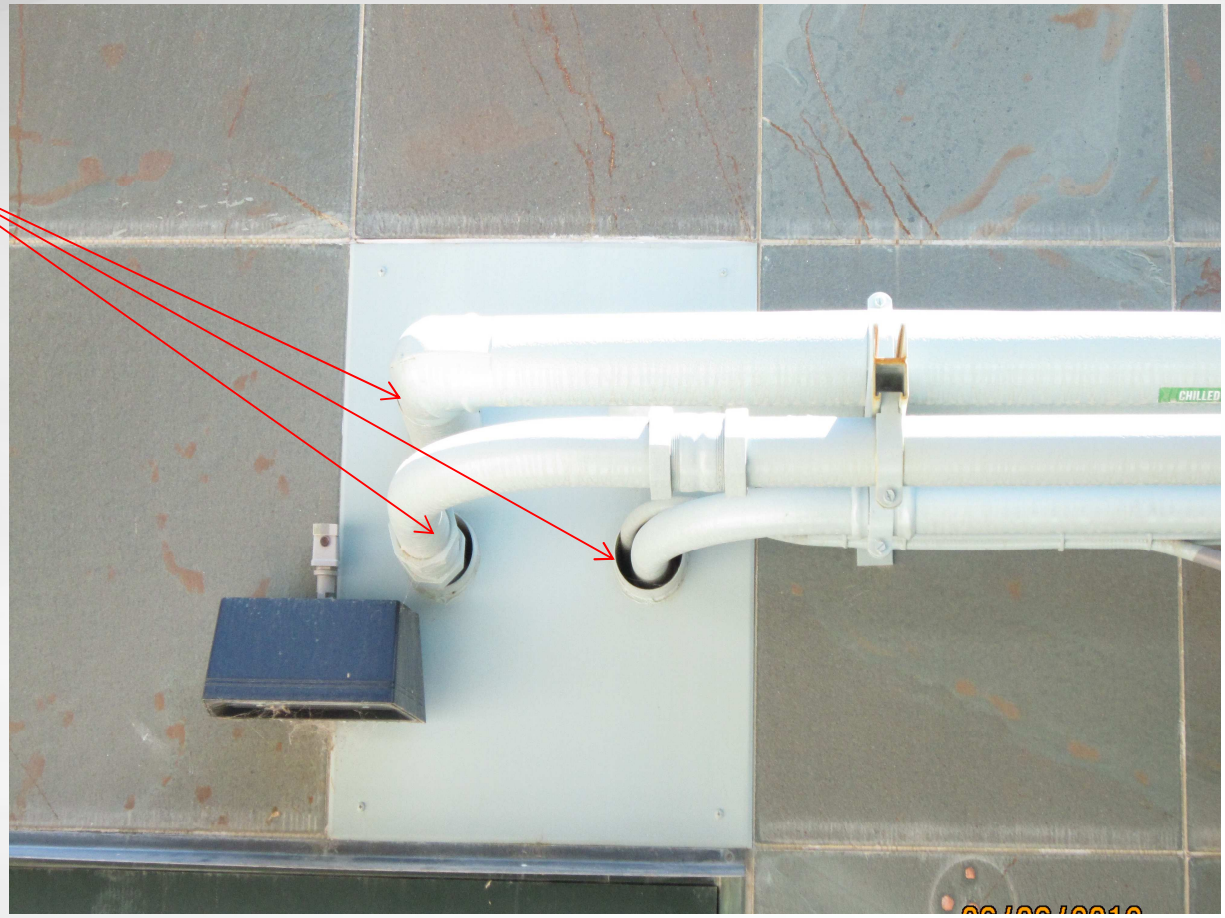
Pipe penetrations often occur from upgrades

Penetrations created by piping (gas, water, electrical, etc.) should be properly sealed

Pipe chases for piping should be sealed on the inside or outside (or both)



Implementation: Clean Roof – White Roof

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Check to ensure that roof is clean. An existing roof that is not white can be updated if the right paint material is applied. If a contractor is used for this effort, this will not be a "No-Cost" effort.

Source:
http://www.greenguidenetwork.com/article-detail/July-22-2010---White-Roofs-Could-Save-U.S.-$735-Million-per-Year-232/
Dec. 11, 2012

Implementation: Building Exterior Plug Loads - Heat Trace

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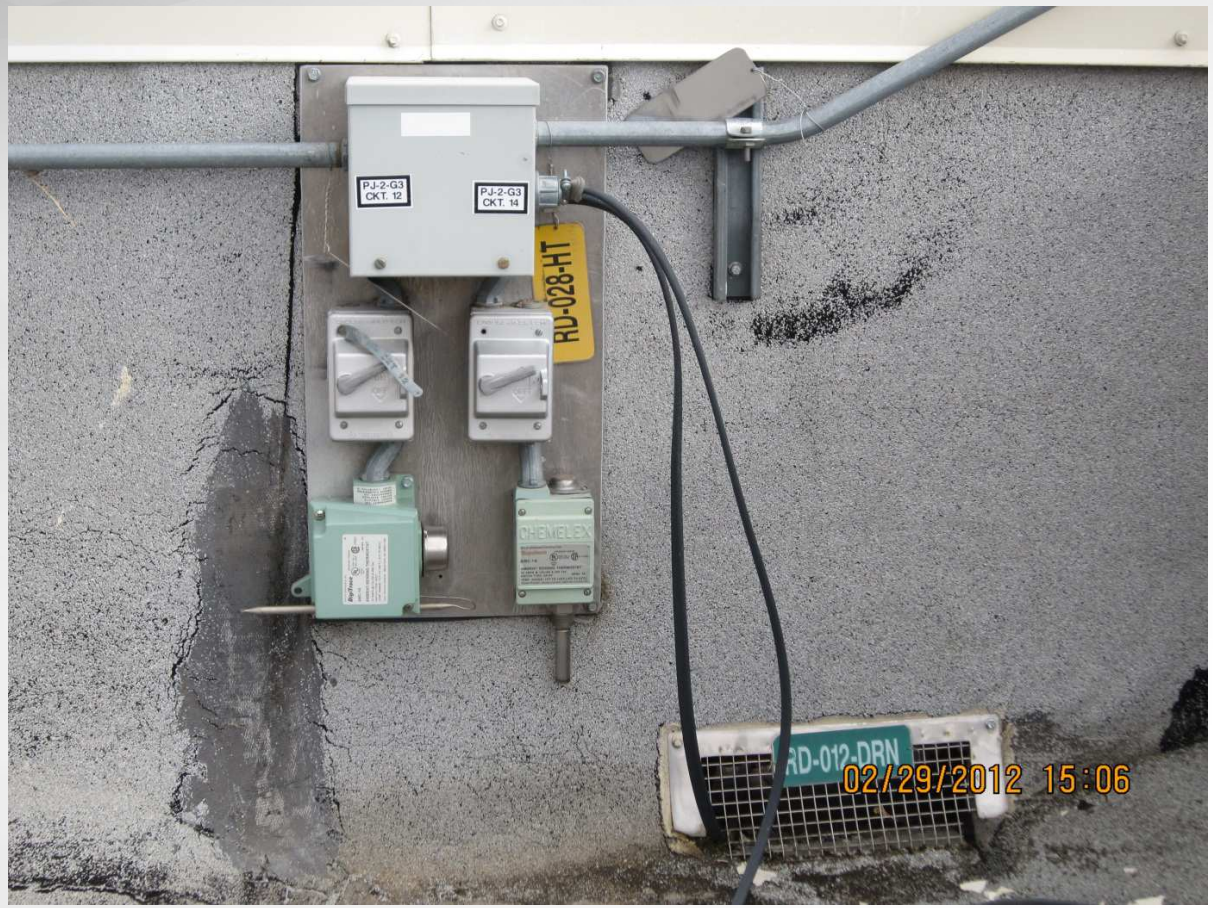
Heat trace should be off when not needed. Heat trace controls should be reviewed seasonally for proper temperature set points and operation



Building Envelope: Exterior Doors - What's Wrong!

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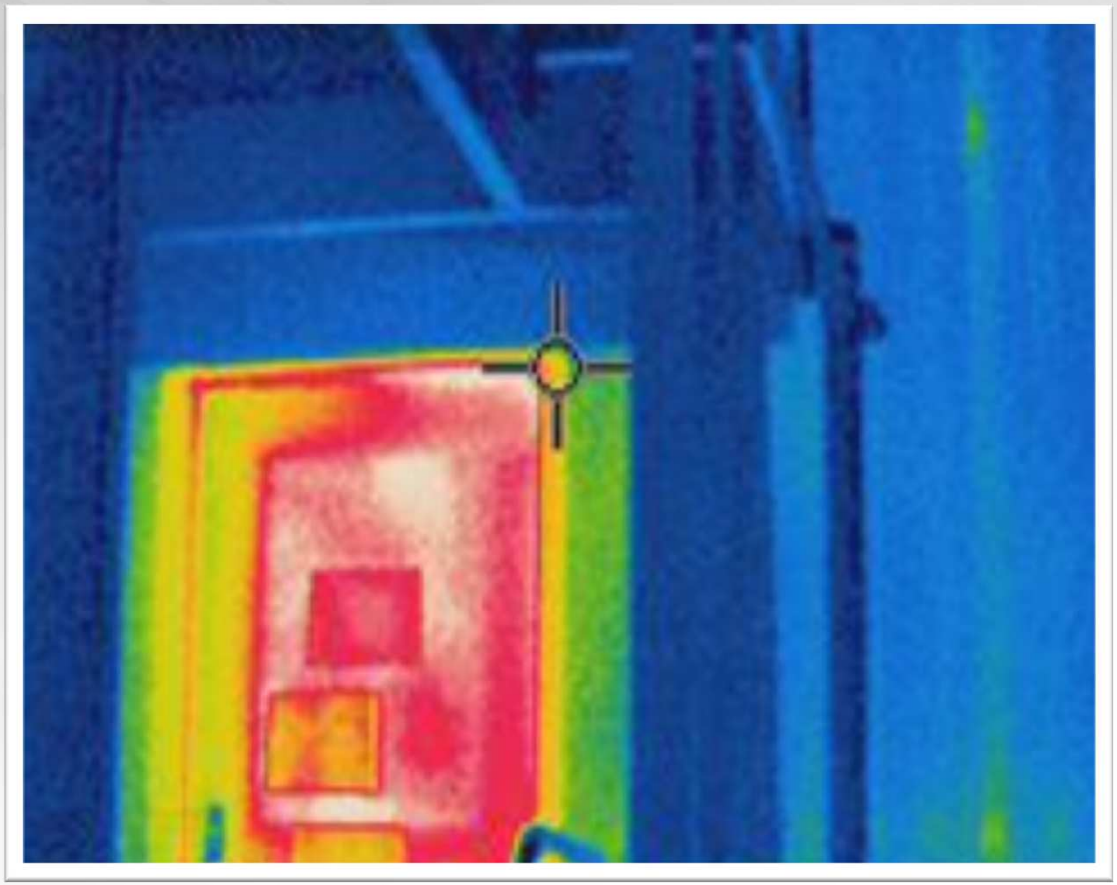
- What should you do?



- Solution: Exterior doors, while not low cost, may need to be replaced and should be considered when existing doors are at the end of their useful life and need to be replaced. Energy-efficient doors should always be considered first.

Building Envelope: Exterior Windows - What's Wrong!

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- What should you do?

- Solution: Exterior windows, while not low cost, may need to be replaced and should be considered when windows are damaged or at the end of their useful life and need to be replaced. Energy-efficient windows should always be considered first.
- The glazing is cracking and peeling and should be repaired.

Small/Medium-Sized Commercial Building Re-tuning: Building Envelope Walk-Down Exercise

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- Exercise
  1. During the building envelope walk-down, what are two things to look for when looking at the doors and windows?
  2. How do you test to see if the heat trace is on in the summer?
  3. Which window is the most energy efficient, a single pane or double pane window?
  4. True or False: Holes in the building envelope are not cause for concern or worth the effort to seal up properly?
  5. View this link to see opportunities that might exist in your home as some or all of these might exist in your building: http://www.energystar.gov/ia/partners/publications/pubdocs/Seal_and_Insulate.pdf?e1c6b233

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Building HVAC: Implementation

APPLYING PRESCRIPTIVE MEASURES TO THE OUTSIDE AND INSIDE OF THE BUILDING

Building HVAC: Implementation- HVAC Economizer Section - Lack of Maintenance

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- Check economizer linkages and damper blades (not loose or broken, intact)
- Check economizer operation
  - Each manufacturer will have a different procedure for checking
  - **Check that during favorable times to economize, the damper is open (partially to fully)**

Building HVAC Implementation: Louvers and Grills

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- Fix louvers
- Clean intake grills

Building HVAC Implementation: Louvers and Grills

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Clean the intake screens on rooftop equipment before they become plugged

Building HVAC Systems Implementation: General Guidance

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- Verify the roof equipment is operational. The power is not on at the disconnect!
- Verify that heat pump defrost cycles are working correctly. Heavily iced outdoor coils will not function correctly.

Building HVAC Implementation: HVAC Economizer Components – What's Wrong?

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- You find a broken outdoor-air damper linkage, making the economizer inoperable!

- Solution: Fix the linkage and make sure the economizer is operating correctly!

Building HVAC Implementation: What's Wrong?

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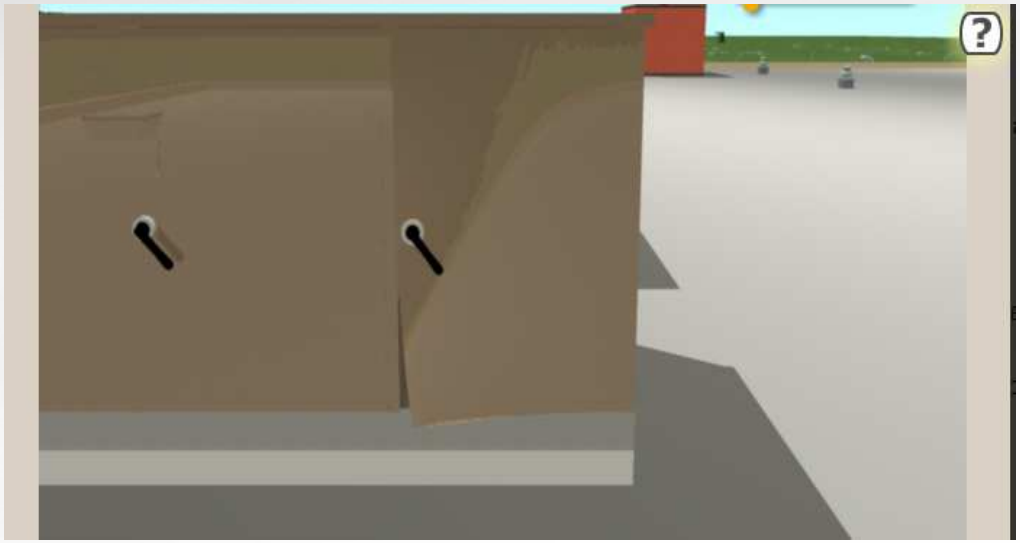
- This maintenance problem has energy implications because the bent panel will cause the system to work harder and longer to condition the building



- Solution: Fix the bent door!

Building HVAC Implementation: Lack of Maintenance

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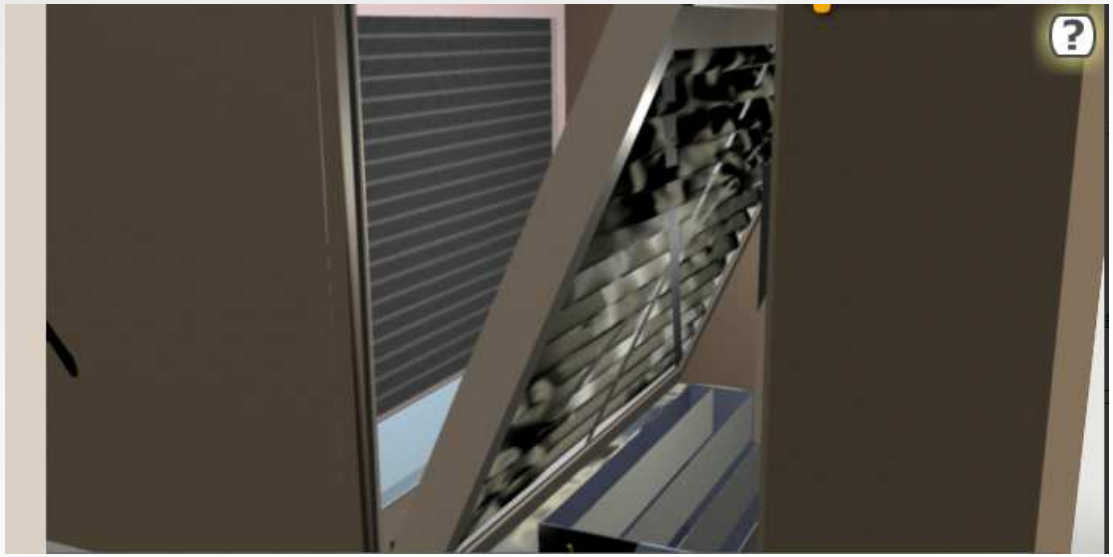
- This maintenance problem has energy implications because the fan must work harder to move air that needs to be delivered to the conditioned spaces



- Solution: Replace the filter!

Building HVAC Implementation: Lack of Maintenance

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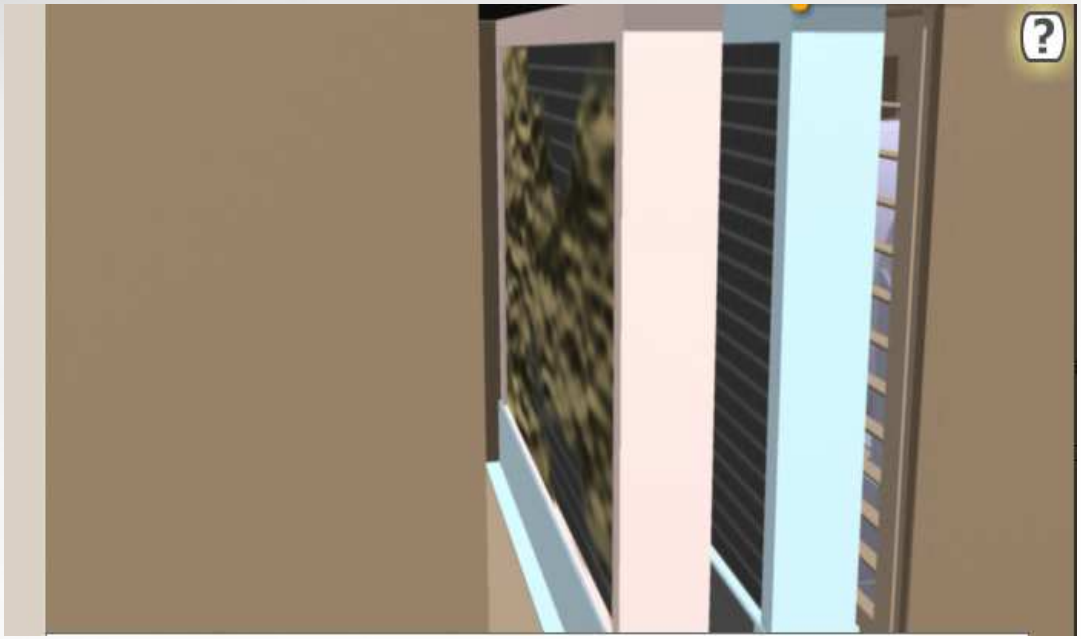
- Dirty and clogged coils can degrade the performance of the unit
- Dirty coils make the refrigeration system work harder and longer to perform the cooling and heating required for the conditioned spaces



- Solution: Clean the coil; in most cases, the coils can be hosed off with water to clean them!

Building HVAC Implementation: Different HVAC System General Guidance Examples

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- Some examples of the packaged units in the field
- Some packaged equipment will have gas-fired heating systems (not electric)
  - Verify that the combustion-air intake is properly configured w/no blockage
  - Verify that the gas pressure regulator is set correctly (trained technician)

Building HVAC Implementation: Thermostats

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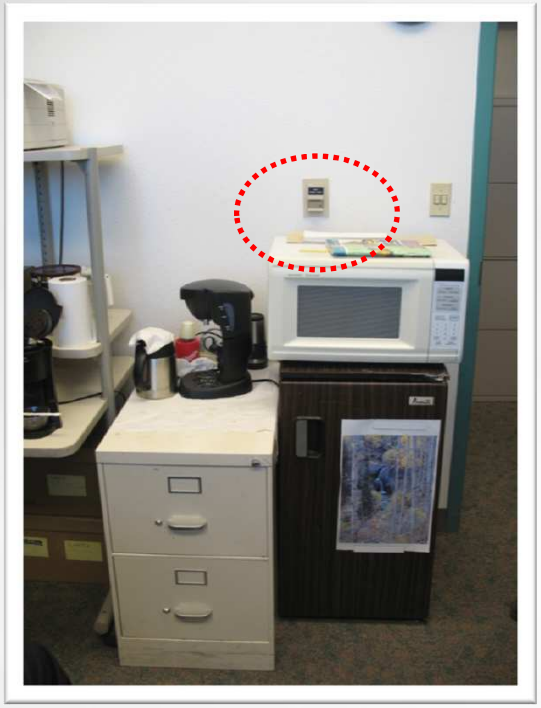
- What's wrong with these pictures?



Building HVAC Implementation: Programmable Thermostat Set Point Scenario

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- The building has a programmable thermostat, but it is not programmed to take advantage of unoccupied setbacks and set ups
- What would you recommend?
- Program the thermostat as follows:
  - Unoccupied heating set point = 65°F
  - Occupied heating set point = 72°F
  - Occupied cooling set point = 75°F
  - Unoccupied cooling set point = 82°F

Building HVAC Implementation: Programmable Thermostat Schedule Scenario

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- The building has a programmable thermostat, but it is not programmed to take advantage of schedules – it can be programmed by day of the week
- What would you recommend?
- Talk to the building occupants/owner/manager and figure out what the typical occupancy is for each day of the week
- Based on discussion with building occupants the building is typically:
  - Occupied from 7:30 a.m. to 6:00 p.m. on Monday through Thursday
  - Occupied from 7:30 a.m. to 5:00 p.m. on Friday's
- No occupancy on weekends

Building HVAC Implementation: Programmable Thermostat Schedule Scenario

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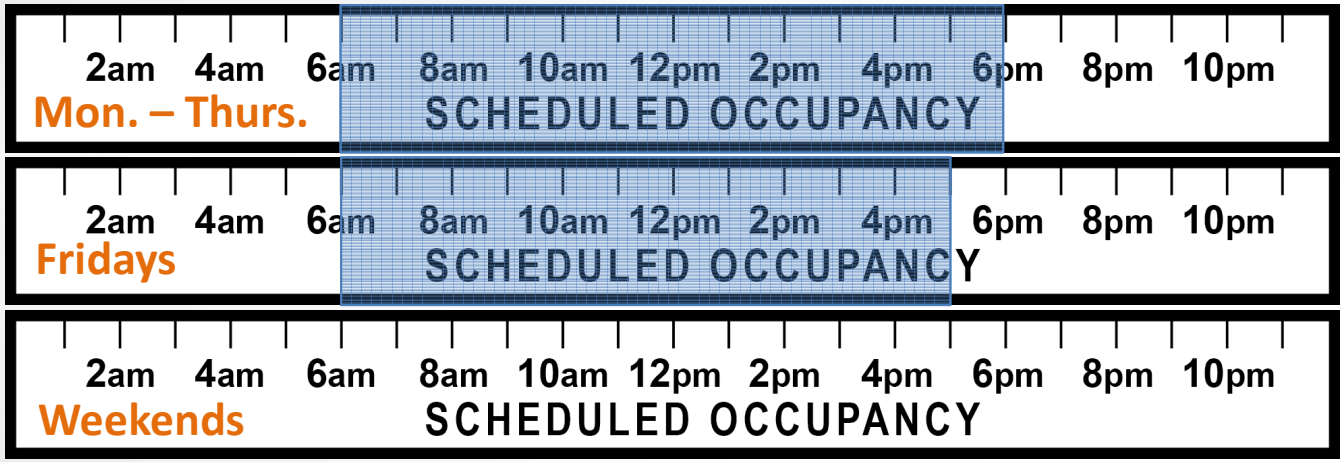
- Program the schedules in the thermostat as follows:
  - Monday - Thursday occupied from 6:00 a.m. to 6:00 p.m.
  - Friday occupied from 6:00 a.m. to 5:00 p.m.
  - Saturday-Sunday unoccupied from 12:00 a.m. to 11:59 p.m.
- If the thermostat has an optimal start capability, then the start times can be configured for later than 6:00 a.m. For example, it can be 7:30 a.m. and the optimal start program will account for earlier starts



Building HVAC Implementation: Programmable Thermostat Schedule Scenario for Heat Pumps

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- If the building has packaged heat pumps with auxiliary electric heat, setbacks can increase a building's electric demand significantly during morning warm up periods as the space warms from unoccupied to occupied set points
- Check to see if the packaged heat pump comes with an independent outdoor air temperature lockout for the auxillary electric heat (some do, some do not). If provided, ensure that the lockout is set at the lowest possible outdoor temperature setting. Most local utilities can advise on this setting
- If the packaged heat pump does not have an independent outdoor air temperature lockout for auxillary electric heat, the programmable thermostat may have this capability (auxillary heat outdoor lockout). If it does, use it
- If it does not, see if the thermostat has multiple scheduling of set points capability. If the thermostat has multiple schedules, consider raising the set point in 2^{o}F increments starting at 5 a.m., 6 a.m. and 7 a.m.
- "Smart" thermostats designed for heat pumps automatically perform the previous function without any additional scheduling (Intelligent Recovery)

Building HVAC Implementation: Programmable Thermostat Set Point Scenario

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- If the difference between the heating and cooling set point is low, for example, 1°F, what should you do?
  - Heating set point - 73°F
  - Cooling set point - 74°F
- Change the set points to:
  - Heating set point - 72°F (or lower)
  - Cooling set point - 75°F (or higher)

Building HVAC Implementation: Programmable Thermostat Fan Operation Scenario

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- The programmable thermostat is set to “Auto Fan,” which means the fan will cycle ON/OFF with the cooling or heating commands.
- Is this an acceptable practice?
- Probably not! Because it may not meet the ventilation code requirements
- Suggest changing the setting to “Fan-On” when the thermostat is in the “Occupied” mode
- Most programmable thermostats support this configuration
- This will increase your electricity consumption, but may also improve comfort and meet the ventilation code requirements
- Putting your thermostat in a “Hold” mode may also increase energy consumption needlessly by always “Holding” the set point and not releasing to the unoccupied settings

Building HVAC Implementation: Exhaust Fans Scenario

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- The building has a large number of exhaust fans that are running 24 hours/day, what can we do?
- If the exhaust fans have time clocks, program them to operate only when needed – when the building is occupied
- If the exhaust fans do not have time clocks, then recommend to the building owner to add time clocks
- If the thermostat has an auxiliary output for exhaust fans and they serve similar areas, consider using the thermostat to control them (Hardwired Interlock)
- In most cases, the pay back for these types of measures will be low, less than 1 to 2 years
- Is the exhaust fan serving a useful purpose anymore (fumes being generated still, abandoned smoking lounges, etc.) or is it simply a legacy to a bygone era?

HVAC Systems Implementation Summary

- Heating and Cooling System
  - Inspect and fix or replace loose fan belts
  - Inspect and adjust sheaves for proper fan operation
  - Inspect and clean dirty fan wheels and dirty coils
  - Inspect and clean condensate drain pan and ensure trap is primed
  - Inspect and secure equipment cabinet doors and panels that are loose
- Economizer
  - Inspect and repair or replace broken dampers or missing seals or missing blades
  - Inspect and repair or replace broken or improperly adjusted damper linkages
  - Verify that outdoor-air dampers are correctly set at their minimum position
- Programmable Thermostats
  - Configure properly for set points and schedules that match occupancy schedules of the building or zone
  - Optimal start in place and not in “Hold” mode
- Gas-Fired Equipment
  - Verify that the combustion-air intake is properly configured w/no blockage
  - Verify that the gas pressure regulator is set correctly (trained technician)

Building HVAC Implementation: Exercise

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1. What are two things that we need to be aware of when verifying the location of existing thermostats (or when preparing to install new thermostats)?
2. Which thermostat has a better chance of saving energy, a programmable thermostat or a mechanical thermostat?
3. If an economizer is not operating correctly, will it affect the energy consumption of a building? If true, what about the comfort?
4. List 3 reasons economizers fail or don't work properly.
5. What are the top 2 reasons that rooftop HVAC equipment is energy inefficient?
6. View this link to see a demonstration of setting up a programmable thermostat's functions: http://www.energystar.gov/index.cfm?fuseaction=vid_gallery.showGenYTVideo

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Indoor Condition: Implementation

APPLYING PRESCRIPTIVE MEASURES TO THE INSIDE OF THE BUILDING

Building Indoor Conditions Implementation: Building Pressurization – What's Wrong?

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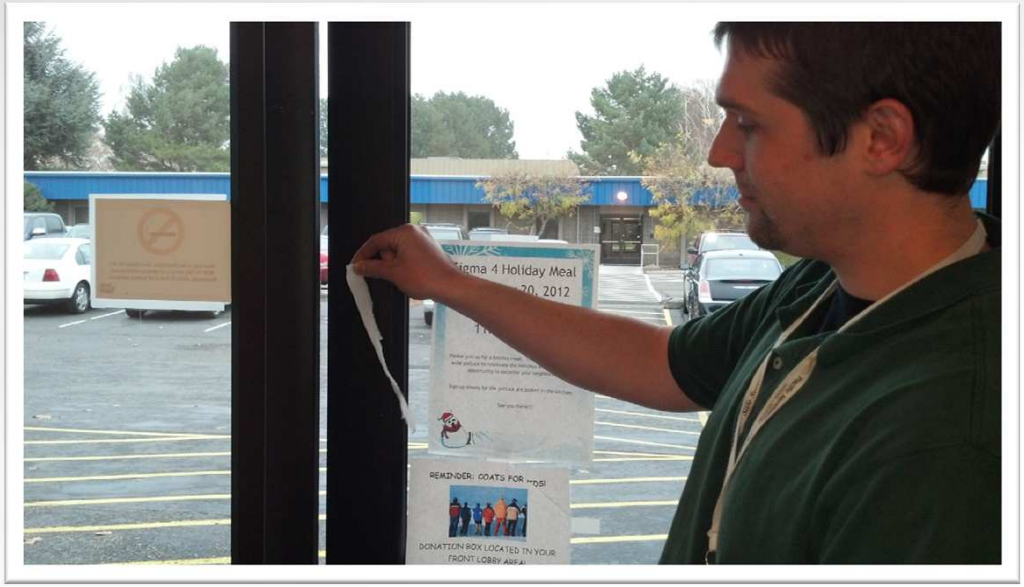
- A small strip of tissue paper is being pulled inward near a gap in the door (or slight opening)



- Buildings should be pressurized to be slightly positive to eliminate unconditioned air from infiltrating into the building. This building seems to be negatively pressurized.
- Side Note: Door gaps indicate a lack of proper door seals and should be fixed.

Indoor Conditions Implementation: Window Management – What's Wrong?

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- The window is open!
- What should you do?

- Solution: Measure the room temperature; if it is too hot or too cold, find out why – it could be air balance problem or excessive heat load
- Is this a security concern for the building?

Indoor Conditions: Implementation
What's wrong with this?

- Partially covered grills or diffusers and space heaters located under a desk are signs of comfort problems
- There may not be a simple solution to this problem
- There are many things that could be the problem when you see occupant efforts to address their own discomfort (e.g., thermostat location, excess air into the space)
- The building may need the HVAC air distribution system balanced to address excess air and air shortage issues

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Lighting Systems and Controls: Implementation

APPLYING PRESCRIPTIVE MEASURES TO THE OUTSIDE AND INSIDE OF THE BUILDING

Lighting Systems and Controls Implementation: What's Wrong With this?

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- You walk into a conference room and find that it is not in use and has not been occupied in a very long time
- What actions might you consider?
- Operable light switch signs (turn off when not in use etc.)?
- Occupancy sensor(s) working?
- Low-cost improvement opportunity for sensors?
- Over-lit (measure light levels)?
- Dimmable lighting measure?

Lighting Systems and Controls Implementation: Outside Lights – What's Wrong With This?

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- Outside lighting
  - You drive by your building at noon and find all the outside lights are burning bright! What should you do to remedy this situation?
  - If the time clock controls are not configured, what should you do to remedy this situation?
  - Inspect and adjust the timer trippers or digital settings
  - If the photo cell is not working correctly, what would you do to remedy the issue? Inspect the photo cell eye and clean if dirty and/or move to better location if necessary

Lighting Systems and Controls Implementation: Outside Lights

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Verify that exterior lighting for building entry points, loading docks and other exterior locations are off during the day. Otherwise, determine the cause and fix.

This photocell is too close to the ground and was covered in dirt, keeping exterior lights on 24/7

Lighting Systems and Controls Implementation: Outside Lights

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Exterior entry or lobby lighting should be off during the day. Determine the cause for the lights being on and fix. This is a common (but easy to fix) problem

Lighting Systems and Controls Implementation: Outside Lights

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What recommendation would make if you found this on a building?

Clean the photocell lens or move the photocell to a better location (too low to the ground and gets dirty easily)

Lighting Systems and Controls Implementation Summary

- Did you find any opportunities to:
  - De-lamp interior lights
  - Replace T-12 lamps with T-8s or T-5s
  - Replace incandescent bulbs with CFLs or light emitting diodes (LEDs)
    - LEDs are especially good for hard to access areas (reduce maintenance cost)
  - Clean fixtures or lamps
  - Reduce exterior lighting
  - Install occupancy sensors
  - Install “Turn off lights when not in use” signs at manual light switches
  - Use photocells for outdoor/indoor lighting controls

Lighting Systems and Controls Implementation Summary

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- Inside lighting
  - Replace T-12 components with T-8 components
  - Replace Incandescent lights with CFLs
  - Group re-lamping & re-ballasting might be considered
  - Clean fixture components during lamp/ballast change
  - Install or upgrade to occupancy/vacancy sensor lighting controls in dedicated offices and similar spaces

Lighting Systems and Controls: Exercise

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1. True or False – Signs used to promote turning lights off help lower energy usage?
2. Which lamps use the most power to provide the same light levels? – T-12, T-8 or T-5
3. True or False – When replacing T-12 lamps with T-8 lamps, the existing ballast can be left in place?
4. True or False – Dirty fixtures reduce the effectiveness of the light fixture?

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Building Hot Water Systems and Controls: Implementation

APPLYING PRESCRIPTIVE MEASURES TO THE INSIDE OF THE BUILDING

Building Hot Water Implementation Summary

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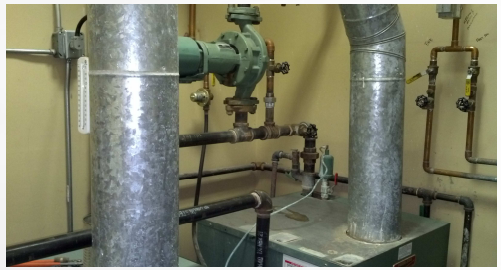
- Look for the following opportunities:
  - Use controls to turn off domestic hot water tanks at night or when not needed
  - Lower the domestic hot water temperature set point (most municipality codes do not allow set points above 125°F for scalding issues)
  - Use controls to turn off heating hot water boiler(s) at night or when not needed
  - Lower the heating hot water temperature set point
  - Use controls to turn off hot water circulating pumps at night or when not needed
  - Insulate tanks and piping
  - Fix leaks
  - Use controls to disable heating hot water systems when outdoor-air temperatures are greater than 50 to 60°F



Small/Medium-Sized Building Re-tuning: Hot Water Systems – Exercise

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1. What is the maximum temperature setting for domestic hot water to mitigate scalding?
2. True or False – Leaks that are found on hot water systems can be ignored?
3. What will happen if hot water lines are not properly insulated?
4. Circulating pumps for domestic hot water systems should be shut off during vacancy periods. Do you know when the building is not occupied?
5. Heating hot water systems can be turned off above what outdoor-air temperature?

Air Distribution Systems: Implementation

APPLYING PRESCRIPTIVE MEASURES TO THE INSIDE OF THE BUILDING

Air Distribution Systems Implementation: Re-Sealing Ductwork

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- If a leak is found, how to repair:
  - Best options for re-sealing sheet metal ductwork is to re-attach the ductwork with screws and re-seal with a UL listed tape or duct sealer
  - Ductwork may need additional support to prevent the ductwork from coming apart again
- For flexible ductwork, there are a couple of options for repair:
  - 1st, remove the damaged ductwork and attach the new piece of ductwork
  - 2nd, splice in a piece of round sheet metal ductwork for the damaged flexible ductwork (need to insulate the piece of round sheet metal ductwork)
  - In both cases, a UL listed ductwork sealing tape should be used
- Fiber board ductwork, also has a couple of repair options:
  - 1st option, replace with sheet metal. (Maybe the most difficult option)
  - 2nd option, replace with fiber board, if the tools are available. (The easiest repair option)
  - Both options will need sealing with an UL listed sealer, and extra reinforcement is generally needed when repairing this type of ductwork

Source
http://www.ductworkinstallation.com/PAQ/DuctworkinBasement/tabid/319/Default.aspx
Dec. 11, 2012

Source:
http://blog.srmi.biz/energy-saving-tips/residential-air-conditioning-aircon-ac/leaky-ducts/
Dec. 11, 2012

Air Distribution Systems Implementation: Re-Sealing Ductwork

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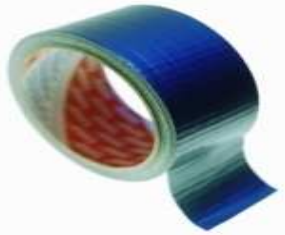
- Tape (UL 181 listed/rated tape) – most of these tapes have a very adequate sticking backing that will allow the tape to stick in a wide temperature and condition range. It also has a thin metal-filmed backed tape design, to provide additional strength.
- Indoor/outdoor rated duct sealer – these sealers are generally painted on with a paint brush or are in a tube of caulk.
- Aerosol ductwork sealant needs to be done by a trained professional. This type of duct sealing is done by spraying aerosol substances down the ductwork, which will stick to the holes in the ductwork and seal any opening, preventing the loss of air.
- **NOT DUCT TAPE** – studies have been done on many different types of tape type duct sealers. The one that failed the quickest was duct tape!



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Small/Medium-Sized Commercial Building Re-tuning Training: Meter Data Profile Analysis

THE HEARTBEAT OF A BUILDING

Small/Medium-Sized Commercial Building Re-tuning: Meter Data Analysis

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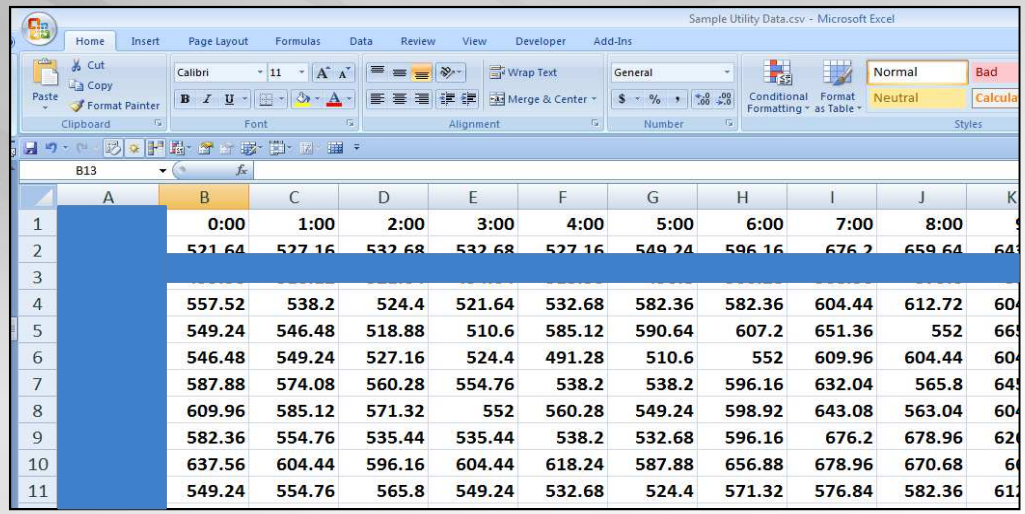
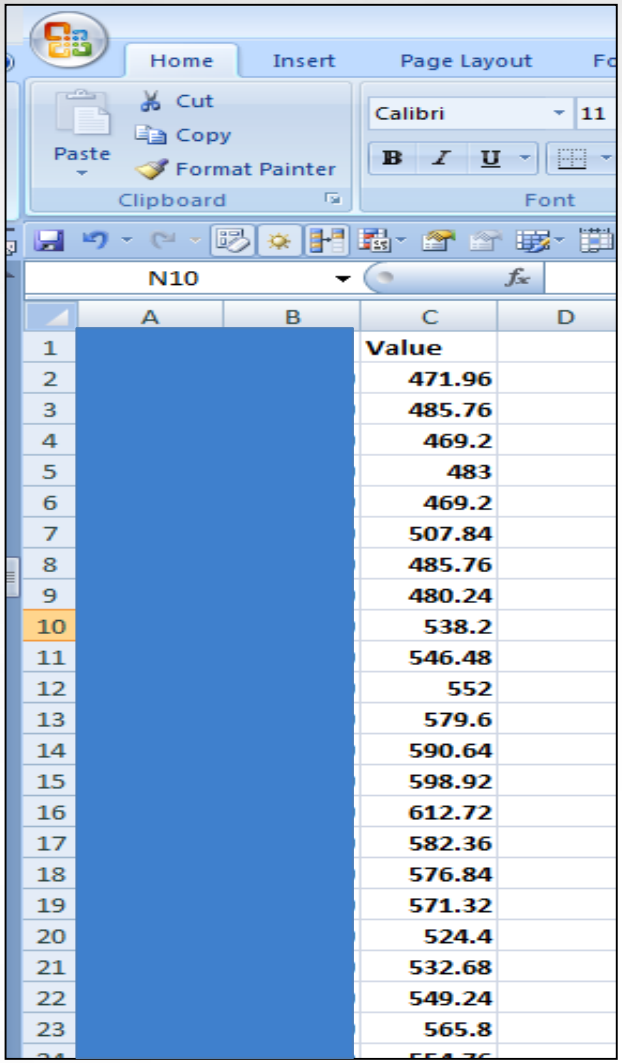
- Meter profiles are like a heartbeat; it should show a variation as the building consumption goes up and down as the demand for services increases
- Periodic review of the meter profile will reveal inconsistent usage
  - However, this requires high resolution data, either hourly or 15-minute
  - Monthly billing data will provide some useful information, but does not show time-of-use of the end use
- Utilities in many regions are installing interval meters that provide high resolution (typically 15-minute) interval data
- Data from the utilities can be downloaded from the utilities' website
  - Data is typically updated daily and up to 12 months of data is typically available online

Meter Data: Format





- Utilities typically provide data in the above format, which need to be converted into a format shown on the right – Energy Charting and Metrics Tool (ECAM) can convert that and also analyze the data for you

  http://www.pnnl.gov/buildingretuning/ecam.stm

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Small/Medium-Sized Commercial Building Re-tuning Training: Documentation Phase and Calculating Savings

Small/Medium-Sized Commercial Building Re-tuning: Documentation Phase

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- Document prescriptive re-tuning measures by cost (no/low-medium-high)
- Select which measures are appropriate for implementation for the building based on:
  - Cost
  - Ease of implementation
  - Return on investment
  - Indoor environmental improvement
  - Safety and security
- Document the selected measures so that calculation and realization of energy savings is possible

Small/Medium-Sized Commercial Building Re-tuning: Estimating Energy Savings

- Post-Re-Tuning: Calculating Energy Savings – Overview of Approach
- Calculated as the difference between the actual energy use in the post-re-tuning 12 months and the energy use that would have occurred during the same 12 months if the building had not been re-tuned.

$$E_{savings,j} = E_{base,j} - E_{actual,j}$$

$E_{savings,j}$ = energy savings for a specific building (j)

$E_{actual,j}$ = actual measured energy use of the building during the 12 months after re-tuning

$E_{base,j}$ = energy consumption of the building during the 12 months after re-tuning if it had not been re-tuned

Small/Medium-Sized Commercial Building Re-tuning: Conclusions

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- Re-tuning is an ongoing process
  - Do it quarterly or at least every six months OR
  - If you see an increase in energy consumption or occupant complaints
- Every set point adjustment you make will have an impact of some sort on the utility meter
- You can save energy and keep staff comfortable
- It takes time to tune a building; there are no magic set points that work all the time
- Look at the big picture when making adjustments
- Learn and know your building's personality
- Basic Energy Management
  - If you do not need it, turn it off
  - If you do not need it at full power, turn it down
  - Make the energy system smart when adjusting to the real needs of the building