FIRST DRAFT

CHPS Best Practices Manual, Volume IV

Maintenance and Operations

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In association with:

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Table of Contents

Introduction

This document is the fourth in the Collaborative for High Performance Schools (CHPS) Best Practices Manual series. It addresses the maintenance and operation needs of high performance schools. High performance school buildings, like automobiles and trucks, must first be designed in a healthy, efficient and sustainable manner. After that, they must be maintained and operated for continued high performance.

The maintenance and operation departments within school districts typically consist of the management staff, the maintenance staff, the custodians, and the groundskeepers. This chapter is targeted more towards the needs of the management staff. The chapters on the building envelope, lighting, HVAC and plumbing are targeted toward the maintenance staff; the chapters on recycling and cleaning are targeted toward the custodians; and the chapters on landscaping and snow removal are targeted towards the groundskeepers. See Table 1 below.

Table 1– M&O Manual Chapters and Their Intended Audiences

Audience	Chapter
Everyone	▪ **Introduction**. This chapter introduces the principles of maintenance and operation for high performance schools, discusses the benefits and __.
Management Staff	▪ **Facilities Management**. This chapter reviews the tools and processes for administering a high performance school facilities program. In includes the role of an energy management system, both at the building level and the school district level and discusses the need for recommissioning, retrocommissioning and periodic audits.
	▪ **Equipment Procurement**
Maintenance Staff	▪ **Building Envelope**
	▪ **Electrical Systems and Lighting**
	▪ **HVAC Systems and Equipment.**
	▪ **Plumbing Systems and Equipment**
Custodians	▪ **Recycling and Waste Management**
	▪ **Cleaning Practices and Products**
Groundskeepers	▪ **Landscaping**
	▪ **Snow Removal and Ice Management**

Anatomy of a Guideline

Most of the material in this document is organized as guidelines. Each guideline addresses the maintenance and operation requirements of a particular system or process. For instance, there are guidelines for instance on how to maintain carpet, how to maintain lighting systems, rooftop HVAC units, and other equipment. Each guideline is organized in a similar manner as described below:

- **Recommendation**: A short summary of the maintenance recommendation (i.e., Spot re-lamp as necessary and group re-lamp at 70-80% of lamp life).
- **Description**: A more detailed explanation of the maintenance recommendation, providing procedure, equipment, and schedule information.

- **Applicable Codes and Standards**: A discussion of building codes and/or standards applicable to this system or building area that staff needs to be aware of, so that any replacement equipment and retrofits do not result in violations.
- **Benefits**: A discussion of the energy, cost, or other environmental benefits associated with this maintenance strategy.
- **Costs**: A description of the costs associated with the maintenance activity, including resulting cost savings (if applicable).
- **Monitoring/Controls**: A discussion of related maintenance activities involving monitoring system controls and/or tracking use of systems.
- **Common Retrofit Opportunities**: An overview of common retrofit needs and opportunities for this equipment or school area. This section addresses both simple equipment replacement opportunities as well as more extensive retrofit possibilities.
- **Verification/Commissioning**: Instructions on what related equipment and systems staff should confirm still operates properly after making a repair to a certain area/system.
- **References/Additional Information**: Information sources referenced in the guideline that can provide additional assistance.

Relationship of CHPS Best Practices Manual Volumes

High performance school buildings – those that incorporate the very best of today's design strategies and building technologies – simultaneously provide better learning environments for our children, cost less to operate, and help protect the environment. CHPS was created to increase the performance of schools by providing information, services, and incentive programs directly to school districts and designers. As part of this effort, CHPS developed a suite of publications that take designers and administrators through the process of planning for, designing, constructing, commissioning, and operating high performance schools:

- *Best Practices Manual Volume I, Planning* – This volume is directed towards school districts and includes detailed information on the advantages, process, and budgeting issues associated with designing high performance schools. A process guide details the questions that districts should ask their design teams.
- *Best Practices Manual Volume II, Design* – Volume II is a set of technical design guidelines written for designers and project managers. It contains information on each building system and provides a variety of detailed design recommendations centered on resource efficiency, daylighting, and indoor air quality. It is intended to be a flexible and complete resource for architects and engineers by including a discussion of application, cost-effectiveness, maintenance, commissioning, and integrated design issues.
- *Best Practices Manual Volume III, Criteria* – Volume III presents the CHPS Criteria, a flexible points system that defines a high performance CHPS School, while managing the regional, district, and site-specific constraints of the design.
- *Best Practices Manual Volume IV, Maintenance and Operations* – The last volume in the Best Practices Manual series, the Maintenance and Operations (M&O) Manual, picks up after planning, design, construction, and commissioning of the school are all complete (see Figure 1). The manual provides guidance for M&O staff, teachers, and administrators, giving strategies for avoiding improper use of building systems and poor maintenance practices that can greatly diminish the energy and cost savings of a high performance school. The topics covered in this manual include cleaning and calibrating building systems, selecting cleaning products, and promoting waste reduction.

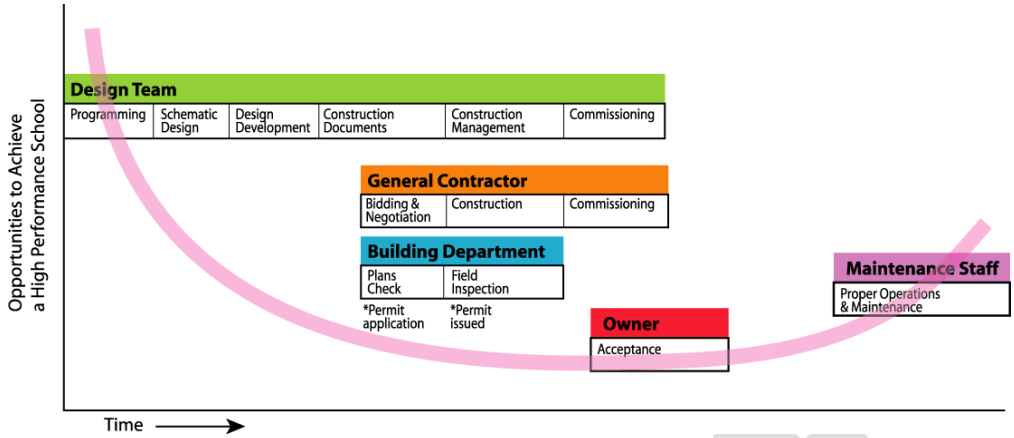

Figure 1 – Efficiency Operation during the School Construction Process

Goals and Cross-Cutting Issues

A high performance school provides a healthy and comfortable environment to its occupants while saving energy and money for the district. But even careful design and construction can only take a school part of the way to its high performance goal. Without specific maintenance and operation follow up, high performance technologies can stop functioning efficiently, high performance ventilation strategies can be foiled by the use of toxic materials or cleaning products, and a lack of training or understanding of maintenance and operation issues can cause classrooms to be less comfortable and healthy than designed. Maintenance and operation for high performance buildings requires planning, communication, and training of maintenance, administrative, and teaching staff.

This chapter discusses the goals of high performance M&O specifically and more in depth – showing how the goals are all affected by M&O practices and procedures. These cross-cutting goals for high performance in schools include:

- Health and indoor air quality (IAQ)
- Thermal comfort
- Visual comfort
- Acoustic comfort
- Security and safety
- Ecosystem protection
- Energy efficiency
- Water efficiency
- Materials efficiency
- Buildings as a teaching tool

In Table 2 below, these goals are cross referenced with the 10 technical chapter topics of this manual, showing how the goals are cross cutting throughout the planning, design, and M&O stages of energy efficient schools.

Table 2 – Relationship Between Goals and Technical Chapters

Technical Chapters	Goals/Cross-Cutting Issues: Health and IAQ	Thermal Comfort	Visual Comfort	Acoustic Comfort	Security and Safety	Ecosystem Protection	Energy Efficiency	Water Efficiency	Materials Efficiency	Building as a Teaching Tool
Facilities Management	●	●	●		●		●			●
Equipment Procurement	●	●	●	●	●		●	●	●	
Building Envelope	●	●	●	●			●		●	●
Electrical Systems and Lighting	●		●		●		●			●
HVAC Systems and Equipment	●	●		●			●			●
Plumbing Systems and Equipment							●	●		●
Recycling and Waste Management						●			●	●
Cleaning Practices and Products	●					●		●	●	●
Landscaping	●					●		●	●	●
Snow Removal and Ice Management					●	●		●		

Health and IAQ

A high performance school should provide superior quality indoor air by eliminating and controlling the sources of contamination, providing adequate ventilation, preventing unwanted moisture accumulation, and implementing effective M&O procedures.

According to the U.S. Environmental Protection Agency (EPA), the concentration of pollutants inside a building may be two to five times higher than outside levels. Children are particularly vulnerable to such pollutants because their breathing and metabolic rates are high relative to their size. Maintaining a high level of IAQ is therefore critical for schools. Failure to do so may, according to the EPA, negatively impact student and teacher performance; increase the potential for long and short-term health problems for students and staff; increase absenteeism, accelerate deterioration; reduce efficiency of the school's physical plant; create negatively publicity; and create potential liability problems.

The best way to prevent your district from having IAQ deterioration is to look for and heed warning signs. Many IAQ issues may not be preventable, but can be handled effectively when staff monitors, is trained, and has enough resources to allow the problem to be identified and addressed in a timely manner.

While the details of IAQ issues can be complicated, more frequently they are straightforward. For example, IAQ investigations often point to expected sources such as a classroom's pet hamster, perfumes worn by students and staff or even allergic reactions to the aloe in tissues and soaps.

When replacing or upgrading materials, select materials that are low emitters of substances such as volatile organic compounds (VOCs) or toxins. Some of these building materials may be unfamiliar to custodial staff, so provide training and select durable products and avoid products that unnecessarily complicate M&O. The following checklist summarizes strategies to improve a school's IAQ.

Health and IAQ Checklist

Eliminate or control contamination at the source

- ✓ *Periodically, inspect ventilation intake vents to ensure that source air is free of pollutants.*
- ✓ *Use recessed grates, "walk off" mats and other techniques to reduce dirt entering the building*

Avoid practices that contaminate indoor air

- ✓ *When replacing or maintaining, use materials that pass the emissions limits in the California Construction Specifications, Section 01350.*
- ✓ *Minimize use of volatile chemicals (in cleaning agents and pesticides), especially while the building is occupied.**
- ✓ *Replace toxic and noxious chemicals with less harmful products as available.**
- ✓ *Store toxic and noxious supplies in areas with adequate exhaust systems, and not near air intake sources.**
- ✓ *Dispose of used cleaning supplies and water-damaged materials immediately and properly (double-bagged in 6-mil polyethylene plastic).**
- ✓ *Ensure adequate make-up air in boilers to minimize backfires and carbon monoxide contamination.**
- ✓ *Seal construction/renovation from occupied areas to minimize air exchange.**
- ✓ *Balance all HVAC systems every five years.*
- ✓ *Periodically test air samples for CO_2 (a sign of poor ventilation), CO (a sign of incomplete combustion), relative humidity (a sign of leaks and moisture problems), and air temperature.*
- ✓ *Sample for microbial growth (e.g., mold) when an IAQ problem is suspected.*

Provide adequate ventilation

- ✓ *Ventilate occupied areas at a minimum rate of 15 cfm/person*
- ✓ *Maintain indoor carbon dioxide between 800 and 1,000 parts per million*.*
- ✓ *Maintain indoor air temperature at comfortable levels (68°-72°F when the room is being heated and 70°-78°F when the room is being cooled).**
- ✓ *Train teachers and administrators about their part in maintaining adequate ventilation – keeping ventilation ducts clear of books and boxes, keeping windows closed during high pollution times, etc.*

Prevent unwanted moisture accumulation

- ✓ *Operate and maintain the ventilation system to keep the indoor relative humidity between 30% and 50%.*
- ✓ *Inspect for and minimize water vapor condensation, especially on walls, the underside of roof decks, and around pipes or ducts.*
- ✓ *Ensure that precipitation is kept out of the building, off the roof, and away from the walls.*
- ✓ *Inspect for water damage and eliminate standing water and elevated humidity.**
- ✓ *Clean, dry, or remove water-damaged materials within 72 hours of wetting.**
- ✓ *Change filters according to manufacturer's instructions. (Filters in high-pollution areas may require more frequent service).**

**Source: Planning Guide for Maintaining School Facilities, U.S. Department of Education and the National Center for Education Statistics*

Thermal Comfort

Thermal comfort is an important variable in student and teacher performance. Hot, stuffy rooms — and cold, drafty ones — reduce attention spans and limit productivity. They also waste energy, adding unnecessary cost to a school's bottom line. Excessively high humidity levels can also contribute to mold and mildew. Thermal comfort is primarily a function of the temperature and relative humidity in a room, but air speed and the temperature of the surrounding surfaces also affect it. A high performance school should ensure that rooms and HVAC systems are designed to allow temperature and humidity levels to remain within the "comfort zone" at all points in an occupied space. Thermal comfort guidelines are provided in the technical chapter on HVAC.

Thermal comfort is strongly influenced by how a specific room is designed (for example, the amount of heat its walls and roof gain or lose, the amount of sunlight its windows let in, whether the windows can be opened) and by how effectively the HVAC system can meet the specific needs of that room. Balancing these two factors — room design and HVAC system design — is a back-and-forth process that continues throughout all the stages of developing a new facility, and continues with proper operation and maintenance.

Though regularly scheduled maintenance and preventative maintenance on HVAC systems is a important part of keeping high performance schools efficiently and effectively, training can be the critical missing link that can determine how thermally comfortable students and teachers feel in a classroom. For example, if teachers don't understand how the ventilation and heating system works, they many times store boxes or books in places that block heat vents – and then bring in energy inefficient space heaters because they are cold.

The following checklist summarizes strategies to improve a school's thermal comfort.

Thermal Comfort Checklist

Install controls and monitor system performance

- ✓ *Install controls in each classroom to give teachers direct control over thermal comfort, and provide training for them so that it is used effectively. Evaluate the potential impact of such controls on the overall efficiency of the HVAC system.*
- ✓ *Consider providing a temperature and humidity monitoring system to ensure optimal thermal comfort performance.*
- ✓ *Consider including temperature and humidity monitoring as part of the building's overall energy management system.*

Create a preventative maintenance plan to help maintain thermal comfort in classrooms

- ✓ *Tune boilers at least annually.**
- ✓ *Inspect all HVAC equipment for moisture, water, air or oil leaks.**
- ✓ *Keep a daily log of pressure, temperature, firing rate, and other data for boilers. Look for variations as a way to determine the need for tube and nozzle cleaning, pressure or linkage adjustments.**
- ✓ *Remove obstructions in front of all heating/cooling units.**
- ✓ *Check ductwork and air handlers for leaks, obstructions, buildup of water or condensation.**

**Source: Preventative Maintenance Checklist, US Department of Energy's EnergySmart Schools, http://www.energysmartschools.gov/energysmartschool/pdfs/checklist.pdf.*

Visual Comfort

Performing visual tasks is a central component of the learning process for both students and teachers. A high performance school should provide a rich visual environment — one that enhances, rather than hinders, learning and teaching — by carefully integrating natural and electric lighting strategies; by balancing the quantity and quality of light in each room; and by controlling or eliminating glare.

Students spend much of their day engaged in visual tasks — writing, reading printed material, reading from visual display terminals, or reading from blackboards, whiteboards, and overheads. They must constantly adjust their vision from a "heads-up" to "heads-down" position and back again. Inadequate lighting and/or glare can seriously affect a student's ability to learn. On the other hand, a comfortable, productive visual environment — one that takes into account more than simply the amount of light hitting the desktop — will enhance the learning experience for both students and teachers.

Visual comfort results from a well-designed, well-integrated, and well-maintained combination of natural and artificial lighting systems. Any strategy for enhancing the visual environment will therefore strongly affect the size and configuration of both these systems (for example, number, type, and placement of windows; number, type, and placement of light fixtures; etc.). The final configurations will, in turn, affect a school's HVAC systems.

An optimized overall design that is maintained properly will provide a high quality luminous environment and will use daylight effectively to reduce the need for artificial lighting. Less artificial lighting means lower electricity bills and less waste heat that, in turn, means less demand for cooling and lower HVAC operating expenses.

The following checklist summarizes strategies to improve a school's visual comfort.

Visual Comfort Checklist

Integrate natural and artificial lighting strategies

- ✓ *Provide controls that turn off lights when sufficient daylight exists.*
- ✓ *Consider dimming controls that continuously adjust lighting levels to respond to daylight conditions.*

Maintain daylighting technologies

- ✓ *If daylighting contributes to lighting, wash windows and/or skylights frequently to maintain illumination levels.**
- ✓ *Clean ceilings, walls, and floors frequently to improve reflective qualities.**
- ✓ *When repainting, consider light-colored pain and panels to help reflect daylighting and electric lighting.*

Maintain lamps and luminaires for optimum efficiency

- ✓ *Wipe lamps clean at regular intervals, and replace all lamps used for area illumination after they have been in service for a substantial portion (approximately 70%) of their rated life, instead of simply replacing lamps one at a time as they burn out.**
- ✓ *Maintain luminaire efficiency by properly cleaning the reflecting surfaces and shielding media.**
- ✓ *Replace lens shielding that has yellowed or become hazy with a clear acrylic lens with good, non-yellowing properties. A clear glass lens can be considered if it is compatible with the luminaire and does not present a safety hazard.**

**Source: Preventative Maintenance Checklist, US Department of Energy's EnergySmart Schools, http://www.energysmartschools.gov/energysmartschool/pdfs/checklist.pdf.*

Acoustic Comfort

Parents, students, teachers, and administrators across the country are increasingly concerned that classroom acoustics are inadequate for proper learning. Noise from outside the school (from vehicles and airplanes, for example), hallways (foot traffic and conversation), other classrooms (amplified sound systems and inadequate sound transmission loss), mechanical equipment (compressors, boilers, and ventilation systems), and even noise from inside the classroom itself (reverberation) can hamper students' concentration.

Trying to hear in a poor acoustical environment is like trying to read in a room with poor lighting: stress increases, concentration decreases, and learning is impaired. This is especially true for younger students (the ability to sort meaningful sounds from noise is not fully developed until children reach their teens); those for whom English is a second language; and those with hearing impairments. Although little consideration has historically been given to acoustic design in classrooms — as opposed to lighting and ventilation — this situation is beginning to change.

The information and tools needed to design and maintain classrooms for high acoustical performance now exist. They can be used to ensure that classrooms provide an acoustic environment that positively enhances the learning experience for students and teachers. And maintenance and operations of these classrooms includes keeping mechanical noise low, maintaining thermal comfort so that windows can be kept closed if noise becomes a problem, and maintaining acoustically superior materials (wall surfaces and ceiling tiles).

The following checklist summarizes strategies to improve a school's acoustic comfort.

Acoustic Comfort Checklist

Ensure a superior acoustical environment

- ✓ *Reduce sound reverberation time inside the classroom.*
- ✓ *Limit transmission of noise from outside the classroom.*
- ✓ *Minimize background noise from the building's HVAC system.*
- ✓ *During repair or renovations, consider acoustically superior materials (ceiling tiles, tackable wall surface, etc.).*
- ✓ *Maintain communication with teachers, since lack of thermal comfort may cause them to open windows and degrade acoustic comfort.*
- ✓ *Maintain HVAC equipment (radiators, fans, etc.) so that they operate efficiently and quietly. During renovation, locate this equipment outside the classroom if possible.*

Security and Safety

Safety and security have become critical concerns for students, teachers, and parents across the country. A high performance school should be a safe and secure environment. Opportunities for natural surveillance should be optimized; a sense of territoriality should be reinforced; access should be controlled; and technology should be used to complement and enhance, rather than substitute for, a facility's security-focused design features.

Crime and vandalism — and the fear they foster — are problems facing school populations throughout the United States. While better buildings alone cannot solve these problems, they can be powerful factors in helping reduce crime and other antisocial behavior. Thoughtful design that builds on basic Crime Prevention through Environmental Design (CPTED) principles is the key.

M&O follow-up for safety concerns will depend on the specific security/safety concerns at each district or school. M&O staff should create a list of security problem areas and then assign inspection and maintenance duties accordingly. M&O staff can create an inspection book for all sites, which should include inspection of fire extinguishers, chemical logs, Material Safety Data Sheets (MSDS), electrical panels, security lighting, and air handler rooms among many others.

The following checklist summarizes strategies to improve a school's safety and security.

Security and Safety Checklist

Increase opportunities for natural surveillance

- ✓ *Maintain landscaping to minimize places that are hidden from view. Ensure that key areas — parking, bicycle storage, drop-off points, play equipment, entries — are easily observable from inside the building.*
- ✓ *Ensure that exterior lighting is operational to facilitate nighttime surveillance. Consider energy efficient lamps.*
- ✓ *Consider exterior lighting on sensors in rural areas where lighting is normally off.*

Reinforce a sense of territoriality

- ✓ *Foster a sense of "ownership" of the school for students and teachers by clearly defining borders — what is part of the school and what is not.*
- ✓ *Consider decorative fencing and special paving treatments to delineate the boundaries of the school grounds.*

Design for easy maintenance

- ✓ *Consider graffiti-resistant materials and finishes.*

Control access to the building and grounds

- ✓ *Consider decorative fencing to control access to school grounds.*
- ✓ *Limit the number of entries to the building. Allow visual surveillance of all entries from inside the school.*
- ✓ *Provide capability to "lock-down" parts of the school when the facility is used for after-hours activities.*
- ✓ *Maintain locking devices responsibly so that keys and combinations are protected.**
- ✓ *Prohibit manipulation of locks and entries (e.g., propping doors open.**

Integrate security technology

- ✓ *Consider incorporating interior and exterior surveillance cameras.*
- ✓ *Ensure that all high-risk areas (office, cafeteria, shops, labs, etc.) are protected by high security locks.*
- ✓ *Consider metal detectors and other security technologies as appropriate.*
- ✓ *Motion sensors for lighting can also provide effective security control.*

**Source: Preventative Maintenance Checklist, US Department of Energy's EnergySmart Schools, http://www.energysmartschools.gov/energysmartschool/pdfs/checklist.pdf.*

Ecosystem Protection

A high performance school protects the natural ecosystem. As much as possible, the school incorporates products and techniques that do not introduce pollutants or degradation at the project site or at the site of extraction, harvest, or production. Give preference to materials that are locally extracted or harvested, and locally manufactured to eliminate potential air pollution due to petroleum-based transportation.

Some of these building materials may be unfamiliar to custodial staff. Avoid products that unnecessarily complicate M&O procedures, and provide training to ensure proper upkeep and ensure full service life. When evaluating materials, be sure to consider their impact on the acoustic and visual quality of a school.

High performance schools are environmentally responsive to the site, incorporating natural conditions such as wind, solar energy, and moisture to enhance the building's performance. Natural features and areas of the site should be preserved; damaged areas should be restored. Take steps to eliminate stormwater runoff and erosion that can affect local waterways and adjacent ecosystems, including overwatering.

Limit the use of fertilizers, pesticides and herbicides, developing instead an integrated pest management plan and using natural fertilizers and compost (leave grass clippings on lawn to mulch and provide nitrogen). Also be responsible with snow removal, not only using environmentally friendly snow removal techniques, but also taking care to store snow in areas that will not kill trees or other harm natural features.

The use of these strategies can help teach students about the importance of protecting natural habitats and the impact of human activities on ecological systems.

The following checklist summarizes strategies to protect a school's ecosystem.

Ecosystem Protection Checklist

Avoid materials that harm the ecosystem

- ✓ *Eliminate materials that harm the natural ecosystem through toxic releases or by producing unsafe concentrations of substances, including fertilizers, pesticides, herbicides, and snow removal substances.*
- ✓ *Eliminate the use of ozone-depleting chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) as refrigerants in all HVAC systems.*
- ✓ *Give preference to locally manufactured materials and products to eliminate air pollution due to transportation.*
- ✓ *Eliminate products that pollute water, air, or other natural resources where they are extracted, manufactured, used, or disposed of.*
- ✓ *Evaluate the potential impact of specified site materials on natural ecosystems located on site or adjacent to the site.*

Preserve and restore natural features and areas on, and near, the site

- ✓ *During construction, develop and implement a construction operations plan to protect the site.*
- ✓ *Develop the site to prevent stormwater runoff and erosion.*
- ✓ *Restore damaged natural areas.*
- ✓ *Maintain connection to nearby natural ecosystems.*
- ✓ *Conserve water by planting native or low-water vegetation, using drip systems and bubblers when appropriate, and never overwatering.*

Energy Efficiency

Energy-efficient schools cost less to operate, which means that more money can be used for books, computers, teacher salaries, maintenance, and other items essential to the educational goals of schools. Energy-efficient schools also reduce emissions to the environment, since energy use is related to emissions of carbon dioxide, sulfur oxides, nitrous oxides, and other pollutants. Smaller air conditioners also reduce the likelihood of ozone-depleting gases escaping to the atmosphere.

Daylighting and Fenestration

Daylighting is the controlled admission of natural light into a space through windows, skylights or roof monitors. A high performance school should use as much daylight as possible, especially in classrooms, while avoiding excessive heat loss, heat gain, and glare.

Access to natural light may be one of the most important attributes of a high performance school. Daylight is the highest quality light source for visual tasks, enhancing the color and appearance of objects. Studies clearly indicate that daylighting can enhance student performance. Views from windows also provide a connection with the natural world and contribute to eye health by allowing frequent changes in focal distance.

Daylighting can also save schools money. Properly designed and maintained systems can substantially reduce the need for electric lighting, which can account for 35% to 50% of a school's electrical energy consumption. As an added benefit, waste heat from the lighting system is reduced, lowering demands on the school's cooling equipment. The savings can be as much as 10% to 20% of a school's cooling energy use. And daylight provides these savings during the day when demand for electric power is at its peak and electricity rates are at their highest.

M&O for daylighting technologies and techniques requires training custodial and M&O staff — who may not have seen or worked with them before. Also, teachers should understand the concepts, so that they do not undermine their effectiveness (by covering up daylighting windows, use overhead lights when task lights are sufficient, etc.). Windows and light ledges, walls, and ceilings should be kept clean and painted in a light, reflective color.

The following checklist summarizes strategies to enhance a school's energy efficiency with daylighting.

Energy Efficiency Checklist for Daylighting

Avoid direct beam sunlight and glare

- ✓ *Maintain interior (shades, louvers, or blinds) and exterior (overhangs, trees) strategies to control glare and filter daylight. Train M&O staff as well as teaching staff on the use of these strategies.*

Design for diffuse, uniform daylight that penetrates deep into the space

- ✓ *Windows should allow daylight to penetrate as far as possible into a room. If light shelves are used (solid horizontal elements placed above eye level, but below the top of the window) to reflect daylight deep into a room, be sure they are kept clean to improve light levels.*
- ✓ *Keep skylights (horizontal glass), roof monitors (vertical glass), light from two sides, and/or clerestory windows clean and operational.*
- ✓ *Consider light-colored ceiling, wall, and floor surfaces to help reflect daylight within the room, and keep these surfaces clean.*

Integrate daylighting with the electric lighting system

- ✓ *Provide controls that turn off lights when sufficient daylight exists. Consider dimming controls that continuously adjust light levels to respond to daylight conditions.*

Electric Lighting

Electric lighting systems interact closely with a school's daylighting and HVAC systems. Daylighting strategies that are well integrated with lighting equipment and controls will reduce the demand for electric light. This decrease in demand, if it is met by a combination of high efficiency electric lighting equipment and controls, can substantially lower a school's electricity usage.

An added benefit: more efficient lighting produces less waste heat, reducing the need for cooling and further reducing operating costs. Cooling equipment can be downsized, resulting in first cost and operating cost savings to the school. These savings are achievable now — in any school — using readily available equipment and controls.

M&O concerns include making sure that efficient lighting is used only when appropriate (when daylighting is not sufficient) and maintained to be efficient.

The following checklist summarizes strategies to enhance a school's energy efficiency with electric lighting.

Energy Efficiency Checklist for Electric Lighting

Specify high efficiency lamps and ballasts

- ✓ *Use "Super" T-8 fluorescent lamps with electronic ballasts for most general lighting applications (classrooms, offices, multipurpose rooms, cafeterias). Consider using T-5 lamps if justified by life-cycle cost.*
- ✓ *Consider dimmable ballasts, especially in daylit rooms.*

Optimize the number and type of luminaires

- ✓ *Consider using a smaller number of higher efficiency luminaires to light specific spaces, resulting in fewer fixtures to purchase, install, maintain, and clean.*

Maintain and operate electric lighting for efficiency

- ✓ *Wipe lamps clean at regular intervals. Lamps that are exposed to substantial amounts of dirt, dust, grease, or other contaminants should be cleaned more frequently than lamps in a relatively clean atmosphere.**
- ✓ *Maintain luminaire efficiency by properly cleaning the reflecting surfaces and shielding media.**
- ✓ *Replace lens shielding that has yellowed or become hazy with a clear acrylic lens with good non-yellowing properties. A clear glass lens can be considered if it is compatible with the luminaire and does not present a safety hazard.*
- ✓ *Clean ceilings, walls, and floors frequently to improve reflective qualities.*
- ✓ *If daylighting contributes to lighting, wash windows frequently to maintain illumination levels.*
- ✓ *Replace* all *lamps used for area illumination after they have been in service for a substantial portion (approximately 70%) of their rated life, instead of replacing lamps one at a time as they burn out.**

Incorporate controls to ensure peak system performance

- ✓ *Use occupancy sensors with manual overrides to control lighting (on-off) in classrooms, offices, restrooms, and other intermittently occupied spaces. Consider scheduled dimming and/or time clocks in other rooms. Periodically inspect these devices to ensure that they are working correctly, and provide training for occupants.*

Integrate electric lighting and daylighting strategies

- ✓ *Treat the electric lighting system as a supplement to natural light. Design for daylighting first and use the electric system to add light as needed during the day and provide sufficient illumination at night.*
- ✓ *Provide controls to dim or turn off lights at times when daylight is sufficient. Consider photoelectric controls that are sensitive to levels of daylight.*
- ✓ *Consider controls that provide continuous, rather than stepped, dimming.*

**Source: Preventative Maintenance Checklist, US Department of Energy's EnergySmart Schools, http://www.energysmartschools.gov/energysmartschool/pdfs/checklist.pdf.*

Building Enclosures

The building enclosure (walls, roofs, floors, and windows) of a high performance school should enhance energy efficiency without compromising durability, maintainability, or acoustic, thermal, or visual comfort. An energy-efficient building enclosure is one that integrates and optimizes moisture control, insulation levels, glazing, shading, thermal mass, air leakage control, and light-colored exterior surfaces. An energy-efficient building enclosure will reduce a school's overall operating expenses and will also help the environment. Many of the techniques employed — high performance glazing, shading devices, light-colored surfaces — are easy for students to understand and can be used as instructional aids.

M&O issues for building enclosures include maintaining the building envelope, so that moisture and air do not infiltrate, which could affect thermal comfort and indoor air quality, and keeping the windows clean and functional, so that light levels and ventilation are maintained at designed levels.

As part of an integrated approach, consider the actions described below.

Energy Efficiency Checklist for the Building Enclosure

Specify high performance glazing

- ✓ *Use glazing that offers the best combination of insulating value, daylight transmittance and solar heat gain coefficient for the specific application.*

Control heat gain and glare

- ✓ *Consider exterior shading devices to reduce solar heat gain and minimize glare.*
- ✓ *Consider using light-colored materials for walls and roofs in order to reflect, rather than absorb, solar energy.*

Control air leakage

- ✓ *Consider air retarder systems (also referred to as "air infiltration barriers") as a means to improve energy performance and comfort.*
- ✓ *Repair broken windows and skylights, consider replacing them with high performance windows.*

Efficient HVAC Systems

A school's HVAC system provides the heating, ventilating and air-conditioning necessary for the comfort and well-being of students, staff, and visitors. To ensure peak operating efficiency, the HVAC system in a high performance school should: use high efficiency equipment; be "right sized" for the estimated demands of the facility; and include controls that boost system performance.

The HVAC system is one of the largest energy consumers in a school. Even modest improvements in system efficiency can represent relatively large savings to a school's operating budget. With the highly efficient systems available today — and the sophisticated analysis tools that can be used to select and size them — there's no reason why every school HVAC system can't be designed to the highest levels of performance.

The key to optimizing HVAC system performance is an integrated design approach that considers the building as an interactive whole rather than as an assembly of individual systems. For example, the benefits of an energy-efficient building enclosure may be wasted if the HVAC equipment is not sized to take advantage of it. Oversized systems, based on rule-of-thumb sizing calculations, will not only cost more, but will be too large to ever run at peak efficiency and will waste energy every time they turn on. An integrated approach, based on an accurate estimate of the impact of the high efficiency building enclosure, will allow the HVAC system to be sized for optimum performance. The resulting system will cost less to purchase, will use less energy, and will run more efficiently over time.

The following checklist summarizes strategies to enhance a school's HVAC system energy efficiency.

Energy Efficiency Checklist for HVAC Systems

Use high efficiency equipment

- ✓ *Specify non-CFC (chlorofluorocarbon)-based refrigerants for systems using large chillers.*
- ✓ *Specify equipment that meets or exceeds the U.S. Department of Energy's "Energy Conservation Voluntary Performance Standards for New Buildings."*
- ✓ *Use ENERGY STAR-approved products.*
- ✓ *Consider recovery systems that pre-heat or pre-cool incoming ventilation air.*
- ✓ *Consider "economizer cycles" for small, packaged systems.*
- ✓ *In hot, dry climates, consider evaporative cooling.*
- ✓ *Investigate the potential for on-site cogeneration.*
- ✓ *Monitor appliances brought in by staff or teachers to be sure they are appropriate, efficient, and safe.*

"Right-size" the system

- ✓ *Consider standard HVAC sizing safety factors as upper limits.*
- ✓ *Apply any safety factors to a reasonable base condition for the building: not the hottest or coldest day of the year with maximum attendance; not the most temperate day of the year with the school half full.*
- ✓ *Select systems that operate well under part-load conditions.*
- ✓ *Monitor existing local systems to size future systems.*

Incorporate controls that boost system performance

- ✓ *Consider integrated building management systems that control HVAC, lighting, outside air ventilation, water heating and building security.*
- ✓ *Consider individual HVAC controls for each classroom.*

Water Efficiency

Fresh water is an increasingly scarce resource in most areas of throughout the country. A high performance school should control and reduce water runoff from its site, consume fresh water as efficiently as possible, and recover and reuse gray water to the extent feasible.

Basic efficiency measures can reduce a school's water use by 30% or more. These reductions help the environment, locally and regionally. They also lower a school's operating expenses. While the cost savings may be modest now, since water is relatively inexpensive in most areas of the country, there is a strong potential that these savings will rise over time, especially in areas of California where water is scarce and becoming more expensive.

M&O issues that apply to water conservation include inspecting for leaks and moisture throughout the plumbing system; ensuring that sprinkling systems and drip irrigation systems are operating and not overwatering; maintaining landscaping as, or upgrading to be, native species or drought-tolerant; and inspecting other water efficient technologies and equipment like low-water faucets and waterless urinals. Training may be required if custodial staff and/or M&O staff have not worked with this equipment before. For example, to repair or maintain low-water sensor faucets, knowledge of electrical issues may be required instead of plumbing issues.

The following checklist summarizes strategies to promote water efficiency.

Water Efficiency Checklist

Design landscaping to use water efficiently

- ✓ *Reduce water use.*
- ✓ *Consider innovative wastewater treatment options.*
- ✓ *Plant hardy, native vegetation.*
- ✓ *Consider using an irrigation system for athletic fields only, not for plantings near buildings or in parking lots.*
- ✓ *Use high efficiency irrigation technology (e.g., drip irrigation in lieu of sprinklers).*
- ✓ *Use captured rain or recycled site water for irrigation.*
- ✓ *"Design in" cisterns for capturing rainwater.*

Set water use goals for the school

- ✓ *Recommended goal: 20% less than the baseline calculated for the building (not including irrigation) after meeting the Energy Policy Act of 1992 fixture performance requirements.*

Upgrade to and/or maintain water-conserving fixtures and equipment

- ✓ *Monitor for leaks around plumbing fixtures and make timely repairs.*
- ✓ *Specify water-conserving plumbing fixtures that exceed Energy Policy Act of 1992 requirements.*
- ✓ *Specify high efficiency equipment (dishwashers, laundry, cooling towers).*
- ✓ *Consider single temperature fittings for student toilets/locker rooms.*
- ✓ *Consider automatic lavatory faucet shutoff controls.*
- ✓ *Consider low-flow showerheads with pause control.*
- ✓ *Consider drip irrigation for applicable landscape watering needs.*
- ✓ *Train staff on appropriate use of water-conserving technologies and equipment.*

Consider using and or maintain recycled or rainwater for non-potable uses

- ✓ *Decrease use of potable water for sewage conveyance by using gray and/or black water systems. Opportunities include toilet flushing, landscape irrigation, etc.*
- ✓ *Consider on-site wastewater treatment, including full or partial "solar aquatics" systems on large sites.*
- ✓ *Possible applications include HVAC and process make-up water.*

Materials Efficiency

Material efficiency in this manual refers specifically to two overarching goals: 1) waste reduction — including construction and demolition (C&D) source reduction, reuse, and recycling; and 2) the use of building products that are manufactured in ways that conserve raw materials, including the use of recycled content products, that conserve energy and water, that are reused or salvaged, or that can be recycled or reused at the end of the building's service life. Addressing these goals provides significant environmental benefit. According to WorldWatch, buildings account for 40% of many processed materials used (such as stone, gravel, and steel) and 25% of virgin wood harvested. These withdrawals can cause landscape destruction, toxic runoff from mines, deforestation, biodiversity losses, air pollution, water pollution, siltation, and other problems.

The checklist below summarizes key material efficiency strategies. When considering recycled content products or other materials-efficient products, be sure to consider their effect on acoustic, visual, and indoor air quality. Be aware that using certain recycled products may conflict with goals for long-term materials efficiency, since a product's recycled composite may be difficult to recycle. Avoid products that unnecessarily complicate M&O procedures, and be sure that the custodial staff receives training in proper upkeep of the products. Using these strategies can help teach students about the role of waste reduction in protecting the environment.

Material Efficiency Checklist

Maintain recycling areas

- ✓ *Make it easy for staff, teachers and students to recycle by keeping recycling collection areas convenient and clean. Provide training/instructions for what recyclables go into which bins.*

Reduce the amount of construction waste going to landfills

- ✓ *Develop and implement a management plan for sorting and recycling construction waste.*
- ✓ *Consider a goal of recycling or salvaging 50% (by weight) of total construction, demolition, or land clearing waste.*

Specify salvaged or refurbished materials

- ✓ *Evaluate the potential impact of salvaged materials on overall performance, including energy and water efficiency, and M&O procedures.*

Maximize recycled content of all new materials

- ✓ *Use EPA-designated recycled content products to the maximum extent practicable.*
- ✓ *Use materials and assemblies with the highest available percentage of post-consumer or post-industrial recycled content.*
- ✓ *Set a goal to achieve a minimum recycled content rate of 25%. (See Volume III for more information.)*

Eliminate materials that may introduce indoor air pollutants

- ✓ *Use materials or assemblies with the lowest level of volatile organic compounds (VOCs).*
- ✓ *Evaluate the potential impact of specified materials on the indoor air quality of the school.*

Choose materials that were made sustainably and that resist vandalism or destruction

- ✓ *Consider high impact wallboards with special laminates that are resistant to vandalism/destruction, and that minimize the need for replacement and/or cleaning with toxic chemicals.*
- ✓ *Consider flooring and carpeting that require only soap and water to clean instead of chemical cleaning.*
- ✓ *Use quality white boards that do not require chemicals to clean.*

High Performance M&O—Issues and Opportunities

In some ways, providing M&O services for high performance school buildings is no different than for traditional buildings – ensuring that all systems and equipment in the school operate efficiently to provide the best educational experience possible.

However, M&O for high performance schools should differ in several significant ways. First is an understanding of the facility as a whole system, working interactively, rather than a collection of independent systems. This way of looking at school systems is the only way that energy efficiency, water efficiency, and materials efficiency can provide superior comfort for occupants and be cost effective for the district.

For example, especially in large school districts, if staff maintaining and repairing HVAC systems don't understand daylighting or passive heating concepts and don't work with custodial staff responsible for maintaining efficient lighting levels, efficiency can go down, and electricity costs can go up. This manual covers these issues and should be an effective tool for maintenance planning.

A second requirement for high performance M&O is a preventative maintenance program. Though many districts struggle to find the resources to address preventative issues, it is critical to meeting high performance goals – and converting your workforce to addressing preventative concerns eventually minimizes emergency calls.

Purchasing the right equipment and materials is also important – with an understanding of which are the most appropriate and most sustainable. For example, when it is time to replace a 30-year-old gravel roof, consider replacing it with a cool roof—taking into consideration that when the HVAC system needs replacement it can be downsized. When creating budgets and maintenance plans, consider that making some of these replacements make require more capital expenditure up front, but eventually should result in lower electric bills.

Finally, one of the biggest issues for high performance M&O, one that is often overlooked, is training. M&O staff, custodial staff, and staff all need various levels of understanding of the unique technologies and equipment in a high performance school as well as the interdependence of the systems and how they work together. With remodels and upgrades and new facilities, M&O staff are ideally involved in the design phase.

Specifically, some of the high performance M&O issues and opportunities discussed in this manual include:

- ***Physical Building Constraints*** – Physical building constraints can prevent efficient M&O at schools. For new facilities and remodeling, custodians/M&O staff should be part of the design phase. Some of the most sustainable products may not work for a particular site, and M&O staff can often provide valuable insight about the districts in which they have been working for years. For example, some sustainable designs might not be effective in urban setting where vandalism is common. Also, practical concerns to make M&O more efficient, such as the need for custodial closets in strategic locations, are often overlooked by designers and administrative staff.
- ***Equipment Constraints*** – Equipment constraints to high performance M&O can be reduced by tracking trouble calls, maintenance costs, and operational consumption. This will allow staff to estimate life cycle costs for equipment throughout the facility and determine when it is economically appropriate to replace rather than maintain the equipment, from light bulbs to HVAC equipment.
- ***Occupant Behavior Constraints*** – Occupants can be one of the biggest constraints to high performance M&O. Staff, teachers, and students may need training to know how to occupy a high performance classroom, and a communications effort is necessary to convey the mission of why changes are necessary. If occupants don't understand the benefits of sustainable design, they can easily override the thermostats, cover air ducts, and bring in appliances that are not energy efficient. Also, high performance upgrades and design can not be made in a vacuum – in one district when a

cool was installed, administrative staff in offices above the roof complained about glare, requiring the replacement of their windows.

- ***Lack of Knowledge/Organization Constraints*** – Lack of knowledge about M&O issues and lack of organization within M&O departments can also limit the efficiency and effectiveness of facilities. Without an organized way to predict and forecast M&O problems in districts, it is difficult for staff to make a case for additional resources and money from the administration. Some districts use a computer maintenance system that can model replacement costs in the short- and long-term. Software is available to help pull systems apart and write preventative maintenance plans, automatically printing work orders to the correct staff members. Though time is a major constraint for every district, a high performance M&O staff can find creative ways to address preventative issues, such as doing inspections and preventative repairs on air conditioning units while fixing a belt, for example. Other districts have funded better tools and training programs by using a portion of the rebates/savings from energy efficiency.
- ***M&O Costs and Funding Shortfalls*** – M&O costs and funding shortfalls is an obvious constraint to high performance O&M issues in most districts. Overcoming this constraint is difficult; districts have to use the technology and tools that are available to them to make more efficient use of staff time and resources. M&O staff training and retention can make the difference between successful and unsuccessful maintenance programs. Skilled staffs that are cross trained, more knowledgeable of systems and components, and that have a better understanding of how to address problems will be the most successful in operating and maintaining high performance schools.
- ***School Board Support Constraints*** – Without school board support, the ability to build, operate, and maintain a high performance school is limited. School board support is critical, and should be more than just passing a resolution. To be successful, the whole organization has to be committed to sustainability and high performance goals from the information technology department to the fleet manager.

How to Achieve High Performance M&O

Develop an organized maintenance plan and process

A comprehensive maintenance plan and organized process is critical to high performance M&O. The plan should document complaints and schedule upcoming maintenance needs, as well as flag needs for diagnostic tests and document their results.

The plan and process should be able to handle and prioritize scheduled, emergency, and preventative work orders and requests. Computer systems are available, if the staff is technology oriented or can be provided training, that are capable of classifying work orders though computerized systems are not necessary. Even a decision matrix in Microsoft Word or Microsoft Excel, will work to help prioritize work orders and provide resources, but the system should be able to decide which work order – leaking roof, exposed wire in the classroom; or air conditioning problem in preschool – gets attention first. This allows M&O staff to be working instead of making decisions with every trouble call.

Teachers should have a written system that goes to an administrator and then to custodial staff – to be handled in house if possible. If not, the request is passed to the district M&O staff with a due date. The loop should be closed, when the maintenance issue has been addressed, by following up with the teacher who made the complaint and providing feedback for M&O staff and administration.

Provide training for M&O, custodial, teaching, and administrative staff

The only way to maintain a high performance school is to train the staff about the technologies, equipment, and necessary practices. M&O staff may have been working for a district for 10 or 15 years and never have seen newer technologies or equipment. They may not understand the dangers of traditional practices, such as cleaning with caustics, or the benefits of newer practices. Both occupants and M&O staff need training at some level on how the building works as a system, and the training needs

to be upgraded on a regularly scheduled basis. For example, when a new system goes into a classroom, each teacher in each classroom should be taught how to operate the system and why it is important to operate it appropriately.

Many districts find it difficult to justify spending money on training. With new construction, some districts have ensured money for training by making the general contractor or manufacturer pay for certain amount of training for staff.

Use commissioning and retrocommissioning to ensure high performance

M&O staff should develop a post-repair checklist to follow up on repairs and ensure that systems continue to operate efficiently. When equipment is replaced, there should be some sort of retrocommissioning process to validate that everything is and continues to function to original design specifications. This kind of verification can be build it into the maintenance plan and process – with performance criteria on mechanical equipment and requirements that it must be recommissioned at replacement. Outsourcing is most effective method for retrocommissioning.

Resources

The following list of links provides additional resources and information for M&O staff at high performance schools.

American School and University Magazine, "32nd Annual M&O Cost Study", April 2003. http://www.asumag.com/.

Ashkin, Stephan and the Pennsylvania Department of Environmental Protection, *Guidelines for Green Building Housekeeping and Maintenance*, http://www.dep.state.pa.us/dep/deputate/fieldops/sw/hpsp/appendix_2.htm.

California's Coalition for Adequate School Housing (CASH), http://www.cashnet.org/.

California Energy Commission (CEC)'s Bright Schools Program, http://www.energy.ca.gov/efficiency/brightschools/info.html.

FacilitiesNet, http://www.facilitiesnet.com/.

Pennsylvania Department of General Services and Green Seal, *Pennsylvania Green Building Maintenance Manual*, http://www.dgs.state.pa.us/dgs/cwp/view.asp?Q=118184.

SchoolDude.com and SchoolDude University, http://www.schooldude.com/.

U.S. Department of Energy, EnergySmart Schools, Preventative Maintenance Checklist, http://www.energysmartschools.gov/energysmartschool/pdfs/checklist.pdf.

Facilities Management

This chapter addresses property and facility management at the level of the school district. Most school districts consist of multiple sites. Unified school districts typically consist of a large number of elementary schools, a smaller number of middle schools and even fewer high schools. Property managed by the school district may also include special education centers or learning centers, joint recreational facilities and other properties. The projects and processes explained in this chapter are extremely useful in maintaining the optimal performance of a high performance school.

A district wide plan for maintenance and operation is essential. This chapter reviews the need for such a plan, but the details of the plan are addressed in each of the technical chapters, e.g. details on the lighting maintenance plan are included in the lighting chapter, HVAC in the HVAC chapter, etc.

This chapter reviews energy audits as a means of finding ways to improve building performance. If an existing school is identified as being inefficient or plagued with comfort complaints, then an energy audit project can be initiated to identify the next steps in improving the school's mechanical and electrical systems' performance. The energy audit may lead to replacing equipment during a retrofit project, retrocommissioning, or a combination of both activities, and in most cases, will demonstrate that energy efficiency projects have favorable payback periods.

For new buildings and modernizations, a commissioning authority should be included in the project to aid in the design of high-performance schools, and to ensure that the equipment is installed and operated at its maximum efficiency. For existing buildings, the school can be recommissioned to sustain its performance with a scheduled recommissioning process.

This chapter also reviews energy management systems which are an excellent tool to save energy; reduce and optimize maintenance; control HVAC, lighting and other systems to best serve facility user needs; and track energy use and other system parameters.

Who Is Responsible for Maintenance and Operation?

The reporting structure for M&O changes district to district, depending on its size and resources, but ultimately M&O responsibilities lie with the superintendent of facilities or the facilities director. Typically, custodial staff are located in each school facility, and M&O staff are located separately, working on a district-wide basis.

Standardizing the structure for maintenance, operations, and custodial work as much as possible within a district can greatly improve a staff's ability to make the most of resources and dollars. If standardized, the custodial supervisor that oversees all of the custodial staff reports to the district M&O director. That way both groups coordinate and can work as a team.

One person from the M&O/custodial team should be designated as an advocate or liaison with the administration – creating one central point of contact minimizes confusion and increases the likelihood that the administration will clearly understand M&O priorities for funding. Training is critical to this process – custodial staff needs training to communicate with administration, give presentations, reports, etc.

Smaller districts may have all staff in one area serving in a number of areas, or even with just one maintenance person. Large districts may have an entire group dedicated to new construction, with realtors, builders, planners, engineers, project managers, and construction managers (see Figure 2).

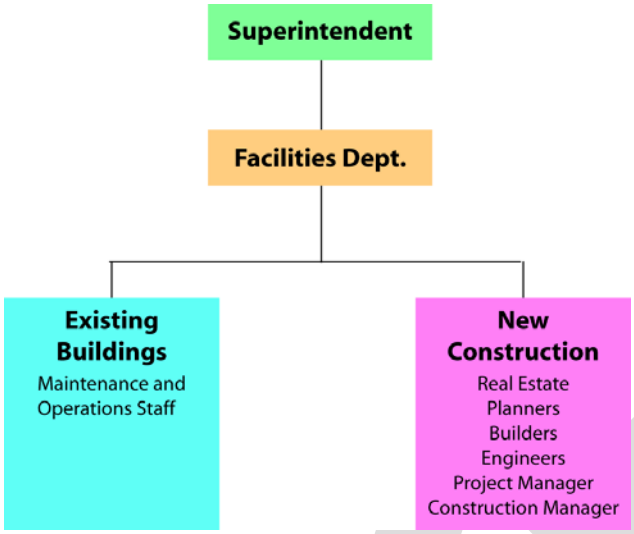

Figure 2 – Typical Organization Chart, Large School District

But for high performance schools to function the most effectively and efficiently, it takes more than just the superintendent of facilities understanding the high performance goals of energy efficiency, water efficiency, and thermal, visual and acoustic comfort. All staff, including custodians, M&O staff, teachers, and administrators have a responsibility as some level to ensuring that a high performance school functions efficiently and effectively.

Resource Management

Large district or small, allocating adequate resources for maintenance and operation is where it begins. With inadequate staff or resources, it is very difficult or even impossible to properly maintain school properties. Each school district should evaluate the number of campuses it must maintain, assess the size and needs of each campus and develop an overall plan for maintenance and operation that specifies staff requirements, equipment needs, supplies and other details. The plan should clearly allocate responsibility for each activity and include a system of accountability.

Table 3 summarizes some of the data from the annual survey by *American School & University* magazine. Custodians each attend to just over 24,000 ft² of floor area. Maintenance workers attend to just over 95,000 ft² each, and groundskeepers take care of about 36 acres each; however, the numbers vary by the size of the school district and many other factors. While the data in Table 3 may be used as a guideline for staffing allocations, these data should be considered a minimum, since expenditures and staffing levels for maintenance and operation are at their lowest levels in decades. For instance, the average floor area maintained by a single custodian was 23,985 ft² in 2002 but increased to 24,167 ft² in 2003. The floor area maintained by a maintenance worker was 89,000 ft² in 2002 and 95,120 ft² in 2003. Landscaping personnel maintained an average of 30 acres in 2002 and 36 acres in 2003.

Table 3 – Buildings and Grounds Area Maintained Per Worker – 2003

Source: American School and University Magazine, "32nd Annual M&O Cost Study", April 2003.

	School District Size			
	National Median	<1,000 Students	1,000-3,499 Students	>3,500 Students
Area Maintained Per Full-Time Custodian	24,167 ft²	29,959 ft²	24,900 ft²	20,000 ft²
Area Maintained Per Full-Time Maintenance Worker	95,120 ft²	74,898 ft²	116,660 ft²	92,500 ft²
Acres Maintained Per Full-Time Grounds Worker	36 acres	18 acres	60 acres	60 acres
Building Area Maintained Per Student	169.85 ft²	197.67 ft²	183.63 ft²	140.03 ft²
Area Maintained Per Building Site	52,500 ft²	23,014 ft²	62,500 ft²	57,781 ft²

In terms of cost, the survey indicates that schools spend about $4.50/ft² or $590/student on maintenance and operation. See Table 4 for per square foot data and Table 5 for per student data. These expenditures are also down when compared to 2002. As a percent of total net current expenditures (NCE), spending for maintenance and operation dropped to 7.4% in 2003 as compared to 7.8% in 2002. As with the data for area served, these data should be used as a minimum since expenditures on maintenance and operation are acknowledged by most to be under funded and are at a very low level compared to previous years. Another caution is that national averages may not be appropriate for some school districts in California where labor rates may be significantly higher.

For more information, see the "32nd Annual Maintenance and Operation Cost Study" conducted by the *American School & University Magazine*. This document is available at http://images.asumag.com/files/134/MO2003.pdf.

Table 4 – Maintenance and Operating Costs per Square Foot – 2003

Source: American School and University Magazine, 32nd Annual M&O Cost Study, April 2003.

	School District Size			
	National Median	<1,000 Students	1,000-3,499 Students	>3,500 Students
Total Payroll	$2.33	$2.25	$1.97	$2.85
Custodial**	$1.61	$1.55	$1.53	$1.68
Maintenance**	$0.48	$0.37	$0.41	$0.67
Grounds**	$0.12	$0.10	$0.09	$0.18
Outside Contract Labor	$0.17	$0.10	$0.23	$0.18
Total Utilities	$1.43	$1.64	$1.23	$1.41
Gas**	$0.28	$0.33	$0.24	$0.23
Electricity**	$0.79	$0.85	$0.70	$0.86
Gas & Electricity (subtotal)	$1.08	$1.22	$0.94	$1.09
Other Fuels	$0.08	$0.07	$0.10	$0.06
Other Utilities	$0.20	$0.24	$0.14	$0.25
Trash Collection/ Disposal	$0.05	$0.07	$0.04	$0.06
Total Equipment & Supplies	$0.46	$0.61	$0.43	$0.30
Custodial/Maintenance Equip. & Supplies**	$0.35	$0.47	$0.36	$0.19
Grounds Equip. & Supplies**	$0.07	$0.06	$0.07	$0.08
Other	$0.09	$0.11	$0.07	$0.09
Total M&O Budget*	$4.48	$4.71	$3.93	$4.83
Total NCE	$51.59	$51.41	$46.59	$56.55

*Calculated from subtotals.

**Based on fewer responses than the total due to schools that combine some of these categories

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Table 5 – Maintenance and Operating Costs per Student

Source: American School and University Magazine, 32nd Annual M&O Cost Study, April 2003.

	School District Size			
	National Median	<1,000 Students	1,000-3,499 Students	>3,500 Students
Total Payroll	$315.91	$309.43	$305.89	$348.22
Custodial**	$230.41	$232.56	$254.61	$201.78
Maintenance**	$57.86	$53.14	$47.31	$73.10
Grounds**	$8.65	$3.69	$9.65	$20.23
Outside Contract Labor	$3.15	$0.00	$3.57	$5.82
Total Utilities	$216.04	$242.76	$205.54	$188.38
Gas**	$41.51	$47.83	$41.86	$28.48
Electricity**	$114.04	$115.23	$112.53	$100.16
Gas & Electricity (subtotal)	$160.08	$182.81	$160.00	$136.69
Other Fuels	$0.00	$0.00	$0.59	$0.00
Other Utilities	$27.03	$30.71	$21.87	$30.11
Trash Collection/ Disposal	$7.11	$7.43	$6.87	$7.33
Total Equipment & Supplies	$55.30	$77.03	$55.78	$34.23
Custodial/Maintenance Equip. & Supplies**	$43.04	$62.04	$47.96	$18.29
Grounds Equip. & Supplies**	$7.15	$8.66	$7.44	$3.29
Other	$0.00	$0.00	$0.00	$0.00
Total M&O Budget*	$590.40	$629.22	$570.78	$576.65
Total NCE	$7,388	$7,610	$7,519	$7,076

*Calculated from subtotals.

**Based on fewer responses than the total due to schools that combine some of these categories

Outsourcing

The trend with most school districts is to reduce, not increase, outsourcing of maintenance and operation activities. School districts cite a number of reasons for not outsourcing, but the two most prominent are accountability and the need for public approval of contracts.

The services most commonly outsourced are transportation (31.8%), vending machines (20.2%), HVAC maintenance (19.9%), computer repairs (18.5%), and office equipment (18.2%). The reasons most commonly cited for outsourcing are better equipment, time savings, professional management, cost containment and labor relations. Outsourcing is expected to decline even more relative to previous years.

For more information on the study that is the basis of the above figures, see “Keeping it Close to Home”, a survey report by the *American School & University Magazine*. This document may be accessed or downloaded from http://images.asumag.com/files/134/109as23.pdf.

Audits, Retrofits, Recommissioning and Retrocommissioning

Maintenance and operations programs should have a component to periodically look for opportunities to improve the quality and efficiency of each campus and to make sure that they are functioning as they are intended to function. The maintenance and operations plan should provide for an audit of each site on a

periodic basis. The purpose of an audit is to look for cost effective investments that will improve the energy efficiency or performance of the facility. When a cost effective improvement is identified and funding is secured, then a retrofit is warranted.

The purpose of commissioning, on the other hand, is to make sure that the systems that are installed (efficient or otherwise) are working as they are intended to work. Recommissioning is when a building that has been previously commissioned is commissioned again. Retrocommissioning is when an existing building is commissioned for the first time.

Often there is a fine line between maintenance and retrofits. For instance, if it is time to replace all the fluorescent lamps at a campus and a newer more energy efficient technology is available, then the upgrade could be considered a retrofit. Others might consider this just routine maintenance. Any time existing equipment needs to be replaced, the maintenance staff should look for improvement options. The incremental cost between a standard product (or a straightforward replacement) and an exceptional product is usually very small and the investment in the differential is most cost effective.

What Are They, How Are They Related, and When Are They Performed?

Energy Audits – The Basics

An energy audit is often the first step in a larger project that may involve equipment retrofit, recommissioning, or retrocommissioning. The energy audits can range from quick “walk-through” energy audits to detailed energy studies (also called investment grade energy audits). The “walk-through” energy audit generally involves a quick assessment of the building, its systems, and energy saving opportunities, while the detailed energy study delves much more deeply into system performance and involves rigorous analysis of potential energy saving opportunities.

An energy audit involves analysis of the energy use within an existing building, usually performed for the purpose of identifying inefficiencies and initiating energy funded projects. The energy audit quantifies the energy consumed by major pieces of equipment and systems such as lighting, heating, ventilation and air conditioning, and determines the performance of these systems. The equipment performance is analyzed through a combination of site observations, spot measurements, short-term monitoring, system trending, and utility bill analysis. Armed with this information and an in-depth understanding of the building systems, the energy auditor can target systems and equipment that may be operating inefficiently, and determine ways to reduce the energy consumption within the building.

Although not discussed here, other types of building audits -- survey of IAQ, acoustics, etc. – can also be done prior to retrofits and renovations planning.

Retrofits – The Basics

The retrofit project scope is based on replacement of older or inefficient pieces of equipment with more appropriate or more efficient pieces of equipment. Equipment that is often replaced in a school retrofit project include:

- Lighting ballasts.
- Lamps.
- Lighting fixtures.
- Lighting controls.
- Chillers.
- Cooling towers.
- Boilers.
- Rooftop unit HVAC systems.
- Unit ventilators.

- Pumps.
- Motors.
- Terminal box reheat devices.
- Control systems:
    - Pneumatics upgraded to direct digital control (DDC).
    - Old DDC system replaced with a new DDC system.
- Air handler coils.
- Kitchen equipment.

The reason these types of equipment are typically targeted for replacement during a retrofit project is due to the fact that they operate at efficiencies that are far inferior to today's standards; they do not function at all; or they do not meet the facility's current requirements.

When a retrofit project is identified, the school district will either contact an equipment vendor or a mechanical or electrical design engineer to further refine the scope and understand the implications of the proposed retrofit project. It is also recommended that a commissioning authority be included at this time, as a commissioning provider can add additional insight into defining the scope of the retrofit project. This scope may involve replacement of equipment, but can also involve commissioning of the new equipment and retrocommissioning or recommissioning of any existing equipment that is to remain. By including retrocommissioning or recommissioning in a retrofit project on all existing and new equipment, the school will operate at an overall new level of efficiency, with all systems maintaining a superior baseline of performance.

Recommissioning – The Basics

Recommissioning is a process that is very similar to commissioning but is applied to an existing, occupied building that has already been commissioned. The standard commissioning process provides a systematic approach to ensure that all building systems perform according to the construction contract documents, the design intent and school's operational needs, and is complete after the construction warranty period expires. Because building performance can degrade over time due to broken mechanical or control equipment, or improper adjustment of devices, the recommissioning process was developed to return a building back to its original state and operation. Recommissioning is the application of the same process and equipment tests used during the initial commissioning effort, many years after the building has been occupied, with the intent to restore the building to its original design parameters and performance. Recommissioning can only occur if a facility has previously been commissioned or retrocommissioned, and can either be performed by the original commissioning authority, or another qualified person.

During recommissioning, the commissioning authority thoroughly checks all equipment during a pre-functional checkout period and then conducts the functional performance tests, exactly as was done during the construction or retrocommissioning project (refer to the Retrocommissioning – The Basics section below). The final commissioning report provided during the previous commissioning effort is used as the starting point for the recommissioning effort, and is a valuable reference to any recommissioning effort. During some commissioning projects, the commissioning authority generates a recommissioning manual, which includes blank versions of all of the tests performed. This recommissioning manual can then be used as the guide for all future recommissioning projects, and provides consistency to the recommissioning process and test procedures for years to come.

The recommissioning of a school is generally initiated either on a regular basis or due to increased energy use or comfort complaints. If the school's use has not changed from its intended use when it was originally designed, then applying the recommissioning process will be effective in returning the school back to its original performance levels. If a major piece of equipment or the building automation system is replaced, recommissioning can be used to ensure that the new system or equipment operates like the old

system, if it is so desired. If, however, the school has had major remodels or dramatic changes to its use patterns, returning the school to its original design parameters may not be appropriate, and therefore the retrocommissioning process should be considered.

Retrocommissioning – The Basics

Retrocommissioning is a structured approach designed to assess equipment problems, develop and implement solutions to the problems, and test final performance. Retrocommissioning applies some of the major components of the commissioning process to existing building systems that have never been commissioned or recommissioned. The goal of a school retrocommissioning project is to reduce the school's energy consumption, improve occupant comfort, and to match the equipment operation to the school's current usage patterns. Retrocommissioning differs from recommissioning in that the original design parameters may not apply and therefore need to be modified, requiring generation of new tests based on new sequences of operation. A retrocommissioning project on a school that has a high-energy consumption will often pay for itself in less than one year from the energy savings that the project creates from the benefit of engineering to usage patterns.

Audits and Retrofits – Strategies and Recommendations for Schools Planning Modernization Projects

To begin to understand the concept and benefits of performing an energy audit on a school, one must first understand how and when to initiate an energy audit. Energy audits aid the school district in understanding the flows and losses of energy within a building, and can serve as a precursor to fixing mechanical problems, financing mechanical improvements or larger modernizations, and increasing comfort within the school.

No longer is the individual that is responsible for paying utility bills the only one privy to records of utility use data, or energy accounting software. With many utility companies providing internet web based access to your energy consumption data, that which used to be difficulty and arduous, is now available at your finger tips with minimal effort The first step of the energy audit process -- quantifying the energy utilization index (EUI) of every facility. The EUI is a term used to describe the annual energy use of a facility on a square foot basis. By calculating this value for every facility within a school district, the district can compare their schools to one another, and identify schools with the highest annual energy use per square foot. This calculation should be done individually for gas, electricity and for the combination of both gas and electricity. In addition to the energy use breakdown of gas and electric, the data-set should be further grouped by HVAC equipment installed, so that schools with air-conditioning are only compared to other schools with air-conditioning. If, for example, two middle schools both have air-conditioning, but only one has an air-conditioned gym, the data-set should include comments to note such types of exceptions.

Knowing which schools have the highest EUI provides the school district with a starting place for potential energy reduction. This understanding about the energy use levels of their schools will also help to further define the potential scope of work for a mechanical retrofit, recommissioning, or retrocommissioning project. Commercially available software packages are available to aid in the management and analysis of school district energy use, and it is highly recommended that every school district utilize such software to aid in maintaining a high performance school. Many of these software tools can also account for differences in weather over the data set period and provide EUI data that is normalized to weather changes. By minimizing the weather factor on school energy use, the fluctuations in energy use due to dramatic changes in weather can be removed from the school's energy use. When the weather factor is removed from the energy data, the school district can analyze a particular school for many years, and watch for any general losses or gains of energy efficiency over time.

Table 6 - Example of an Elementary School EUI Table

School Name	Size [ft²]	Gas Use [kBTU/yr]	Elecrtical Use [kwh/yr]	Gas EUI [kBtu/ft²/yr]	Electrical EUI [kWh/ft²/yr]	Total Energy EUI [kBtu/ft²/yr]	Notes
Elementary 12	65,125	1,387,000	642,154	21	9.9	55	CHPS School
Elementary 11	62,348	1,443,825	779,873	23	12.5	66	CHPS School
Elementary 4	71,873	1,795,180	969,656	25	13.5	71	No AC
Elementary 2	54,437	1,391,247	751,474	26	13.8	73	
Elementary 6	57,834	1,543,897	833,927	27	14.4	76	
Elementary 8	40,423	1,151,582	622,020	28	15.4	81	Partial AC
Elementary 7	58,424	1,681,380	908,187	29	15.5	82	
Elementary 3	66,637	2,037,412	1,100,496	31	16.5	87	
Elementary 1	48,934	1,546,164	835,151	32	17.1	90	Unit Vents
Elementary 5	52,676	1,851,380	1,000,012	35	19.0	100	No BAS
Elementary 9	37,865	1,559,075	842,125	41	22.2	117	No BAS
Elementary 10	47,356	2,081,588	1,124,357	44	23.7	125	T-12 Lights

If the EUI of a particular school indicates that it uses more overall energy than it should, compared to other schools with similar HVAC components, the energy analyst should then look to see if gas or electric is the energy component with the highest overall EUI, or if they are comparable. If the gas use appears excessive, then some areas to focus further investigation are:

- Wall and ceiling insulation.
- Window U-value and seals.
- Thermostat control.
- Night setback setpoint parameters.
- Boiler efficiency.
- Domestic hot water fixture water flow.
- Kitchen equipment efficiency.
- Rooftop unit gas furnace efficiency.
- Heat and ventilation unit gas furnace efficiency.
- Control set-points and sequences.
- Equipment schedules.
- Air Handler system minimum outside air quantity and control.
- Unoccupied control of mechanical heating systems.
- Cooling equipment de-energized when heating is energized.
- Building pressure control.
- Kilns.

If electrical use appears to be excessive, some areas to investigate are:

- Lighting fixture efficiency.
- Lighting power density.

- Unoccupied lighting controls.
- Power factor losses.
- Unoccupied exhaust fan control.
- Equipment schedules match occupancy schedules.
- Fan and pump motor efficiency.
- Air and water system balancing.
- Electric heat control and operation.
- Economizer operation on air handlers for maximized “free-cooling”.
- Chiller efficiency.
- Cooling tower condition.
- Building controls and sequences.
- Air filter status.
- Building pressure control.
- Outdoor air damper control when cooling is enabled.
- Electric kiln (time of use; i.e., you shouldn’t use during peak rate times).

Energy audits can be performed merely to identify where the energy is being used within a school, or they can be taken to the next level and used to also identify energy conservation measures (ECMs). Typical ECMs that are identified involve replacement of mechanical equipment, lighting retrofits, installing or replacing a building automation system, adding wall or ceiling insulation, replacing windows, adding window films, or retrocommissioning. These types of projects are energy-conserving projects, and therefore are also utility cost savings projects. Because these projects can save the school district utility costs, they have the ability to pay for themselves with proper financing. Payback periods for these types of projects can range from a few months to several years, which is often why ECM projects involve many different ECMs under one project scope, so that the combined payback period is within a reasonable time frame. The benefits of ECM projects go beyond utility bill savings and include; increased occupant comfort, addressing deferred maintenance, and replacement of old deteriorating or inefficient equipment. Some school districts have even been able to use the energy saved from a group of schools to finance installation of air-conditioning in schools that are in need of summer cooling.

Energy Service Companies and Energy Audits

The energy audit is often performed by an engineer that specializes in building energy use, and is often affiliated with an energy service company (ESCo). There are a few different types of ESCos, and each company may have a slightly different approach to solving the school’s energy problems. Some ESCos provide energy audits and analysis for a fee to be paid by the school district (or utility, state or other) directly, while others receive their engineering fees from the energy savings that result from the project. However, in the latter case, if the audit is performed, but the energy saving project does not go forth, reimbursement for the auditing services may still be required.

In general, the ESCo that requires direct payment from the school district for the audit tends to produce a more detailed audit, with a reduced margin of error of estimated energy savings. The detailed report that is produced as a result of this energy audit can then be used as a statement of work for retrofit work or retrocommissioning activities. The ESCo that finances their efforts through the future energy savings of the project may provide less rigorous energy savings calculations (since this work essentially cuts into their profit margin or margin for error), but they often account for this reduced accuracy with factors of safety applied to their savings calculations, coupled with a guaranteed utility bill savings program.

A guaranteed savings program, which is also referred to as a performance contract, involves a contract between the ESCo and the school district that essentially guarantees the school district that the expense

incurred from conducting the retrofit will be offset by the energy savings. The monthly expenditure by the school district continues to be approximately the same as before, however, now part of the expenditure pays for the ESCo contract, the balance is paid to the utility company whose monthly bill is significantly reduced due to the energy efficient equipment savings. Some ESCo contracts are set up to have the ESCo pay the monthly utility bills and receives the difference in funds between the new utility bill and the bills of previous years. This payment plan will continue until an agreed upon date, at which point the ESCo estimates it will have recovered its capital costs, engineering costs, and a profit margin (if it is a for-profit ESCo). Once the agreed time period has elapsed, the school district then gets to realize the reduced utility costs by paying the bills directly.

In some cases, the local utility will provide ESCo services and a performance contract for schools within their region. When this occurs, the utility provides the energy audit, evaluates the ECM options, and generates a performance contract for the school district. Often, the payment of this type of arrangement is handled through the regular monthly utility bills, which can make this option convenient when available.

In other cases, an independent third-party energy consultant or consulting firm is used to perform the energy audit and ECM analysis. This still requires that the school district enter into a performance contract with the utility or an ESCo, but provides the advantage of a truly unbiased audit and calculation of potential for energy savings.

Recommissioning – Strategies and Recommendations for Schools

There are three key questions to ask when determining if a school should be recommissioned:

- Has the school has previously been commissioned or retrocommissioned?
- Has the energy use of the school increased over time, without a known explanation (such as occupancy or operational changes)?
- Has the school had an unusual amount of comfort complaints?
- If the school has been commissioned in the past and has faced either increased energy use and/or occupant complaints, it is likely the time to recommission the school.

The goal of recommissioning is to return the school to its previously commissioned state, which includes tuning and adjusting equipment, optimizing equipment operation, and identifying equipment that needs repair or replacement.

The recommissioning process is an effective way to provide a documented, systematic approach to building tune-ups, and return the building to its design operation, many years later. While it is recommended that schools recommission at regular intervals, such as every five years, this may not be practical or may be cost-prohibitive. In these cases, tracking the school's EUI, or comfort complaints, and reacting when either of these indices rise above a pre-determined level, can act as a surrogate to the regularly scheduled recommissioning process by indicating when recommissioning is needed.

When a high performance school is designed and commissioned during the construction phase, recommissioning the school many years later to return it to the original condition provides consistent high performance operation over the life of the school. If a school has not previously been commissioned, or it was not built under the CHPS program, and is not a high performance school, applying the *retrocommissioning* process may be more effective at reducing energy use and increasing comfort. To get the most value out of recommissioning, the previous commissioning effort needs to have been applied against energy efficient design strategies and optimized equipment operation. If the school's design parameters have changed dramatically since the previous commissioning effort, then recommissioning will not be appropriate, and retrocommissioning will be the preferred approach to solving the school's energy and/or comfort problems.

Retrocommissioning – Strategies and Recommendations for Schools

There are two main types of retrocommissioning approaches applied to schools, both of which will increase comfort and energy efficiency within a school.

Retrocommissioning Soon After Construction

The first type occurs after a school is constructed, and is initiated because the maintenance or administrative staff is unsatisfied with the integrity or efficiency of their mechanical or electrical systems. In this first case, the school did not have a formal commissioning process during construction, which has been determined to be the reason for the unsatisfactory conditions and poor system efficiency. By performing retrocommissioning after the construction is complete, the school can still benefit from some of the major aspects of the commissioning process.

Applying the commissioning process after construction in the form of retrocommissioning, the school will never benefit from having input from the commissioning authority during the design and construction phases, but can at least benefit from the rigorous testing that is involved with the commissioning process. During the retrocommissioning testing, the commissioning authority will use the original design documents to write the test plans and to insure that the installed equipment and controls meet the original design requirements. Through the testing process, failed equipment or improperly installed controls will be identified, and can then be corrected for proper operation. This type of retrocommissioning provides the school district a means to identify construction deficiencies, and create a plan to get them corrected. The drawback to this type of retrocommissioning over construction commissioning is that during the construction process, deficiencies identified by the commissioning authority can be corrected by the contractors for no additional fee, but construction problems found through retrocommissioning after the warranty period has expired may become costly for a school district to address.

Retrocommissioning Due to School Use Changes, or for Energy Efficiency

The second type of retrocommissioning differs in that the commissioning authority uses the design documents as a starting reference, but may rewrite the design requirements based on the current school operation and the need to improve the school's energy efficiency. The new revised design parameters may also incorporate energy conservation strategies that the original design engineer was either unfamiliar with or uncertain about concerning details for implementation.

During a low-bid construction project (which schools often are) the design and construction teams may sacrifice energy efficiency and system optimization due to time and budget constraints. Because this type of retrocommissioning is more open-ended, it can have a significant impact on the school's energy use and comfort. This approach to retrocommissioning may also include an energy and equipment status audit, and a performance contract.

The Retrocommissioning Process

The process begins with a thorough site assessment for the selected systems which includes staff interviews to identify operating strategies and maintenance issues; an in-depth survey of equipment and conditions, schedules and setpoints; and possibly short-term diagnostic testing. Short-term diagnostic testing involves data collection of equipment or systems suspected to be operating at non-optimal efficiency levels, and investigates the dynamic interaction between building system components. Short-term diagnostic monitoring also documents the pre-commissioning status of the equipment, for a comparative analysis of the before and after retrocommissioning status of the school.

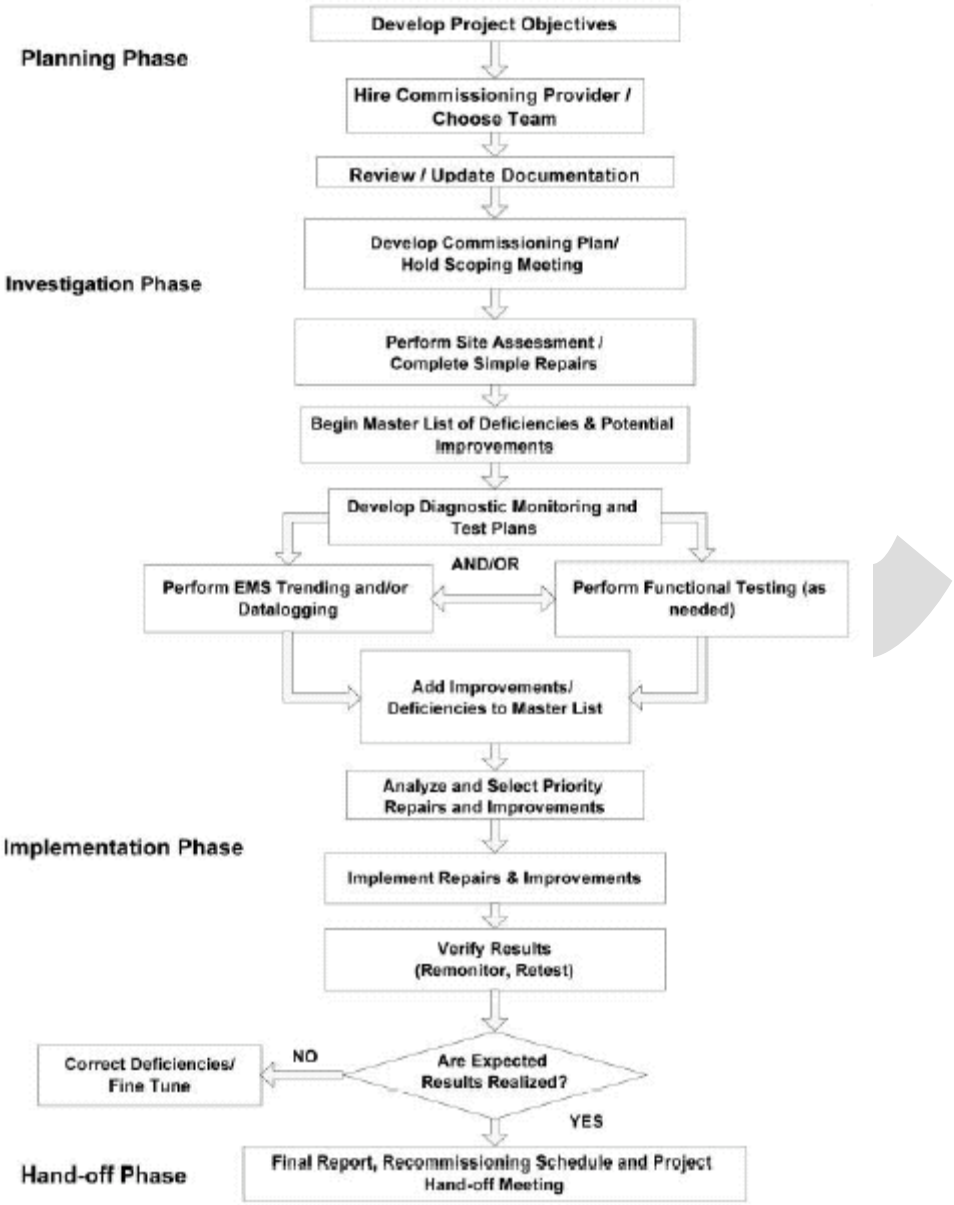


Figure 3 – The Phases and Activities of the Retrocommissioning Process

Source: Portland Energy Conservation Incorporated, Inc., A Practical Guide for Commissioning Existing Buildings

From the site assessment, short-term diagnostic monitoring, and master list of deficiencies, the retrocommissioning scope of work is defined, and remedies to the problems are presented to the operations staff. Often times the solutions to problems discovered during a retrocommissioning program involve alternative control strategies to existing ones. These new strategies are then discussed with the operations staff to understand the feasibility and any potential conflicting issues that may arise while implementing the new procedures. Once the operations staff and the retrocommissioning authority have agreed on the items to be corrected, and the way in which they will be corrected, the retrocommissioning plan will be generated to act as the guideline and scope of work for implementing the project.

Implementation Phase

The implementation phase of the retrocommissioning process begins with pre-functional checkouts, which includes a thorough assessment of the mechanical and electrical equipment, a point-to-point checkout of all control points, calibrations of sensors and transducers, and adjustments to control devices.

The next step is to develop any new control sequences that may be needed, and have them programmed into the system. Once the contractor has tested the new control sequences, the commissioning authority will conduct functional performance tests. Functional performance testing ensures that all systems are properly programmed and meet the designed sequences of operation. Generally, the building automation contractor is brought into this process to re-program the system to the new sequences, and perform the hardware and software manipulations required for testing the sequences of operation, while the commissioning staff direct, witness, and record the results of the functional performance testing.

Retrocommissioning Project Closeout

To validate that the changes made to the mechanical or electrical systems are providing persistent energy savings and optimal operation, post-commissioning short-term monitoring should be performed while the school is occupied to verify operation of the systems, and add insight into system performance. Monitoring during this phase can either be done with the building automation system or through the use of temporarily installed data loggers. By performing short-term monitoring after the functional testing is complete, the commissioning authority will be able to catch any additional items that may require correction, and will have valuable data to compare to the pre-retrocommissioning state of the school.

An example of the potential benefits of short-term monitoring in the retrocommissioning process can be seen in Figure 4. In this example, short-term monitoring at the beginning of the retrocommissioning project revealed that the school's hot water plant hot water supply reset sequence was not properly functioning (data in pink triangles), as there should have been a linear sloping relationship between hot water supply temperature and outside air temperature. Short-term monitoring after the retrocommissioning project confirmed that the work performed through the retrocommissioning process was successful in implementing the hot water temperature reset control (data in blue squares).

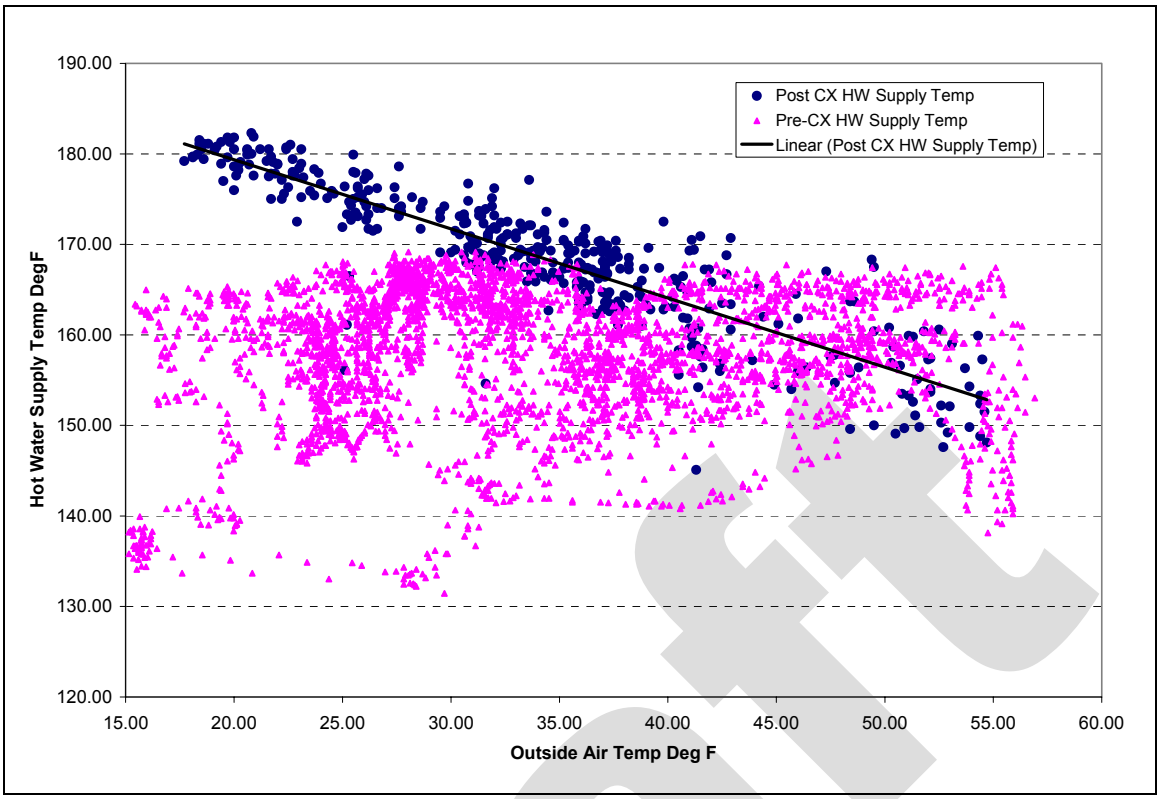


Figure 4 - Example of the Benefits of Short-Term Monitoring, Properly vs. Improperly Operating Hot Water Reset Strategy

Energy Management Systems

(Resource: Haasl, Trudi and Terry Sharp. *A Practical Guide for Commissioning Existing Buildings,* Prepared by Portland Energy Conservation, Inc. and Oak Ridge National Laboratory for the Office of Building Technology, State and Community Programs, U.S. Department of Energy. April 1999.)

Energy management systems enjoy increasing use throughout school facilities, based on their overall energy and cost savings. Although they require a significant investment in money and maintenance effort, a properly installed and maintained system will save energy costs. An EMS also provides opportunities for increasing security, identifying and managing maintenance activities, and providing better comfort. They can sometimes diagnose problems before they happen and signal the need to replace a filter, adjust a thermostat or attend to other maintenance tasks. With these advantages, keep in mind that an EMS system also requires maintenance itself. Unless the sensors that collect information are periodically calibrated and the software is maintained, the EMS may seize to function and become a liability. It is critical that the right system be selected, one that the maintenance and operation staff is comfortable with and understands.

In its simplest form, an EMS is a timing system that controls lighting, HVAC, and other building systems. As a centralized system it allows direct capability to integrate the controls so that all systems operate supportively instead of independently. EMSs have evolved over the decades since their initial development into sophisticated computer control systems with many capabilities. Besides simple timers, they can respond to a wide variety of sensors, control building systems with many combinations of hard wiring, radio control and local area networks (LAN). They display situations, results and historical data in many user-friendly ways. Many of them allow access by maintenance administrators at their desks, in the field and anywhere Internet access is available. Sometimes an EMS is called Energy Management Control System (EMCS) or Building Automation System (BAS).

SHOW AN ARRAY OF SENSORS AND ACTUATORS CONNECTED TO A COMPUTER AND THE COMPUTER NETWORKED TO THE DISTRICT OFFICE.

Figure 5 – Energy Management System

Installing and Commissioning an EMS System

Most EMS systems are installed by the vendor or a contractor, who should provide commissioning and full equipment documentation. This commissioning also serves as a time to train the staff responsible for operation and to provide the documentation for future staff, leaving a framework for successful EMS operation. If a contractor or controls company installs the EMS, the agreement should included on-site training of the school district maintenance and operations staff.

Service Contracts for the EMS System

EMS systems can be either simple very complicated, or somewhere in between. These systems may be very sophisticated and comprehensive, but the more complicated the system, the greater the potential for problems. Complex EMSs need very careful consideration for maintenance to make sure they reach their intended potential.

Unless staff members have experience with the selected EMS, or a similar system, a service contract should be considered. A complicated system can fail in many ways, some of them obscure. Alternatively a dedicated, well-trained staff member may be able to provide skilled and timely maintenance. Staff availability and their EMS experience or training will determine the best approach to service needs.

In many ways a service contract is like an extended warranty. Typical warranties last a year, but carefully consider just what the warranty covers. If an independent contractor installs the EMS, the labor warranty may be for a different period. Consider also a longer warranty, perhaps two years. While such a warranty may be more expensive, it could also bring more confidence to implementing an EMS. In addition it could assist administrators in their financial and facility staff planning.

Providers for EMS Service Contracts

- EMS manufacturers.
- HVAC contractors.
- Maintenance service contractors.

Check carefully for experience with the specific EMS installed if considering a service contract with any provider who is not directly associated with the EMS manufacturer.

Available Service Contract Types

- Full-service agreements, including both software and all system components.
- Software monitoring agreements to remotely identify any EMS problems identified by the software. This may include system backup, a valuable item for a comprehensive EMS.
- Hardware service agreement to repair any component failures.
- Preventative and routine maintenance agreements to perform any regularly scheduled maintenance; typically for a specific number of annual calls.
- Flexible agreements usually for a specific number of labor hours annually, but may include parts of any of the above types of agreements.
- Extended time purchasing agreement to maintain an inventory of key replacement parts on location.
- Technical support agreement to coach staff as necessary for any maintenance issues.

Increasing Occupant Comfort

An EMS will usually increase the comfort for occupants, minimizing their need to fiddle with controls such as the thermostat. It will also decrease inappropriate thermostat settings .One strategy is to restrict the temperature range allowed in a room. This way a user can not set a thermostat excessively high or low in an attempt to get faster temperature change, forgetting to readjust the thermostat when the comfortable temperature arrives. While a quick review of existing space temperatures can highlight a misadjusted control, restricting the range can help minimize wasted energy due to forgetfulness or willful misuse.

Decrease Maintenance Calls

A well operating EMS can make users more comfortable, therefore decreasing the maintenance calls to improve comfort. One consideration for optimization is to make sure that alarms are properly routed for rapid response. Perhaps by using a local area network (LAN) throughout the school district, the alarms can produce more timely notification and response.

Scheduling

Scheduling means programming the EMS to adjust to specific conditions at specific time intervals. This basic function of an EMS normally occurs daily (also considering weekends, holidays and stand down periods), but the EMS operator can include special needs based on a circulated calendar and on an announced exception.

- Daily— including the usual activity and use schedule, day-in and day-out.
- Calendar— for scheduled events, often promulgated on an official calendar. It makes sense to verify most of these close to their scheduled time, in case changes do not reach all calendar viewers.
- Exception— for a special activity, often planned a day or less before it occurs. When discussing this event (or reading the e-mail request), ask for notification of any additional change. Since these activities may be planned quickly, changes can also happen on a real time basis.

Setpoints

Temperature setpoints can be the most basic and most time-consuming task for the EMS key staff. Besides a simple room temperature, temperature setpoints may include supply air, mixed air, coil discharge, chilled water supply, emerging condensing water, and user thermostat adjustment range. Depending on the EMS configuration, an almost infinite number of parameters may need consideration. The most successful EMS will allow both flexibility and close response to the user's expectations. Dual setpoints, one for heating and another for cooling, is most typical. Another possibility is a single setpoint with a relatively wide deadband (at least four degrees). Key components of temperature setpoint review include:

- Time of day or night.
- Occupant number and variations.
- Humidity.
- Zone size.
- Zone location.
- Zone boundary exposure (core, south, etc.).
- Impact on reheat or simultaneous heating and cooling.
- Pump, fan or plant efficiency impact.
- Equipment in zone, such as office equipment or computers.

Most EMS establish setpoints other than temperature. They may include:

- Heating water.

- Boiler blockout.
- Duct static pressure.
- Chiller lockout.
- Economizer changeover.
- Pump or piping differential pressure.
- Return or supply air relative humidity.
- Carbon dioxide concentrations.

Alarms

Logging alarms with all related information is an important part of EMS operation. Some EMSs will give a warning before sending an alarm, for example, if a temperature is high, but not yet high enough for the alarm. Typical alarm triggers include:

- Equipment or sensor failures.
- High, low or invalid values (temperature, pressure, etc.).
- Manual override.
- Communications or software problems.

Safeties

A safety is a critical situation automatic procedure, such as a program that steps equipment through specific functions to protect equipment, property or occupant health and safety. A safety may shut down equipment, such as a boiler upon detecting an extreme high temperature condition (then allowing a manual reset when maintenance staff addresses the problem). A life safety condition, such as a fire alarm or high-pressure limit, might be hard-wired, with associated alarm activation and safety professional notification.

Trending

Trending shows changes and fluctuations to a parameter, such as temperature or pressure, over time. The trend reveals how that parameter fluctuates, and therefore how needs or equipment performance change. A sharp change in a parameter such as temperature can indicate equipment failure (or sometimes a new occupant for a space). A moderate, continual change, such as for airflow, can show system aging in preparation for routine maintenance. At the school district level, administrators can track the total energy use of various campuses.

Documentation

Documentation on how to operate the EMS must be provided by the vendor or installer and made available to the maintenance and operation staff. The minimum required documentation includes:

- Product literature on the system and all components.
- Technical engineering manual, including use guide, operations and detailed programming guide.
- Operator guide.
- Points (either a sensor or an actuator) list.
- Current daily schedules for each piece of equipment.
- Complete, current control sequences for all equipment.
- Complete, current control drawings for all equipment.

Operation Sequences

Fine-tuning sequences of operation is a very common technique for optimization. But well-documented sequences are not so common. Make sure both original and current sequences documentation is readily available and clear.

Sensor Calibration

Reliable, believable accuracy is critical for effective EMS operation.

As a first cut on calibration, rely on the manufacturer's recommendations for sensor calibration intervals. But if sensor and system calibration always seems questionable, especially before the intervals finish, then a shorter calibration interval is likely appropriate. On the other hand, many calibration labs can share details of statistical calibration analysis to reliably determine necessary calibration intervals.

Sensors can be calibrated in-house if the calibration equipment and appropriately trained staff are available. Remember that the calibration equipment must have regularly scheduled calibrations themselves.

Demand Savings Along with Energy Savings

Energy savings is a basic reason for most EMSs, but demand savings can be just as important. Demand savings means keeping peak power reasonable, so that utility demand charges, based on the peak power draw over a specified time period, do not raise the overall electric costs. EMS will usually allow better control and control options to keep demand in check. Real-time displays, warnings and system trending and monitoring will point toward problem areas and key players. Then staff can develop and implement better control strategies.

Key Energy Saving Control Strategies

- Scheduling.
- Holiday scheduling Zonal scheduling:
    - Override control.
    - Night setup/setback.
    - Optimum start and stop.
    - Morning warm-up or cool-down.
- Ventilation control:
    - Carbon dioxide sensors.
    - Occupancy sensors.
    - Supply air volume/damper routines.
    - Exhaust fans.
- Air-side economizers:
    - Typical air-side.
    - Night ventilation purge.
- Resets:
    - Supply air or discharge air temperature.
    - Hot and cold deck temperature.
    - Mixed air temperature.
    - Entering condenser water temperature.

  - Chilled water supply temperature.
  - VAV fan duct flow and pressure.
  - Chilled water pressure.
- Lockouts:
  - Boiler system.
  - Chiller system.
  - Direct expansion compressor cooling.
  - Resistance heat.
- Energy monitoring:
  - Whole building.
  - End use.
  - kWh or Watts (demand).
- Lighting:
  - Lighting sweep.
  - Occupancy sensors.
  - Daylight dimming.
  - Zonal lighting control.
  - Demand dimming.
- Miscellaneous:
  - Simultaneous heating/cooling control.
  - Zone-based HVAC.
  - Dual duct heat control.
  - Chiller staging.
  - Boiler control.
  - Building space pressure.
  - Variable speed drive control.
  - Heat recovery.
- Demand control:
  - Demand limiting (load shedding).
  - Sequential equipment startup.
  - Duty cycling.
  - Off-hours equipment start.

Non-Energy Applications for EMS Systems

Besides saving energy and responding to user needs and comfort, EMS systems can offer a number of other benefits. The benefit potential is based primarily on the details of the EMS system and how facility staffs use EMS and the information it generates.

Security

Security can be a key secondary benefit of EMS. By tracking the time and date of energy use, staff can ascertain if users are in areas during unplanned times. One example was a Scandinavian school gymnasium, newly constructed and including an EMS. Energy use was more than planned, but by reviewing the lighting system energy use hours staff discovered that planners completely missed the interest in a midnight basketball league.

IAQ Monitoring

Some EMS monitor and/or control parameters that are part of or affect indoor air quality. For example, some systems monitor carbon dioxide and respond with more ventilation when levels are excessive. Other spaces, such as a chemistry lab or auto shop, may have additional types of chemical sensors.

Maintenance Diagnostics and Scheduling

Another possible benefit from EMS can be maintenance scheduling information. Monitoring the power used by ventilating fans can show when filters need attention, and some EMS will make this power information available. Another possibility is using EMS data to show the actual hours of operation for lighting systems or other systems that use components with hourly rated lives. When combined with accurate lamp life ratings for the lighting system components, based on cycle time information, scheduled group relamping may be more accurate than possible with an estimated use schedule. Additional opportunities include Chemical treatments for chill water (time based), fan belt and machinery lubrication (runtime based).

While the primary reason to install an EMS is to optimize the control of the primary energy-using systems, many EMS's permit or even encourage collecting data that can highlight problems occurring with these systems. An EMS may, for example, show a graphic display of the temperatures in each room of a building. A quick look may highlight a room with too high or too low a temperature for that time, indicating either a faulty sensor, a problem with the HVAC system, or tampering by a user.

Trends

EMS data collection typically provides a display of sensor records as a function of time. Often displayed graphically, the primary rationale is to show how the parameter changes as the system or components age. Computerized analysis may offer a wide range of display options, often with a number of choices for the factors included in each display. While alarms can alert the EMS operator to a problem, analyzing trends may allow proper maintenance before a problem occurs. It can also allow maintenance planning by helping to identify proper maintenance scheduling.

Key factors to trend:

- Systems with problems in comfort or systems operation.
- Systems suspected of improper operation.
- Recently repaired systems.
- Systems with a history of problems.
- Systems that have a high energy use or demand.

Sampling Rates

Sampling rates are determined by considering the purpose, the number of sensors involved, and the memory capacity. Obviously, the memory availability will determine the number of data points recordable, so a compromise between the number of sensors recorded and the number of samples per sensor will probably be necessary. But at the same time, too few data points can obscure key analysis.

Trending Types

Trending comes in two types: value stream and change of value (COV). Value stream records the value as a simple function of time. COV records a value only when the value exceeds or falls under an established set point for the value. While the COV type may save EMS memory space, an inappropriate set point using COV will eliminate key data points.

Manual Tests

EMS controllability allows testing for many system parts and components. In many cases the sensor data can reveal any faults in system operation and control, and indicate hidden maintenance needs. Simply put, an EMS will allow cycling system components through their performance range, and the sensors and data recording will display how well the components complete those performance tests. While these tests should not normally occur during usual times for building use, the EMS controllability can permit tests at other convenient times.

Some key items in manual tests:

- All sensors that provide critical test results need recent calibration to ensure that the results are accurate.
- Responses that do not have direct sensor monitoring may be observed by the response of related sensors, or may need an observer to verify results. For example, if a damper does not have a position sensor, staff may need to monitor the position during the test.
- A critical test will verify a response just at its breakpoint, or point of change; this will demonstrate both that something operates and that it operates at the planned condition. On the other hand, some systems may respond quickly if a parameter is well away from a breakpoint, but the response could be much slower when the test condition is essentially at the breakpoint. Also, hysteresis may be built into the system, confounding an attempt to quickly test at a breakpoint. Know these characteristics when planning the test, or the test results may be inaccurate or even incorrect.

Some items that often work well for manual tests:

- Variable speed drives.
- Lighting photocontrols.
- Boiler staging.
- Economizer functions.
- Lighting sweep controls.
- EMS equipment interfaces.

Test documentation is important. While some minor tests may not need written instructions, all are important from a maintenance standpoint, and need careful description and reported results in the maintenance records.

Resources/Additional Information

Haasl, Trudi and Terry Sharp. *A Practical Guide for Commissioning Existing Buildings,* Prepared by Portland Energy Conservation, Inc. and Oak Ridge National Laboratory for the Office of Building Technology, State and Community Programs, U.S. Department of Energy. April 1999.

Equipment Procurement

Overview

Quality, well-stocked equipment is a key cog in high performance maintenance and operation of a school. Selecting the best equipment to keep the school maintained in an efficient and healthy manner is an important responsibility for the maintenance staff.

- Equipment Procurement Plan (Guideline EP1)
- Electronics/Office Equipment (Guideline EP2)
- Paper Products (Guideline EP3)
- Art Supplies (Guideline EP4)

Making the Best Product Decision

The number of products and vendors selling school equipment is vast. Often school district will establish guidelines for vendor contact so that staff are not overwhelmed with visits and product literature.

It is vital that decision makers on the maintenance staff spend the time to thoroughly evaluate the products, especially in the custodial arena where there are a large variety of products and districts often purchase in bulk. A poor product decision could affect a school for months. Staff has to make an honest evaluation of the products. Before making a decision, maintenance staff should spend some time determining if the product/equipment meets the needs of their sites in an effective manner. This type of evaluation is generally done in the following ways:

1. For smaller purchases, manufacturers will sometimes give the district some product samples. Maintenance staff should use the product in test areas in several school sites over the course of a couple of months. It is important to see how it works in a true-life situation. Staff should monitor the effectiveness of the product and look for any improvements/problems generated.
2. If samples aren't available, manufactures will provide demonstrations to the staff and/or actually perform some maintenance on site using the equipment. Since most sales representatives are more than willing to put in the time, staff should be able to get a good sense for the product and get all their questions answered.

In short, staff should put the product out there under fair conditions to give it a proper test. Certain products like floor finishes may need much more evaluation than others since there is more variety on the market and performance can differ greatly from product to product.

For larger equipment, it is uncommon for the sales representative to loan samples to the school district. Generally, they will bring the equipment out to the site and allow staff to try it out. If the sales representatives are not allowing the staff to get their questions answered or get a good feel for the equipment, they are not doing their job.

For all equipment – big and small – managers should listen to their staff about what equipment works best, what the new technologies are. Staff personal preference also can come into play. If there are certain types of hand tools that staff know are durable and reliable, they may be the manufacturer they turn to when purchasing a new tool. For larger equipment purchases, it is common for the decisionmaker to work closely with the various manufacturer reps to thoroughly educate themselves about the product options, to let the staff try out the equipment and to evaluate the costs. Managers should have a feel for what the staff is using, what the needs are, how the current equipment is performing, what the problems have been, what is poor performing equipment and what are good values. Ultimately, the final equipment purchase decision is the maintenance manager/director, but that person needs to work closely with the staff that actually uses the equipment to ensure that the best purchasing decision is made.

Purchasing "Green"

According to the California Integrated Waste Management Board (CIWMB), "purchasing is a key component in a comprehensive integrated waste management program for any school district." Recycling campus-generated materials such as paper, glass, and aluminum is an important step, but the recycling program isn't truly complete unless the school also purchases recycled-content products, or in other words, "closes the loop." As the demand for recycled-content product increases, the amount of raw materials and energy reduces.

Because recycled-content products have diversified, M&O staff can purchase an array of recycled products, from carpeting and insulation, to the reams of office paper purchased each day.

Here are some recycled-content products that are available:

- Paper and Paper Products
- Park and Recreation Products
- Plastic Fencing
- Engine coolants
- Playground Surfaces
- Re-refined Lubricating Oils
- Running Tracks
- Retread Tires
- Garden and Soaker Hoses
- Building Insulation Products
- Hydraulic Mulch
- Carpet
- Lawn and Garden Edging
- Cement and Concrete
- Yard Trimmings Compost
- Consolidated and Reprocessed Latex Paint
- Floor Tiles
- Binders
- Shower and Restroom Partitions
- Office Waste Receptacles
- Structural Fiberboard
- Plastic Desktop Accessories
- Laminated Paperboard
- Plastic Trash Bags
- Printer Ribbons
- Toner Cartridges
- Parking Stops
- Traffic Barricades
- Traffic Cones

The basis for each purchasing decision must include packaging, level of recycled content, and the amount of waste produced. Employ effective and efficient purchasing to produce cost savings for your school district. Purchase recycle-content products to complete the recycling loop and to create a demand for materials collected in recycling programs.

What is Recycled Content?

"Recycled Content" refers to two types of recycled materials:

1. Post-consumer recycled content is "a finished material which would have been disposed of a solid waste, having completed its life-cycle as a consumer item."[1]
2. Secondary, or post-industrial, recycled content is "fragments of finished products or finished products of a manufacturing process, which has converted a resource into a commodity of real economic value, but does not include excess virgin resources of the manufacturing process."[2]

[1] CIWMB. Manufacturer Identification of Recycled Content. http://www.ciwmb.ca.gov/publications/buyrecycled/43301018.doc.

[2] CIWMB. Manufacturer Identification of Recycled Content. http://www.ciwmb.ca.gov/publications/buyrecycled/43301018.doc.

Preferable Purchases

- Select products that contain the highest amount of "post-consumer" recycled content, rather than those containing secondary recycled content. If the product is not available with the former type of content, then choose the latter.
- Maximize the amount of post-consumer recycled content by setting a minimum recycled content rate of 25% for all products.
- Purchase commonly used products in bulk packaging, such as hot chocolate and other beverage mixes can be scooped into machines using a measuring cup instead of using proportioned packets. Do not purchase items in bulk that will spoil before the entire product is consumed.
- Purchase refurbished toner cartridges for printers, which are of comparable quality to the new cartridges, but are 30 to 50 percent less expensive. Most major brands of printer cartridges (e.g., Hewlett Packard, IBM etc.) offer refurbished alternatives.
- In addition to purchasing recycled-content products, purchase supplies that come in containers can be recycled.

Resources/Additional Information

California Integrated Waste Management Board, Buy Recycled: Green Procurement Policies, http://www.ciwmb.ca.gov/BuyRecycled/Policies/.

King County Environmentally Preferable Purchasing Tools, King County, WA. This site contains numerous links to green purchasing information sites for states and regions throughout the United States. http://www.metrokc.gov/procure/green/EPPtools.htm.

U.S. Environmental Protection Agency, Comprehensive Procurement Guidelines, http://www.epa.gov/epaoswer/non-hw/procure/.

Guideline EP1: Equipment Procurement Plan

Recommendation

Have an equipment procurement manual that outlines the school/district policies and proper procedures for equipment and supply purchases. Ensure that this document is easily accessible for relevant staff members, either electronically (intranet) or in a resource binder, and that staff is trained on the necessary information. Update manual as necessary.

Description

Schools must follow equipment procurement guidelines, which are generally handed down from the district, but can sometimes be determined at an individual site. The equipment procurement plan should discuss these policies and provide guidance to the responsible staff to ensure that equipment requests meet these regulations.

Areas addressed by the plan should include:

- Approved methods of procurement. The district generally sets the procurement policy for purchases based on cost. An example of this:
    - Purchases up to $5,000 may be submitted using an approved purchase order form. The lowest price product that is appropriate for the situation should be designated for purchase.
    - Purchases up to $7,500 require three verbal quotes. These should be submitted for consideration following the procedure outlined by the district.
    - Purchases up to $15,000 require three written quotes. These should be submitted for consideration following the procedure outlined by the district.
    - Purchases of $15,000 or more require three sealed bids. The school board is required to give final approval.
- Information on developing specifications. This section can help staff develop the required requests for quotes and bids, including the General Provisions and Terms and Conditions. The most important information for M&O staff that are submitting requests is the Technical Specifications. When submitting Technical Specifications, M&O staff need to provide:
    - Descriptions of the item(s) or service(s) required
    - Specific quantities required
    - Any technical specifications for the required item or service
- Types of contracts and their uses. For example:
    - Purchase orders are not true contracts, but are often most commonly used when procuring equipment. These are generally used for one-time purchases.
    - Blanket purchase orders are for commonly recurring orders throughout the fiscal year. These often have set dollar limits.
    - Open-ended contracts can be established for certain products and services. These contracts can be extended or canceled at any time by the purchasing staff.
- Quantity guidelines for common supplies.
- Recycled-content guidelines for procurement.
- Standardization information. Many schools in a district will have the same type of systems, so supplies and replacement equipment can be purchased in bulk, as appropriate. A list should be kept of the standardized supplies and equipment for ease of re-order.

- Contact information for vendors and sales reps. When possible, local vendors should be used for ease of delivery, installation, and support.
- Storage and delivery information.

Schedule

Since the budget year begins for most school districts on July 1, planning for the upcoming year usually begins about three months before that. In April or May, departments should begin looking at equipment planning for the upcoming year, asking the following questions:

- What are the needs for the upcoming year?
- Where are the needs most pressing?

Staff should research prices and get quotes from vendors for the selected products, so that on July 1, all the purchase orders can be submitted to the purchasing department.

It is important for maintenance staff to plan for the seasonal variations in work demand. . For instance, schools are most thoroughly cleaned after classes get out for the summer. It's important to ensure all cleaning and custodial supplies are stocked and ready by the first day of summer vacation. Similarly, with winter-specific equipment and supply needs, it is vital that needs are evaluated and orders placed several months in advance, so that equipment is available during the first winter storms.

Be sure that the equipment procurement plan includes schedules for ordering and reordering of various types of supplies and equipment.

Schedule bulk purchases carefully to avoid peak order times, such as just before summer break, which can increase cost and threaten product availability.

Other Procurement Options

New types of services and technologies are changing the way schools purchase supplies. If your school district uses any of these options, the equipment procurement plan should lay out the requirements for their use in detail.

- **Procurement Cards**. Some school districts have begun using procurement cards for purchases under $1000. These cards can have set purchase limits and can be limited to certain vendors and/or types of supplies. These can help streamline procurement, eliminating paperwork and approval time.
- **Consignment Cabinets**. According to the U.S. Department of Education's *Planning Guide for Maintaining School Facilities,* consignment cabinets are another option facilities staff has to ease the procurement process. Vendors stock the cabinet or other supply storage area with their product, but the school is only charged for the amount of supplies they use. In this system, schools always have stock on hand and don't pay for what they don't use, while the vendor is ensured that the school uses their product.
- **Procurement Consultants and Services**. Larger districts and/or districts needing to purchase a significant amount of technology equipment may hire procurement consultants and services to evaluate needs and coordinate large-scale purchases.

Applicable Codes and Standards

As mentioned above, school boards set procedure and policy guidelines for equipment procurement. These policies are often in line with equipment procurement requirements passed by the state legislatures.

K-12 schools in California can participate in many of the State's procurement contracts (Public Contract Codes 10324 and 12110). This allows schools to take advantage of the collective contracting power for many commonly used equipment and supplies. Programs include Digital High School Solutions and Universal Service (E-Rate). See the References/Additional Information section for additional information.

Benefits

Well-planned equipment procurement saves schools time and money. Storage needs and costs are reduced. With appropriate planning, the best products can be bought to meet school's needs rather than making quick, emergency purchases.

Costs

N/A.

Monitoring/Controls

N/A.

Common Retrofit Opportunities

Replacing equipment requires an analysis of current conditions and a needs assessment usually of the overall removal operations. Replacing equipment as facilities expand and change, and as districts grow or reduce in size, provides an opportunity to make adjustments to many areas. Taking advantage of times of replacement need may be an opportunity to reduce costs in other locations. Viewing the necessity of having to purchase a new piece of equipment in this light can often be a good thing. From an ergonomic and safety standpoint, replacement is also often welcomed.

Verification/Commissioning

N/A.

References/Additional Information

See the References/Additional Information section in the chapter overview, and:

California Division of General Services, K12 Procurement Solutions, http://www.pd.dgs.ca.gov/educsolu/default.htm.

Harrisonburg City Public Schools, Operations and Finance: Procurement(315), http://www.harrisonburg.k12.va.us/policy/315.

Howard County Public School System, Ellicott City, MD, Procurement of Materials, Supplies, Equipment, and Services, http://www.howard.k12.md.us:16080/AboutHCPSS/policies/1311.pdf.

U.S. Department of Education, National Center for Education Statistics, National Forum of Education Statistics. *Planning Guide for Maintaining School Facilities*, NCES 2003-347, prepared by T. Szuba, R. Young, and the School Facilities Maintenance Task Force. Washington, DC: 2003.

Guideline EP2: Electronics/Office Equipment

Recommendation

Purchase ENERGY STAR qualified equipment for school electronics needs, including computers, copiers, fax machines, printers, scanners, and audio-video products. Also consider products that promote materials efficiency, such as use of minimal packaging and recycled components. Purchase from environmentally responsible vendors and corporations that are ISO 14000 certified, have implemented an environmental management system, and/or sell products with ENERGY STAR labels.

Description

When selecting electronics and office equipment, consider cost-effective products that are energy efficient, materials efficient, and promote toxics reduction.

Energy Efficiency

- Save electricity by purchasing ENERGY STAR labeled equipment. According to the ENERGY STAR web site, office equipment with the ENERGY STAR label use nearly half as much electricity than non-ENEGY STAR products. The key to this savings is the power management technology required of all ENERGY STAR labeled products. For instance, all ENERGY STAR office equipment will power down into "sleep" mode after varying periods of inactivity.
- Energy efficiency not only saves schools money by extending equipment life and lowering utility costs, but helps protect the environment by keeping billions of pounds of greenhouse gases from being produced.
- Energy efficiency (as well as materials efficiency) can be increased through networking printers and scanners, as well as ensuring that the equipment purchased has expansion capabilities.

Materials Efficiency

- Consider products that do not contain excessive or hard to recycle packaging.
- Request packaging that is made from recycled content and ask that suppliers take back packaging for reuse or recycling.
- Consider products that contain recycled content materials in the plastic components of the device's CPU, equipment casing and keyboard.

Toxics Reduction

Many electronics equipment contains toxic material such as mercury, lead, cadmium and chromium. To help ensure that these materials do not harm the environment, consider the following when purchasing equipment:

- Select copies and laser printers that have low ozone emission specifications and/or come with an active carbon filter.
- Ask the vendor if services exist to reuse and/or recycle used toner cartridges.
- Request end-of-life services from the vendor, including such things as take-back clauses, trade-in credit, or a lease on equipment.

Applicable Codes and Standards

Check with district and/or school administrators to see if any ENERGY STAR requirements are in place. While ENERGY STAR is a voluntary program, many school districts around the country have partner with ENERGY STAR, expressing their commitment to improving energy efficiency at their facilities. Also, many utilities offer financial incentives for the purchase of ENERGY STAR equipment.

California state agencies are required to purchase ENERGY STAR equipment, as mandated in SAM Management Memo 01-04. For federal facilities, a law went into effect in 1999 requiring that all federal agencies purchase ENERGY STAR rated office equipment.

Benefits

- Reduced electricity use.
- Lower utility bills.
- Less heat production by equipment can result in lower air conditioning costs.
- Improved reliability from better power management.
- Reduced packaging and/or recycled content packaging cuts down on materials headed for landfills.

Costs

Initial costs for ENERGY STAR equipment are the same as for non-ENERGY STAR products. However, the energy savings over the life cycle of an ENERGY STAR product are significant. According to the ENERGY STAR website, an ENERGY STAR computer and monitor will save $45 per year in electricity costs. When you multiply that by 100 computers at a site, a facility can save $4,500 in utility costs per year from the computers alone.

Monitoring/Controls

N/A.

Common Retrofit Opportunities

Often new classroom electronics equipment is purchased as part of a renovation. Be sure to specify ENERGY STAR products.

Verification/Commissioning

N/A.

References/Additional Information

See the References/Additional Information section in the chapter overview, and:

California Department of General Services, *Guidelines for Procurement, Use and End-of-Life Management of Electronic Equipment*, http://www.ciwmb.ca.gov/Electronics/Procurement/PUEOL/FinalGuide.pdf. This document contains generic procurement language for key environmental considerations regarding electronic equipment that organizations can use in developing procurement contracts.

ENERGY STAR for Office Equipment, US Environmental Protection Agency, Arid Rios Building, 1200 Pennsylvania Avenue NW, MC 6202J, Washington, DC 20460, http://www.energystar.gov. ENERGY STAR Hotline: (888) STAR-YES.

Guideline EP3: Paper Products

Recommendation

For all paper products, select products containing recycled content, preferably post-consumer recycled content. Purchase paper products in bulk (as much as can be accommodated by storage space) whenever possible for the best price savings.

Description

Approximately 4.5 billion pounds of janitorial paper (i.e. toilet tissue and paper hand towels) are consumed in the US each year in our institutional and commercial buildings of which schools are a significant portion. Because the vast majority of these products are made without the use of any recycled content, approximately 50 million trees are consumed in the process with enormous impacts are our forests, recreational areas, water and other resources. Purchasing janitorial paper products with a high amount of recycled content is easy and can make an important difference.

Purchasing recycled content paper products helps "close the loop" on the recycling process. According to the California Integrated Waste Management Board, recycled paper is produced in most varieties that virgin paper is produced, with quality generally equal to virgin paper.

The U.S. Environmental Protection Agency recommends the following guidelines (recovered fiber should include the recommended percentage of post-consumer content):

- Printing and writing paper = 30% postconsumer, 30% recovered fiber.
- Envelopes (white and manila) = 10-20% postconsumer, 10-20% recovered fiber.
- Bathroom tissue = 20-60% postconsumer, 20-100% recovered fiber.
- Paper towels = 40-60% post consumer, 40-100% recovered fiber.
- Paper napkins = 30-60% postconsumer, 30-100% recovered fiber.
- Industrial wipes = 40% minimum post consumer recycled content.
- Facial tissues = 10% minimum post-consumer recycled content.
- Plastic trash can liners = 10% minimum post-consumer recycled content.

Some additional strategies include:

- Product dispensers that limit the amount of paper being dispensed.
- Product dispensers that can hold two rolls, which eliminates waste as custodians may feel the need to replace partial rolls so that they do not run-out prior to restocking.
- Coreless rolls of paper products, which reduce packaging waste.
- Finally, from a human health perspective, a strategy that can be employed to reduce potential exposure to pathogenic organisms is to utilize "hands-free" dispensers, which eliminate the levers and cranks that users share when getting the paper.

The CIWMB's Recycled-Content Product Directory (http://www.ciwmb.ca.gov/RCP/) provides information on recycled-content percentages of various products. Searches can be done by name and/or product type, with vendor information easily accessible.

Applicable Codes and Standards

California Education Code Section 32373 encourages school districts to purchase recycled paper if the supplier of recycled paper offers the paper at a cost that does not exceed by more than 5% the lowest offer of non-recycled paper of comparable quality.

The State of California's definition of definition of "recycled paper products" states that the product must contain at least 10% post-consumer recovered material and at least 50% total recovered material.

Benefits

- Conserves forest resources.
- Saves energy.
- Reduces air and water pollution.
- Diverts waste from landfills.
- Promotes recycling by helping to create a market for recycled-content products.

Costs

Although recycled content paper products can be slightly more expensive than virgin paper products, bulk purchases can save a district money. Also, as demand increases, the economy of scale for recycled content paper will increase to lower prices.

Monitoring/Controls

N/A.

Common Retrofit Opportunities

N/A.

Verification/Commissioning

N/A.

References/Additional Information

See the References/Additional Information section in the chapter overview, and:

California Integrated Waste Management Board, School Waste Reduction Program -- Purchasing, http://www.ciwmb.ca.gov/Schools/WasteReduce/Purchasing/.

California Integrated Waste Management Board, Buy Recycled Program -- Green Procurement Policies, http://www.ciwmb.ca.gov/BuyRecycled/Policies/.

California Integrated Waste Management Board, Business Waste Reduction – Purchasing for Waste Reduction, http://www.ciwmb.ca.gov/BizWaste/FactSheets/Purchase.htm.

U.S. Environmental Protection Agency, Comprehensive Procurement Guidelines – Paper and Paper Products, http://www.epa.gov/cpg/products/paper.htm.

Guideline EP4: Art Supplies

Recommendation

Purchase non-toxic art supplies to protect the health and indoor air quality of students and staff.

Description

Chemicals in many commonly used art supplies can have a negative effect on respiratory health. According to the U.S. Environmental Protection Agency, some products that may contain contaminants include: solvents, inks, glues, lacquers, clays and paints.

Non-toxic supplies are identified with one of the following labels:

- ASTM D-4236.
- AP Nontoxic.
- CP Nontoxic.
- Health Label by the Art and Craft Materials Institute or the Center for Safety in the Arts.

Proper ventilation is also important when art products are being used.

Applicable Codes and Standards

Congress recently passed the Art Materials Labeling Act in 2001, which mandates compliance with ASTM D4236. In order to bear this seal, the product must undergo toxicity testing to confirm that it is safe for use by children.

Benefits

- Protects indoor air quality.
- Safe for students and staff.
- Does not harm the environment.

Costs

Costs for non-toxic supplies are comparable to those without the non-toxic labels.

Monitoring/Controls

N/A.

Common Retrofit Opportunities

N/A.

Verification/Commissioning

N/A.

References/Additional Information

See the References/Additional Information section in the chapter overview, and:

U.S. Environmental Protection Agency, Environmentally Preferable Products Database. http://yosemite1.epa.gov/oppt/eppstand2.nsf

U.S. Environmental Protection Agency, IAQ Tools for Schools Kit. http://www.epa.gov/iaq/schools/tools4s2.html

Building Envelope

Overview

Maintaining the building envelope is essential in ensuring a comfortable environment for the building's occupants. A proper inspection program is an important aspect of maintenance, and can identify problems before they impact energy use and affect occupants' health. Leaky roofs are often a primary concern, but a school building's maintenance program should cover all components of the building, including exterior walls, windows and doors, and building foundation. This chapter addresses preventive maintenance for the exterior of the building. Effective building maintenance requires regular inspections, cleaning, and detection of problems such as water penetration, structural damage, or insect infestation.

- Building Envelope Maintenance Plan (Guideline BE1)
- Exterior Walls (Guideline BE2)
- Roofing (Guideline BE3)
- Windows and Doors (Guideline BE4)
- Pest Management – Termites (Guideline BE5)

Guideline BE1: Building Envelope Maintenance Plan

Recommendation

Document the tasks involved in routine maintenance, and assign responsibilities for carrying out the tasks. A regular building inspection should be a key task covered by the plan. The inspection plan should identify the frequency of inspection for each building component. Cleaning practices of the building exterior, and site maintenance duties, such as ensuring proper drainage away from the building, should also be identified.

The plan should include procedures for reporting problems and tracking resolution of problems when they occur. This may only be a simple log by a maintenance technician, but the procedure should be documented.

Architectural drawings, inspection procedures and schedules, as well as reporting and documentation requirements for repairs should also be included in the plan. The plan list recommended funding levels for capital improvement.

Description

The maintenance plan covers all components of the structure: roofs, exterior walls, foundation and doors and windows. While grounds and landscaping maintenance is covered in the Landscaping chapter, the building envelope plan should address site issues such as proper drainage, keeping the building façade free of plant overgrowth and termites.

Roof Maintenance

The first step is documenting roofing details, including:

- Type(s) of roof (built-up, single-ply, metal) and the manufacturer(s).
- Estimated area of each section.
- Installation date of each section of roof.
- Warranty information.
- Name(s) of contractor(s) who installed the roof.
- Record of any repair to roof sections.
- Inspection record.

Identify and schedule regular maintenance, based on the roofing type. According to the State of Minnesota Facilities Maintenance Guide, BURs will require resurfacing every 12 to 25 years, and resurfacing/replacement of flashings every five to eight years. For single-ply roofs, replace flashings every five years. For metal roofs, resurface seams every five years.

Preventive maintenance also involves routine inspection of the roof, including checking for leaks. Inspections should occur at least twice a year. (Refer to the Monitoring/Controls section below for an inspection checklist.) Leaks repairs should be performed by qualified roofing contractors. Roofing specialists can also detect leaks through infrared thermal imaging.

Wall Maintenance

Exterior walls also require regular inspection. The plan should include inspection checklists and schedules, as well as schedules for painting and refinishing of the building exterior. The plan should also outline procedures for moisture detection. Qualified professionals will be able to best detect the extent of moisture damage, through the use of infrared scans and other monitoring equipment. The plan should include information on outsourcing such services.

Budget/Contracting

While most of the maintenance plan should cover the activities that are performed by in-house staff, the plan should also address those tasks that require outside contractors. Some services, such as landscaping, are sometimes contracted out separately. Moreover, while facilities staff can perform building inspections, independent assessments may be required to determine the extent of problems such as moisture penetration and insect infestation.

The maintenance plan should identify a budget for in-house maintenance and identify funding levels for outsourced work. Job order contracting is a way to efficiently manage work performed by outside contractors. With this method, a single contract is used for a variety of maintenance services. Such a contract is usually set to renew annually, based on contractor performance.

Applicable Codes and Standards

N/A.

Benefits

Good preventative maintenance will extend the life span of the envelope and ensure that smaller issues are addressed before they turn into major, expensive repairs.

Costs

The costs to develop and follow a preventative maintenance plan are far less than the costs for major building envelope repair from water damage, termites, etc.

Monitoring/Controls

Building Envelope Inspection Checklist

The following is a sample checklist for inspection of the building exterior.

1. Foundation:

[ ] Foundation Footing – cracks, unsupported areas, water infiltration, rot/decay

[ ] Foundation Post/Pile – cracks, decay

[ ] Insulation Condition

[ ] Flashings Condition

2. Floor: beams, joists, deck, insulation, vapor barrier

3. Exterior Wall Type, components

[ ] Exterior trim: warping/cracking

[ ] Cracking or peeling of paint or sealants

[ ] Presence of moisture or stains

[ ] Exterior finish

[ ] Mortar joints: check for cracking or expansion

[ ] Are masonry units cracked or broken? If so indicate locations.

[ ] Is metal flashing rusted or deteriorating?

[ ] Drainage holes plugged

[ ] Insulation

[ ] Vapor barrier

[ ] Wood Surfaces: Is there rotting or splitting present?

[ ] Grade: Is there proper drainage away from the wall?

[ ] Is street number properly identified on site? Are campus buildings clearly identified?

[ ] Are exits free from obstruction?

4. Windows

[ ] Glazing – check for breaks, scratches, condensation

[ ] Frame – rust, deterioration

[ ] Presence of moisture or stains

[ ] Weather-stripping Condition

[ ] Hardware: Hinges and locks, verify operation of operable windows

5. Roofs

[ ] Beams – decay, deflection

[ ] Trusses/joints – rot/decay, deflection

[ ] Deck – cracks, decay, deflection

[ ] Roofing – (note type) corrosion, deterioration, cracks

[ ] Penetrations – deterioration, corrosion, water penetration

[ ] Check that curbs, joints and flashings are properly sealed.

[ ] Insulation / Vapor Barrier

[ ] Is there any UV damage to roof coating?

[ ] Is there proper water drainage away from the building? Are gutters clear of debris?

[ ] Is the HVAC equipment discharging condensate?

6. Doors

[ ] Type

[ ] Door – splits/gaps, rust/decay, finish

[ ] Frame condition

[ ] weather-stripping

[ ] Insulation

[ ] Hardware

Recommended practices for maintaining each of these building components are addressed as individual guidelines.

Common Retrofit Opportunities

N/A.

Verification/Commissioning

N/A.

References/Additional Information

Hobson, Joseph W. "Specifying, Installing and Maintaining Built-Up and Modified Bitumen Roofing Systems", College Planning and Management 2000, published online by the Peter Li Education Group, 2621 Dryden Road, Suite 300Dayton, OH 45439, Ph: (800) 523-4625, Fax: (800) 370-4450.

Planning Guide for Maintaining School Facilities, School Facilities Maintenance Task Force, National Forum on Education Statistics and the Association of School Business Officials International, National Center for Education Statistics, February 2003. US Department of Education, ED Pubs, P.O. Box 1398, Jessup, MD 20794-1398. For further information, contact Lee Hoffman, (202) 502-7356.

Single-Ply Roof Institute, "How to Implement A Roof Maintenance Program", http://www.spri.org/news_5.html, 77 Rumford Avenue, Suite 3B, Waltham, MA 02453, Phone: 781-647-7026, Fax: 781 647-7222, Email: info@spri.org.

State of Minnesota Facility Maintenance Guide, http://www.health.state.mn.us/divs/eh/indoorair/schools/plan/appdxf.doc.

Guideline BE2: Exterior Walls

Recommendation

- Inspect all exterior walls as part of an overall building inspection program.
- Periodically clean the exterior walls. Exterior walls should be cleaned at least twice a year, more frequently in coastal or high-pollution areas.
- Cut back any overgrown branches or vegetation regularly to prevent future mildew and fungus damage.
- Caulk all windows and doorframes, and seal any joints or gaps in the exterior wall covering, to prevent water and draft penetration. Caulking in exposed locations should be touched up or replaced each time the school is painted.
- Inspected for air-tightness to minimize effects of infiltration. Areas in particular that should be looked at include: joints around fenestration and door frame, junctions between walls and foundations, between walls and building corners, site-built fenestration and doors.
- Paint or stain exterior wood or hardboard walls every three to five years to prevent wood decay and moisture penetration. Proper surface preparation and application techniques are critical.
- Monitor areas around rooftop equipment or other roof penetrations. Ensure that steam outlets are not adjacent to building panels.
- Check exterior plywood at least once a year.
- Keep exterior wood trim, such as on windows and doors, well painted.
- Keep rain gutters and downspouts cleaned out and leak free so that water is effectively carried away from the exterior surface. Peeling paint, rotting wood, and cracks in masonry may all be related to improper run-off. If signs of water infiltration are present, the building should be inspected by a professional.
- Schedule a routine inspection by a building professional once a year.
- Monitor smoke detectors and fire sprinkler systems. Schools should be equipped with automatic smoke detectors. With manual alarm systems, someone has to detect the fire, and after pulling the alarm, remember to make an emergency call for help. Also, automatic sprinkler systems will help control the fire until the fire department arrives. This minimizes fire damage and reduces the amount of water the fire department has to use to control the fire.

Description

Exterior Building Inspection

A visual inspection of the exterior of the school building should be done to look for the changing conditions of the exterior walls and covering. Problem signs to look for include peeling paint, missing mortar or caulking between masonry joints, cracks that have appeared since the last observations, mildew or mold growing on walls or overgrowth of bushes and shrubs near the school building's exterior. The exterior walls of the school building have to be kept clean and free of debris to ensure proper water drainage away from the building. A semiannual exterior cleaning is an important step in the maintenance process.

For masonry and concrete, cracks and water penetration are the primary concerns. A whitish film on the masonry surface is efflorescence, the result of dried mineral salts. Water in the masonry picks up minerals, and when the water meets the outside air it evaporates, leaving a residue of mineral salts. If there is mortar falling out of the joints, fresh mortar should be filled in the open joints, using a small triangular shaped trowel.

Water intrusion through exterior surfaces can be a problem, particularly beneath windows, roof flashing, or penetrations for conduit or refrigerant lines. Some exterior finishes, such as EIFS, are specifically designed to keep moisture out; other finishes have a separate water barrier or a drainage channel for water entering the structure. Moisture levels can be assessed with surface scanners, which provide indications of large areas with problems, or with probes that are detect contact resistance of the substrate or framing.

Keep in mind that a physical inspection alone may not detect moisture that is present in the building envelope. Various testing methods provide more accurate assessments and earlier detection of problems:

- Random core sampling – determines presence of moisture in insulation systems.
- Moisture adsorption tests.
- Infrared moisture surveys of substrate material.
- Air and water infiltration tests.
- Testing by outside professionals is often difficult to include in maintenance budgets. A plan for routine inspections should be included when planning maintenance programs.

Cleaning

An exterior cleaning should be performed at least twice a year, more frequently (four times a year) in marine or high-pollution environments. For regular cleaning of sand and dirt, the building can be cleaned with desalinated water and a nylon brush. For marine climates, dried salt deposits and algae may be removed with a combination of a mild detergent with tri-sodium phosphate and a small amount of household bleach. Avoid sandblasting as this may leave permanent stains on the wall. Avoid using solvent or acid-based cleaning products.

Baking soda blasting can be used to clean many different types of exteriors including brick and stucco. Soda blasting can also be effective for paint, grime and dirt removal from these substrates, but is not recommended. Solvents or paint strippers can break down paints, but may discolor or permanently stain masonry surfaces. A high pressure water spray can remove dirt and stains from exterior walls.

Control of graffiti requires steps taken to prevent vandalism and inspection and removal procedures. To prevent vandalism, consider using fencing to prevent access to the building perimeter, except for entryways and doors. Provide sufficient outdoor lighting and use security cameras in problem or remote areas. Make roof areas inaccessible from the ground level. Construct exterior door and window frames of hollow metal instead of aluminum. Cleaning graffiti may require repainting; avoid sandblasting on the building exterior.

Moisture Detection and Control

A properly constructed building envelope should keep moisture and the elements outside. If moisture is allowed to enter the building envelope, mold can develop. In addition to deteriorating the building structure, mold will cause health problems for the occupants. Through routine building inspection, problems can be detected before they become a threat to the health of the building occupants.

Preventive Maintenance

Routine inspections will help identify moisture control problems before they cause major damage. Mold or fungi formation and wood rot are obvious signs of moisture problems. Other signs to look for include:

- Water flowing down the sides of the building, instead of from eaves or drainpipes
- Wind blowing through the walls
- Cracked paint
- Cracked or missing sealant

- Water stains on the interior walls or ceilings
- Gaps that allow moisture to penetrate the walls
- Windows that are wet on the inside

For preventive maintenance, have a routine inspection annually by a building professional, beginning with the first year of operation.

Maintenance personnel must also include fire detection and protection as part of the building inspection program. Many schools are fitted only with manual fire alarms. It may take several minutes for a fire to be detected, and once it is, someone has to remember to call 911. Smoke alarms and automatic notification to fire departments is essential in ensuring safety to students and minimizing fire damage. The Fire Safe Schools Coalition reports that nearly two-thirds of school fires are, or are suspected to be, caused by arson. Thus, providing a fire-resistant building envelope is only one step in fire protection. Automatic sprinklers will help control a fire until the fire department arrives, limiting fire damage and reducing the amount of water needed by the department to put out the fire.

Applicable Codes and Standards

For building exteriors, Section 17920.3 of the California State Health and Safety Code contains common violations:

"17920.3. Any building or portion thereof including any dwelling unit, guestroom or suite of rooms, or the premises on which the same is located, in which there exists any of the following listed conditions to an extent that endangers the life, limb, health, property, safety, or welfare of the public or the occupants thereof shall be deemed and hereby is declared to be a substandard building:" …

"(g) Faulty weather protection, which shall include, but not be limited to, the following:

- Deteriorated, crumbling, or loose plaster.
- Deteriorated or ineffective waterproofing of exterior walls, roof, foundations, or floors, including broken windows and doors.
- Defective or lack of weather protection for exterior wall coverings, including lack of paint, or weathering due to lack of paint or other approved protective covering.
- Broken, rotted, split, or buckled exterior wall coverings or roof coverings."

Also, the National Fire Protection Agency has a series of standards covering fire protection for building assemblies. The standards include:

- NFPA 80: Recommended Practice for Protection of Buildings from Exterior Fire Exposures.
- NFPA 256: Standard Methods of Fire Tests of Roof Coverings.
- NFPA 268: Standard Test Method for Determining Ignitibility of Exterior Wall Assemblies Using a Radiant Energy Heat Source.

Benefits

Preventive maintenance of the building exterior will have health and repair benefits, in that problems with costly water damage and mold can be mitigated or prevented.

There are other aesthetic benefits in maintaining a clean building exterior. Preventing vandalism will improve the feelings of comfort and safety in the school campus environment.

Costs

NEED MORE COST INFO. MAYBE GET AN ESTIMATE OF REPAIR COSTS FOR WATER DAMAGE

Monitoring/Controls

Specialized equipment is available for detecting moisture in wall assemblies. There are two general types of equipment: infrared scanners that produce thermal images to identify cold or hot spots, and probes that detect damage to wood studs by measuring contact resistance. The scanners are used to identify where large problem areas exist. Thermographic scanners can also identify gaps in insulation or areas where infiltration is a problem. These instruments should be used by trained professionals experienced in interpreting the measurements.

Common Retrofit Opportunities

A common improvement for older buildings is weatherproofing of exposed wood or other surfaces that require better protection against moisture.

Verification/Commissioning

N/A.

References/Additional Information

Fire Safe Schools Coalition, http://www.firesafeschools.org.

Healthy Schools Network, 1999, “Healthier Cleaning & Maintenance: Practices and Products for Schools”, New York State Association for Superintendents of School Buildings and Grounds.

Johnson, Charles H., “Designing Schools to Reduce On-Going And Future Maintenance and Repair Costs”, School Facilities Planning Division, California Department of Education, March 7, 2001. (858)-451-2051.

National Inspection Services, "The Inspector Speaks: Tips for Inspecting and Maintaining a Commercial Property", c.2000, National Inspection Services, Fort Collins, CO. http://www.nationalinspection.net/inspector/articles/tips_commercial.html.

Pappalardo, William J., “Proofing schools against vandalism”, *School Administrator*, June 2002. Association of School Administrators, Gale Group.

School Business Affairs, Dec. 2002, Volume 68, Number 11, p.23, "Alternate Project Delivery Methods: New Ways to Build and Renovate School Facilities", Gary Aller, Association of School Business Officials International.

State of Minnesota Facility Maintenance Guide, http://www.health.state.mn.us/divs/eh/indoorair/schools/plan/appdxf.doc.

State of Wisconsin, Department of Administration, Division of Facilities Development, “Minimum Requirements and Guidelines for the Exterior Building Envelope”, February 2001.

U.S. Environmental Protection Agency, Tools for Schools, http://www.epa.gov/iaq/schools/tfs/walkthrough.html#Exterior%20Inspection.

U.S. Department of Education, National Center for Education Statistics, National Forum of Education Statistics. *Planning Guide for Maintaining School Facilities*, NCES 2003-347, prepared by T. Szuba, R. Young, and the School Facilities Maintenance Task Force. Washington, DC: 2003.

Guideline BE3: Roofing

Recommendation

To effectively maintain roofing, staff should perform three types of maintenance:

- **Regular Maintenance:** response to requests for routine repairs.
- **Preventive Maintenance**: undertaken on a scheduled basis to maintain systems by inspections, cleaning, and other efforts. An effective preventive maintenance program can delay the need for major repairs and replacements. Inspections should occur at least twice a year, including a pre-winter inspection in October or November.
    - Roof maintenance requires regular inspections. Inspections often start with a check of the roof interior to look for signs of water damage. When inspecting the outside of the roof, the following should be checked:
        - Cap flashings.
        - Edge metal.
        - Base flashings.
        - Penetrations.
        - Field of the roof.
        - Ballast.
        - Roof adhesives and surface coatings, if present.
- **Major Repair/Replacement Maintenance:** major repairs include total replacement of roofs. Major maintenance is expensive and requires careful planning before contracts are signed. This planning should be performed by a roofing professional thoroughly familiar with energy efficient roofing, as well as the unique problems associated with performing roofing at school sites.

For cool roofs with reflective coatings, the roof should be cleaned at least once a year with a high-pressure water spray.

Photo source: Los Angeles Unified School District

Description

Roof Types

Maintenance practices for the school's specific type of roof. Built-up roofs (BUR) are the most common low-slope roofing, consisting of multiple layers of felt with waterproofing bitumens in-between. BURs provide good strength and protection from environmental conditions and have a low life-cycle cost. A modified bitumen system uses polymers to modify or change the properties of bitumen so that it can be applied over a wide range of temperatures. Modified bitumens are factory-produced, fabric-reinforced sheets formulated with polymer-modified asphalt (ARMA Modified Bitumen Design Guide for Building Owners, 1997).

Metal roofing may consist of galvanized steel, aluminum and copper, and has different maintenance requirements than BURs. Manufacturers typically provide information on maintenance for specific products.

Preventive Maintenance

The goal of the preventive maintenance program is to decrease the rate of "normal aging" of roofs and drastically reduce the amount of leak calls during the rainy season. Minor defects left unattended can escalate to cause widespread water damage, as well as mold. Additionally, for roofs that are still under some form of warranty, be it contractor or manufacturer, there is a requirement that in order for the warranty to stay in effect, preventative maintenance is required.

One of the most important aspects of a maintenance program for roofing is record keeping. These should include a record of all roofing work completed on a building as well as a bi-annual inspection checklist, which is roof type specific (i.e., built-up, foam, single ply, etc.). The National Roof Contractors Association (NRCA) is an excellent source for generic inspection forms. Additionally, many registered roof consultants will perform this task, and some will also have the capability of compiling the information into computer database so that the information can be retrieved and sorted for future planning.

Most roofing specialists recommend inspections at least twice a year, including an inspection in late fall (October or November) to make sure it is ready for winter weather. In addition to inspections, the following will help maintain roof durability:

- Make sure there is proper drainage from the roof and away from the building.
- Flashing construction and usage are vital. System manufacturers and the NRCA have more detailed information.
- Make sure roof edges are secured properly.
- Minimize rooftop foot traffic and provide protective walkways where traffic is expected.
- Inspect frequently.
- For cool roofs with reflective coatings, the roof should be cleaned at least once a year with a high-pressure water spray. This should be done in compliance with manufacturer's recommendations, so that the warranty is not voided.

Inspections

Detailed roof inspections should include checks of the following:

- Cap flashings are metal or other covers at membrane terminations. They should be inspected for loose or missing fasteners, deformed metal, corrosion, loose covers, or cracking or weather aging of sealants.
- Edge metal at the ends of the roof provides waterproof flashing. This area should be checked for loose or missing fasteners or flashing, corroded metal, gaps in the joint covers, or open joints showing signs of cracking or weathering.
- Base flashings are at the connections at walls and curbs. They should have a secure seal with continuous adhesion to the substrate. Check for loose membrane material and verify that the sealants are in good condition. The flashing material should be checked for signs of deterioration or building movement.
- Penetrations such as pipes, drains and exhausts must be flashed properly. The drain clamping ring should be checked to ensure a watertight seal between the drain and the membrane. Adhesion of sealant inside pitch pockets and membrane adhesion outside should be verified. Pipe boot flanges should be tightly sealed to the roof membrane.
- On the roof membrane, check for worn spots, holes, or deteriorated sections. Verify adequate drainage. Check for structural uniformity when walking over the roof.

Repairs

Inspection and maintenance procedures specific to a particular roofing product are often available from the manufacturer. If repair is required, it is often up to the maintenance staff to determine whether a roof can be repaired or should be replaced, which often depends on school budgets and maintenance

procedures. Routine inspections will identify problems before they impact the comfort and air quality of the room.

Specific repair procedures depend upon the type of roof. For built-up roofs, hot tar is the acceptable repair method. For single-ply roofs, metal roofs and other types, manufacturer's recommended repair procedures should be followed. Maintenance procedures often must be in accordance with manufacturer's guidelines, so that the warranty is not invalidated.

Applicable Codes and Standards

In the case of re-roofing, although these projects are not required to be submitted for approval to the Division of the State Architect, the California Building Code does not allow more than one additional layer in low slope roofing, and then only if certain additional criteria is met. At this time, the addition of reflective coating is considered a maintenance item and not an additional roof.

Under the 2005 California Title24 Energy Efficiency Standards, cool roofs certified by rating procedure CRRC-1 will be required for all low-sloped roofs. In order to be considered a cool roof, the roofing product must be labeled that it has been certified by the Cool Roof Rating Council (CRRC).

Benefits

As discussed above, preventative maintenance of roofing has many benefits, including extending the life of the roof and protecting the health of school occupants.

When part of the preventative maintenance is to maintain or introduce the addition of a reflective surface (or cool roof), the occupants will experience a higher degree of comfort, mechanical equipment will last longer, maintenance cost on the equipment will be reduced, and energy consumption in relation to cooling costs will be reduced. Evidence suggests that by installing a cool roof, the peak load demand on cooling equipment is reduced by 20% on average. Additionally, the roofing lasts longer because the effects of solar radiation, pollutants, and thermal stresses are reduced on the roofing membrane.

Costs

Preventive maintenance on roofing systems can be accomplished with existing maintenance personnel. Most of the work is going to consist of cleaning, and documentation. The net cost for this activity will be the reduction of other work items ordinarily performed by these employees. If roofers are on staff, the follow-up repairs identified during the inspections would not have to be contracted out.

Acrylic coating can be applied over existing low sloped roofing for $0.50-$0.80 per foot at a finished thickness of 25 dry mils. Installing coating at the 10 year point, and then again every eight years thereafter would effectively put the existing roof "to sleep," stopping the aging process. This coating will degrade due to UV rays at a rate of approximately 2 mils per year. This process could theoretically go on indefinitely. According to some coating manufacturers there are built-up asphalt roofs approaching 50 years old that have been treated this way, and they are still performing to this day. With the average life expectancy of built-up roofing being 20 years, this is a significant increase.

Additionally, the environmental benefits from extending the life of roofing material are substantial. It would reduce the amount of debris going into landfills. According to some environmental organizations roofing debris comprises up to 10% of landfills. Additionally, adding or maintaining the existing reflectivity helps to reduce the urban heat island effect, and reduces peak demand energy usage.

Monitoring/Controls

N/A.

Common Retrofit Opportunities

If the existing roofing is determined to be beyond repair, or it is not economically feasible to continue maintenance activity, the roofing will need to be replaced. The first decision is whether or not the existing

roofing will be left in place and the new roofing applied as a second layer, or if the existing roofing be removed prior to the installation of the new roofing. Many items should be evaluated before a decision to overlay the existing roofing is made. (See the Resources/Additional Information section at the end of this guideline for detailed information.)

One item that should be considered in any decision about re-roofing is the presence of asbestos-containing material (ACM). ACM is very common in built-up roofing systems. Asbestos-containing roofing cement is still being sold. If the actual layers of the existing roofing are ACM, and the decision is made to overlay, abatement will have to be doubled when the new roof reaches the end of its life unless excellent records are kept and the new roof is easily separated from the old. Additionally, if only the plastic cement is ACM, then it is better to remove it now, rather than roof over it. If a future inspection sample is taken from one of these covered up plastic cement patches, it will reveal asbestos. It only takes one sample to be positive for the entire homogeneous area to be considered asbestos containing.

If the decision is made to remove the existing roofing, consideration should be given to school hours. Roof removal is noisy and dusty, which can be very disruptive to the daily operations of a school.

Polyurethane foam roofing (PUF) and thermoplastic single ply roofing are both excellent choices for re-roofing. They are both very lightweight and can be both highly reflective and emissive. Additionally, PUF has an average R-rating of 6.5 per inch making it an excellent choice when added insulation as well as cool roofing is a criterion.

Cool roofs are recommended, and are required by the 2005 Title24 code for low-sloped roofs. Cool roofs will not only lower cooling loads, but will also reduce thermal stresses due to daily temperature cycles.

Garden (“green”) roofing is another type of roofing that is starting to see inroads into the North American market. Used widely throughout Europe, it consists of a waterproof barrier, a drainage layer, a filter membrane, growing medium, and vegetation. These systems have shown the ability to reduce energy consumption as well as limit storm water runoff to a higher degree than any other system currently being specified.

Verification/Commissioning N/A

N/A.

References/Additional Information

ARMA/NRCA/SPRI Repair Manual for Low-Slope Membrane Roof Systems. It contains over 300 pages of text and more than 800 photographs. This manual costs $195, plus shipping and handling, and can be ordered from the NRCA at 1-800-323-9545.

Energy Star, http://yosemite1.epa.gov/estar/consumers.nsf/content/roofbus.htm for a complete list of energy saving roofing products.

National Roofing Contractors Association. (847) 299-9070; FAX (847) 299-1183; E-MAIL NRCA@NRCA.NET http://www.ncra.net/.

Roof Coatings Manufacturers Association-1156 - 15th Street, NW Suite 900 Washington, DC 20005 Tel: 202 / 207-0919 • Fax: 202 / 223-9741 Email: info@roofcoatings.org or online at http://www.roofcoatings.org.

Roof Consultants Institute, 1500 Sunday Drive, Suite 204, Raleigh, North Carolina 276071-800-828-1902, or online at http://www.RCI-Online.org . The Roof Consultant Institute is an international, non-profit association of architects, engineers, and professional roof consultants who specialize in the specification and design of every type of roof system used in the world today.

Single Ply Roofing Institute, 77 Rumford Avenue, Suite 3B, Waltham, MA 02453 Phone: 781-647-7026, Fax: 781 647-7222. The Single-Ply Roofing Institute (SPRI) provides a low-cost guide, "Manual of Roof Inspection, Maintenance and Emergency Repair for Existing Single-Ply Roofing Systems." See http://www.spri.org for ordering information. This illustrated guide outlines the causes of roof problems, how to conduct roof inspections, and forms for inspection record keeping.

Title 24, Part 6-California Energy Code, section 118. Mandatory requirements for insulation and cool roofs. Can be obtained online at http://www.energy.ca.gov.

Western States Roofing Contractors Association, 450 Peninsula Avenue, Suite B. San Mateo, CA 94401,Phone: (650) 548-0112,(800) 725-0333,Fax: (650) 548-1443, or information online at http://www.wsrca.com/.

Guideline BE 4: Windows and Doors

Recommendation

- The exterior windows and doors should be inspected routinely for physical damage and proper seals.
- Weatherstripping around doors should be checked during the building exterior inspection, and is typically replaced every five to 10 years.
- Caulking around exposed surfaces may need refinishing or replacement when the building exterior is repainted.
- Verify proper operation of operable windows and window and door hardware (hinges, locks, etc.) during inspection. Verify that exit or other doors intended to be self-closing operate properly.
- Clean frame surfaces, but avoid using petroleum-based cleaners and solvents. Wax aluminum frames with a high quality car wax.
- Keep sill and track areas clean and free of dirt and other debris. If required, use a silicone spray to lubricate rollers and tracks. Keep weep holes clear.
- Make sure that corners of mechanically joined frames are caulked to prevent water penetration.
- Never use a high-pressure spray nozzle when rinsing windows.

Photo source: NREL PIX 12439

Description

Anodized aluminum windows offer low maintenance in most California climates. In coastal areas, aluminum windows should be coated to minimize oxidation with salt air. Painted wood or steel sash windows should be avoided because of high maintenance costs. Exterior doors should be metal clad for durability and fire resistance, and should be recessed or shaded to prevent door surfaces from getting too hot. Window glass should be tempered or laminated to resist breakage. Lexan and polycarbonate materials can be scratched easily, and should be avoided. Security screen products can prevent both breakage and intrusion in high-risk areas.

Windows should be checked for air-tightness. Condensation on the window interior could be a sign of an improper seal. Reports of drafts also may be an indication of a problem. Typically windows are covered by warranties of 10 years or more.

The American Architectural Manufacturers Association (AAMA) provides a voluntary standard for windows, doors and skylights, and contains product listings meeting standards. The standard also applies to caulks and sealants and window and door hardware. Refer to http://www.aama.org for more information.

Applicable Codes and Standards

The recent ANSI/AAMA/NWWDA 101/I.S.2 standard encompasses not only the performance of vinyl, wood and aluminum windows and doors, but also the performance standards for window and door components like extrusions, glass, sealants and hardware.

The National Fenestration Rating Council (NFRC) has standards for rating the energy performance of windows and doors.

The California Title 24 Energy Efficiency Standards provide minimum prescriptive performance requirements for windows and doors.

Benefits

Weatherstripping on doors will reduce infiltration and lower heating and cooling costs. Cleaning practices will help maintain intended daylighting through exterior windows and skylights.

Costs

INFO NEEDED.

Common Retrofit Opportunities

Window replacement with double-paned windows and low-e coatings will lower both cooling and heating costs.

References

American Architectural Manufacturers Association, http://www.aama.org

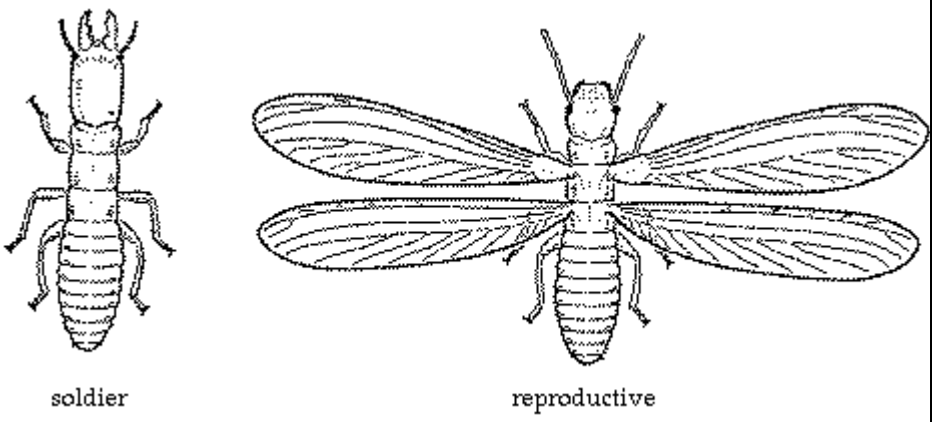
National Fenestration Rating Council, http://www.nfrc.org

Title 24, Part 6-California Energy Code, http://www.energy.ca.gov.

Guideline BE5: Pest Management -- Termites

Recommendation

Proper control of termites requires preventive procedures, proper detection, and hiring a pest control company if a problem occurs.



Western Drywood Termite. Illustration by D. Kidd.

Source: University of California, Integrated Pest Management Online. http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pni7440-1a.html

- Never plant or mulch more than 24" from the base of the foundation. Use inorganic materials as ground cover near the foundation.
- Remove any leaves or debris that has accumulated near the base of the foundation.
- Ensure that water from sprinklers is not hitting the exterior of the building.
- Clean gutters at least twice a year to ensure proper drainage away from the foundation.
- Ensure that exterior walls are free of moisture (see Exterior Wall Guideline).
- Contract with a professional pest control company, and if possible, accompany them on the inspection. The California Structural Pest Control Board (916-561-8708) can provide information on whether a company is registered and in good standing.
- Employ an inspection procedure to check for signs of possible termite damage.

Description

Identifying Termites

The first step is to correctly identify the pest. Termites are often confused with ants. Termites have broad, bead-like bodies; winged termites have equal-sized front and hind wings. Ants, in contrast, have a very narrow waist, and the front wings are larger than the hind wings. Termites are social insects that live in colonies, with different castes carrying out different functions. Samples are collected to identify the caste (reproductive, worker, soldier).

Preventive Maintenance

There are two types of termites of concern to facility maintenance personnel, drywood termites and subterranean termites. Drywood termites are predominantly present in Southern California and the Central Valley, but can be found in bay areas south of San Francisco as well. This type of termite, which does not require contact with soil, lives in colonies of a few hundred. Subterranean termites live in the soil a few feet beneath the surface in colonies of over a hundred thousand, and find their way into wood structures when foraging for food.

Termites rely on the moisture in the wood for their survival. A few basic principles should be included in preventing termite infestation. First, wood should be protected against moisture infiltration. Second, a barrier will either halt activity or make it visible. Termites make mud tubes to protect themselves from predators and dehydration.

Another preventive action is to separate wood from grade, the termite's natural habitat. Painting of drywood with enamel or other coatings provides little protection against infestation. Of commonly used structural wood, Douglas fir is the most resistant to termites. Stucco siding in contact with the soil also promotes infestation of subterranean termites. When wood has contact with soil, wood that is chemically protected with pressure treatments provides greater protection than topical treatments.

A routine building inspection should check for signs of infestation. Sawdust, mud pipes, deterioration are signs of possible infestation. Swarms are an obvious sign of termites. Drywood termites swarm from early April through June. They begin flying at dusk and are attracted to lights. Subterranean termites swarm from January to April, and fly during the day.

Controlling Drywood Termites

The removal of termites can be accomplished either through local control or a whole-building eradication, both of should be performed by a pest control company. Local control involves treatment or replacement of the structural members that have been infested. Treatment methods include injecting pesticides into the assembly and topical application, delivering electric current, or extreme heat or cold (liquid nitrogen) treatments. (Source: Department of Consumer Affairs, Structural Pest Control Fact Sheet, Termites, July 1998.)

Complete eradication requires either fumigation or heat treatment. Effects from fumigation may last up to a week, and should obviously be performed during prolonged unoccupied periods. Heat treatment involves heating the interior of the structure with hot air so that the indoor room temperature reaches 150°F and the interior wall temperature reaches 120°F.

The California Department of Pesticide Regulation (http://www.cdpr.ca.gov/cfdocs/apps/schoolipm/health_issues/tactics_detail.cfm?crumbs_list=1,6,30pest_code=K&pest_code=K) contains information on registered chemicals for wood treatment and insecticides for termite control. Material Safety Data Sheets (MSDS) should be obtained for any chemicals used on the building grounds.

Controlling Subterranean and Dampwood Termites

Subterranean and dampwood termites in structures cannot be adequately controlled by the treatment methods above because the reproductive insects are concentrated in the soil beneath the building structure. The primary methods of controlling these termites are the application of insecticides or baiting programs.

Use of insecticides or baits should be supplemented with the destruction of their access points or nests. Destroy their shelter tubes whenever possible to interrupt access to wooden substructures and to open colonies to attack from natural enemies such as ants. Insecticides are applied either by drenching the soil or by injection. A licensed professional will be aware of the special precautions required with the use of insecticides. Improper applications can cause contamination of heating ducts, plumbing, or in some cases, groundwater. Active ingredients in termite insecticides can be either repellent or non-repellent. Repellent chemicals, such as permethrin and cypermethrin, must be applied so that there are no gaps in the barrier, since the termites are not receiving lethal doses. Adjoining structures should be considered so that the termites do not move to infest them.

Imidacloprid and fipronil are recently introduced chemicals that are less toxic to humans but highly toxic to insects. Both of these insecticides are also nonrepellent to termites and have been shown to be effective in killing termites at low dosage rates under California's climatic conditions.

Baits for subterranean termites are also available. Research on effective baiting systems is continuing to evolve. While several bait products are available only to pest control professionals, there is an over-the-

counter product, Terminate, which is available in retail stores. Once infestation is controlled with baiting, the bait stations should be monitored monthly.

Applicable Codes & Standards

The Healthy Schools Act of 2000 implements the voluntary Integrated Pest Management (IPM) program of the California Department of Pesticide Regulations (DPR), and has additional requirements for schools, such as parental notification of pesticide use for schools. Refer to the DPR website at http://www.schoolipm.info/overview/main.cfm?crumbs_list=1,3 for further information.

The applicable code for companies that provide pest control is Title 16 Professional And Vocational Regulations, Division 19, Structural Pest Control Board. This can be found at http://www.pestboard.ca.gov/regstoc.htm.

Benefits

Preventive maintenance actions, such as clearing debris and verifying sprinkler operation, have minimal costs and can prevent costly structural damage.

Costs

INFO NEEDED.

Common Retrofit Opportunities N/A

N/A.

References

California Department of Pesticide Regulation, "School IPM HELPR Potential Environmental and Health Impacts of Management Alternatives for: Drywood termites," http://www.cdpr.ca.gov/cfdocs/apps/schoolipm/health_issues/tactics_detail.cfm?crumbs_list=1,6,30pest_code=K&pest_code=K.

Log Homes Council, Technical Bulletin, Log Tech Note 03-02, "Termite Prevention and Control".

Pest Notes: Drywood Termites, UC ANR Publication 7440. V. R. Lewis, Insect Biology, UC Berkeley, Produced by IPM Education and Publications, University of California Statewide IPM Program.

Structural Pest Control Board, 1418 Howe Avenue, Suite 18, Sacramento, CA 95825. Administration: (916) 561-8700, Enforcement/Consumer Complaints: (916) 561-8708.

University of California, Agriculture and Natural Resources, Integrated Pest Management Program, http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn7440.html.

Electrical Systems and Lighting

Overview

Proper maintenance of electric lighting is crucial for keeping systems operating as efficiently as possible. This chapter discusses general relamping and cleaning procedures, as well as specific maintenance information for the types of luminaires (lighting fixtures) and lighting systems found in schools.

Lighting system maintenance is probably far from the thoughts of students and school staff when a new building begins operations, but lighting maintenance is key to preserving the intended visibility in classrooms, corridors and throughout the school. Without good visibility, learning deteriorates and safety and security may become problems. While lighting systems start to deteriorate as soon as they are put into use, continuing maintenance planned and as necessary, can keep visibility as the lighting designer intended.

- Lighting Maintenance Plan (Guideline ES1)
- Lighting Supply Procurement (Guideline ES2)
- Fluorescent Troffers, Pendant and Surface Luminaire Maintenance (Guideline ES3)
- Maintenance for Luminaires with Screw-Based Sockets (Guideline ES4)
- HID Luminaire Maintenance (Guideline ES5)
- Control Maintenance: Occupant and Motion Sensors (Guideline ES6)
- Daylighting Controls Maintenance (Guideline ES7)
- Timers and Timeclock Maintenance (Guideline ES8)
- Exit and Emergency Lighting Maintenance (Guideline ES9)
- Photovoltaic Arrays (Guideline ES10)

Group Relamping and Cleaning

Group re-lamping means replacing all or a large part of the lamps at one scheduled time (such as all fluorescent lamps every 5 years, or one third of fluorescent lamps bi-annually). It is recommended to group re-lamp at 70%-80% of rated lamp life and spot re-lamp as necessary. Clean luminaires when they are open to change lamps, or as otherwise scheduled.

Why do the group lamp replacement before reaching the rated lamp life? A look at Figure 6 shows that at 75% of rated lamp life (15,000 hours in Figure 6) about 20% of the lamps have already failed. Although spot relamping will maintain the light level, the rate of lamp failure (i.e. how many fail per unit time) approaches its highest level (the mortality curve is steepest). That means the labor to replace failed lamps is greatest during this period. Group lamp replacement at the start of the period of significant lamp failures maximizes useable lamp life before the labor costs become excessive.

Spot re-lamping means replacing each individual lamp as it fails. Sometimes spot re-lamping is modified, allowing failed lamps to remain for a short period of time such as a week or two. Although changing a failed lamp within hours of failure will keep an area looking good and provide the designed amount of light, the costs of replacing a single lamp are usually high. An exception should be if a lamp flickers badly at end of life, causing a disruption in a classroom or workplace.

Another aspect is to use the remaining good lamps saved from a group re-lamping (that is, save the ones used to replace early failures, since they have significant life remaining) to replace the next early lamp failures following a group lamp replacement. Since these lamps are not new, they are apt to look similar to the remaining group of lamps and have approximately the same remaining life. By writing the installation date on the lamp base or other discrete location, verifying the replacement lamps is easy.

When to Relamp

Plan group re-lamping for 75-80% of rated lamp life, considering any projected longer lamp life based on longer usual operating hours per start. This method allows planning months or years ahead, and permits scheduling relamping at convenient, cost effective intervals. For example, 13 watt CFLs have a rated life of 10,000 hours based on 3 hours per start (usual for fluorescent lamps; HID lamp ratings are based on 10 hours per start). That would be 7,500 hours, or almost a year of continuous use and almost 2 years of use on a photocell dusk-to-dawn control (average about 11 hours of operation each 24 hour day).

But used outdoors with a photocell. One example yielded 16,000 hour average lamp life for name-brand lamps. Group relamping at 75% of average life would mean relamping after 3 years (about 12,000 hours).

An alternate plan is to group relamp after 25% of the system lamps have failed. While this method automatically compensates for any increased or decreased lamp life due to actual use, it may indicate relamping during inconvenient budget periods or user needs.

While it is possible to determine when 25% of incandescent lamps have failed based on lighting circuit power or current draw, counting failed lamps is at least as precise and will work for HID and fluorescent lamps, too.

Table 7 - Typical Group Relamping Intervals

Rated Lamp Life (hours)	Typical Relamping Interval*	Example Lamp Types
1,000	2.5 months of use	small incandescent lamps
2,500	9 months	some incandescent lamps
10,000	3 years	CFL, some metal halide
12,000	3 years	old HO fluorescent, some CFL and metal halide
15,000	3.5 years	some metal halide
20,000	5 years	many fluorescent and metal halide, some CFL
24,000	6 years	many new fluorescent, HPS
30,000	7.5 years	special fluorescent, special HPS and special metal halide

*Based on a typical 3,200 hour use per school year. Different areas may receive more or less use; adjust these values accordingly.

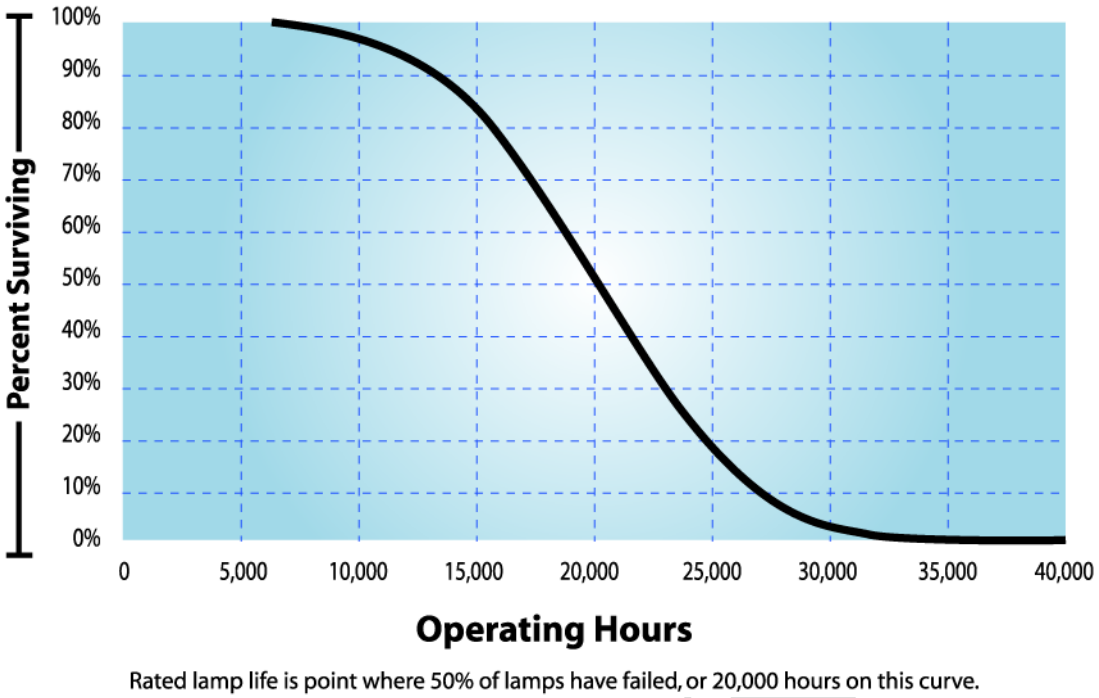


Figure 6 – Typical Fluorescent Lamp Mortality Curve

Cleaning

A related good practice is to clean the luminaire when changing lamps. Since the maintenance staff has accessed the luminaire anyway, taking a few minutes more to clean the luminaire will allow more light without more cost. Cleaning may be as simple as wiping the accumulated dust from the interior luminaire surfaces with a damp rag. Sometimes, especially for indirect luminaires, vacuuming can work well. More often cleaning with a mild detergent solution, followed by a rinse rag or sponge, removes more dirt. Dry the surface with a soft cloth unless static charges are a problem; in that case vacuuming the surface dry may work better. Use care with transparent plastic lenses that scratch easily with rough rags. For almost any lighting optical surface, do not use an abrasive cleaner. Of course for safety, turn off the lighting circuit before opening the luminaires for cleaning, and be careful about static charge surprises.

Disposing of Used Lamps

Lamp ballasts and fluorescent lamps that are removed from service ("spent lamps") are considered to be hazardous waste if they contain specific amounts or more of toxic substances. For example, many fluorescent lamps contain enough mercury to be considered as hazardous waste by the US Environmental Protection Agency (EPA). Many states use the US EPA Universal Waste regulations for lamp disposal as part of their regulations, although some states such as Minnesota and California have more stringent regulations. A few ballasts made before 1978 use capacitors that contain PCB materials, notoriously toxic substances with specific US EPA disposal regulations. Treat fluorescent and HID lamps (and ballasts that are older than 1978) according to the school's toxic waste handling policy and lighting maintenance plan.

Group re-lamping encourages spent lamp recycling, since a large number of lamps will need disposal after re-lamping. Working with a lamp and ballast recycler will eliminate problems and questions about disposal for these hazardous wastes. All fluorescent lamps (including most neon and cold cathode lamps) contain mercury and should be recycled when removed from service. Almost all HID lamps contain mercury (except for low pressure sodium and a very few special high pressure sodium lamps) and should be recycled. For recyclers, see references.

Recycling costs a small amount of money, but it is the best and most responsible way to dispose of spent lamps. Even for the few fluorescent and HID lamps that meet Universal Waste Rules requirements for landfill disposal, recycling is desirable. Furthermore, Universal Waste Rule disposal regulations continue to tighten, so planning for and implementing lamp recycling is the prudent way for lamp disposal.

Many lighting ballasts use capacitors to provide desirable electrical characteristics. Before 1978, most of these capacitors contained toxic PCBs. If a ballast states "no PCBs" or similar, the ballast is free from this toxic material. Unfortunately, ballasts that contain PBCs do not say anything about it. If the ballast has a capacitor, either external or internal (usually a high power factor ballast, such as most fluorescent lamp ballasts), and the label does not comment about PCB content, assume that the ballast is hazardous waste. Should a ballast containing PCBs leak this oil in a school, the cleanup and remediation can be very difficult and expensive. Most lamp recycle contractors can help identify and properly dispose of lighting ballasts (see references).

Why group re-lamping?

Group re-lamping helps to maintain appearance, with greater uniformity from lamp to lamp. Some lamps like metal halide can change appearance significantly through life.

Another benefit is that a group of same-age lamps will not experience many failures until approaching rated life. If the lamps in a space have a mixture of burning hours, there will be a continuing need to replace some failed lamps. Typically, at 70-80% of rated lamp life, 25% of the lamps will have failed. However, only a few percent will have failed before 50% of rated life. This gives a significant window when the number of lamp failures is very small, so maintenance staff can concentrate on other duties.

Replacing a group of lamps at the same time can allow maintenance scheduling, which makes large quantity lamp purchases more feasible, or might make subcontracting the lamp replacement more practical. It also makes planning easier, possibly for school holiday periods or after hours sessions. Naturally, implementing any appropriate lighting system upgrades should be considered at the time of group lamp replacement (See Common Retrofit Opportunities section below).

Re-lamping Costs

The largest flexible cost to re-lamping is labor. Spot re-lamping is most expensive due to the extensive time necessary to change an individual lamp. Changing all the lamps of a type, when the staff is prepared with all equipment to reach the lamp and clean the optical system, saves time and money.

A general misconception is that a lamp still operating does not need replacing ("The lamp still lights, so it must be good. Check it again in another year."). But if staff accesses a lamp, the cost of the lamp is often less than the labor cost of changing the lamp when it burns, perhaps the next week.

Some maintenance plans do not spot relamp at all. Instead, they just leave failed lamps in place until the date for group re-lamping arrives. While this strategy may at first appear cost effective (no costly spot re-lamping), it requires significant investment in additional lighting equipment to ensure that the minimum lighting levels are still achieved with many failed lamps. Of course, this additional equipment costs more initially both to purchase and install, and ballasts continue to use energy (the largest contributor to lighting costs) even if lamps have failed. Furthermore, there is no way to predict where a number of lamps will fail in close proximity, creating dark areas where visibility and task performance would be compromised. While only a careful life cycle cost benefit analysis will provide details, a re-lamping plan without provision for spot re-lamping is apt to prove costly.

Organized storage can make the time investment even better for group re-lamping by locating lamps and other supplies above the floor, keeping new and used lamps separated, and making sure each lamp is dated and wiped clean.

References/Additional Information

Association of Lighting and Mercury Recyclers. http://www.almr.org/index.htm

EPRI, *Lighting Fundamentals Handbook*, TR-101710, Dec. 1992, Palo Alto, California, 94304

EPRI, *Lighting Retrofit Manual*, TR-107130, April 1998, Palo Alto, California, 94304

Note on EPRI documents: EPRI (formerly Electric Power Research Institute) developed a number of publications related to wise energy use. While these are often still available directly from EPRI, their price, based on recovering research costs, can be amazingly prohibitive. However, EPRI developed these items for their member utilities, and those utilities often distribute EPRI documents to their deserving customers. Before calling EPRI about publication availability, check with your electric utility (especially the library staff at the utility) to see if they qualify for a specific EPRI product and therefore can make it available at low or no charge.

Illuminating Engineering Society of North America, Chapter 28 "Lighting Maintenance", *Lighting Handbook*, Ninth Edition, New York, 2000.

Illuminating Engineering Society of North America; Address: 120 Wall Street, Floor 17, New York, NY 10005; Phone 212-248-5000, Fax 212-248-5017, e-mail: iesna@iesna.org. IESNA develops a wide range of technical publications, papers and information on the technical aspects. The *Lighting Handbook* (cited above) provides details on lighting science and application, including many items pertinent to lighting maintenance. Besides the *Lighting Handbook*, IESNA publishes a number of Recommended Procedures, Technical Memorandums and other shorter publications that offer information that could assist developing a comprehensive lighting maintenance plan. http://www.iesna.org/

NALMCO: International Association of Lighting Management Companies; http://www.nalmco.org. Address: 431 E. Locust, Suite 300, Des Moines, IA 50309; Phone: 515-243-2360; Fax: 515-243-2049; e-mail: director@nalmco.org. NALMCO consists of member companies that perform all aspects of lighting maintenance, and encourage professional competence in this area.

New Buildings Institute, *Advanced Lighting Guidelines*, PO Box 653, White Salmon, WA 98672; 2003. http://www.newbuildings.org

U.S. Environmental Protection Agency, Where to Recycle Universal Waste, http://www.epa.gov/epaoswer/hazwaste/id/univwast/where.htm

Guideline ES1: Lighting Maintenance Plan

Recommendation

Develop a maintenance plan for lighting, making it available to all maintenance and administrative staff to promote good procedures and enhance planning and budgeting.

Description

Prepare a written lighting maintenance plan that discusses, explains and implements the following items:

- Staffing and budget requirements for effective management of electrical systems and lighting at the school.
- Reporting requirements and staff responsibilities for the tasks outlined in the plan.
- Procedures and schedules for a relamping plan, discussing both group and spot relamping, for each luminaire type.
- Luminaire cleaning schedules and procedures, including parts to clean, tools and proper cleaning supplies.
- Recycling plans for used lamps and ballasts, including toxic waste procedures.
- Equipment request/procurement information for lamps and other electrical system parts.
- Safety information for cleaning and repairs of electrical systems. Risk of electric shock and static charge buildup exists when dealing with this type of equipment.

Applicable Codes and Standards

Disposal regulations should be covered in the maintenance plan. As mentioned in the chapter overview, many fluorescent lamps contain enough mercury to be considered as hazardous waste by the US Environmental Protection Agency (EPA), and their disposal should follow the U.S. EPA Universal Waste regulations. Some states such as Minnesota and California have more stringent regulations, which should be followed.

Benefits

A lighting maintenance plan documents planned, expected practices to help staff implement effective procedures and to assist administrators budget for needs, expenses and staff.

Costs

Developing a lighting maintenance plan takes some time and thought, but there is a short payback in time saved while busily keeping a school in operation. Facilities contractors and equipment manufacturers may supply part of the plan, based on their experience.

Monitoring/Controls

Include lighting system controls in the maintenance plan.

Common Retrofit Opportunities

Include periodic energy audits and analysis in the lighting maintenance plan, along with evaluation for energy and cost savings. Retrofit options will be part of this analysis.

Verification/Commissioning/Acceptance Testing

Include required acceptance testing and equipment verification as part of the lighting maintenance plan.

References/Additional Information

See the References/Additional Information section in the Overview.

Guideline ES2: Lighting Supply Procurement

Recommendation

Lamps

If newer, improved-efficiency lamps are not available, use the model number of the lamp being replaced to reorder the appropriate equipment. Since group relamping is a scheduled event, plan lamp procurement so as to eliminate the need to store large quantities of stock. Determine an appropriate quantity to keep on site (or at a centralized storage area) for individual replacements, as needed.

Ballasts

Determining ballast quality is impossible without long complicated tests, therefore purchase brand(s) based on reputation. Check to make sure that ballasts will be compatible with the intended lamps (HID ballasts especially operate a single lamp type), and that for fluorescent ballasts the start method is as specified or required. If frequent switching for fluorescent lamps makes lamp life short, more expensive programmed start ballasts may solve the problem.

Controls

Since controls are often very specific in function, replacements typically should be the same manufacturer and model number. The control manufacturer's representative may be able to suggest upgraded models with better performance. For example, motion sensors may incorporate microprocessors to give better detection with fewer false alarms. When electromechanical timers fail, electronic versions usually give fewer maintenance problems with more accurate switching.

Description

Lighting technologies continue to change, so what was most appropriate for an application a few years ago may no longer be the best compromise of performance and cost. Furthermore, some vendors encourage the purchase of products with dubious performance, especially for a premium price.

The best way to identify and specify lighting equipment that provides maximum value is to follow the directions of a lighting professional, which may be impractical for purchasing department staff.

The representatives for major lamp and ballast manufacturers can provide many good suggestions. Although they have an interest in promoting their latest technologies, especially if they are proprietary, since they also offer standard types of products their advice is apt to have less bias than a vendor offering only a single type of product. Furthermore, if their advice is good a purchaser may return for all types of lighting products. One way to help verify the knowledge of a representative is to ask if that person is Lighting Certified ("LC") by NCQLP.

Applicable Codes and Standards

Lamp and ballast manufacturers usually comply with federal and state standards that require minimum lamp and ballast performance. For example, the Federal Energy Policy Act of 1992 eliminated the manufacture or importation for sale of 40 watt T12 lamps with a CRI less than 70. Another example is the September 19, 2000 amendment to Federal Energy Policy Act of 1992 that requires electronic ballasts for F40 and F96 T12 fluorescent lamps by April 1, 2005 (other very common fluorescent lamps use electronic ballasts preferentially or exclusively, so the law only covers T12 lamps).

Benefits

- Maintaining (or possibly improving) the quality of lighting in the school.
- Good planning ensures that the proper lighting equipment is in stock when required.
- Buying lamps in bulk can result in cost savings.

Costs

Careful review will show which lamps provide the best combination of lighting performance and value, and also are compatible with existing ballasts. In some cases retrofitting higher performance lighting equipment would have a lower overall cost, but except for identifying better replacement lamps, general retrofitting should follow a lighting audit and life cycle cost benefit analysis by a lighting professional.

Monitoring/Controls

N/A.

Common Retrofit Opportunities

While luminaires are open, an excellent opportunity exists to save some labor costs in upgrading ballasts and lamps. Of course, changing magnetic ballasts to electronic (and T8 lamps if T12's are still used) might save enough energy to justify an immediate retrofit and group lamp replacement, no matter how recent the existing lamps. A lighting audit and life cycle cost benefit analysis by a lighting professional can provide the details for a particular application.

Verification/Commissioning

N/A.

References/Additional Information

See the References/Additional Information section in the chapter overview, and:

Illuminating Engineering Society of North America, Chapter 28 "Lighting Maintenance", *Lighting Handbook*, Ninth Edition, New York, 2000. http://www.iesna.org/.

NALMCO: International Association of Lighting Management Companies; Address: 431 E. Locust, Suite 300, Des Moines, IA 50309; Phone: 515-243-2360; Fax: 515-243-2049; e-mail: director@nalmco.org. NALMCO consists of member companies that perform all aspects of lighting maintenance, and encourage professional competence in this area. http://www.nalmco.org

New Buildings Institute, *Advanced Lighting Guidelines*, PO Box 653, White Salmon, WA 98672; 2001. http://www.newbuildings.org

Guideline ES3: Fluorescent Troffers, Pendant and Surface Luminaire Maintenance

Recommendation

Maintain fluorescent luminaires based on the lighting maintenance plan, including relamping, cleaning and replacing failures. Replace ballasts and other failures according to the lighting maintenance plan.

Description

Relamp according to the lighting maintenance plan, usually group relamping with spot relamping for certain applications and critical failures. Clean luminaires according to the lighting maintenance plan schedule, following the proper procedure for the luminaire design. Refer to Overview for details on relamping and cleaning methods.

Applicable Codes and Standards

Lamp and ballast manufacturers usually comply with federal and state standards that require minimum lamp and ballast performance. For example, the Federal Energy Policy Act of 1992 eliminated the manufacture or importation for sale of 40 watt T12 lamps with a CRI less than 70. Another example is the September 19, 2000 amendment to Federal Energy Policy Act of 1992 that requires electronic ballasts for F40 and F96 T12 fluorescent lamps by April 1, 2005 (other very common fluorescent lamps use electronic ballasts preferentially or exclusively, so the law only covers T12 lamps).

Benefits

Schools depend on fluorescent lighting for its low cost and energy efficiency. Good maintenance keeps the overall lighting costs lowest while preserving good visibility.

Costs

Properly maintained lighting systems cost less overall than poorly maintained lighting, due primarily to providing appropriate visibility and preventing urgent, costly maintenance. Planning by both maintenance staff and administrators can minimize maintenance costs.

Monitoring/Controls

See guidelines for occupant and motion sensors, daylighting controls and timers and timeclock maintenance.

Common Retrofit Opportunities

While luminaires are open, an excellent opportunity exists to save some labor costs in upgrading ballasts and lamps. A lighting audit and life cycle cost benefit analysis, perhaps at no additional charge by a lighting professional, can provide the details for a particular application.

Lenses for recessed lighting may also need retrofitting, either due to deterioration or to new tasks such as computer displays. In some areas where computers are prevalent consider a retrofit to louvers, lower light levels or other ways to minimize glare on the computer display.

Lighting technologies seem to advance continually. By the time a lighting system reaches five years old, retrofitting with a newer technology to improve the lighting quality or to save energy might make sense. Since many long-life lamps need group replacement at about five years, that is a good interval to consider newer lighting technologies that could save money in the long term. The lighting plan should indicate a periodic lighting audit to ascertain if an upgrade is appropriate, and group relamping intervals may be the same length of time.

Verification/Commissioning

Ensure proper operation after completing maintenance tasks.

References/Additional Information

See the References/Additional Information section in the Overview.

Guideline ES4: Maintenance for Luminaires with Screw-Based Sockets

Recommendation

Maintain luminaires based on the lighting maintenance plan, including relamping, cleaning and replacing failures.

In general, use compact fluorescent lamps (CFL) in screw-based sockets not designed for HID lamps. These lamp types have lower maintenance needs and reduce long-term costs. Although screw-based sockets were traditionally designed for incandescent lamps (which are inexpensive to purchase), their ongoing costs for energy and lamp replacement usually make them more expensive overall.

Description

Deciding what lamp to use in a screw-base socket (designed for an incandescent lamp) may take some time, but it can also decrease lighting costs significantly for many existing lighting systems. On the other hand, a poor decision can mean that the resulting lighting does not allow needed visibility and function, or it may not approach the lowest cost to provide that visibility.

Incandescent lamps

Incandescent lamps have exclusive performance benefits in some applications where a narrow beam of light is required from a spotlight or other precise beam for accent lighting.

CFL

CFLs with screw bases ("integral" means the lamp includes a ballast and has a screw base) will work in place of incandescent lamps in many locations, but selecting the best type for the space means addressing a number of items.

- CFLs come in a wide variety of shapes and sizes; one of these will reasonably fit into about any socket designed for an incandescent lamp, but the light output or the light distribution from the CFL may not be appropriate. The helical shaped lamp (twist, screw, spring, or ice-cream-cone shape) may be physically closest in size to the incandescent A-line shape.
- The power used by a CFL is about 1/3 to 1/4 that of an equivalent incandescent lamp. Select the CFL lamp power at about 30% of the incandescent rating. Or select about the same light output (lumens) as an incandescent lamp that provides adequate light.
- Reflector CFL lamps are available, and can work well to replace a wide-beam R or PAR floodlight lamps ("R" means reflector lamp, "PAR" means parabolic aluminized reflector). A CFL cannot replace a narrow or sharply defined beam pattern reflector lamp.
- Most CFLs do not work on dimmers (in fact, they may start a fire!). A few will work fine on dimmers, which is clearly noted on the packaging literature. Never use a CFL on a dimmer unless the lamp or directions specifically allow dimming.
- All fluorescent lamps, including CFLs, change light quality with temperature variation. Even if a CFL will start at the lowest expected temperature, the light output may be disappointing if the lamp gets significantly colder or warmer than room temperature (recessed luminaires may get very warm inside, decreasing CFL output). However, some CFLs use amalgam technology to make them much less sensitive to temperature changes. If temperature, and resulting light output, is a concern, try a lamp that uses amalgam.
- CFLs offer a wide range of colors not available in incandescent lamps. 2700K correlated color temperature (CCT) looks a lot like typical yellowish incandescent lamps; many people could not tell the difference based simply on the light. 3500K is a neutral white color, while 4100K looks crisply cool. Even cooler colors (5000K, 6500K) are available in some CFL sizes for special applications. 2700K lamps work in most places, while 3500K matches good linear fluorescent lamps. 4100K makes green landscapes look very good, and looks similar to the color of cool linear fluorescent lamps.

- Energy Star compliance can provide confidence that a CFL will give reasonable performance.
- Relamp and clean as suggested in the Overview section.

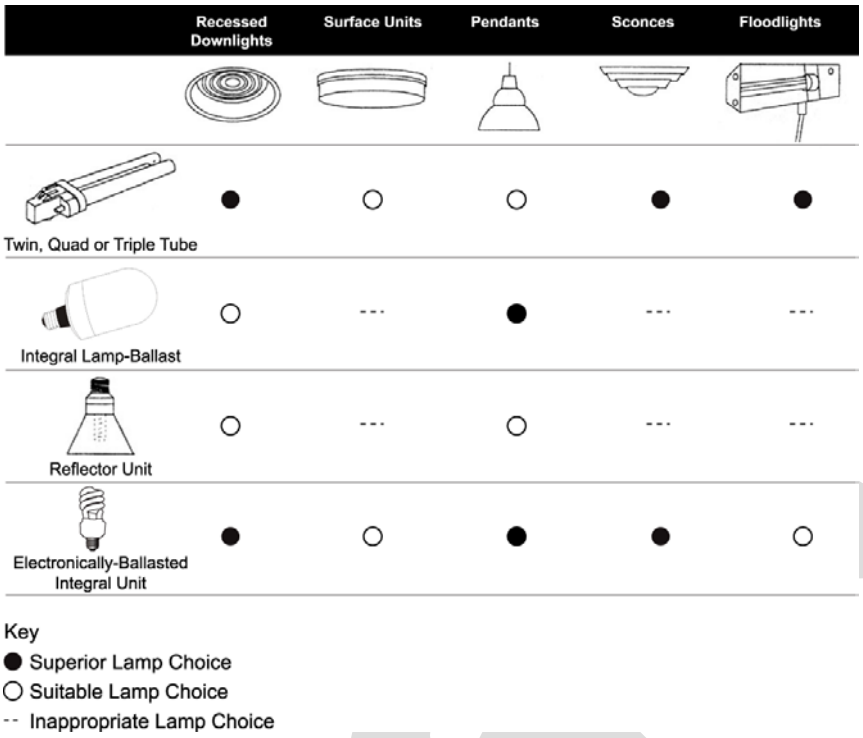


Figure 7 – Compact Fluorescent Lamp Selection Guide.

Applicable Codes and Standards

Like linear fluorescent lamps, CFLs should be recycled when they are removed from service. See Overview sections on group re-lamping for details. CFLs are too new to use ballasts that might have PCB capacitors, so CFL ballast disposal is not a problem.

Benefits

The key benefit to using efficient screw-based lamps is that they save overall lighting costs (see below). Many efficient lamps will also last much longer incandescents, decreasing maintenance.

Costs

While efficient CFL lamps cost more initially than incandescent lamps, their overall cost is usually less due to much lower energy costs and less required maintenance. Durability is not obvious by looking a CFL, so a poorly made lamp can look about like a well made lamp. Even though an Energy Star or brand name lamp might cost more initially, longer life or better performance can easily offset lower first cost.

Monitoring/Controls

See the controls guidelines below.

Common Retrofit Opportunities

Any screw-based socket that still uses an incandescent or mercury lamp should be considered for retrofit with a CFL or metal halide lamp. Be careful, though, about spotlamps (R or PAR with a narrow beam) since a CFL will not provide the narrow beam.

However, applying a motion sensor or timer to an incandescent lighting system could make that system cost less than converting to CFLs. The key is estimating how long (minutes or hours per day) the system would be operating with a control. A few more calculations will show the payback period for installing a motion sensor, CFLs, or maybe both, thereby indicating how valuable the control retrofit would be.

Verification/Commissioning

Lamp replacement itself usually just needs an operational check upon completion. Lighting control retrofitting needs additional acceptance testing or verification, and controls need periodic (perhaps annual or semi-annual) verification.

References/Additional Information

See the References/Additional Information section in the Overview.

Guideline ES5: HID Luminaire Maintenance

Recommendation

Maintain HID luminaires based on the lighting maintenance plan, including relamping, cleaning and replacing failures. Replace ballasts and other failures according to the lighting maintenance plan.

Typical Metal Halide HID Lamps.

Source: New Buildings Institute, Advanced Lighting Guidelines

Description

Metal halide lamps (MH) offer white light with energy efficiency and relatively long lamp life. Clear (uncoated) lamps are effectively a point source, making them good for accent lighting or controlled beam patterns. Newer technology lamps (all 150 watt and smaller lamps, plus selected lamps up to 1000 watts) use pulse-start (PS) technology for longer life and higher light output. Some also offer outstanding color rendering (standard metal halide lamps are already good in this regard). PS lamps have shorter restrike times than older MH lamps, but they may still require emergency back-up lighting in case the MH lamps are switched off but are immediately needed again. These lamps need an igniter as part of the ballast (like HPS lamps), and they are not interchangeable with older probe start lamps. A complete new ballast is required to operate PS lamps, even if they have the same power rating as old probe start lamps.

MH lamps may be available in a range of colors and color rendering properties. For example, a 70 watt ceramic MH lamp may offer correlated color temperature (CCT) of 3000K and color rendering index (CRI) of 89. A 70 watt standard MH lamp (that operates on the same ballast) would offer CCT of about 4000K and CRI of 65, lower light output, poorer lamp lumen depreciation and shorter life. Although the price of the standard lamp is lower, the ceramic MH lamp offers better lighting quality and life. Do not replace a ceramic MH lamp with a standard lamp without considering the tradeoffs.

The light output of any MH lamp decreases markedly over life, so a new lamp will generate quite a bit more light than an old lamp. In addition the color will shift over time, often creating a rainbow of lamp colors unless group relamping keeps age for all lamps about the same. If the lamp color appearance needs to be uniform, be sure to use group lamp replacement and save good used lamps for spot replacement of early failures in the next group (see overview section).

Some MH lamps will operate properly in any position, while others work properly in one or a two positions. In general, the position oriented lamps offer better performance but cost more.

High pressure sodium (HPS) lamps offer energy efficiency and long life, but the "golden-white" light may not be acceptable for many applications. HPS lamps normally cycle when they reach end-of-life: they turn on and run for a few minutes, then spontaneously extinguish, starting the cycle again. This characteristic means often a lamp that needs replacing seems to operate fine, causing a maintenance headache. Some lamps, called non-saturated HPS, do not cycle. They have the same performance as regular HPS lamps and use less mercury, too. Another type of HPS lamp has twin arc tubes to provide instant restrike from a momentary power failure. Their rated life (and cost) is much longer. A few ceramic MH lamps will directly replace HPS lamps and operate on HPS ballasts, offering much better color while sacrificing some light output and lamp life. Compared to existing MH lamps, these new lamps offer better performance but the price could be high.

HID ballasts are usually very specific for a lamp type, although most have multiple taps for a range of voltage compatibility. Most HID lamps and ballasts use ANSI (American National Standards Institute)

designations such as S50 or M108; if both lamp and ballast have the same designation they are compatible. HID ballasts usually last many years. Almost all are magnetic, with a capacitor and many use an electronic igniter. Any of the three ballast elements can fail, so troubleshooting may mean trying known good replacement components on a trial basis. Sometimes that process works best when the complete ballast is replaced in the luminaire, then checked for failed parts on a shop workbench. Note that igniters give pulses of thousands of volts, which is both a hazard if maintenance staff is careless, and a hazard to meters looking for lamp power. To repair a ballast, either replace components on a trial basis (with the power off!), or use a specialized ballast tester to verify appropriate voltage and starting pulses.

Applicable Codes and Standards

Lamp and ballast manufacturers comply with federal and state standards that require minimum lamp and ballast performance.

Some old ballasts, purchased before 1979, could have capacitors that use toxic PCB oil inside. If a failed ballast or capacitor may contain PCBs, treat the ballast according to the school's toxic waste procedure. Unless a capacitor is actually leaking oil, it is not an immediate hazard but should be protected from rough handling. A ballast recycling contractor can properly identify and dispose of a failed ballast that could contain PCBs. See Overview-Group Lamp Replacement for details.

Benefits

TO COME.

Costs

TO COME.

Monitoring/Controls

See the controls guidelines below.

Common Retrofit Opportunities

Mercury lamps are an old, inefficient technology that should generally be replaced. MH is often the best choice, although HPS offers similar CRI and rated life to mercury. Some pulse-start MH lamps last about as long as mercury, along with much better lumen depreciation over time. If very long life is paramount, some induction fluorescent lamps offer four times the rated life of mercury.

A few retrofit lamps are available for common applications, such as HPS lamps for mercury ballasts, or MH lamps for HPS ballasts where white light is really desirable. Proper application for these lamps means both the lamp has the proper power rating and the ballast is an exact match. Often these retrofit lamps cost enough that replacing the entire lamp-ballast system with modern equipment would be more economical after a couple of group relampings. One particular MH lamp type with a ceramic arc tube can operate on a 250 or a 400-watt HPS ballast but has long life, good lamp lumen depreciation, and excellent color rendering.

Verification/Commissioning

Lamp replacement itself usually just needs an operational check upon completion. Lighting control retrofitting needs additional acceptance testing or verification, and controls need periodic (perhaps annual or semi-annual) verification.

References/Additional Informationon

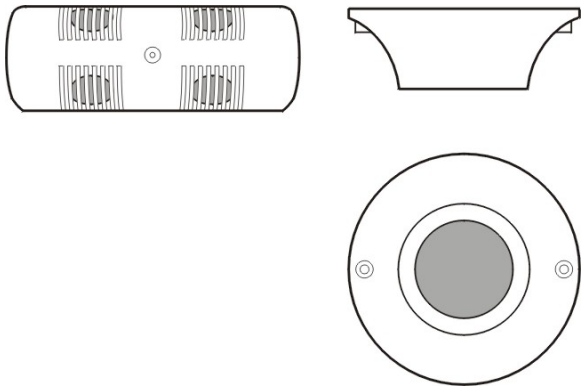
See the References/Additional Information section in the Overview, and:

NALMCO: International Association of Lighting Management Companies; http://www.nalmco.org. Address: 431 E. Locust, Suite 300, Des Moines, IA 50309; Phone: 515-243-2360; Fax: 515-243-2049; e-mail: director@nalmco.org. NALMCO consists of member companies that perform all aspects of lighting maintenance, and encourage professional competence in this area.

Guideline ES6: Control Maintenance: Occupant and Motion Sensors

Recommendation

Test the controls on a regular basis to ensure they are operating properly. Respond promptly to any control complaints to prevent tampering. Explain simplified control operation to key users so they feel included in team. Keep a copy of the manufacturer's brief control instructions with the control (e.g., inside the cover). If a control is accessible to room occupants, place a contact number near the control for individuals to call for assistance if have difficulty with the control. This can help encourage occupants to get assistance before manually disarming (or damaging) a control.



Ceiling and wall mounted occupancy sensors have good school applications.

Description

Lighting controls can save surprising quantities of energy and energy costs by turning off lighting that is not used at a particular time. Although they require periodic checks to verify operation, and careful adjustment to make sure they do not affect needed lighting, the payback for good lighting controls can be large. The keys to good energy savings from lighting controls are to adjust them properly initially (commissioning), maintain their proper operation carefully, and respond to user observations to keep them responsive to user needs.

Have the occupant sensor instructions readily available, either a summary in the control cover or in a very convenient binder that maintenance staff can access. Keeping instructions readily at hand can save lots of time and frustration.

If a motion sensor is exposed to room occupants the user may try to adjust or disable a unit that appears uncooperative. Attaching a label to that control with the maintenance extension number and an admonition to call staff for any adjustment can help keep the controls operating properly and the users happy. An unhappy user may creatively undermine the operation and savings potential of the control. Listen to any comments the users have about control operation, then adjust accordingly. Ask users for comments if they do not volunteer any.

Periodic performance verifications will make sure that lighting controls effectively save energy over time. An annual verification (recommissioning) schedule would be typical, although controls that need frequent adjustment may need attention sooner. The control manufacturer may have more specific guidelines. The lighting management plan should show the control verification schedule.

Applicable Codes and Standards

Some states, like California, have special regulations for occupant sensors and other lighting controls (see Title 24 Part 6 Subchapter 2 Section 119, "Mandatory Requirements for Lighting Control Devices"). Since manufacturers must assure compliance, the products available in the state for commercial applications comply. Other states may have similar standards.

Benefits

TO COME.

Costs

TO COME.

Monitoring/Controls

See the controls guidelines below.

Common Retrofit Opportunities

On a case-by-case basis, older controls that function marginally may be retrofitted with more recent controls that offer better operation. For example, newer occupant sensors may provide better detection or self-programming capabilities.

Verification/Commissioning

N/A.

References/Additional Information

See Overview Section references, and:

EPRI, *Lighting Controls- Patterns for Design*, TR-107230, 1996, Palo Alto, CA.

NALMCO: International Association of Lighting Management Companies; http://www.nalmco.org. Address: 431 E. Locust, Suite 300, Des Moines, IA 50309; Phone: 515-243-2360; Fax: 515-243-2049; e-mail: director@nalmco.org. NALMCO consists of member companies that perform all aspects of lighting maintenance, and encourage professional competence in this area.

Guideline ES7: Daylighting Controls Maintenance

Recommendation

Keep a copy of the manufacturer's brief instructions with the control (e.g., inside the cover). If a control is accessible to room occupants, tape a contact number for individuals to call for assistance if they have difficulty with the control. This can help encourage occupants to get assistance before manually disarming (or damaging) a control.

Test the controls on a regular basis to ensure they are still operating properly.

For complex control systems, ensure staff training on maintenance procedures and special needs.

Description

Lighting controls can range from simple photoelectric switches to complex computerized energy management systems. While the simplest can, in some cases, save dramatic amounts of energy, the more complicated ones can closely pattern lighting needs to save as much energy as possible. Most facilities try something in between.

When installing a daylighting control, bundling a copy or summary of the instructions with the control (inside the cover, for example, if there is room), may save time. Having the instructions readily at hand can save time and frustration.

If a daylighting control is exposed to room occupants, the user may try to adjust or disable a control that appears uncooperative. Attaching a label to that control with the maintenance extension number and an admonition to call for any adjustment can help keep the controls operating properly and the users happy. An unhappy user may creatively undermine the operation and savings potential of the control. Listen to any comments the users have about control operation, then adjust accordingly. Ask users for comments if they do not volunteer any.

Performance verification should be conducted for all controls. Each type of control, and its exposure to potential unauthorized fiddling, will determine the proper performance verification schedule. The control manufacturer can assist setting up the schedule initially. The lighting maintenance plan should include all verification schedules, test techniques and adjustment methods.

Typical daylighting control adjustments require a calibrated lightmeter. The lightmeter itself needs periodic calibration by a cal lab, perhaps by the meter manufacturer or the daylighting control manufacturer. While many modern lightmeters retain their calibration very well, a meter that falls out of calibration may look no different than an accurate meter.

Applicable Codes and Standards

Some states have specific standards for lighting controls, and manufacturers make sure their products comply. Use caution, however, if purchasing a new or replacement control from an out-of-state vendor.

Benefits

Periodic performance verifications will make sure that lighting controls effectively save energy and money over time.

Costs

The financial payback for properly functioning daylighting lighting controls can be large.

Monitoring/Controls

N/A.

Common Retrofit Opportunities

On a case-by-case basis, older daylighting controls that function marginally may be retrofitted with more recent controls that offer more transparent operation. Too, adding daylighting controls when performing other lighting maintenance (such as cleaning or other retrofits) can make sense if enough daylight is available.

Verification/Commissioning

N/A.

References/Additional Information

See Overview Section references, and:

EPRI, Daylighting Design Smart and Simple, TR-109720, 1997, Palo Alto, CA.

EPRI, *Lighting Controls- Patterns for Design*, TR-107230, 1996, Palo Alto, CA.

NALMCO: International Association of Lighting Management Companies; http://www.nalmco.org. Address: 431 E. Locust, Suite 300, Des Moines, IA 50309; Phone: 515-243-2360; Fax: 515-243-2049; e-mail: director@nalmco.org. NALMCO consists of member companies that perform all aspects of lighting maintenance, and encourage professional competence in this area.

Guideline ES8: Timers and Timeclock Maintenance

Recommendation

Test the controls on a regular basis to ensure they are still operating properly, as indicated in the lighting maintenance plan.

Keep a copy of the manufacturer's brief control instructions with the control (e.g., inside the cover).

For more complex timers, train staff properly on maintenance procedures and programming.

Description

Timers and timeclocks can save surprising amounts of energy costs by turning off lighting that is not used at a particular time. The keys to good energy savings from lighting controls are to adjust them properly initially, maintain their proper operation carefully, and respond to user observations to keep them working properly.

Although apparently simple, timers and timeclocks need a little bit of expertise for installation and maintenance and careful strategy analysis and maintenance verification. The more complicated the timer, the more important it is to ensure proper application, installation and continuing maintenance.

When installing a lighting timer or timeclock that might need adjustment or reprogramming in the future, bundle a copy or summary of the instructions with the control (inside the cover, for example). The more service-free a manufacturer makes the control, the longer until maintenance staff will readjust it, and the easier it is to forget how to program the control or where the instructions might be. Having the instructions readily at hand can save lots of time and frustration following a problem.

Periodic performance verifications will make sure that lighting timers effectively save energy. Typical verification would be weekly during a general inspection, and seasonally for programming to a specific, odd-hour need.

Applicable Codes and Standards

Some states have specific standards for lighting controls, including timers, and manufacturers make sure their products comply. Use caution, however, if purchasing a new or replacement control from an out-of-state vendor.

Benefits

Well-calibrated timers save significant amounts of energy by turning off lights when they are not needed.

Costs

The payback for properly set and maintained timers can be large.

Monitoring/Controls

N/A.

Common Retrofit Opportunities

On a case-by-case basis, older timers and timeclocks that function marginally may be retrofitted with more recent controls that offer better operation. Electro-mechanical timers, for example, may be replaced with electronic timers that offer precise control, power back-up and freedom from lost trippers.

Verification/Commissioning

N/A.

References/Additional Information

See Overview Section references, and:

EPRI, *Lighting Controls- Patterns for Design*, TR-107230, 1996, Palo Alto, CA.

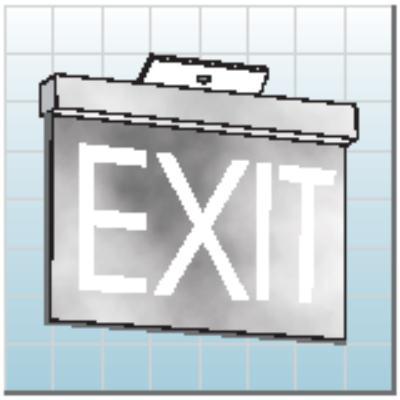
NALMCO: International Association of Lighting Management Companies; http://www.nalmco.org. Address: 431 E. Locust, Suite 300, Des Moines, IA 50309; Phone: 515-243-2360; Fax: 515-243-2049; e-mail: director@nalmco.org. NALMCO consists of member companies that perform all aspects of lighting maintenance, and encourage professional competence in this area.

Guideline ES9: Exit and Emergency Lighting Maintenance

Recommendation

To minimize maintenance costs, retrofit any exit signs using incandescent lamps with LEDs as soon as possible. Exit signs using fluorescent lamps are also cost effective to retrofit with LEDs, but the energy use difference is not so significant.

All emergency lighting needs routine maintenance, both for periodic testing and replacing failed components such as batteries.



Edge-lit LED Exit Sign
Source: Advanced Lighting Guidelines

Description

Light emitting diodes (LEDs) are the best light source for almost all exit signs, either red or green. LEDs provide an excellent combination of moderate first cost, low maintenance and tiny energy use (less than 5 Watts per face). For incandescent exit signs, retrofit with LEDs as soon as possible. Unless fluorescent exit signs use less than 5 watts per face they are also cost effective to retrofit with LEDs.

LED exit signs come in three general types: reflective, direct-view and edge-lit panels (in order of increasing usual cost). Selecting any of these types is a matter of owner preference. In a retrofit situation, the electrical engineer should specify red or green color to comply with any local fire or electrical codes, or a preference for visibility.

A great advantage to LED exit signs is that they need almost no routine maintenance (just the periodic checks). LEDs are rated to last about 11 years of continuous operation; at that time almost all of them should still work, but their output will gradually degrade until the exit sign will not meet performance requirements. The sign (or retrofit) manufacturer, in the instruction sheet, should indicate the appropriate age to plan for sign replacement. The lighting maintenance plan should include this information.

Emergency lighting usually relies on either batteries or an emergency generator to provide visibility during a power interruption. Typically these require monthly verification, as specified in the lighting maintenance plan. Batteries gradually deteriorate, and the lighting manufacturer will indicate a typical battery life. Group battery replacement may be cost effective, and a life cycle cost benefit analysis can determine so. Many batteries contain toxic materials; use them in accordance with the toxic waste handling policy.

Since emergency lighting only operates a tiny fraction of the time, incandescent lamps are typical. Sometimes they fail, however, and periodic inspection will show failures. Fluorescent lamps use less energy for the same duration of light, so they have smaller (and less expensive) batteries. Sometimes emergency fluorescent lighting ballasts have batteries built in. LEDs offer good promise for future emergency lighting as their technology improves. They can use small batteries and simpler (more reliable) electronics (including the LED itself!), but LED light output is too feeble for many emergency lighting applications.

Where operational verification is difficult, emergency lighting manufacturers offer computerized testing apparatus that will test on schedule, alerting the maintenance staff to any problem.

Applicable Codes and Standards

National Fire Protection Association (NFPA) Life Safety Code and Uniform Building Code (ICBO: International Conference of Building Officials) both specify exit and emergency lighting performance. Local codes may also require certain types, such as the color of exit signs.

Underwriters Laboratories (UL) Standard 924 gives performance requirements for exit signs, and an exit sign listed (by UL or other laboratory) to that standard provides additional performance confidence.

Some retrofit kits (replacing incandescent or compact fluorescent lamps with LEDs) also have listings by UL or another laboratory, indicating that a specific retrofit kit will also provide appropriate performance.

Benefits

LED exit lights offer long performance life at very low maintenance costs.

Regular maintenance of emergency lights will ensure that the system functions properly in crisis situations.

Costs

Maintenance costs for LED exit lights are very low.

Monitoring/Controls

N/A.

Common Retrofit Opportunities

From a cost and maintenance standpoint, all incandescent exit signs should be replaced or retrofit. A careful life cycle cost benefit analysis may also indicate that fluorescent and CFL lamp exit signs need to be replaced or retrofit. LED retrofit products exist that can directly replace either incandescents or CFLs at the next scheduled lamp replacement.

Verification/Commissioning

N/A.

References/Additional Information

See Overview Section references.

NALMCO: International Association of Lighting Management Companies; http://www.nalmco.org. Address: 431 E. Locust, Suite 300, Des Moines, IA 50309; Phone: 515-243-2360; Fax: 515-243-2049; e-mail: director@nalmco.org. NALMCO consists of member companies that perform all aspects of lighting maintenance, and encourage professional competence in this area.

Lighting Research Institute, *Specifier Reports-Exit Signs*, Vol. 2 No. 2, Rensselaer Polytechnic Institute, 1998, Troy NY, http://www.lrc.rpi.edu/nlpip/publications.cfm

Guideline ES10: Photovoltaic Arrays

Recommendation

Maintain photovoltaic (PV) systems by keeping panels clean and periodically checking that both panels and inverter are functioning to produce electricity at efficient levels. Battery systems need periodic maintenance if used.

Fort Benton High School, Montana.

Source: NREL/PIX 09277

Description

Because photovoltaic systems have no moving parts, they require very little maintenance once they are installed and tested for efficient performance. In fact, most systems applicable to school settings are usually under warranty for at least 20 years (and the inverter at least five years), so any problem can be resolved at little cost.

The most important maintenance activity for PV systems is inspection. A person should be designated responsible for the inspection of the PV panels and inverter at least once or twice throughout the year to be sure they are producing the expected amount of electricity. Some districts have grants with the local utility to do this maintenance, some districts work with consultants and/or manufacturers, and some districts budget in two to six hours annually for their staff to inspect and resolve problems for the systems. The following are maintenance and operation recommendations for PV systems (from the Federal Energy Management Program):

- Inspect the PV array surface for excessive dirt or debris (a thin layer of dust is not a concern).
- Inspect the mechanical bolting system and wiring to see if anything is loose or damaged (sometimes vandalism can be a concern as well).
- Inspect the array for damaged modules or shading by trees, weeds, and other obstructions.
- Measure the array output current and voltage to verify proper operation.
- If work is done near the panels or system, upon completion ensure that the panels, wiring, mounting mechanism, and inverter were not disturbed.
- Seasonally adjust the PV array tilt angle to optimize energy output (cost effective for larger systems only).
- If batteries are being used, inspect for corroded terminals and clean if required, and measure battery voltage to verify state of charge. Maintenance-free batteries should be inspected approximately once each year.
- If flooded batteries are being used, add distilled water if the electrolyte level is low. Flooded batteries should be inspected every three to six months.

Applicable Codes and Standards

Photovoltaic systems should be installed in compliance with the National Electrical Code (NEC), Section 690. This section specifies the required wire sizes, fuses, disconnects, and other considerations that make a safe system possible. Local codes and standards may also apply. PV systems should be installed by qualified licensed electricians who are familiar with NEC requirements.

Benefits

- PV requires very little staff time for maintenance or operation – wear and tear is minimized since it has no moving parts and produces power silently.
- PV is most cost effective in remote locations that are at a distance from an electrical grid. PV can be up to three to six times more expensive than utility-supplied electricity. However, this figure does not take into account the "real" or environmental cost of utility-generated electricity or local rebates.
- PV is environmentally benign during use and does not produce any greenhouse gases or acid gas emissions associated with other methods of generating electricity. It has zero environmental costs.
- PV produces electricity from an abundant and reliable "fuel" – sunlight. Coupled with storage batteries, PV is capable of supplying uninterrupted power.
- Although PV may be combined with other power sources in hybrid systems to increase system reliability, PV itself requires no connection to an existing power source or fuel supply. It can also be grid connected, requiring no batteries.
- For grid-tied PV systems, net metering allows schools to receive utility credits for the surplus electricity generated by PV systems.
- By putting power back into the electrical grid and shaving peak loads, PV can have far-reaching implications.
- PV can withstand severe weather conditions including snow and ice.
- PV can be combined with other types of electric generators (wind, hydro, and diesel, for example) to charge batteries and provide power on demand.

Costs

Little research has been done on the costs of maintaining and operating photovoltaic systems. However, a 2003 study by Sandia National Laboratory[3] reports that annual operation and maintenance costs for small, off-grid residential systems average about 0.6% of the initial capital cost. Annual costs for maintaining large, utility-scale, grid-tied systems average 0.4% of installed capital cost.

Monitoring/Controls

If the PV system uses batteries, a good controller specially designed for photovoltaic systems will prevent batteries from overcharging as well as undercharging.

Common Retrofit Opportunities

Refer to the CHPS Best Practices Manual Volume II for information on choosing to install PV systems at schools.

Verification/Commissioning

After a PV system has been installed, the commissioning agent should verify that the system is operating at the designed efficiency. Periodic inspections are recommended to ensure that the system continues to operate efficiently (see Description, above).

References/Additional Information

Federal Technology Alert: Photovoltaics. Federal Energy Management Program. http://www.eere.energy.gov/femp/prodtech/pvfta.html.

Lifecycle Cost Assessment of Fielded Photovoltaic Systems. L. Moore, L. Malczynski, J. Strachan, and H Post. Presented at the NCPV and Solar Program Review Meeting. 2003. NREL/CD-520-33586. http://www.nrel.gov/ncpv_prm/pdfs/33586050.pdf.

[3] Moore, L., L. Malczynski, J. Strachan, and H Post. *Lifecycle Cost Assessment of Fielded Photovoltaic Systems.* Presented at the NCPV and Solar Program Review Meeting. 2003. NREL/CD-520-33586.

HVAC and Mechanical Equipment

Overview

The mission of a school's HVAC system is to provide comfort and good indoor air quality. The goal of an HVAC maintenance program is to meet those needs while also ensuring reliability, energy efficiency, and minimum system life cycle cost. This chapter covers maintenance of ventilation, cooling and heating systems.

- HVAC Maintenance Plan (Guideline HV1)
- HVAC Performance Evaluation (Guideline HV2)
- Packaged Air Conditioning Systems (Guideline HV3)
- Fan Coils and Unit Ventilators (Guideline HV4)
- VAV Systems (Guideline HV5)
- Chilled Water Systems (Guideline HV6)
- Hot Water Systems (Guideline HV7)
- Air Filters (Guideline HV8)
- Economizers (Guideline HV9)
- Ducts (Guideline HV10)

There are a lot of reasons that HVAC maintenance is important. Good maintenance helps control operating costs by keeping systems operating efficiently. Maintenance helps ensure good indoor air quality with proper ventilation and elimination of contaminant sources. Maintenance reduces life cycle cost by extending equipment life and avoiding premature replacement. Maintenance improves comfort by ensuring that systems operate at proper capacity and by ensuring that controls work as intended. Maintenance also improves reliability and helps avoid classroom disruptions.

The benefits of maintenance must be weighed against the costs, and funding for school maintenance is often tight. However, it usually works out that an investment in maintenance pays off in the long run.

Probably the biggest benefit of good HVAC maintenance is less staff time spent dealing with costly complaint calls and emergency equipment failures. Maintenance staffs are often kept busy responding to emergencies and complaints, and there seems to be little time for preventive maintenance tasks. But experience of many facility managers has shown that with an extra effort in proactive maintenance they can get the upper hand on those emergencies and be able to find more time for preventive work. As a side benefit, it can be more rewarding for the maintenance staff to take charge of the situation and maintain good HVAC operation rather than constantly respond to comfort complaints and system failures.

Indoor Air Quality

HVAC maintenance affects indoor air quality in several ways, but the most important task related to air quality is to ensure that proper ventilation is provided. Proper ventilation consists of a continuous supply of outside air at a rate that varies somewhat based on the space type.

The appropriate ventilation rate is usually around 15 cubic feet per minute (cfm) per occupant, which is the typical requirement for new construction (see the CHPS Best Practices Manual Volume II, California Building Code Title 24, Part 6, Section 121 or ASHRAE Standard 62-2001). However, existing school buildings often have lower ventilation rates, usually based on the codes in affect at the time of construction. Older HVAC systems were usually designed for a ventilation rate of 5 cfm per person.

State safety and health law (Cal-OSHA §5142 Mechanically Driven Heating, Ventilating and Air Conditioning (HVAC) Systems to Provide Minimum Building Ventilation) states that, "The HVAC system shall be maintained and operated to provide at least the quantity of outdoor air required by the State Building Standards Code, Title 24, Part 2, California Administrative Code, in effect at the time the building permit was issued." That portion of Title 24 is the California Building Code, which requires at least 5 cfm per person in educational facilities. The appropriate rate may be higher based on more recent codes, but 5 cfm per person is the minimum.

Benefits of HVAC Maintenance:

► Lower energy cost

► Better indoor air quality (less risk of air quality problems)

► Longer equipment life

► Potentially better occupant comfort

►Better information for facilities planning, such as equipment status and maintenance costs.

Most HVAC systems that have the capability to provide ventilation air have been designed to provide at least 5 cfm per person, but §5142 also requires that ventilation be provided continuously when the space is occupied. Many school spaces fail to meet the continuous ventilation requirement. Often the HVAC fan is set to "auto" mode, and the fan runs only when there is a need for either heating or cooling. In those systems, the fan cycles on and off like a typical residential system. In many cases this problem may be solved by simply changing the control setting so that the fan runs continuously during occupied hours. However, in cases with excessive fan noise, continuous operation may create an acoustics problem. Those cases do not always have an easy solution, and an alteration or replacement of the HVAC system may be necessary.

There is an exception to §5142 that allows the mechanical ventilation system to be shut off when spaces are naturally ventilated. However, it must be shown via calculations that natural ventilation is meeting the minimum ventilation rate when the fan is not running. In practice, natural ventilation is accepted as an alternative if the area of operable openings is at least 5% of the floor area and that no part of the space is farther than 20 feet from an opening (this is the exception in the ventilation requirements for new construction in Title 24).

So what is the bottom line for HVAC maintenance?

- Ensure that continuous ventilation is provided, or that windows or other openings are being used to provide ventilation when the fan is not running.
- Confirm that the HVAC is bringing in an adequate amount of outside air.

The second task related to indoor air quality is to make sure that the HVAC system itself does not become a source of indoor air contaminants. Inspection and periodic cleaning is important to avoid potential problems such as standing water in cooling coil condensate drain pans and dirty filters. See the guidelines below regarding air filters, cooling coils and ducts. Inspection of the environment around outside air intakes is also important. Conditions to avoid include things like standing water (where mold growth may occur) and idling cars or buses nearby.

Tracking of air quality is also a valuable part of the HVAC maintenance process. See the guideline on preventive maintenance plans for recommendations.

It is also important to remember that HVAC maintenance is only one piece of a successful IAQ maintenance program. Attention must also be paid to cleaning practices, pest control, and moisture control. Those topics are covered in other sections of this manual.

Occupant Comfort

There are also several ways that maintenance can help ensure that the HVAC system provides good comfort as intended. Maintaining temperature controls are probably the biggest priority. Another priority is to ensure adequate airflow and refrigerant charge, especially for systems that have problems meeting

cooling loads. Noise is also an important factor in students' indoor environment, and maintenance can help to minimize unnecessary noise generated by fan belts or loose parts within the HVAC equipment.

As most maintenance personnel know from experience, there is no single temperature setting that satisfies all people all the time. And there are many other factors besides air temperature that affect comfort. Humidity, air movement, and the temperature of the surfaces surrounding occupants all have an impact. Preferences also vary by time of year. (The CHPS Best Practices Manual Volume II provides additional information about thermal comfort.) ASHRAE Standard 55 defines a range of conditions where most people feel comfortable, but, of course, the standard means nothing to a teacher who is feeling too hot or too cold. The fundamental decision for a system designer and maintenance staff is whether to give the occupants control over their own temperature setpoints. There is no correct answer; either central control or occupant control can be successful. But it is important to note that the CHPS Criteria (Best Practices Manual Volume III) give credit for systems that allows occupants control over the temperature setpoints in their spaces.

Another question without a simple answer is how to deal with the efforts of people to take control of their own environments, sometimes at the expense of excess energy consumption. Staff may bring in electric space heaters in the winter or prop open doors during warmer times. It is likely that these kinds of behavior are more common in facilities with central control. For those cases, it may be appropriate to install switches on doors and windows that shut of the HVAC system when the doors or windows have been open for 15 minutes or so. Another option is to provide occupants with at least some range of control, say allowing them to vary the temperature plus or minus three degrees relative to the standard setpoint. Probably the best solution is to provide simple and readily accessible controls for the occupants to shut off the system when windows can be opened for natural ventilation. In each of these cases, occupant education is helpful. It's important to regularly inform staff about how to control the temperature as well as about the importance of ventilation and how to control the ventilation system.

Energy Efficiency

Maintenance practices can have a significant impact on HVAC energy consumption. Probably the most important issue is time-of-day controls. Making sure that the HVAC system runs only during occupied periods (including some morning startup time) is usually the easiest way to save energy. Several other ways to save energy are discussed in the sections below that cover ducts (duct sealing), economizers (fixing faulty economizers), and packaged air conditioning systems (verifying and adjusting refrigerant charge).

Replacement of older equipment with newer, more efficient units can save a significant amount of energy, but is usually not a cost effective measure unless the existing equipment is near the end of its useful life.

There are some maintenance practices that may end up unavoidably increasing energy consumption. The biggest impact comes when switching from intermittent to continuous fan operation for ventilation purposes. In extreme climates it may be worth looking into heat recovery options to reduce the heating and cooling loads due to the extra ventilation air.

Codes and Regulations

There are a number of regulations related to HVAC system maintenance and operation. Some of them have been mentioned above but are also listed here for completeness.

- Title 8 CCR §5142. Mechanically Driven Heating, Ventilating and Air Conditioning (HVAC) Systems to Provide Minimum Building Ventilation. Described above. (California Division of Occupational Safety and Health, www.dir.ca.gov/dosh).
- Title 8 CCR §5155. Airborne Contaminants. Lists permissable exposure limits (PEL) for a variety of potential contaminants. Requires monitoring if it is reasonable to expect that employees may be exposed to concentrations greater than the PEL. (California Division of Occupational Safety and Health, www.dir.ca.gov/dosh).

- Section 608 of the Clean Air Act. Sets requirements for the management and recovery of refrigerants. Requires record keeping for equipment with more than 50 pounds of refrigerant. (US EPA, www.epa.gov)
- Boilers and Water Heaters. The requirements vary among the 35 local air districts in California. See www.arb.ca.gov for a database of regulations. As an example, the following rules apply in the South Coast Air Quality Management District.
    - Rule 1146. Emissions of Oxides of Nitrogen from Industrial, Institutional and Commercial Boilers, Steam Generators, and Process Heaters. (For units larger than 5,000,000 Btu/hr heat input)
    - Rule 1146.1. Emissions Of Oxides Of Nitrogen From Small Industrial, Institutional, And Commercial Boilers, Steam Generators, And Process Heaters. (For units from 75,000 Btu/hr to 2,000,000 Btu/hr heat input)
    - Rule 1146.2 - Emissions Of Oxides Of Nitrogen From Large Water Heaters And Small Boilers. (For units between 2,000,000 Btu/hr and 5,000,000 Btu/hr heat input)
- Title 8 CCR §1529. Asbestos. (California Division of Occupational Safety and Health, www.dir.ca.gov/dosh)
- For information on regulations related to lead see www.dhs.ca.gov/childlead, the California Department of Health Services
- Other employee safety standards related to personal protective equipment, occupational noise exposure, respiratory protection, hazardous material handling, and confined space entry. See www.dir.ca.gov/dosh, Division of Occupational Safety and Health.

In-House or Outsource

Some districts decide to outsource HVAC maintenance tasks and others do most of the work in-house with district staff. Typically, a mix of in-house and contracted staff share the HVAC maintenance duties. The best approach will vary from one district to the next, depending on the size of the district and the complexity of HVAC systems. Often the periodic maintenance of large chillers and boilers is handled by a service contractor while other tasks such as filter replacement and air handler cleaning are carried out by district staff. One of the benefits to using in-house maintenance staff is retention of experience and benefits of learning.

Resources/Additional Information

2003 ASHRAE Handbook – HVAC Applications, Chapter 38, Operations and Maintenance Management.

ASHRAE Standard 62-2001 Ventilation for Acceptable Indoor Air Quality, http://www.ashrae.org/.

Pennsylvania Department of General Services and Green Seal, *Pennsylvania Green Building Maintenance Manual*, http://www.dgs.state.pa.us/dgs/cwp/view.asp?Q=118184.

Portland Energy Conservation, Inc., Fifteen O&M Best Practices for Energy Efficient Buildings, September 1999.

Portland Energy Conservation, Inc., Putting the "O" Back in O&M, September 1999.

Washington State Department of Health, *School Indoor Air Quality Best Management Practices*, February 1995.

University of California Indoor Air Quality Work Group, Indoor Air Quality Tools: Education, Prevention, and Investigation, http://ehs.ucdavis.edu/ftpd/ucih/iaqtools.pdf.

U.S. Environmental Protection Agency, *Building Air Quality – A Guide for Building Owners and Managers*. EPA/400/1-91/003, 1991.

U.S. Environmental Protection Agency, IAQ Tools for Schools, http://www.epa.gov/iaq/schools/tools4s2.html.

Guideline HV1: HVAC Maintenance Plan

POTENTIAL GRAPHICS: COMPUTER, CHECKLIST, TECHNICIAN DOING SOMETHING, PHOTO OF A MAINTENANCE PERSON IN UNIFORM.

Recommendation

Develop a maintenance plan for the HVAC system and set up a process to update and revise the plan over time. Implement the plan!

Description

An HVAC maintenance plan can take many forms. There is no one "best" format or content. In fact, one of the most important benefits of a plan is the act of putting it together. But in general, any plan should address the issues listed below, and the plan would most likely take the form of a document with the following headings, supplemented with lots of other information as described below.

- HVAC maintenance goals.
- Responsibilities.
- System documentation.
- Maintenance task list and schedule.
- Evaluation task list and schedule.
- Recordkeeping process.

Many school districts now take advantage of packaged maintenance software to help schedule work orders and track results. These programs may also provide assistance in setting up the list of appropriate tasks and maintenance procedures for typical equipment. While these software packages can help boost productivity and improve recordkeeping, they do not eliminate the need for developing an overall plan. The software should be considered a tool to be used to help implement portions of the plan.

The following sections provide more details on the suggested contents of a maintenance plan for HVAC systems.

Maintenance Goals

Traditionally, the primary goals of an HVAC maintenance plan are system reliability and equipment longevity. Today, that list should also include the critical goals of maintaining indoor air quality, comfort, and energy efficiency. The plan should clearly state these goals, and the maintenance tasks should be set up with these goals in mind. It is also important to communicate these goals to the staff to provide them guidance in making day-to-day maintenance decisions. One of the maintenance goals should be compliance with regulations, so it is also important to list the specific codes that affect maintenance tasks.

Responsibilities

In many cases it may be clear who has responsibility for setting up and implementing the maintenance plan, but it doesn't hurt to write it down. This is especially important in larger school districts. Some of the responsibilities include:

- Plan development and periodic updates.
- System documentation compilation and updates.
- Task scheduling and recordkeeping.
- Specific maintenance tasks (e.g. replace air filters).
- Evaluation of maintenance effectiveness.

System Documentation

Assembling and maintaining accurate documentation of the HVAC system is always challenging, but it is usually worth the effort. This information does not have to physically be part of the plan document, but the plan should identify which documents are stored, where they are located, and who is responsible for maintaining and updating them. (The plan might also prescribe severe punishment for those who "borrow" the as-built plans and never return them.) The type of information that is important to collect and maintain includes:

- Sketches showing equipment locations and zones served by each system.
- HVAC system design description, design intent document, or other narratives that describe how the system is supposed to work.
- As-built mechanical and control system plans.
- M&O Manuals. These manuals are usually assembled by the contractors on HVAC construction projects as a requirement of their contract. However, the quality of these documents varies significantly from one facility to the next. A standard reference for the appropriate contents is ASHRAE Guideline 4-1993 Preparation of Operating and Maintenance Documentation for Building Systems. See also the ASHRAE 2003 Applications Handbook p 38.3 for a brief description.
- Test and balance reports for air-side and water-side systems. These typically include measured air flows, water flows, fan and pump speeds, and motor amps. These reports provide a useful reference when checking to see if the systems are operating as they were originally set up. Update the reports if system changes are made.
- Commissioning reports.

In cases where all or a part of this system documentation is missing, it will be necessary to perform a survey of the systems to record equipment information and to perform some research to record appropriate maintenance and operation procedures. It may be helpful to work with a contractor or engineer to set up the system documentation.

Maintenance Task List and Schedule

This list is the heart of the plan, describing specific maintenance tasks and indicating how often they need to be carried out. The plan document itself may either include all the detailed checklists and procedures, or the plan may simply list the systems and their corresponding maintenance goals. Then the details can be described elsewhere such as a maintenance software package that would issue work orders. Tasks to be listed cover the following systems:

- Packaged units.
- Split systems.
- Fan coils and unit ventilators.
- Air handlers.
- Ducts.
- Chilled water systems.
- Hot water systems.
- Controls setpoints. System scheduling, operating time.
- Training.

The type of information to be included for each task includes:

- Task description (e.g. inspect, measure, test).
- Detailed instructions or reference to location of instructions.

- Appropriate corrective actions for typical problems (clean, lubricate, replace, adjust, tighten, program, schedule additional service).
- Tools, data loggers required.
- Notes about why the task is important or how it helps meet the goals.
- Location of related system documentation.
- Summer shut down/fall start up issues.

The detailed maintenance instructions are often available from equipment manufacturers. Otherwise, professional organizations or contractors can provide information. See the following sections of this chapter for more information.

This part of the PM plan should also describe a process for resolving maintenance problems. Some problems will be simple, and the appropriate corrective action can be included among the other information in the PM task list. Other problems may not have an obvious solution, and in these cases the responsibility and the process for addressing the problem should be clear.

Once a "wish list" of maintenance tasks is developed, it may be necessary to prioritize items or adjust the frequency of tasks to fit available staff time. Resources are finite, and the facility manager may need to use some judgment about which tasks are most important. When setting these priorities, it is critical to keep in mind the goals listed above so that issues of indoor air quality, comfort, and energy efficiency are not overlooked.

Evaluation Task List and Schedule

In addition to regular inspections, which are already performed by most school districts, a best practices maintenance plan should include performance monitoring and system testing. These additional steps go beyond traditional inspections and help to ensure that the HVAC systems are meeting their performance goals. This part of the HVAC maintenance plan should describe the work required to evaluate the following performance characteristics:

- Air quality.
- Thermal comfort.
- Noise.
- Efficiency.

The section entitled HVAC Performance Evaluation includes more details on specific tasks to include in this portion of the maintenance plan.

A related item to consider including in this part of the maintenance plan is evaluation of the success of the maintenance process itself. The intent of this task is to evaluate the maintenance program in terms of cost, productivity, safety, and customer satisfaction. Sometimes this work is referred to as a maintenance management audit.

Recordkeeping Process

Maintenance recordkeeping is an area where maintenance software packages can be especially helpful. The plan should describe the recordkeeping process, including the type of information to be recorded and the storage location of records. It is generally a good idea to retain records for at least three years and perhaps up to five years. For each task, record actions taken and reasons. Also record the name and affiliation of the person performing the work and the date of response.

Applicable Codes and Standards

IS THERE ANY CALIFORNIA LEGISLATION REQUIRING PREVENTIVE MAINTENANCE IN SCHOOLS? (AZ HAS SOME)

Benefits

The importance of an HVAC maintenance plan is recognized by the CHPS Criteria (see Volume III) in the "District Credits" section. Therefore, development of a maintenance plan can earn points towards qualification as a high performance school for new construction projects:

- District Credit 2: IAQ Management Plan.
- District Credit 3: Maintenance Plan.

Costs

N/A.

Monitoring/Controls

N/A.

Common Retrofit Opportunities

N/A.

Verification/Commissioning

N/A.

References/Additional Information

See the References/Additional Information section in the Overview, and:

Al*aska School Facilities Preventive Maintenance Handbook*, Alaska Department of Education and Early Development, 1999, www.eed.state.ak.us.

Arizona School Facilities Board, *Preventive Maintenance Guidelines*, 6/13/03, http://www.sfb.state.az.us/sfb/sfbMain/core_implementation.asp.

Guideline HV2: HVAC Performance Evaluation

FIGURE: SHOW EXAMPLE PLOT OF MONITORED ELECTRIC DEMAND OVER TIME, PERHAPS WITH NOTES POINTING OUT PROBLEM

Recommendation

Determine performance targets, monitor performance over time, and evaluate the results in order to identify problems. Include the specific evaluation tasks in the HVAC maintenance plan along with the traditional maintenance tasks.

Description

This section describes evaluation procedures to check that HVAC systems are performing properly. The recommended tasks focus on air quality, thermal comfort, noise, and efficiency. There are three general elements to the evaluation process.

- Establishing performance targets, baselines, or benchmarks.
- Monitoring or periodically testing performance.
- Evaluating results, either manually or automatically, and assigning actions.

In general, the first task is to determine the appropriate performance targets. These targets may come from several sources. One potential source is regulations, such as Title 24's minimum outside air flow ventilation rate. Another example is benchmarking data for comparing energy performance to other facilities. In many cases the design documentation will provide the necessary information.

The second element, monitoring and testing, is described in the following sections. In some cases the monitoring tasks can be performed with the existing EMCS. Other tasks require periodic testing.

The third step is to evaluate and interpret the information that has been collected. In some cases, the data can be interpreted by software, which can signal an alarm if something is going wrong. Other information requires periodic review by the maintenance staff or other specialists to identify potential problems. The following sections provide some guidance and suggestions about how to use the data.

The tasks listed in the following sections are presented in order of priority based on a combination of value and practicality. The ranking is somewhat subjective, but the more important, low-cost tasks are listed first. Judgment, of course, should be used when applying the lists to specific schools because the costs will vary depending on the capabilities of the existing systems.

Air Quality Evaluation

Task:	**Define ventilation rate targets.**
Description:	Determine the outside air ventilation rate required for each space, usually from design documentation.
Frequency:	One time, or following change in occupancy.
Evaluation:	None.

Task:	**Determine appropriate ventilation strategy.**
Description:	For each system, record how outside air is to be provided to each space. In many cases, this requires continuous fan operation. Spaces designed for natural ventilation may be able to meet ventilation needs without the fan running, but there should be some strategy to make sure that ventilation is provided at all times. One possibility is the use of switches on operable openings. Another possibility is to

	educate the teachers about proper operation of the fans when windows are closed.
Frequency:	One time, or following change in occupancy.
Evaluation:	None.
Task:	**Measure outside air flow for each system.**
Description:	Measure and record the outside air flow for each air handling system. For variable air volume systems, be sure to measure the outside air ventilation rate over the full range of potential supply air flow rates.
Frequency:	Annually, or following changes to air distribution system.
Evaluation:	Compare measured ventilation rate and compare to the target defined in the previous task. If measured value is more than 20 percent higher or lower than the target then determine appropriate adjustments. Be sure not to damage or disable economizer controls (if present) in the process.
Task:	**Survey occupants.**
Description:	Survey teachers or other occupants to identify problems with odors or stuffiness.
Frequency:	Quarterly.
Evaluation:	Review surveys and investigate reported problems. Record actions taken.
Task:	**Monitor fan status.**
Description:	Record fan on/off status for each system to ensure that ventilation is being provided continuously during occupied hours. (Note that it may be acceptable for the fan to be off at times if the space has been designed for natural ventilation). This data point may not be necessary if the control system is set up so that the fan always runs when the system is enabled.
Frequency:	Review data monthly.
Evaluation:	Check that fan operation is continuous during occupied hours for spaces without natural ventilation and that fan operation appears appropriate for naturally ventilated spaces (requires some judgment).
Task:	**Monitor CO_2.**
Description:	Install CO_2 sensors within each classroom and record data on 15-minute intervals via the EMCS. The concentration of CO_2 is a good indicator of whether the space is getting enough ventilation per occupant. Continuous CO_2 monitoring may not be practical due to cost of installation, but it may be possible to use the CO_2 sensor for demand control ventilation (see CHPS Volume II) and save energy at the same time. Another option is to use portable dataloggers with CO_2 sensors for short-term evaluation of rooms with comfort complaints.
Frequency:	Record data at 15-minute intervals. Review data monthly.
Evaluation:	CO_2 concentrations should not exceed 1100 ppm for significant periods of time. Note that outdoor air is typically around 300 to 400 ppm.
Task:	**Air quality tests.**
Description:	Periodically test for other contaminants.
Frequency:	
Evaluation:	

Thermal Comfort Evaluation

Task:	**Record space temperatures.**
Description:	Record the reading from a space temperature sensor, typically via the EMCS. A record of temperature at 15-minute intervals is usually adequate. It may be necessary to record temperatures on a shorter interval, such as 1 minute, to identify problems with excessive cycling of space temperature caused by improper HVAC operation.
Frequency:	Record data at 15-minute intervals. Review data quarterly.
Evaluation:	Review the data together with results of the occupant survey listed below. Look for excessive temperature variations and for high and low extremes.
Task:	**Facility inspection.**
Description:	Visit spaces to check for evidence of occupant attempts to address comfort problems such as blocked diffusers, closed diffusers, space heaters, and personal fans.
Frequency:	Quarterly.
Evaluation:	Record problems, investigate potential solutions, and record actions taken.
Task:	**Survey occupants.**
Description:	Survey teachers or other occupants to identify problems with temperature, humidity, or air movement (drafts).
Frequency:	Quarterly.
Evaluation:	Review surveys and investigate reported problems. Remember that air temperature is not the only factor in thermal comfort. Also consider surface temperatures (windows, walls, ceiling, floor), air movement, and humidity. An infrared temperature-sensing device can be useful in identifying surface temperature problems. Unfortunately, remedies to surface temperature problems can be costly, and it may be necessary to adjust the air temperature setpoints to offset the problem. Record actions taken.

Noise Evaluation

Task:	*Measure noise levels.*
Description:	Measure the acoustic performance of classrooms, including: **LIST MEASUREMENT STANDARDS**
Frequency:	Every two years, or following a change to the HVAC system such as a rebalancing of airflows.
Evaluation:	Compare the measurements to ANSI Standard. For rooms with poor performance, identify the sources of the problem. Typical problems include mechanical equipment noise, old magnetically ballasted lighting systems, and outdoor sources such as traffic and other school activities.
Task:	*Survey occupants.*
Description:	Survey teachers or other occupants to identify noise problems, especially focusing on changes in HVAC noise that might indicate a mechanical problem.
Frequency:	Quarterly.

Evaluation:	Review surveys and investigate reported problems. Record actions taken.

Efficiency Evaluation

Task:	*Establish energy benchmarks.*
Description:	A rough level of efficiency evaluation is possible by comparing total energy consumption to similar schools. There are various sources of benchmarking data. The most appropriate is probably other similar schools in the same district or neighboring districts. Other potential sources include CalArch, a Internet database tool developed by Lawrence Berkeley National Laboratory, and the EnergyStar rating system available from the U.S. EPA . An alternative to real building benchmarking data is simulated energy consumption. A simulation model of a school facility can provide a reasonably accurate estimate of energy consumption based on the assumption that systems are working properly.
Frequency:	Annually update the benchmarks based on latest available data.
Evaluation:	Compare actual electricity and gas consumption from the utility bill to the benchmarks. Identify facilities that exceed the benchmarks without an obvious reason (e.g. intensive after hours usage, swimming pool, or large kitchen). Give those facilities high priority for energy audits or retrocommissioning (see the Facilities Management chapter for details).

Task:	**Record monthly utility bill information.**
Description:	Record electricity (kWh), electric demand (kW), and gas (therms) for each meter (often there is a single meter serving the whole campus). In addition to the total amounts reported on the bills, also report the energy consumption in terms of floor area (e.g. kWh per square foot) and number of students (e.g. kWh per student). These numbers are useful for comparing performance of schools of different size.
Frequency:	Monthly
Evaluation:	In addition to comparison with benchmarks, as described above, check each month for unexplained changes in energy consumption. Increases might indicate, for example, that fan controls setting have changed, or lighting controls have been altered. Changes might also indicate equipment problems.

Task:	**Record submetered energy consumption.**
Description:	Some facilities have submeters on individual buildings or systems (such as chilled water plants) that are not read by the utility and do not show up on the utility bill. These submeters can provide valuable information and should also be read and recorded monthly.
Frequency:	Monthly.
Evaluation:	Check for unexplained changes. Use the data as part of an energy audit to help identify where energy is being used in the facility.

Task:	**Monitor total electric demand (kW).**
Description:	Utility bills usually report the peak electric demand for each month, but they don't show the variation in demand from one hour to the next. The demand data can be very valuable in identifying excess energy consumption, especially during evening hours and weekends. Some utility meters are capable of providing this information, so it is worth checking with the utility representative to see if it can be provided.

	Otherwise, it is a reasonable investment to install a power meter that can be connected to the EMCS. Another potential benefit to monitoring electric demand is the ability to implement electricity load management controls.
Frequency:	Preferably as 5 minute averages, but 15 minute or 1 hour averages are also useful.
Evaluation:	Review the shape of the "load curve", the plot of electricity demand over a 24 hour period. Consumption should drop significantly in the evening if lights, HVAC systems, and plug loads are properly controlled, and nighttime demand should not exceed 10 to 20 percent of daytime demand. The acceptable level will vary, of course, because it depends on the amount of outdoor lighting, refrigeration or other loads that must run at night. Also check for excessive daytime peaks that can lead to high electric demand charges from the utility. It may be possible to change equipment startup schedules to stagger start times and reduce peak demand. It may also be possible to implement load management controls to change setpoints when demand approaches a specific threshold.
Task:	**Establish expected HVAC system efficiency.**
Description:	Write down the expected efficiency of HVAC systems, usually from manufacturers' literature or design documents, to use as a baseline for evaluation. This information should be added to the maintenance plan documentation. The obvious information to record includes the EER or kW/ton of cooling equipment and the thermal efficiency or HSPF for heating equipment. Other useful values include bhp for fan and pump motors as well as expected air and water flows.
Frequency:	One time, or following installation of new equipment.
Evaluation:	None.
Task:	**Test packaged air conditioning equipment performance.**
Description:	There are several options for evaluating the performance of both packaged rooftop and split system air conditioners. Two common elements of these procedures include refrigerant charge testing and airflow testing. See the separate section on Packaged Air Conditioning Systems that follows for details. Another important feature of many packaged air conditioners that requires periodic evaluation is an outside air economizer. See also the separate section on Economizers later in this chapter.
Frequency:	Airflow and refrigerant charge every 3 to 5 years. Economizer operation annually.
Evaluation:	See the section Packaged Air Conditioning Systems and the section Economizers.
Task:	**Monitor chiller efficiency.**
Description:	Monitor chiller efficiency via the EMCS by recording chiller electric demand (kW), temperature of supply and return chilled water, and chilled water flow. From those values it is possible to calculate the chiller efficiency in terms of kW per ton. Also record the temperature of the condenser water entering the chiller.
Frequency:	Record the values as 15-minute averages (or more frequently if data storage space is available). More frequent recording may be appropriate for periodic evaluation, such as part of a retrocommissioning process. Review data monthly during the cooling season.

Evaluation:	Plot the kW/ton values as a function of chilled water load (e.g. tons on the x-axis and kW/ton on the y-axis). Compare the monitored efficiency at full load and partial load to the expected value based on the manufacturer's original performance reports. Note that there can be many reasons for a discrepancy in performance, so it takes a bit of judgment and experience to interpret the results. If the actual condenser water temperature is different from the manufacturer's test conditions then that can have a big impact. It is also possible that the calculated chilled water load is inaccurate due to the difficultly of getting good water flow measurements or to the lack of calibration of water temperature sensors. Another part of the evaluation, besides comparing the efficiency to the manufacturer's report, is to look for changes in performance over time. These changes might indicate an equipment or sensor problem or an inadvertent change to the control sequences. See the guideline on Chilled Water Systems later in this chapter.

Task:	**Test boiler combustion efficiency.**
Description:	Measure the combustion efficiency by flue gas analysis. Also check local air quality management district regulations for required boiler tests.
Frequency:	Monthly during heating season.
Evaluation:	Typical combustion efficiencies for standard boilers range from 70 to 85 percent depending on the firing rate of the boiler. Efficiency usually drops at lower firing rates. The efficiency for condensing boilers should be as high as 95 percent. See the section covering boiler maintenance later in this chapter.

Task:	**Test duct leakage.**
Description:	Measure duct leakage for each system. Leakage from ducts (and air handlers) has a big impact on system efficiency and capacity, and the leakage is often much higher than expected. See the section covering duct maintenance later in this chapter for more information on testing procedures.
Frequency:	Once every five years, or following a change to the duct system or replacement of HVAC equipment
Evaluation:	Compare measured duct leakage to a performance target, and repair leaks if necessary to achieve that target.

References/Additional Information

See the References/Additional Information section in the Overview.

Guideline HV3: Packaged Air Conditioning Systems

INSERT PHOTOS OF BOTH WALL-MOUNT AND ROOFTOP UNITS. PERHAPS WITH TECHNICIAN WORKING ON THEM.

Recommendation

Include the tasks from this section in the HVAC maintenance plan. These tasks include the inspection, testing, and monitoring of packaged air conditioning systems.

Description

Packaged air conditioning systems, either wall-mounted or rooftop, are very common in California schools. These units are exposed to outdoor elements and require regular maintenance to ensure efficient operation and reliability. This section describes recommended maintenance tasks for typical systems. See also the manufacturer's recommendations for each piece of equipment, and modify the checklist if necessary.

Task:	**Replace air filters.**
Description:	Replace air filters, making sure to use the correct filter for the application. The maintenance plan should include a detailed specfication including filter dimensions, filter media type, and filter efficiency. See the following chapter on Air Filters for more detailed recommendations. Shut off the fan before replacing the filter to prevent dirt on the filter from entering the duct system. Clean any dirt from the area around the filter housing. Ensure that the filter is properly fitted in its holder to prevent air bypass. Also make sure that the filter is installed facing the proper direction relative to air flow, which is usually marked on the filter housing.
Frequency:	Quarterly.
Evaluation/ Action:	If the filter is especially dirty at time of replacement, then consider a more frequent replacement schedule. If the filter is damp or moldy, then try to find the source of moisture and repair any leaks.

Task:	**Inspect and test economizer dampers.**
Description:	Check economizer damper linkage for tightness and free movement. Be sure the economizer fully closes the return air passage when admitting 100% outside air. ***Test economizer operation as described in the Economizer section later in this chapter.***
Frequency:	Inspect quarterly. Test operation semi-annually.
Evaluation/ Action:	Tighten and adjust linkages if necessary. If testing shows the economizer does not work properly, there can be several causes. See the Economizer chapter for guidance on diagnosing economizer problems.

Task:	**Check fan, belts, and bearings.**
Description:	Check fan belts for wear and correct tension. Too loose hurts performance and increases belt wear. Too tight can damage motor and fan bearings as well as the belts. The maintenance plan should state how to test the belt tightness for each piece of equipment (based on the manufacturer's recommendations). Check alignment of belt and pulleys using a straight edge.

	Check for noise, vibration, or heat from the bearing. Check fan blades for chips or cracks that may cause noise or vibration. Check fan blades for dirt build-up.
Frequency:	Quarterly.
Evaluation/ Action:	Replace fan belts annually or more frequently if necessary. Sealed bearings will need to be replaced if there is a problem. Greased ball bearings may need lubrication or replacement. Avoid overgreasing. Clean fan blades if they are found to be dirty. Unfortunately this can be time consuming. Lubricate motor if called for in manufacturer's recommendations.
Task:	**Check coils and condensate drain pan**
Description:	Inspect the evaporator (cooling) coils for dirt build-up. Be on the lookout for mold growth on the coils. Wet evaporator coils can harbor mold. The problem is worst in warm, humid climates. Check the drain pan under the evaporator coil for standing water, debris or mold growth. After cleaning, fill the pan with water to check for proper drainage and to ensure that the condensate pump works (if there is one). Inspect the condenser ("outdoor") coils for debris, dirt build up and bent fins (the fins are sometimes subject to vandalism).
Frequency:	Quarterly.
Evaluation/ Action:	Clean coils and straighten fins if necessary. Make sure that the fan is turned off when coils and drain pan are being cleaned. Moldy coils are difficult to clean. Use a quality cleaning solution with an adequate dwell time. Overly aggressive cleaners can damage the metal coils. Coils should be well rinsed to remove chemicals so that they don't contaminate indoor air. Treat coils with biocide after cleaning.
Task:	**Check control settings.**
Description:	This is the maintenance task that can have the biggest impact on energy consumption. Verify that the following settings match values in the maintenance plan. ▪ Setback and setup temperatures. ▪ Start and stop times. ▪ Fan operation (e.g. always on). ▪ Adequate deadband between cooling and heating operation (or manual changeover between heating and cooling mode). ▪ Heat pumps controlled to use electric strip heaters only when necessary.
Frequency:	Quarterly.
Evaluation/ Action:	Determine the cause of control changes, such as occupant discomfort), and try to resolve any problems. If possible, reset controls to maintenance plan settings. If necessary, update the values in the maintenance plan to record changes necessary due to any comfort problems or changes in space usage.
Task:	**Inspect acoustic isolators**

Description:	Inspect any spring isolators or other acoustic isolators inside or outside the unit to make sure they are not worn out or grounded out (meaning that they are not doing their job). This is an important task because mechanical equipment can be a significant contributor to classroom noise.
Frequency:	***Quarterly.***
Evaluation/ Action:	Repair or replace the failed parts.

Task:	**Inspect refrigerant system fittings.**
Description:	Inspect tubing connections and fitting in the refrigerant loop for evidence of oil, which may indicate a refrigerant leak.
Frequency:	***Quarterly.***
Evaluation/ Action:	If a leak is discovered, then tighten or replace fitting and check refrigerant charge.

Task:	**Compressor maintenance.**
Description:	***Check the manufacturer's guidelines for compressor maintenance tasks.***
Frequency:	Per manufacturer.
Evaluation/ Action:	Per manufacturer.

Task:	**Check furnace operation.**
Description:	Inspect for smooth ignition and proper flame color. Check the operation of limit devices or flame sensors. See manufacturer's guidelines for proper operation. Test gas connections for leaks. Inspect the heat exchanger for cracks. Inspect the flue for blockages.
Frequency:	***Quarterly.***
Evaluation/ Action:	Clean burners as needed if there are problems with ignition or flame. Repair or replace other components as necessary.

Task:	**Check cabinet for air leaks**
Description:	Check access panels for tight fit, and check for any other air leaks in the cabinet or duct connections.
Frequency:	***Quarterly.***
Evaluation/ Action:	Seal any leaks. Replace seals around access panels if necessary.

Task:	**Inspect piping insulation.**
Description:	Check the condition of insulation on the refrigerant piping. Insulation may degrade over time, especially if exposed to sunlight.
Frequency:	Annually
Evaluation/ Action:	Replace or repair damaged insulation and replace missing insulation.

Task	**Inspect electrical connections.**

Description:	Check for loose electrical connections, which can lead to overheating and/or improper equipment operation.
Frequency:	Semi-annually.
Evaluation/ Action:	Tighten connections if necessary. For safety, be sure to shut off power to the unit before checking the connections.

Task: Measure supply air flow.

Description: Check that actual supply air flow matches the design value. The target air flow is typically 350 to 400 cfm per ton of cooling capacity (may be lower in warm, humid climates), but the actual value often turns out lower due to duct design or construction problems. Low air flow results in somewhat lower cooling efficiency and reduced total cooling capacity. The maintenance plan should list the appropriate supply air flow for each system.

The maintenance plan must also describe the air flow measurement method. There are several options that vary in complexity and accuracy.

- Temperature split. This is a very rough estimation method. Estimated air flow is based on the difference in temperature before and after the cooling coil when the compressor is running.
- Flow grid. This device is inserted in place of the filters and provides a readout of air flow. Accuracy is fairly good.
- Flow hood. A flow hood can be used to measure the air flow leaving each supply diffuser (four diffusers in a typical classroom). This method is reasonably accurate but doesn't account for duct leakage. An advantage is that air balance problems can be identified.

These measurements should be performed by trained technicians. For more details on air flow measurement, refer to the *2005 Residential ACM Manual*, Appendix RE – Field Verification and Diagnostic Testing of Forced Air System Fan Flow and Air Handler Fan Watt Draw. This document is available at www.energy.ca.gov/title24.

It usually makes sense to perform this measurement as part of system check up that includes refrigerant charge testing and outdoor ventilation airflow verification.

Frequency: Every three to five years, or following a change to the HVAC system.

Evaluation/ Action: In the rare case of excess airflow, reduce the fan speed per manufacturer's instructions to achieve correct airflow and save fan energy. Some units have several possible electrical connections for the fan that can be used to select different motor speeds. Other units may require a pulley (sheave) adjustment or replacement to change the fan speed.

In the more likely case that airflow is lower than manufacturer's specification, look for obstructions in the ducts, unnecessary turns or sharp turns in the ducts, or closed balancing dampers before increasing the fan speed setting. Eliminating obstructions is preferable to increasing the fan speed because the system will be quieter and consume less electricity.

Task: Check refrigerant charge

Description: Verify correct refrigerant charge. Start unit and allow it to run for 15 minutes. Measure high and/or low side refrigerant pressures and refrigerant line temperatures to verify correct superheat (for fixed throttling devices) or correct sub cooling or approach temperature (for thermostatic expansion valve units),

	according to instructions furnished by the manufacturer. Also check the superheat on TXV units to verify proper operation of the TXV. Be sure to replace Schrader valve cores if refrigerant charge is tested. These measurements must be performed by a US EPA certified technician. See manufacturers' recommendations for more information. It usually makes sense to perform this measurement as part of system check up that includes supply air testing.
Frequency:	Every three to five years, or following a change to the HVAC system, or when evidence of a leak is detected.
Evaluation/ Action:	Adjust refrigerant charge if necessary. Low charge results in reduced cooling efficiency, especially for the typical system with a fixed expansion valve (i.e. no thermostatic expansion valve).
Task:	**Check cooling efficiency.**
Description:	It is also possible to check the actual cooling efficiency based on measurements of airflow, temperatures and electric demand. Measurement systems are commercially available that help to automate the procedure and that also help to diagnose problems (e.g. Service Assistant by Honeywell). Air flow and refrigerant charge measurements should be the first priorities, but efficiency estimation may not add too much extra cost if an automated measurement and diagnostic system is used.
Frequency:	Every three to five years, or following a change to the HVAC system.
Evaluation/ Action:	Correct refrigerant charge or fix faulty components as necessary.
Task:	**Setup performance monitoring.**
Description:	An EMCS connection to packaged AC units can be used to detect performance problems and alert the maintenance staff that the equipment should be inspected. The maintenance plan should specify monitoring points and measurement frequency. The minimum monitoring points include: ▪ Supply air temperature. ▪ Room temperature. ▪ Fan status. ▪ Outdoor air temperature (one point for the whole facility is adequate). Additional monitoring points that are useful but not always available include: ▪ Electric demand (kW). ▪ Room temperature setpoint. Examples of things to look for include excessive on/off cycling of the compressor (viewed as rapid cycling of supply air temperature) relative to the outdoor air temperature, excessive time required to achieve room setpoint temperature following a setback or setup period (which might indicate a capacity problem), or intermittent fan operation (where continuous operation is required for ventilation). Monitored data can also be used to determine whether an economizer is working properly. A further step in performance monitoring is to implement an automatic fault detection and diagnosis systems. Check with the equipment manufacturer and

	control system vendor to find out if an FDD option is available. These systems alert the operator to potential problems and reduce the amount of manual data review required.
Frequency:	Review data monthly. Monitoring should be continuous. The appropriate monitoring frequency varies depending on what is being measured. Room air temperature and outdoor air temperature should be measured on about 15 minute intervals. Supply air temperature should be measured more frequently, perhaps every 5 minutes or less, in order to detect compressor cycling.
Evaluation/ Action:	Interpretation of the monitored data will require some judgment and experience. The highest priority should be to start and stop times (to avoid unnecessary operation) and make sure that the fan is being operated properly for ventilation. Checking economizer operation is also a high priority due to it's potential impact on energy consumption.

Applicable Codes and Standards

Building energy efficiency standards may apply when equipment is replaced. In California, the 2001 Title 24 Standard requires that new equipment meet efficiency requirements. In the 2005 Title 24 Standard, equipment replacement also triggers a requirement to test and seals ducts.

Benefits

See task descriptions above.

Costs

INFO TO COME.

Monitoring/Controls

See task descriptions above.

Common Retrofit Opportunities

Replacement of packaged air conditioning units is not usually cost effective based on energy efficiency alone, but if units are close to the end of their life then it can make sense. At time of replacement it is important to also seal and insulate ducts and check for airflow constrictions. It is also critical to perform cooling load calculations to check whether a different capacity is appropriate (a smaller unit may cost less and perform better). See Volume II of the CHPS Best Practices Manual for recommendations related to packaged air conditioner selection and system design.

Controls are another retrofit option. The most basic function is connection to an EMCS for start/stop control. The actual energy savings will vary depending on how the existing system is being operated, but the EMCS connection may also offer savings in staff time. An EMCS can also be used for performance monitoring as described earlier.

Installation of better (more efficient) filters may be an option. A different filter will not necessarily save energy, but it might improve air quality and keep the air distribution system more clean.

Verification/Commissioning

See task descriptions above.

References/Additional Information

See the References/Additional Information section in the Overview, and:

ASHRAE Journal, Smart Maintenance for Rooftop Units, ASHRAE Journal, November 2000.

Small HVAC System Design Guide, Prepared by Architectural Energy Corporation, California Energy Commission document No. P500-03-082-A12, October 2003.

Guideline HV4: Fan Coils and Unit Ventilators

PHOTOS OF FAN COIL AND UNIT VENTILATOR

Recommendation

Include the tasks from this section in the HVAC maintenance plan. These tasks include the inspection, testing, and monitoring of fan coils and unit ventilators.

Description

These units consist of a fan and one or two coils. In some cases a single coil is used for both cooling (with chilled water) and heating (with hot water). In other cases the unit has two coils, one for cooling and the other for heating. These units also include filters and may have outside air economizers. Maintenance of fan coils and unit ventilators is similar to Packaged Air Conditioning Systems as described in the previous section. The tasks that are identical are listed below. Additional tasks and modified tasks are described in more detail.

Tasks: (Identical to Packaged Air Conditioning Systems)	**Replace air filters.** **Inspect and test economizer dampers.** **Check fan, belts, and bearings.** **Check coils and condensate drain pan.** **Check control settings.** **Inspect acoustic isolators.** **Check cabinet for air leaks.** **Inspect electrical connections.**
Task:	**Inspect piping insulation.**
Description:	Check the condition of insulation on the chilled water and hot water (or steam) piping. Insulation may degrade over time, especially if exposed to sunlight. ***Missing or damaged insulation can be a source of energy loss and may also allow condensation to form on the outside of chilled water pipes. The condensation can lead to moisture damage and mold growth.***
Frequency:	Annually.
Evaluation/ Action:	Replace or repair damaged insulation and replace missing insulation.
Task:	**Check valve operation**
Description:	Check that the chilled water and hot water valves (or a single valve in two-pipe systems) operate properly and do not leak. Command the valve fully open and fully closed to make sure that it operates over the full range. Check for leaking valves by checking the temperature of the coil when the valve has been closed for a few hours while the pump has been running. A cool coil (during the cooling season) or warm coil (during the heating season) may indicate a problem.

Frequency:	Semi-annually, before start of heating season and before start of cooling season.
Evaluation/ Action:	Clean and lubricate valves according to manufacturer recommendations, and replace valves if necessary.

Task:	**Setup performance monitoring.**
Description:	An EMCS connection to a fan coil unit can be used to detect performance problems and alert the maintenance staff that the equipment should be inspected. The maintenance plan should specify monitoring points and measurement frequency. The minimum monitoring points include: ▪ Supply air temperature. ▪ Room temperature. ▪ Fan status. ▪ Outdoor air temperature (one point for the whole facility is adequate). Additional monitoring points that are useful but not always available include: ▪ Room temperature setpoint. Examples of things to look for include rapid cycling of supply air temperature (which probably indicates a control problem), excessive time required to achieve room setpoint temperature following a setback or setup period (which might indicate a problem with the coil or control valve), or intermittent fan operation (where continuous operation is required for ventilation). Monitored data can also be used to determine whether an economizer is working properly.
Frequency:	Review data monthly. Monitoring should be continuous. The appropriate monitoring frequency varies depending on what is being measured. Room air temperature and outdoor air temperature should be measured on about 15 minute intervals. Supply air temperature should be measured more frequently, perhaps every five minutes or less, in order to detect cycling of controls.
Evaluation/ Action:	Interpretation of the monitored data will require some judgment and experience. The highest priority should be to start and stop times (to avoid unnecessary operation) and make sure that the fan is being operated properly for ventilation. Checking economizer operation is also a high priority due to its potential impact on energy consumption.

Guideline HV5: VAV Systems

IMAGE: SIMPLE SCHEMATIC OF TYPICAL VAV SYSTEM

Recommendation

Address VAV systems in the HVAC maintenance plan, including the tasks listed in this section.

Description

Variable air volume (VAV) HVAC systems serve multiple zones with a single air handler. These are more commonly used in administration areas, but are also used in classroom buildings with each classroom set up as a separate zone. The amount of air supplied to each zone is controlled by a damper within a terminal unit (VAV box). These dampers – one for each zone – vary the airflow to maintain the space temperature setpoint. The supply air temperature leaving the air handler is held relatively constant, but it usually varied ("reset") somewhat either automatically or manually depending on the amount of cooling required. Each VAV box usually has a minimum damper position or minimum airflow rate (if the box contains an airflow sensor) that ensures ventilation is provided to each space. If a zone requires heating or has low cooling loads, then too much cooling may occur at the minimum airflow rate. Therefore, many VAV boxes include reheat coils – either hot water or electric – that raise the temperature of the air supplied to the zone to prevent overcooling.

As cooling loads drop and the VAV box dampers close, the total supply air flow through the central fan also drops. Without any controls, the pressure within the supply ducts would increase. To save energy, the central fan is usually controlled with a variable speed drive or inlet guide vanes to maintain a constant pressure within the supply duct. Therefore, as the VAV boxes close down, the central fan speed will drop or the inlet guide vanes will begin to close.

There are often opportunities in existing VAV systems to improve system efficiency by tuning or modifying the controls. See the section below on Retrofit Opportunities and see also Volume II of the Best Practices Manual for more information about VAV systems.

VAV systems typically have either a chilled water coil or a refrigerant coil to provide cooling. Heating (when present) is usually from a hot water coil or a gas furnace. The appropriate list of maintenance task varies depends on the type of cooling and heating.

The appropriate list of maintenance tasks also depends partly on the type of control system. Older systems often have pneumatic controls, which use the pressure in compressed air lines to control dampers and valves. Newer systems typically have direct digital control (DDC) systems that use electrical connections between sensors and actuators and a digital controller. Dampers and valves are moved by electric motors.

Tasks: (Identical to Packaged Air Conditioning Systems)	**Replace air filters.**
	Inspect and test economizer dampers.
	Check fan, belts, and bearings.
	Check coils and condensate drain pan.
	Inspect acoustic isolators.
	Check cabinet for air leaks.
	Inspect electrical connections.
	Inspect refrigerant system fittings (for packaged VAV systems).
	Compressor maintenance (for packaged VAV systems).

	Check refrigerant charge (for packaged VAV systems). **Check furnace operation (if applicable)**
Tasks: (Identical to Fan Coils and Unit Ventilators)	**Inspect piping insulation.** **Check valve operation (for chilled water VAV systems).**
Task:	**Determine appropriate control sequences.**
Description:	Document the intended control sequences for each VAV system and each zone so that information is available for verifying actual operation. Good VAV system performance depends on proper controls. ▪ Fan start/stop. May include optimal start control that varies the start time depending on conditions. ▪ Morning warm up. Often there is a special control mode to warm up the building before occupancy in the morning. ▪ Supply air duct pressure control. Most systems use a constant duct static pressure setpoint, but significant savings are often available if a static pressure reset control scheme is implemented. ▪ Supply air temperature control. VAV systems should have controls to adjust the supply air temperature upwards to save cooling energy and reheat energy during low load periods. ▪ Minimum outside air control. There are several different ways that VAV systems are set up to maintain minimum ventilation. A fixed outdoor air damper minimum position will generally not work because the outdoor air flow will vary along with the supply air flow. ▪ Economizer control. The economizer damper position is usually controlled based on comparison of return air temperature to outdoor air temperature. ▪ Zone airflow maximums and minimums. For DDC systems, there are typically maximum and minimum airflow settings for each VAV box. The maximum is based on cooling load calculations and the minimum is based on ventilation requirements. For pneumatic control systems there is typically a physical stop for minimum damper position. In either case, the minimum airflow setpoint has a big impact on fan energy and reheat energy and should be no higher than necessary. ▪ Zone temperature control. VAV boxes are typically controlled to increase airflow as the space temperature rises and reduce airflow to a mininum setpoint as loads in the space drop. As loads drop further, the reheat coil is activated. “Dual-maximum” controls will then also increase the airflow in heating mode to avoid excessively high supply air temperatures.
Frequency:	One time, when assembling the System Documentation portion of the HVAC Maintenance Plan, and then update the information following changes to the system.
Evaluation/ Action:	If documents are not available that describe the intended control sequences, then it may be a good idea to consult with a controls expert to develop and document appropriate control sequences. And there are often opportunities to improve upon the original controls sequences to achieve more efficient operation. There are several references that cover the topic of optimal VAV system control listed at the

end of this section.

Task:	**Verify VAV box operation.**
Description:	Detailed verification is probably outside the scope of normal maintenance and is appropriate as part of a retro-commissioning or re-commissioning process (See the Facilities Maintenance chapter). During that process it is a good idea to force the VAV box to minimum and maximum airflows by adjusting the zone temperature setpoint and compare measured airflows to desired values. The airflow sensor (if there is one) should be calibrated. Reheat coil operation and discharge air temperature should be observed to confirm proper reheat control. Tasks appropriate for regular maintenance include: ▪ Observe VAV damper operation to ensure free movement over its full range. ▪ Observe reheat coil control valve (for hot water reheat systems) to check for stuck or leaking valves. ▪ Set up and review trend logs of zone temperature. Depending on the capabilities of the control system is may also be possible to track VAV damper position, airflow, discharge temperature, and reheat valve position. While this adds up to lots of data in a large VAV system with many zones, the data can be very valuable in diagnosing problems. ▪ Pneumatic controls need regular calibration every six months.
Frequency:	Review trend data monthly. Check damper and valve operation annually.
Evaluation/ Action:	Problems with VAV boxes are sometimes hard to identify because zone temperatures may still be acceptable even though the box is not working properly. For example, the heat from a leaking reheat valve may be overcome by increased airflow. Or a minimum airflow setpoint that is higher than necessary may not produce comfort problems because the reheat coil offsets the extra cooling.
Task:	**Verify fan start/stop controls.**
Description:	Using trend logs or observation, verify that the system is turned on and off according to the intended schedule.
Frequency:	Review trend data monthly.
Evaluation/ Action:	If the system-operating schedule has changed, determine the reason and reset the schedule if appropriate. Update system documentation to reflect any changes in the required operating schedule.
Task:	**Verify supply air static pressure control.**
Description:	***Set up a trend log of the static pressure sensor reading (if available). Perform periodic calibration of the static pressure sensor. Try to make sure that pressure is no higher than necessary, because otherwise fan energy is wasted.***
Frequency:	Review trend data monthly. Calibrate sensor annually.
Evaluation/ Action:	Replace and/or relocate sensor if necessary. Consider static pressure reset control.
Task:	**Verify supply air temperature control.**
Description:	***Set up trend logs of supply air temperature and periodically review the data to verify that the supply air temperature is being reset as intended***

Frequency:	Monthly.
Evaluation/ Action:	Investigate the reason for any supply air temperature control problems. Modify controls if necessary. May indicate a problem with cooling equipment.

Applicable Codes and Standards

See the Overview to this chapter.

Benefits

Proper maintenance of VAV system controls can reduce fan energy by up to 50 percent, and also provide significant cooling and reheat energy savings.

Costs

INFO TO COME.

Monitoring/Controls

See task information above.

Common Retrofit Opportunities

There are often opportunities for improving the energy efficiency of a VAV system.

- Implement supply air pressure reset controls to save fan energy.
- Reduce the supply fan minimum speed setpoint. Often this is set higher than necessary due to the default settings of the variable speed drive. Savings may be possible by allowing the fan speed to drop further during low flow periods. Check with the fan and drive manufacturer for actual limits.
- Reduce the minimum airflow settings for VAV boxes to the minimum required for ventilation. Sometimes the minimum is set fairly high so that airflow is high enough in heating mode. However, it may be possible in many cases to reduce the minimum airflow for periods when little cooling or heating is required and then increase the airflow again in heating mode. See the Advanced VAV System Design Guide for details of “dual maximum” control.
- Identify “rogue” zones that have either excessive cooling loads, undersized VAV boxes or other control problems that prevent the system from resetting either the supply air temperature or supply air pressure. These zones may not be meeting their temperature setpoints, requiring the supply air temperature to remain low, even though all the other zones could be satisfied with a higher supply air temperature.
- Retrofit pneumatic VAV box controls with a DDC system including zone temperature sensors and electric damper actuators.

Verification/Commissioning

Retro commissioning or recommissioning is valuable due to the complexity of VAV system controls. This manual does not address the issue of optimal VAV system control, which is a fairly big topic. Good references include the Advanced VAV System Design Guide. See also the Facilities Management chapter of this manual for more information about commissioning.

References/Additional Information

See the References/Additional Information section in the Overview, and:

Collaborative for High Performance Schools, CHPS Best Practices Manual, Volume II – Design. www.chps.net.

New Buildings Institute, Advanced VAV System Design Guide, prepared by Taylor Engineering and Eley Associates, available at www.newbuildings.org or www.energy.ca.gov.

Guideline HV6: Chilled Water Systems

FIGURE OF MONITORED CHILLER PERFORMANCE (X-Y PLOT WITH CAPACITY ON X-AXIS AND KW/TON ON Y-AXIS), PERHAPS ILLUSTRATING COMPARISON TO MANUFACTURER DATA.

Recommendation

Include tasks for chillers, cooling towers, pumps, chilled water piping, and valves in the HVAC maintenance plan. Refer to manufacturers' recommendations for equipment maintenance tasks. Also implement a performance monitoring system to verify that controls are properly implemented and to track chilled water plant efficiency.

Description

Task:	**Chiller maintenance.**
Description:	Follow the manufacturer's recommendations for chiller maintenance. Fouling is an important issue because it affects both chiller efficiency and capacity. Consider automatic tube cleaning system as an alternative to chemicals.
Frequency:	Per manufacturer.
Evaluation/ Action:	

Task:	**Cooling tower maintenance.**
Description:	Treat cooling tower water to prevent corrosion, scale accumulation, and microbial growth. Carefully adjust bleed-off (blow down) rates to prevent accumulation of minerals in the water while avoiding excess water (and chemical) consumption. Follow a strict maintenance schedule that describes blow down times and the amount of water needed. Legionella can be an issue. Maintain separation between cooling towers and ventilation air intakes. Minimize chemical use by following a strict schedule of water treatment. Avoid chromate-based and chloride-based additives where possible. Avoid additives with phosphates where possible. Give preference to propylene-based over ethylene-based products. Consider ozone water treatment as non-chemical biocide alternative. Set up a testing program for water quality. Set up a schedule for periodic cleaning.
Frequency:	Per manufacturer recommendations.
Evaluation/ Action:	Modify maintenance practices if scale, corrosion or microbial growth become a problem.

Task:	**Pump maintenance.**
Description:	Perform manufacturer recommended maintenance on pumps and pump motors, including both the chilled water and condenser water pumps.
Frequency:	***Per manufacturer.***

Evaluation/ Action:	Repair or replace as necessary.

Task:	**Piping maintenance.**
Description:	Pipe insulation damage is common. Visually inspect for damage. Missing insulation on chilled water pipes can lead to condensation and moisture damage. Also inspect for leaks.
Frequency:	***Annually.***
Evaluation/ Action:	Repair or replace damaged insulation.

Task:	**Set up performance monitoring.**
Description:	Set up monitoring of cooling load and electricity consumption to track the efficiency of the chilled water plant. The necessary monitoring points include: ▪ Chilled water flow. ▪ Chilled water supply and return temperature. ▪ Chiller electric demand (kW). Other desirable points include: ▪ Condenser water supply and return temperature. ▪ Cooling tower and pump electric demand. See the PECI document, *Putting the "O" back in O&M* for more guidance (listed in the Resources/Additional Information section in this chapter's Overview).
Frequency:	Review data monthly during cooling season.
Evaluation/ Action:	Compare monitored performance to expected performance from the manufacturer's test reports. Also look for changes in performance or in cooling load that might indicate a problem.

Applicable Codes and Standards

See Overview section of this chapter.

Benefits

See Overview section of this chapter.

Costs

Automatic tube cleaner costs about $300 per ton.

Monitoring/Controls

See tasks listed above.

Common Retrofit Opportunities

- Reduce the condenser water (cooling tower) temperature setpoint to improve efficiency at partial load. First, however, check with the manufacturer to make sure that the chiller can operate properly with lower temperature.

- Trim the pump impeller rather than using a balancing valve to reduce flow in constant pump speed applications. Pump power can be reduced significantly.
- Replace standard efficiency with premium efficiency motors for pumps with long run hours.
- Replace three-way valves with two-way valves on cooling coils and implement variable flow control on the chilled water loop.
- Install variable speed fan controls on cooling tower to reduce fan energy consumption.
- Review chiller sequencing controls for plants with more than one chiller to determine the optimal strategy for efficiency.

Verification/Commissioning

Just as for VAV systems, retro commissioning or recommissioning is valuable due to the complexity of chilled water plant controls and equipment interactions. This manual does not address the issue of optimal chilled water plant operation control, which is a fairly big topic. A reference is the CoolTools: A Tool Kit to Optimize Chilled Water Plants. See also the Facilities Management chapter of this manual for more information about commissioning.

References/Additional Information

See the References/Additional Information section in the Overview, and:

HVAC Exchange, CoolTools: A Tool Kit to Optimize Chilled Water Plants. http://www.hvacexchange.com/cooltools/.

Guideline HV7: Hot Water Systems

Recommendation

Add hot water system maintenance tasks to the HVAC maintenance plan.

Description

Task: (identical to chilled water plant tasks):	**Pump maintenance.** **Piping maintenance.**
Task:	*Boiler maintenance.*
Description:	Check with the local air quality management district (AQMD) for boiler maintenance requirements, and set up a schedule for inspection and testing.
Frequency:	Per manufacturer and AQMD recommendations.
Evaluation/ Action:	A tune up may be required.

Applicable Codes and Standards

See the Overview section of this chapter.

Benefits

See the Overview section of this chapter.

Costs

INFO TO COME.

Monitoring/Controls

See tasks above.

Common Retrofit Opportunities

Energy savings opportunities are similar to those for the chilled water distribution system.

- Trim the pump impeller rather than using a balancing valve to reduce flow in constant pump speed applications. Pump power can be reduced significantly.
- Replace standard efficiency with premium efficiency motors for pumps with long run hours.
- Replace three-way valves with two-way valves on cooling coils and implement variable flow control on the hot water loop.

Verification/Commissioning

Include the hot water system in any retro-commissioning or re-commissioning activities.

References/Additional Information

See the References/Additional Information section in the Overview.

Guideline HV8: Air Filters

Recommendation

Select filters that provide the best filtration possible (up to efficiency of 85% or MERV 13) without compromising system performance (reducing airflow below acceptable levels or causing a significant increase in fan energy). Inspect and replace filters regularly, as described in the maintenance recommendations for specific systems elsewhere in this chapter. In general, year-round schools should change filters about four times per year. Standard schedule schools should replace filters three times per year.

For small packaged air handlers and fan coils, it may be difficult to find filters that fit and have ratings of higher than 35 percent or MERV _ due to the limits on the thickness of filters that can be installed. Where more room is available, many filters are available in the 4 to 6 inch range that offer good performance.

Source: Airex Corporation

Description

Air filtration is one element of an integrated indoor air quality approach, which also includes outdoor air ventilation and pollutant source control.

Filtration's first priority is to protect the HVAC system, keeping the fan, coils and ducts clean. Clean components perform better and are less likely to harbor mold or bacteria growth.

The second priority of HVAC air filters is to reduce concentrations of particles in indoor air. Standard low-cost filters provide little benefit in this regard. Filters with efficiency lower than 45% are generally not effective in reducing concentrations of indoor particles. However, increasing the filter efficiency up to 85% (or MERV 13) does help improve indoor air quality. Going beyond 85% has been shown to provide little additional benefit (Fisk, et al, "Particle Air Filtration in HVAC Supply-Air Streams", HPAC Engineering, July 2003).

There are two commonly used filter performance ratings: dust spot efficiency and MERV (minimum efficiency reporting value). These ratings indicate the amount of particulate removed from the air stream. A higher efficiency filter removes more material. The dust spot efficiency is more common because it has been around longer, but the MERV rating provides a better indication of performance. See ASHRAE Standard 52.1-1992 for details on dust spot efficiency and ASHRAE Standard 52.2-1999 for details on MERV ratings.

INSERT DIAGRAM ILLUSTRATING DUST SPOT EFFICIENCY VS. MERV RANGES

Several types of air filters are used in HVAC systems, including flat panels, pleated panels and bag filters. Bag filters are used only in larger air handlers with adequate space. Therefore, pleated panels are the appropriate choice for most school air handlers. Pleated panel filters usually provide better filtration with lower air pressure loss compared to flat panel filters. Unfortunately the efficiency of typical pleated 1- or 2-inch thick filter does not usually exceed 45 percent, and it more typically around 25 percent. Therefore it may not be possible to easily install 85 percent efficient filters in a typical school air handler.

Other less commonly used products include electronic polarization filters and electrostatic filters. The electronic polarization filters create a high voltage electrical field to statically charge the particles, which

then are more likely to collect on the filter medium. Electrostatic filters (also called electrostatic precipitators) charge the particles as they pass through and collect them on metal plates. Both of these types of filters require a small amount of electric energy. Both are also more efficient when new and their performance degrades over time. This is in contrast to a standard filter which tends to filter more particles as it gets loaded. However, the electronic polarization and electrostatic filters typically create less pressure loss and may require less fan energy.

Other general recommendations include:

- Turn off fan while replacing filters to prevent debris from entering the ductwork.
- Clean and wash the filter area while the fans are off.
- Use larger filter areas, don't block off portions of the filter bank unless excess airflow is a problem (which is not too common, and is better solved by adjusting the fan speed).
- Make sure that filters are properly fitted to prevent air from bypassing the filter. Check filter seals.

Applicable Codes and Standards

ASHRAE Standard 52.1-1992. Includes dust spot ratings.

ASHRAE Standard 52.2-1999 Method of Testing General Ventilation Air Cleaning Devices for Removal Efficiency by Particle Size. Includes MERV ratings.

References/Additional Information

See the References/Additional Information section in the Overview, and:

Environmental Building News, "Air Filtration in Buildings", Volume 12, Number 10, October 2003.

Fisk, et al, "Particle Air Filtration in HVAC Supply-Air Streams", HPAC Engineering, July 2003.

Kowalski, et al, "Airborne-Microbe Filtration in Indoor Environments", HPAC Engineering, January 2002.

Guidance for Filtration and Air-Cleaning Systems to Protect Building Environments from Airborne Chemical, Biological, or Radiological Attacks, Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, April 2003.

Guideline HV9: Economizers

Recommendation

Give special attention to economizers in the HVAC maintenance plan.

Description

Economizers are covered here in their own section due to their significant energy savings potential as well as the fact that they usually require maintenance to work over the long term. An outside air economizer can be part of any air handler, from small packaged air conditioners to the largest VAV systems.

An economizer is set of automatically controlled dampers that can open to draw 100 percent outside air when conditions are favorable for free cooling. Otherwise when the outdoor air temperature is higher than indoors, or outdoor air is very cold, the outside air damper closes to a minimum position (for ventilation) and the return air damper opens up.

Due to the need for moving parts, economizers can have reliability problems. Field studies of commercial building HVAC systems have shown that roughly 60 percent of economizers on small rooftop units are not functioning properly. It is possible that performance in schools is somewhat better due to regular maintenance, but there is certainly a fairly high failure rate.

Task:	**Determine type of economizer and proper operation.**
Description:	Collect information on the type of economizer installed in each system and document the intended operation. There are a few different types of controls: fixed drybulb temperature setpoint, fixed enthalpy setpoint or differential drybulb or enthalpy control. Also note whether the economizer is intended for integrated (together with compressor) or non-integrated operation. For more information about economizers see the CHPS Best Practices Manual Volume II. Add the economizer information to the maintenance plan.
Frequency:	One time, and then following installation of new equipment with economizers.
Evaluation/ Action:	None.

Task:	**Inspect, clean and lubricate economizer.**
Description:	Check that dampers are not obstructed and that dampers are free to move. Also check the condition of damper seals to ensure that leakage is not excessive.
Frequency:	Quarterly.
Evaluation/ Action:	Clean and lubricate if necessary.

Task:	**Test economizer operation.**
Description:	It is not enough to ensure that the dampers can move. It is also important to test that the dampers are being controlled properly. A good reference for testing and diagnostic ideas is the Energy Design Resource Design Brief on Economizers (see references below). That document outlines several options: Observe the damper position under a range of outside-air conditions.

	Fool the economizer controls with your hands or an electric hair dryer. Look for jumps in heating and cooling energy consumption. Install temperature dataloggers. The collected temperature data may then be downloaded and diagnosed using simple spreadsheet software. Conduct ongoing diagnostics with an energy management system. Use an EMS as an extra set of eyes. Look for supply and exhaust air imbalances.
Frequency:	Twice each year.
Evaluation/ Action:	Repair or replace economizer components as necessary.

References/Additional Information

See the References/Additional Information section in the Overview, and:

Small HVAC Design Guide. Available at www.newbuildings.org or www.energy.ca.gov.

Energy Design Resources Design Brief – Economizers, www.energydesignresources.com.

Guideline HV10: Ducts

Recommendation

Add duct inspection, cleaning, testing, and sealing tasks to the HVAC maintenance plan.

Description

Duct maintenance has two primary goals: keep the ducts clean to avoid air quality problems, and save energy by sealing duct leaks.

Task:	**Inspect duct system.**
Description:	Check for cleanliness, obstructions that block airflow, water damage, visible microbial growth, leaks, or hazardous materials. Accumulated debris is not necessarily an immediate hazard unless it is being transported into the occupied space or it may come in contact with water and become a microbial hazard. Also inspect for obvious air leaks in both the supply air and return air ducts.
Frequency:	The National Air Duct Cleaners Association (NADCA) recommends inspection every two years.
Evaluation/ Action:	If an inspection finds that mold or other contamination are inside the ducts, then take measures to prevent the problem from reoccuring in addition to cleaning the ducts. Seal leaks (see below).
Task:	*Clean ducts.*
Description:	Duct cleaning typically consists of attaching a large vacuum device with a HEPA filter. These devices suck air from the duct and collect any dirt that is dislodged by the agitation device. The agitation device may use air pressure or rotary brushes to dislodge dirt. Considerations related to duct cleaning include the following: ▪ Use HEPA vacuuming equipment if the collection unit is located within occupied space. ▪ When using biocides, choose products that are registered by the US EPA and follow manufacturer's instructions. ▪ Clean ducts only during unoccupied periods to minimize exposure to chemicals and dirt. ▪ Maintain negative pressure in the duct cleaning area. ▪ Also clean coils and drip pans at the same time. ▪ Check www.nadca.com for more information. ▪ It is possible to either hire a duct cleaner or obtain equipment and use in-house staff. Either way it is important to have properly trained personnel familiar with NADCA 1992-01, Mechanical Cleaning of Non-Porous Air Conveyance System Components.
Frequency:	When an inspection reveals contamination.
Evaluation/ Action:	Water damaged or contaminated porous materials within the duct system should be removed and replaced.

Task:	**Test duct leakage.**
Description:	***Perform pressure tests to measure duct leakage.*** Duct leakage has been found to be significant in small commercial systems and can have a big impact on energy consumption and system capacity.
Frequency:	Once, and then following changes to the duct system.
Evaluation/ Action:	Seal ducts as described below.

Task:	**Seal ducts.**
Description:	There are a few options for duct sealing. One is to use traditional mastic on the outside of duct joints and connections. The other method is to seal the ducts from the inside with an aerosol sealing system. Using the latter method, the ducts are tested and sealed at the same time. Leaks are plugged as small droplets deposit around the edge of leaks.
Frequency:	***Once, and then following changes to the duct system.***
Evaluation/ Action:	***Seal leaks to achieve leakage rate of six percent or less.***

References/Additional Information

See the References/Additional Information section in the Overview, and:

Small HVAC Design Guide. Available at www.newbuildings.org or www.energy.ca.gov.

Plumbing

Overview

Maintenance of plumbing systems involves repairing of stoppages and leaks, but may also include maintenance of steam and gas lines, kitchen appliances, waste systems, irrigation systems. Plumbing maintenance staff may also maintain water lines for HVAC equipment, such as water source heat pumps.

- Plumbing Maintenance Plan (Guideline PM1)
- Fixtures (Guideline PM2)
- Water Heaters (Guideline PM3)
- Domestic Water System (Guideline PM4)
- Water Waste Management (Guideline PM5)
- Steam and Gas Systems (Guideline PM6)

Plumbing Maintenance Checklist

This is a general list of common maintenance checks. This list should be tailored to the needs and resources of individual school districts.

What to Inspect	Frequent Checks	Annual/Periodic Checks
Water Heaters	Joint and pipe leaks Pressure gages and relief valves Temperature control Overflow drain operation Insulation condition	Scaling Mixing valve operation Heating coil Electrical wiring
Backflow Preventer	Leaks	Seal, scaling Certification
Fixtures	Lavatory faucets, toilets, urinals Showerheads	Drinking fountains
Domestic water	Test safety / shutoff valves Flow rate	Water filter replacement Entrapped air Sprinkler systems Circulation pumps
Disposal Systems	Automatic disposal Floor drains	Grease traps Roof drains, site drainage
Steam and Gas Lines	Steam traps Pressure relief valves	

Sample Maintenance Checklist. (Material adapted from the Arizona Facilities School Board PM Checklist).

Guideline PM1: Plumbing Maintenance Plan

Recommendation

Develop a plumbing maintenance plan that includes information on building equipment, inspection procedures, schedules and reporting requirements for repairs and maintenance.

Here are some fundamental elements to include in the plumbing maintenance plan:

- Identify system requirements: storage temperature, delivery temperature, fixture flow rates, required cleanouts and isolation valves, safety standards, health standards.
- Obtain installation, reference and maintenance manuals for all parts.
- Establish expected life of equipment and identify required maintenance tasks to meet or exceed product's life.
- Identify recommended staffing levels and budget requirements.
- Identify a record keeping procedure and work order process for routine maintenance and responses to calls for stoppages and outages.

Description

Establish system operation standards. The maintenance plan should establish operating and performance standards for domestic water lines, sanitary lines, and gas lines. Specifications include water heater storage temperatures, control of mixing valves, operating pressures and flow rates. Water use standards, such as the use of low-flow faucets and urinals, should be specified.

Obtain system information. Like other building maintenance plans, a first step is to obtain detailed information about all plumbing equipment. Reference manuals for valves, pumps, controls, water heaters, kitchen appliances and other plumbing equipment should be obtained. Detailed drawings of domestic water systems and sanitary systems should be available.

Establish a preventive maintenance plan. For preventive maintenance, the expected life of equipment should be identified. Then, determine the routine maintenance required to meet or exceed the expected life of the component. The level of preventive maintenance will depend on manufacturer's recommendations, industry guidelines and facility managers' experience and district operating budgets.

The plumbing maintenance plan should include a list of scheduled tasks performed by maintenance personnel. Identify the frequency the tasks will be performed, the personnel or level of skill required to perform the task and the time required.

The maintenance plan should address the following areas:

- Domestic water system.
- Sanitary system.
- Onsite waste management, where applicable.
- Fixtures: sinks, toilets, urinals, water fountains, showerheads.
- Stormwater system.
- Pumps, controls.
- Backflow preventers, grease traps.
- Fire Suppression Systems: kitchen hood, area sprinklers, room sprinklers (if present).
- Large-scale modernizations.

For each area or equipment, identify specific preventive maintenance tasks (i.e., inspect for leaks). Specify the frequency for which each task is to be performed, and establish a time estimate for performing the maintenance check.

A record keeping process should be specified and implemented. Records of all preventive and unscheduled maintenance tasks should be recorded, with information on part repair or replacement and the time required to complete the task. Part costs and labor costs (time) should be recorded, so that annual maintenance costs can be determined. Also, obtain plumbing layout diagrams and reference manuals for pumps, valves, and other mechanical devices.

Identify staffing levels. For staffing, the Association of Physical Plant Administrators recommends one plumbing technician for every 390,000 ft^2 of gross building floor space. The California Association of School Business Officials (CASBO) also has guidelines for maintenance department staffing levels. The maintenance plan should identify staffing requirements to perform scheduled and unscheduled maintenance.

Applicable Codes and Standards

Uniform Plumbing Code
California Building Code

Benefits

A written maintenance plan can prevent backlogs of scheduled work. Record keeping of major repairs, part replacement and inspections will help ensure that systems are properly maintained. Records will also help in identifying resource requirements and capital budgets for maintenance activities.

Costs

An excellent general source for estimating costs of repairs, preventive maintenance or equipment replacement is *Facilities Maintenance and Repair Cost Data 2004*, published by RS Means.

Monitoring/Controls

N/A.

Common Retrofit Opportunities

N/A.

Verification/Commissioning

N/A.

References

Arizona School Facilities Board, *Plumbing Preventive Maintenance Plan*. The Arizona School Facilities Board provides lists of PM tasks, with frequency of task, and the time and skill level required to complete each task. For more information, see http://www.sfb.state.az.us/sfb/sfbMain/core_implementation.asp.

School Board of Brevard County, FL, *Facility Standards and Guide Specifications*, Office of Plant Operations and Maintenance, 2002.

State of Alaska, Department of Education & Early Development, *Alaska School Facilities Preventive Maintenance Handbook*, 1999 edition, http://www.eed.state.ak.us/facilities/publications/PreventiveMaintenance.pdf.

Guideline PM2: Fixtures

Recommendation

Perform routine maintenance on all terminal devices and associated piping.

Waterless urinals can save thousands of gallons annually and require little maintenance. Disposable traps can provide up to 1,500 uses. Source: Waterless No-flush Urinals.

- Implement inspection procedures for all potable water delivery devices: drinking fountains, sinks, showerheads, emergency wash stations and kitchens.
- Check piping monthly for leaks, corrosion or signs of deterioration.
- Check the seals of all fittings and valves for leaks, scaling or other signs of deterioration.
- Check drainage piping for blocked lines. Check water piping joints – corrosion build-up may occur if there is a pH imbalance or improperly joined metals.
- Verify that shut-off valves and backflow devices are fully operational for all equipment. Verify that emergency shut-off valves for gas-fired equipment in kitchens and labs, and for gas-fired water heaters, are functioning properly.
- Check for proper operation of disposals where placed.
- Clean showerheads to remove any accumulated mineral deposits.
- Consider using separate cleanouts for urinals and toilets, to minimize disturbance to the educational environment.
- Provide shutoff valves to isolate sections of the building when problems occur. Isolate group restrooms, building wings or groups of classrooms to minimize impacts of problems.
- Wall-mounted water closets that have blowout-design flush valves can reduce maintenance requirements.
- Concealing valves and connections behind walls helps to prevent vandalism. Using stainless steel fixtures makes for easier cleaning.
- Provide user training for metering and low-flow devices to ensure proper operation.

Description

Hot- and cold-water piping systems are typically copper; steam and gas piping are usually constructed from malleable iron. School maintenance staff spend a lot of their time responding to stoppages and leaks of fixtures and fittings. With piping, problems occur most often with the fittings, the result of corrosion, erosion and mineral buildup. Water hammer can crack piping and cause leaks in header piping and heating coils. Discoloration (or rust, for steel pipes) may be one of the first noticeable signs of a small leak. Seldom exercised valves should be routinely checked, at least once a year, so that mineral deposits don't "lock" them in place.

Science labs often have special plumbing requirements. Acid-resistant sinks and plumbing to accommodate acid waste may be required. Sinks should have (basket) strainers. Labs may require a natural gas shutoff valve for safety.

Preventive Maintenance Begins with Design

With the use and abuse that occurs in a school environment, maintenance work for leaks, stoppages and vandalism is unavoidable. However, one first step is to design the system to minimize down time. Having separate cleanouts for urinals and toilets will reduce down time in school lavatories, and minimize the disturbance to children. Careful placement of shutoff valves will also localize problems. At a minimum, a group of classrooms in a wing or bathrooms should be isolated with shutoff valves. Wall-mounted closets provide for easier maintenance than floor mounts, but the design must withstand possible tampering from students.

Hidden automatic flush valves with infrared sensors are easy to install and minimize the spread of bacteria. They also reduce the likelihood of vandalism in school lavatories.

Water Conservation

One area where improvements can be made is with water conservation. New requirements mandate the use of low-flow faucets and showerheads. Schools must provide proper training on water conservation, so that devices are used properly. Students will find ways to tamper with devices if they are unhappy with the lower flow or unaware of the benefits. Providing training to the users is critical to the success of water conservation measures. The Los Angeles Unified School District (LAUSD) uses metering devices to automatically shut off flow.

Ultra-low-flush (ULF) devices for toilets in urinals will significantly reduce water usage. It is important to distinguish *low flush* from *low flow*. Low flush toilets and urinals may reduce the consumption per flush by reducing flush time; piping for these fixtures should be sized for the same flow rate. Assuming a lower flow rate in the design can lead to water hammer and other problems. Verify the recommended flow rate for low-flush devices.

Waterless urinals have the benefits of lower maintenance, since they do not use mechanical parts to flush and remove waste. Their low maintenance requirements are also an obstacle to their use: since they do not require the same daily cleaning procedure, odors can develop before the cartridges require replacement. Also, in some larger districts such as LAUSD, irrigation has a large impact on water usage and may be a better focus for water conservation programs.

Applicable Codes and Standards

The California Code of Regulations Title24, Part 5 is the California Plumbing Code. This references the Uniform Plumbing Code established by the International Association of Plumbing and Mechanical Officials.

The National Energy Policy Act of 1995 mandates low-flow toilets that use 1.6 gallons per flush or less. The National Energy Policy Act of 1992 requires showerheads and faucets to have a maximum flow rate of 2.5 gpm or less, for standard water pressure of 80 psi.

The Americans with Disabilities Act Accessibility Guidelines (ADAAG) provides requirements for faucets, toilets for lavatories. Requirements for school lavatories can be found at http://www.disability-laws.org/Facility_Access/ADAAG/Tech_Rqmts/ADAAG_4-17.html.

K-12 Toilet Requirements Summary

http://www.cde.ca.gov/facilities/field (California Department of Education, School Facilities Planning Division, Sacramento, 1999) Summary of minimum K-12 toilet requirements in California according to male and female students and staff, and comparison with 1994 requirements.

For science labs, emergency shower/eyewash equipment must conform to ANSI Z358.1-1998. This specifies:

1. Emergency showerheads should be capable of delivering a minimum of 20 gpm of tepid water at 30 psi for a minimum 15-minute period.

2. Eyewash equipment should be capable of delivering a minimum of 0.4 gpm at 30 psi for a minimum 15-minute period.

3. Eye/face wash equipment should be capable of delivering a minimum of 3 gpm at 30 psi for a minimum 15-minute period.

4. Emergency shower/eyewash equipment should be in accessible locations that require no more than 10 seconds to reach.

Benefits

The benefits are reduced water consumption and reduced energy use from reduced hot water consumption.

Costs

Waterless urinals have a payback period of four years or less, and have estimated savings of $150-300 annually for each unit. Low-flow showerheads cost approximately $10 to $20. Low-flow faucet aerators cost up to $8; newer faucets can compensate for increased water pressure to maintain a fixed flow rate. Automatic sensors can cost up to $160 more than conventional faucets. Low-flow fixtures are cost-effective in the long run: the U.S. Energy Department estimates that they can pay for themselves in less than a year.

Monitoring/Controls

N/A.

Common Retrofit Opportunities

Installation of automatic faucet controls and low-flow showerheads and toilets will reduce hot water consumption. Another possible upgrade is installation of waterless urinals, which uses a biodegradable liquid to trap and dispose of urine without the use of mechanical parts. The sealant liquid lasts up to 1,500 uses and the trap needs replacement three or four times a year. Maintenance for waterless urinals is easier, since there are no valves or mechanical components to maintain.

Shower valves have evolved over the years, and a number of options are available. Electronic metering, mechanical metering, pressure balancing and thermostatically controlled valves are some of the options available.

Verification/Commissioning

Replacement of plumbing fixtures or valves does not require commissioning.

References/Additional Information

American Society of Plumbing Engineers, http://www.aspe.org.

American Water Works Association, Provides information on drinking water standards and regulations, and information on cross connection control. http://www.awwa.org.

Arizona School Facilities Board, Maintenance Checklist. Contains a thorough list of preventive maintenance tasks, with recommended frequency, skill level, and the time that is required to complete each task.

Collaborative for High Performance Schools, Best Practices Manual, Volume II – Design, http://www.chps.net.

Fitzemeyer, Ted, “Construction Guide: Plugging Leaks”, School Designs, 2004. Primedia Business Magazines & Media, a PRIMEDIA company. http://www.schooldesigns.com/constr_PluggingLeaks.html.

Florida Department of Education, *Maintenance and Operations Guidelines for School Districts and Community Colleges*, Office of Educational Facilities, 1054 Turlington Building, 325 West Gaines

Street, Tallahassee, Florida 32399-0400. Telephone: (850) 245-0494, SUNCOM: 205-0494, Fax: (850) 245-9236 SUNCOM: 205-9236. http://www.firn.edu/doe/edfacil/manoguid.htm.

Plumbing & Drainage Institute, 800 Turnpike Street, Suite 300, North Andover, MA 01845 USA Phone: 1-978-557-0720, 1-800-589-8956, Fax: 1-978-557-0721, Email: info@PDIonline.org. This organization provides information on products and standards. http://www.pdionline.org.

Guideline PM3: Water Heaters

Recommendation

The following maintenance activities should be regularly performed on water heaters:

- Tanks should be flushed at least annually. Chemical tests should be performed after flushing to test for deposits on the tank.
- Pressure gauges and relief valves should be checked for proper operation four times a year.
- Check thermal insulation condition periodically.
- Temperature control: limit hot water to a maximum of about 60°C (140°F). Verify that mixing valves deliver a maximum outlet delivery temperature of 40-45°F (105-110°F).
- For energy efficiency, provide a separate heating capability for school kitchens that require higher delivery temperatures of 140°F. Showers and other hot water faucets only require a maximum of 110°F.
- Install timers on water heaters to turn off heating during extended unoccupied periods.
- For retrofits, consider using instantaneous water heaters, timers on recirculation pumps, and heat-tracing on distribution piping.

The result of lack of maintenance. Annual flushing of tanks will extend the tank life and improve performance. Source: http://www.waterheatersrusinc.com/how.htm.

Description

Modern schools typically require hot water at 60°C (140°F) for heating, and may use 140 to 180°F water for sanitizing or automatic dishwashers. Hot water for sanitizing is often run through a second booster pump to provide the necessary delivery temperature. School kitchens must conform to local health codes. Hot water may be delivered at temperatures of 140° F, sometimes higher for sanitation. Since kitchens have higher temperature requirements, installing a separate water heater or point-of-use heater may be efficient in some situations.

Hot water delivery at faucets and showers should be limited to 105-110°F through the use of a mixing valve. Although lowering storage temperatures will reduce energy use, plumbing organizations such as the Plumbing Manufacturers Institute report that set points are often set higher than 120°F to prevent health issues such as Legionnaire's disease.

Schools may have either gas-fired or electric water heaters. A rough rule-of-thumb for hot water consumption is 3 gallons per day per student, with a peak demand of 1 gal/h for each student.

The expected life of commercial electric water storage tanks is around 10-15 years, less for gas tanks. Corrosion is the primary cause of premature failure of storage tanks. Performing routine flushes will remove mineral deposits and extend the life of the water tank. Tanks that are properly maintained can last 20 to 40 years. Tanks may be glass-lined (porcelain enamel) or stainless steel. Glass-lined tanks contain anodes, magnesium or aluminum rods that are suspended in the tank to prevent corrosion. Stainless-steel lined tanks are more expensive but are more corrosion resistant. Anode rods may need replacement every 2-3 years. Replace the rod if more than six inches of the rod's core wire is exposed.

For maintenance, flush the tank at least once annually. Drain the water until the water runs clear. Inspect the pressure-relief valve for corrosion. For gas-fired units, check the combustion chamber and flue for rust or corrosion. For electric heaters, check heating elements with the power off and the tank drained.

Applicable Codes and Standards

For replacement of water heaters, the California Title 24 Energy Efficiency code has minimum efficiency requirements. Efficiency is represented with the energy factor for electric heaters and flue efficiency or recovery efficiency for gas-fired heaters. Keep in mind that electric heaters will have much higher energy costs than gas.

For temperature control, water heaters are not designed to maintain tight temperature control. To prevent scalding the temperature must be controlled near the point-of-use. Standards are available from the American Society of Sanitation Engineers for control of hot water delivery temperature. Additional information is available from the Plumbing Manufacturers Institute.

ASSE 1016, *Performance Requirements for Individual Thermostatic, Pressure Balancing and Combination Control Valves for Bathing Facilities*.

ASSE 1017, *Performance Requirements for Thermostatic Control Valves, Self-Actuated for Primary Domestic Use.*

ASSE 1062, *Performance Requirements for Temperature Actuated, Flow Reduction (TAFR) Valves for Individual Fixture Fittings.* This standard applies to valves that are designed to restrict flow when the outlet temperature exceeds a specified limit (usually 120°F).

ASSE 1066, *Performance Requirements for Individual Pressure Balancing In-Line Valves for Individual Fixture Fittings.* This standard applies to pressure balancing valves used to reduce the risk of thermal shock caused by pressure fluctuations in the hot and cold water supply lines.

Benefits

Regular maintenance will extend the life of water heaters.

Costs

The cost of maintaining water heater storage tanks is low.

Monitoring/Controls

Temperature controls should be checked periodically to verify proper delivery temperature to showers, sinks and kitchens. The hot water temperature to these devices should not exceed 110°F (see codes and standards).

Common Retrofit Opportunities

In certain areas with extensive distribution piping, electric instantaneous water heaters may be a good option, but this really depends on the design needs of the building.

Verification/Commissioning

N/A.

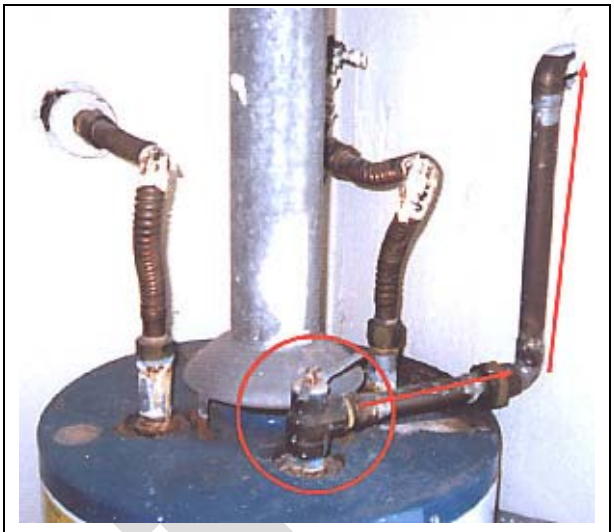
References/Additional Information

Viola, David W., “Water Temperature Control and Limitation”, Technical Director, Plumbing Manufacturers Institute, 2002. http://www.pmihome.org/tempcontrol.shtml. Contact: PMI, Suite A, 1340 Remington Road, Schaumburg, IL 60173, (847) 884-9764, FAX (847)-884-9775.

Guideline PM4: Domestic Water Systems

Recommendation

- Perform preventive maintenance checks for leaks. Test pressure relief valves and check for trapped air. Check manual or automatic bleeder devices twice a year for operability.
- Check condition of pumps and motors for circulation pumps. Test for proper pressure and check for leaks, noise or vibration.
- In areas where water quality is a problem, perform routine testing of water quality. Water quality testing is important not only for public health, but also for the maintenance of the piping system.
- Monitor the pH in the water system. Problems can be prevented by periodically inspecting the water quality. Facility managers can use water treatment kits to treat unbalanced pH levels. Testing the water quality annually will reduce the mineral build-up that leads to scaling.
- Check domestic hot water circulator pumps for proper operation. Periodically check the flow rate through domestic water lines.



Installation of a pressure relief valve. This water heater replaced a taller water heater; the previous T&P relief line went across, down and out. Excessive uphill turns and elbows could result in inadequate venting. Source: http://www.waterheaterrescue.com.

- Maintain spare supply for valves and controls, and indicators for fire suppression systems.
- Installing additional shut-off valves will isolate problems so that sections of schools do not have to be shut down.
- Sprinkler systems for fire control should be inspected annually, although some school districts will set their own inspection schedules. (For instance, Los Angeles Unified School District inspects them the first year, and every five years after the first inspection).

Description

Maintenance personnel respond to problems such as stoppages, plumbing repairs, vandalism and deterioration of plumbing lines. In the winter, underground water lines may rupture after heavy rains. Plumbers may work on irrigation systems during the summer months. With all of these tasks, maintenance personnel have little time for preventive maintenance.

School plumbing technicians should periodically check safety and shutoff valves for proper operation. For faucets, clean aerators if the flow appears restricted or irregular. Vinegar will remove calcium and lime deposits. Showerheads should also be inspected for deposits, debris or build-up.

Applicable Codes and Standards

The American Disabilities Act Accessibility Guidelines (ADAAG) has standards for locating drinking fountains and lavatories.

Benefits

Preventative maintenance can help avoid serious water heating problems such as ruptured lines and leaks. Addressing these issues early can help avoid losing service from these heaters and/or needing to replace them before their expected lifecycle.

Costs

Replacing these units is quite costly, so the cost benefits of preventative maintenance is very significant.

Monitoring/Controls

N/A.

Common Retrofit Opportunities

Automatic timers can be used to control circulation of hot water based on demand. These are inexpensive and work well with school water systems, where schedules are predictable. Timers will significantly decrease the distribution losses from systems. Refer to the CHPS Best Practices Manual, Volume III, for more information.

Providing separate heating systems for areas with higher temperature requirements such as kitchens may provide energy savings. This will allow for lower storage temperatures for the main hot water lines to lavatories and showers.

Tankless water heaters may be a good option for areas with smaller hot water requirements. These systems provide low maintenance costs.

Solar water heating involves additional first cost but can provide savings over the life of the system. With these systems there are additional maintenance concerns, such as collector cleaning, roof penetrations for collector mounts, and periodic replacement of antifreeze fluid, for closed systems. An excellent introduction to the types of systems available is provided by the DOE's Energy Efficiency and Renewable Energy Office at: http://www.eere.energy.gov/erec/factsheets/solrwatr.html. They also have a list of maintenance requirements for solar hot water heating systems. The California Solar Energy Industries Association provides consumers with system manufacturers, distributors and installers. For product information, contact: California Solar Energy Industries Association, P.O. Box 782, Rio Vista, CA 94571, (916) 340-2605, email: info@calseia.org.

Verification/Commissioning

N/A.

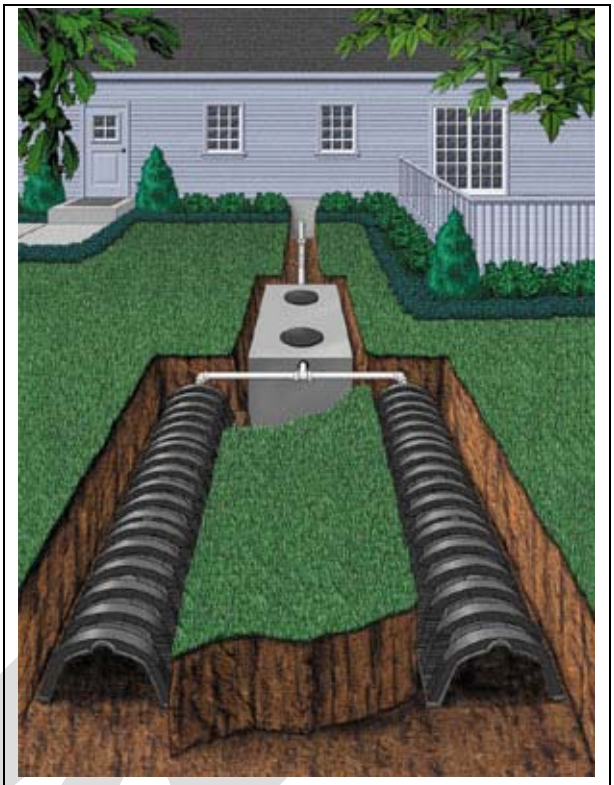
References/Additional Information

Personal correspondence with Jon Fernandez, Plumbing Technical Supervisor, Los Angeles Unified School District, January 2004.

Plumbing and Drainage Institute, http://www.pdionline.org.

Guideline PM5: Water Waste Management

Recommendation



(From http://www.septic-info.com)

For Storm Water Systems

- Provide cleanouts at regular intervals. The Brevard Country maintenance standards recommends cleanouts every 75 feet for lines 4" or greater, and every 50 feet for smaller lines.
- For storm drains that have collection sumps, clean accumulated debris when the debris has reached a depth of half the distance between the bottom of the drain pipe and the bottom of the sump.
- For storm drains that have no filters or collection sumps, consider installing a sediment filter and oil absorbing medium on the end of the drain pipe.
- Verify proper roof drainage and site drainage away from foundation (see Building Envelope Chapter).
- Inspect storm sewage lines annually for debris or other blockage.

For Sanitary Waste Disposal

- For school kitchens use grease traps or interceptors and clean periodically.
- Isolate potable line from non-potable water line with backflow prevention devices. Inspect periodically, and have the devices tested and certified annually.
- Flush exterior water mains periodically to prevent sediment build-up in distribution piping.

For Onsite Waste Management Systems

- Check septic tank sludge levels annually. Clean effluent pump filters annually.
- Inspect distribution piping at least twice a year.
- Materials not readily decomposed (napkins, towels, coffee grounds, cooking fats and bones) should not be transported into septic tanks.

Description

Storm Water Systems

Most schools will connect their waste lines to the municipal water system. Storm drains should be checked annually to remove and clear debris and prevent blocked lines. School plumbing staff members often have little time for preventive maintenance, but it is important to maintain the exterior storm water systems as well. Storm runoff may be untreated before reaching area streams and rivers.

Sanitary Systems

Kitchen plumbing should contain grease traps or interceptors, so that fats, oil and grease do not clog sewage lines. Grease interceptors that are certified by the Plumbing and Drainage Institute can hold a mass of waste that is proportional to their design flow rate (20 pounds for a 10gpm flow rate, for example). The trap may have to be cleaned weekly or even more frequently, depending upon kitchen

practices. Check the cleanout ability of acid and sand interceptors. Periodically clean out filters and replace when necessary. More information on grease trap operation and maintenance can be obtained from the Plumbing and Drainage Institute.

Backflow preventers are used to prevent cross-contamination with the main supply line. This is sometimes referred to as cross connection control. When this type of device is used in a hot water distribution system, an expansion tank should be installed to prevent any pressure build-up from thermal expansion. An excellent resource for product-specific repair information is available from the Backflow Prevention Valve Company (BAVCO); their reference manual contains repair procedures for specific products.

Backflow preventers should be checked periodically for leaks. They should be tested annually for proper operation.

Onsite Waste Management Systems

Onsite waste disposal systems may be a cost-effective waste management solution in rural areas where access to public waste disposal is difficult. While there are many methods to treating and disposing of waste, most involve an initial treatment in a septic tank, and a means of dispersing the treated waste into the soil. Careful design and maintenance ensures proper operation and prevents contamination of groundwater supplies.

Conventional Septic Systems

Septic systems are used for onsite waste disposal. First, waste solids and grease separate in a septic tank. The remaining liquid effluent is pumped through a distribution box to an absorption field ("leach field"), where it is slowly emitted from a series of pipes. Onsite waste management systems can be cost-effective but must be carefully designed to avoid contaminating the groundwater supply.

The first step in maintenance is identifying the location and size of the septic tank and the leach field. The septic tank will require pumping approximately every few years to remove accumulated solids. For proper separation of solids, the waste should remain in the septic tank for about 24 hours. The required size of the septic tank depends upon the wastewater flow rate. Daily flows of waste water range from 5-17 gallons per student for schools without cafeterias or showers, to 15-30 gallons per student for schools with cafeterias, gyms and showers (Crites and Tchobanoglous, 1997).

Septic tanks must be watertight and airtight for proper operation. Infiltration into the tank could lead to overfilling and pressures on the tank walls. Leaks of untreated waste could impact the groundwater supply. During installation, checks for airtightness can be performed either with hydrostatic testing or vacuum testing. Hydrostatic testing involves filling the tank with water and checking if the water level decreases over time. Vacuum testing is a faster means of testing tank pressure. Both of these checks are performed when the system is installed.

Septic tanks are designed to hold a large amount of solid waste (sludge). Tanks that are constructed of concrete, fiberglass or plastic should last up to 50 years. The sludge level should be checked annually, and pumped if necessary. Current practices suggest that pumping of sludge from septic tanks may be required every three to 11 years. Accumulated sludge will decrease retention and may eventually cause solids to be pumped out the outlet. The suggested guideline is to pump when the top level of the sludge is within six to 12 inches of the bottom outlet of the tank. Many tanks have controls to monitor fluid levels, and alarms if the level is exceeded. The tank should be pumped by a licensed contractor with a vacuum pump; the removed septage must be transported to a licensed disposal site.

The other maintenance required on the tank is to clean the filter on the pump outlet. The effluent pump filter should be cleaned annually. This is a simple procedure: the filter is removed from the housing, washed off and reinserted into the housing.

Alternative Onsite Disposal Systems

Evapotranspiration is a process where the effluent is pumped through distribution piping to a sealed bed. Wastewater rises through fine sand to the surface, where it is either directly evaporated or carried through

roots to plants and transpired to the air. These systems require little maintenance, aside from upkeep of vegetation and diversion of storm water away from the treatment area. This disposal method prevents contamination of groundwater and is useful in arid and semi-arid climates.

Constructed wetlands mimic natural wetlands and are designed to treat wastewater at the soil surface or beneath the surface. These systems also require little maintenance.

Low-pressure dosing systems (LPDS) are designed to provide more even distribution of effluent throughout the piping. With traditional systems, water is transported through the pipes by gravity and will be emitted first by the closest outlets. Moreover, the waste is pumped out to the piping to offset incoming waste into the septic tank. Over time the piping outlets closest to the source may become overloaded. The LPDS provides a more even distribution through a series of pressurized lines, and allows for a "rest period" between exhaust doses. The septic tank is fitted with a pump and controls that allow for a timed dose to be pumped to the distribution piping. The distribution piping is a network of PVC pipes with small perforated holes, typically at 3-5 foot intervals. The piping is at a low pressure (5 ft of head) and is placed in shallow trenches about a foot deep. The periodic small doses ensure that the ground doesn't become too saturated. The pump chamber will require periodic inspection, and maintenance of controls and electrical parts as specified by the manufacturer. The distribution system should be checked for clogging of pipes and the soil checked for ponding.

The U.S. Environmental Protection Agency is an excellent resource for additional information on the design and installation of various types of onsite waste management systems. See the references section of this guideline for additional information.

Applicable Codes and Standards

Federal laws such as the Clean Water Act, Safe Drinking Water Act and Coastal Zone Management Act apply. Septic systems that serve more than 20 people are considered Class V wells by the U.S. Environmental Protection Agency (http://www.epa.gov/region8/water/uic/classv.html). In addition, onsite septic systems may be regulated by local (county) ordinances.

Benefits

Proper management of waste water systems protects the environment, helps protect the health of school staff and students, and protects the life cycle of sewage systems.

Costs

Replacing these systems is extremely costly.

Common Retrofit Opportunities

Implementing reuse of "gray water" can reduce water use for landscaping and sanitation. Used water from sinks and kitchens can be reused in lavatories or boiler makeup water. These systems require piping to route the wastewater out the building and appropriate valves to control flow to irrigation systems.

References

County of Los Angeles, Department of Health Services, Cross Connection and Water Pollution Control Program, 5050 Commerce Drive, RM 116, Baldwin Park, CA 91706-1423. (626)-430-5290. – This program provides testing and certification for backflow prevention devices. This program also certifies individuals as testers. Any individual in Los Angeles County engaged in the business or occupation of testing, repairing or installing backflow prevention devices must be certified as a Certified Backflow Tester.

Seabloom, Robert W., Terry Bounds, Ted Loudon, "University Curriculum Development for Decentralized Wastewater Management: Septic Tanks", Sept 2003. Developed for the National Decentralized Water Resources Capacity Development Project, U.S. EPA.

Trotta, Paul D., Justin O. Ramsey, Onsite Wastewater Demonstration Program, Treatment Technologies, Northern Arizona University, September 2000.

U.S. Environmental Protection Agency, Office of Water, Office of Research and Development, Voluntary Guidelines for Management of Onsite and Clustered (Decentralized) Wastewater Treatment Systems, March 2003.

U.S. Environmental Protection Agency, Onsite Wastewater Treatment Systems Manual". U.S. EPA, February 2002. http://www.epa.gov/ORD/NRMRL/Pubs/625R00008/625R00008prelim.pdf.

Guideline PM6: Steam and Gas Lines

Recommendation

- Ensure that all personnel who operate boilers are properly trained.
- After any boiler repair, have the entire system checked by a qualified inspector.
- Develop a preventive maintenance schedule from maintenance records and manufacturer's recommendations.
- Establish written checklists for startup and shutdown of boilers.
- Check steam traps for process equipment twice a year. Check steam traps for space heating annually. Use infrared thermometers or ultrasound for inspections.
- Check all gas appliances for possible leaks.

Description

Boiler maintenance

Proper operation and maintenance of boilers and furnaces by trained staff is essential for occupant safety. The National Board of Boiler and Pressure Vessel Inspectors points out that the first step in safety is to purchase equipment built to the ASME Boiler and Pressure Vessel Code. Ensure that proper training is provided for all staff that operate or maintain boilers and furnaces. Local districts should identify available training for their personnel.

Establish routine safety inspection and testing that complies with manufacturers' recommendations and local regulations. Inspections should be performed by qualified personnel. Boiler inspection should include the following practices:

1. A good place to start with boiler maintenance is to ensure proper installation; most operational problems can be traced to improper installation. Verify air supply to ventilation and combustion openings. Keep boiler room clear of unnecessary items; don't use it as a storage room. Any storage item that affects the air quality in the storage room affects the operation of the boiler.
2. Inspect the piping. High flow rates (greater than 5 feet per second (check ASHRAE) wear down fittings. Improper flow to the boiler can affect the operating cycle of the boiler. Inspect the pressure relief valve and verify it is plumbed to an adequate drain. Periodically test its operation.
3. Check temperature and pressure controls. Check safety devices per ASME Standard CD-1, "Controls and Safety Devices for Automatically Fired Boilers". Although boilers will have automatic sensors and controls, periodic inspections should be performed in case of malfunctions. Flow switches and low flow cutoffs should properly shut down the boiler in the event of a sensor or control failure.
4. Verify the venting lines are sized and located according to National Fuel Gas Code guidelines **(ANY LOCAL REGULATIONS?)**. Route the ventilation piping directly to the chimney or roof with a minimum of fittings. Check flue vent pipes for rust or exterior streaks. Exterior streaks are signs that condensate is forming before exhaust leaves the building.
5. Inspect, clean and adjust boiler according to manufacturer's specifications. Follow manufacturer's recommendations for removing and cleaning burners, and replace seals and gaskets after removing burners. Inspect the combustion chamber for cracks, deterioration or signs of incomplete combustion. Clean soot or condensate off of the exterior heat exchanger surface according to procedures recommended by the manufacturer.
6. After cleaning or maintenance of any parts, check all connections for leaks after initial firing. Verify proper fan discharge, temperature control and high limit controls.

Steam traps remove condensate and purge air and other non-condensable gases from steam lines. A regulator controls the input side of the process, and the steam, after releasing energy to the process, condenses and reverts back to its liquid state. The purpose of the steam trap is to retain steam in the heating element and to release the non-condensable gases and condensate. Properly functioning devices trap the steam, allowing air and other gases to escape. Like any mechanical device, steam traps are subject to failure. They can fail open or closed. A device failing closed will not release the intended condensate from the line, leading to quality issues. Accumulated condensate can also cause water hammer, where a "slug" of fluid moves at a high velocity through the lines. A device failing open will waste energy, as some steam will blow through. Since a trap could fail partially open, a slow leak would not be detected without routine inspections.

Gary Mohr, in an article for *American School and Hospital Magazine*, discusses typical inspection procedures for steam traps. First, visual inspections require discharging steam from the trap and are not the most reliable method. Portable infrared thermometers can provide estimates of pressures on valves, traps and coils. Ultrasound is the most reliable method of detecting small leaks in steam traps.

NOTE: PLUMBING PERSONNEL MAY ALSO MAINTAIN COMPONENTS OF HVAC SYSTEMS (E.G., WATER COOLED HEAT PUMPS).

Applicable Codes and Standards

ASME Boiler and Pressure Vessel Code – standards for purchases of new boilers (http://www.asme.org/bpvc/).

American Boilers Manufacturing Association provides product standards.

American National Standard for Gas-Fired Low Pressure Steam and Hot Water Boilers, ANSI Z21.13-2000.

ASME-CD1 - Controls and Safety Devices for Automatically Fired Boilers. This standard provides guidelines for maintaining safety devices, and does not allow modification of existing safety devices.

National Fuel Gas Code – regulations on size and location of combustion and ventilation air openings. Local regulations may also apply.

Benefits

Energy efficiency and occupant safety are key benefits to properly maintained boilers.

Costs

Union Gas, a Duke Energy company, cites studies indicating that 7% of boiler fuel costs can be attributed to inadequate maintenance. There have been incidences of boiler and furnace failures in schools, resulting in injuries to maintenance personnel. Proper maintenance is essential for a safe environment.

Common Retrofit Opportunities

Replacement of older inefficient boilers will provide a savings in the long run. Newer pulse combustion boilers can have efficiencies of 98%. In addition, since older units are oversized, installing a smaller, more efficient unit will substantially lower maintenance costs.

References/Additional Information

ASHRAE Handbook, HVAC Systems and Equipment, 2000.

Mohr, Gary W., "Maintaining Steam Traps", American School and Hospital Maintenance Magazine, http://www.facilitymanagement.com/articles/artsteam.html.

Moore, Jerry, "Quick Tips on Boiler Maintenance", *Contracting Business*, February 2002, http://www.contractingbusiness.com/editorial/serviceclinic/SC0202.pdf.

National Board of Boiler and Pressure Vessel Inspectors, 2004, “School Boiler Maintenance Programs: How safe are the children?”, http://www.nationalboard.org/Classics/classic43.html.

Union Gas, a Duke Energy Company, has summarized daily, weekly, monthly and annual preventive maintenance checks for gas-fired and oil-fired boilers. Their information, derived from the Ontario Natural Gas Association, can be found at: http://www.uniongas.com/business/otherci/techsol/heating/boiler/inspection.asp.

Recycling and Waste Management

Introduction

Statistics show that Americans today each generate approximately 4.4 pounds of garbage per day. All forms of disposal negatively impact the environment and public health. These negative effects include water contamination by landfills; and pollution of air, soil, and water by garbage burned in incinerators. For these reasons, waste prevention processes are necessary pollution prevention strategies that promote the conservation of energy and other natural resources, while providing a healthier, more sustainable environment.

- Recycling and Waste Management Plan (Guideline ED1)
- Waste Management (Guideline ED2)
- Recycling – Paper, Aluminum, and Glass (Guideline ED3)
- Composting (Guideline ED4)
- Indoor Pest Management – Rodents (Guideline ED5)

Guideline ED1: Recycling and Waste Management Plan

Recommendation

As part of a school's overall maintenance and operations plan, have a document that outlines the procedures, responsibilities and necessary contacts for effective management of garbage and recyclable at the school site. Ensure that this document is easily accessible for relevant staff members, either electronically (intranet) or in a resource binder, and that staff is trained on the necessary information. Update manual as necessary.

Description

An effective recycling and waste management plan should address the following areas:

- Staffing and budget requirements for effective management of waste and recyclable materials at the school.
- List of what materials are collected for recycling (i.e., aluminum cans, white paper, corrugated cardboard, glass, newsprint, etc.)
- For each of the recyclables that are collected at the campus, outline any special requirements for staff when dealing with these materials (i.e., separating white and colored paper; rinsing out soda cans, etc.) See the recycling guidelines later in this chapter for specific recommendations.
- Procedures for collection, handling and storage of waste and recyclable materials, including:
    - Size and type of waste and recycling bins found on campus.
    - Locations of bins.
    - How the materials should be prepared and handled for pickup.
    - OSHA Standards and other safety regulation for potentially harmful waste.
    - Care of bins and waste storage areas.
- Pick-up schedules for waste and recyclables by local solid waste services. For recycling, some services require minimum volumes for pickup. If this is the case in your area, outline the process for scheduling a pickup.
- Contact information for local solid waste agencies.
- Reporting requirements
- Some districts may have set policies for recycling policies and goals for the district as a whole, and may have a committee made up of administrators, teachers, students, and facilities staff that works to ensure that the recycling programs are effective on campus. If your district has such an organization, be sure to include information on the group and its activities relevant to M&O in the plan.

Codes/Standards

The California Integrated Waste Management Act of 1989 (AB 939, Sher, Chapter 1095, Statutes of 1989) requires that all California cities and counties reduce solid generation waste by 50%.

Benefits

According to the California Integrated Waste Management Board, a good waste prevention and recycling plan provide a number of benefits, such as:

- Increased efficiency of school operations.
- Improved worker safety.
- Reduced long-term liability.

Costs

- Decreased associated purchasing costs
- Reduced disposal costs
- More efficient use of staff time can help stretch budget dollars further.

Monitoring/Controls

N/A.

Common Retrofit Opportunities

N/A.

Verification/Commissioning

N/A.

References/Additional Information

California Integrated Waste Management Board. *A District-wide Approach To Recycling: A Guide For School Districts*, 1994. http://www.ciwmb.ca.gov/.

Environmental Protection Agency. WasteWise Program (5306W): U.S. Environmental Protection Agency; Ariel Rios Building; 1200 Pennsylvania Avenue, N.W.; Washington, DC 20460. Website: http://www.epa.gov/wastewise/wrr/prevent.htm.

Texas School Recycling Guide. Texas Natural Resource Conservation Commission: P.O. Box 13087, Austin, TX 78711-3087. Telephone: 512/239-0028, Fax 512/239-4488. Website: http://www.tnrcc.state.tx.us/admin/topdoc/gi/030.pdf.

Guideline ED2: Waste Management

Recommendation:

Empty trash bins daily in classrooms, offices, restrooms, locker rooms, cafeterias, and kitchens as well as in any outdoor areas such as playgrounds and picnic bench areas. Wash out trashcans weekly, as necessary.

Description

General

- Do not overload bags. If bags are overfull, the seams may split, causing garbage to leak during transport or within the garbage bin and/or dumpster.
- If the bag seems too heavy, double bag it or divide it into multiple bags.
- Securely seal the tops of bags with twist ties or by tying the top to prevent spills and odor.
- Do not toss bags into dumpster or receptacle, but stack them in as carefully as possible to prevent breakage and spills.
- Make sure the dumpster is located away from doors, windows, and other points of entry to the building. Fifty yards away or more is recommended.
- Carts should be available for staff to move waste to the dumpster area.
- Always keep dumpster rain covers closed.
- Clean the area around dumpsters regularly using power washing or other technique.
- Request that the local waste service provider replace dumpsters on a regular basis, as they become heavily soiled from months of use.

Food Waste

- Proper handling of food waste is vital to protecting indoor environmental quality by preventing insect and rodent problems.
- Use strong, good quality plastic bag to dispose of wet and dry food waste.
- Consider rinsing out kitchen/cafeteria waste bins daily to maintain good sanitary conditions and reduce pest infiltration.

Hazardous Material

Regulations exist surrounding the disposal of hazardous materials from middle school and high school science classes. A list of chemical wastes expected should be generated by the school each year. M&O staff can then establish an agreement with a qualified hazardous waste disposal service that is responsible for lab packing, transporting and disposing of the waste.

Codes/Standards

Regulations exist for the management of hazardous materials. The California Department of Toxic Substances Control contains up-to-date information on laws and regulations on its website: http://www.dtsc.ca.gov/LawsRegulationsPolicies/

Benefits

Effective waste management practices result in good sanitation, improved indoor environmental quality, and sustained pest management.

Costs

Disposal services and staff time are the major costs. However, effective waste management can prevent the significant costs of dealing with pest infiltration and unhealthy sanitary conditions that result from poor and/or irregular maintenance.

Monitoring/Controls

N/A.

Resources/Additional Information

Arlington Public Schools, Operations, http://www.arlington.k12.va.us/facilities/operations/trash.html.

California Integrated Waste Management Board. *A District-wide Approach To Recycling: A Guide For School Districts*, 1994. http://www.ciwmb.ca.gov/.

Corrigan, Bobby Ph.D., "Reducing pest activity via proper handling of food waste," IPM Technical Resource Center, Integrated Pest Management for Schools and Childcare Facilities, Purdue University Entomology Extension; http://www.entm.purdue.edu/entomology/outreach/schoolipm/AI/PDF%20Files/Trashtips5_9.pdf.

Jefferson County Public Schools, Custodial Specifications, http://jeffcoweb.jeffco.k12.co.us/facmgmt/custspecs.html#top.

Guideline ED3: Recycling – Paper, Aluminum, and Glass

Recommendation:

Place recycling bins next to trashcans to provides students, faculty and staff with disposal options, and reduce or prevent contamination of recycling bins with trash.

Students at Concord High School collect paper, cans, and plastic bottles in special dumpsters.

(Photo credit:: California Integrated Waste Management Board)

Description

It is important that school staff and students are reminded on a regular basis of the proper items and the correct methods of preparation. Collected recyclables are a raw material for industry and therefore they must meet manufacturers' specifications just like any other raw material. Improperly prepared recyclables may lose value or become so contaminated that they cannot be recovered and must be disposed of as trash instead. For example, the addition of a broken ceramic cup to a load of glass containers at a glass recycling plant might result in rejection of the entire load. Recyclables contaminated with food residue may cause odor or pest problems.

Glass

Glass manufacturers are in great demand of recyclable glass because it takes less energy and therefore less capital to produce containers from used glass, than with raw materials. Note that all types of glass cannot be recycled. The key to glass recycling is quality. Recycled glass, called cullet, must meet the following requirements:

- Cullet must be separated by color (clear, amber, or green);
- Cullet must be contaminant free;
- Cullet must be up to par with market specifications; and
- Cullet must be container glass.

Almost all glass food and beverage containers are recyclable. Common materials that contaminate cullet are:

- Ceramic dishware and pottery;
- Clay garden pots;
- Laboratory glass;
- Crystal and opaque drinking glasses;
- Mirrors;
- Light bulbs; and
- Heat resistant ovenware.

Paper

Design your program to maximize both the quality and the quantity of waste paper collection. Install a compactor for cardboard, and mixed paper to facilitate the management of some recyclables and to increase storage space.

The five categories of paper that are most relevant to schools are:

- **Corrugated cardboard.** Remove contaminants, such as polystyrene, packing materials, plastic-coated cartons, and other debris.
- **Old newspaper.** Keep newspapers clean, dry, and away from direct sunlight.
- **High-grade white office paper.** This includes white typing, writing, and copy paper, white scratch paper, tab cards, index cards, and computer paper. Do not include carbon paper, NCR forms, blueprint paper, taped or glued paper, post-it notes, newspaper, tissue, and paper cups.
- **Sorted office paper.** Similar to high-grade office paper with the addition of colored paper.
- **Mixed office paper.** This is clean paper recovered that is unsorted.

Aluminum

An aluminum can produced from raw materials takes 95% more energy to produce than it does from recycled aluminum, a dramatic example fact of the energy efficiency of producing goods from recycled products.

Implement a recycling program that allows students to recycle containers generated during food preparation, vending machines, and packed lunches.

Other

- Recycle spent fluorescent lamps properly to reduce risk of exposure to hazardous wastes. Fluorescent lamps contain mercury, which is released into the atmosphere when tubes are broken in trash. Collecting them in their original containers and shipping them to a fluorescent lamp recycler reduces the risk of exposure to hazardous wastes.
- Establish a program for students to empty milk cartons and separate them for recycling. The containers may be collected with other mixed containers, such as glass bottles, steel cans, and aluminum beverage cans. Purchasing a small compactor may be one way to manage the cartons if storage and odor is a problem. A compactor can reduce the cartons at a ratio of 30:1 and encases the compacted cubes in a plastic bag.

Codes/Standards

Signed into law in 2001, California Senate Bill 373 requires increased presence of recycling programs on K-12 schools statewide. As part of this law, school districts have online access to waste reduction resources from the California Integrated Waste Management Board (CIWMB) and the Cal/EPA to assist districts in putting recycling programs in place. (http://www.ciwmb.ca.gov/PressRoom/2002/April/033.htm)

The California Integrated Waste Management Act of 1989 (AB 939, Sher, Chapter 1095, Statutes of 1989) requires that all California cities and counties reduce solid generation waste by 50%.

Benefits

- Recycling can save school districts money.
- Recycling reduces the amount of waste that goes into landfills.

Costs

Recycling collection services are the main cost. School districts have many options when selecting a service provider and developing a contract that meets the school's budget and needs.

Visit the CIWMB's Business Services page on their Waste Reduction site for additional tips and resources: http://www.ciwmb.ca.gov/Schools/WasteReduce/BusinessServ/.

Monitoring/Controls

N/A.

Resources

California Integrated Waste Management Board. *A District-wide Approach To Recycling: A Guide For School Districts*, 1994. http://www.ciwmb.ca.gov/.

Environmental Protection Agency. WasteWise Program (5306W): U.S. Environmental Protection Agency; Ariel Rios Building; 1200 Pennsylvania Avenue, N.W.; Washington, DC 20460. Website: http://www.epa.gov/wastewise/wrr/prevent.htm.

Guideline ED4: Composting

Recommendation

Implement a composting program that emphasizes the importance of preventing yard trimmings from going into landfills and implements composting operations to serve as a teaching tool, while allowing the school to save capital in terms of labor, chemicals, and water. The following district-level measures are necessary before executing day-to-day procedures.

Compost bins should be placed on grass or soil for drainage purposes.

(Photo credit:: Alameda Country Waste Management Authority)

Organizing a Composting Program

- Organize a committee that involves the support of administrators, teachers, and students.
- Generate the support of your school administration.

Researching and Developing

- Find out what is involved in a school-wide composting program.
- Develop a plan with clearly defined goals.

Involvement is Key

The success of your composting program depends on involvement from:

- Teachers are instrumental in providing students with the scientific concepts and ideas of composting. Encourage teachers to use audiovisual tools to integrate composting into curriculum.
- Students constitute the target audience for the program because it is up to them to sort their lunch wastes everyday. Get students involved directly by recruiting a group of students to help regulate composting operations, under adult supervision.
- Custodial Staff recommendations are needed in selecting a practical location for compost bins; they are needed to transport organic materials into compost bins.
- Kitchen Staff are important in executing program goals in terms of separating food scraps and packaging wastes. Involve the kitchen staff and provide bins with clear signage, one for food scraps and one for packaging wastes.

Description

Necessary Ingredients for Making Compost

- **Nitrogen:** Good sources include grass clippings, landscape trimmings, green garden waste, as well as vegetable and fruit trimmings.
- **Carbon:** Good sources include dry yard and garden material such as dry leaves, twigs, or hay, as well as untreated wood chips and sawdust.
- **Water:** Regularly monitor compost to ascertain that compost maintains 40%–60% moisture content.
- **Air:** Regularly turn and fluff compost to expose contents to oxygen.

Here is a list of items that can be composted:

Bagels (with cream cheese is OK)	Bread (with mayonnaise is OK)	Cereal (with milk is OK)
		Cookies

Fruit – all parts	Rolls (with butter is OK)	Soup
Pasta	Salad (with dressing is OK)	Vegetables – raw or cooked
Pizza		Waffles (with syrup is OK)

Please note that meat cannot be composted.

The School Composting Manual for Connecticut Schools provides the following recommendations for implementing an onsite composting program.

Compost Bins

- **Location:** Place bins conveniently on grass or soil for drainage purposes. It is important that the bins are accessible to machinery allowing bulking materials to be easily delivered and deposited beside the bins. Avoid placing bins directly against any walls to allow space for cleaning spillage. For safety, place bins behind the school building, in a low traffic area, away from large dumpsters.
- **Bin Size and Number:** It is recommended that each school keep at least four bins that are at least one cubic yard (3'x3'x3'). However, the number and size of bins depends on the amount of food waste that is collected. Schools that produce 50 pounds of food waste per day should use four bins that each measure 4'x4'x4'; to avoid bins that are taller than 4' (to allow students to easily reach to open the lids) add more bins.
- **Design:** Select four bins that share walls and have removable walls and fronts, to allow compost to be easily moved from one bin to the next. Deposit fresh food waste into the first bin and once it is full transfer it to the adjacent bin. After the first bin is full again, move the material from the 2nd bin to the 3rd bin, and next move the material from the 1st bin to the 2nd bin.

Outdoor Composting Equipment[4]

- Cloth rags;
- Shovel;
- Pitchfork or garden fork;
- Work gloves;
- Compost thermometer;
- Scale that measures in one pound increments;
- Clipboard with record sheets;
- A steady supply of bulking material, such as leaves, wood chips, and wood shavings;
- Labeled food waste barrels or receptacles on wheels; and
- Sifting screen.

Day to Day Composting Tasks

The following tasks should be carried out on a daily basis by a team of two or three students (with adult supervision).

- **Collect food scraps:** Place specific containers for food scraps in the cafeteria and kitchen areas. In the cafeteria, place food scrap containers alongside other recycle bins, where students sort out their lunch trays. In the kitchen, place one or two food scrap containers for leftovers and coffee grounds. Retrieve these and consolidate the contents of the cafeteria and kitchen food scrap containers into a single barrel lined with a plastic bag.

[4] Indoor composting: For different types of classroom composting techniques, refer to Cornell University's "Composting in Schools" website.

- **Weigh food scraps:** Have students place the plastic bag of food waste in a container before weighing contents (first weigh the container, in order to subtract its weight from the total) and then place the container on the scale. Consider purchasing a scale that has a locking feature or one that shows the weight from the side view. (This step important to track your progress in how much waste you are diverting from disposal.)
- **Transport food scraps to bins:** Wheel out the barrel of compost and make sure to pick up work gloves, pitchfork and thermometer on the way there, if they are not located near the composting bins.
- **Take compost temperature:** Regularly determine the temperature to measure the progress of the compost by placing the thermometer into the center of the pile. If compost temperatures drop before the most of the decomposition occurs, it indicates an imbalance of food, moisture, air, and bulking materials.
- **Spread food scraps:** Manage food waste by lining the barrel with a plastic trash bag, securing the top with a bungee cord. Lift the bag from the barrel and pour contents into the compost bin. Spread food scraps evenly and level out any piles initially formed.
- **Layer with bulking material:** Cover the food scraps completely with a few inches of bulking material (wood chips, wood shavings, or leaves). Latch on the lid.
- **Clean-up:** Using a cloth rag wipe off the shovel and thermometer. Place equipment and barrel in appropriate locations.

Vermicomposting

Vermicomposting is a form of composting that uses worms ("vermi" is Latin for "worm") to process organic food waste into nutrient-rich soil—vermicompost.

Here are the basics of vermicomposting:

- **How many bins and what size?** To determine the number and size of bins needed calculate the average amount of food waste that your class or school produces.
- **Where to place bins?** Place outdoor bins in a shady spot to allow vermicompost temperature to stay within 55–77 degrees Fahrenheit.
- **Designing bins:**
    1) Drill holes in your bin to allow air to reach contents.
    2) Place wood or brick blocks underneath bin to prop up for drainage.
    3) Collect drainage by placing a tray underneath the bin; this nutrient-rich mixture can be used as a supplement for plants and gardens.
    4) Place a lid over bins to protect contents from the sun.
- **Filling bins with bedding:** Fill up two-thirds of your bin with bedding (one-inch newspaper strips; or peat moss (leached); or office paper; or coconut fiber; or shredded cardboard). Fluff up bedding and add several cups of water, while stirring, until all the bedding is thoroughly moist; do not add too much water to avoid a soupy consistency, and yet add enough water to prevent dry bedding. Once you have reached about a 3:1 weight ratio of water to bedding, use your hands to fluff up the bedding.
- **What types of worms to use?**
    - Red worms, the Eisenia foetida, also referred to as "red wigglers," "red worms," or "manure worms" are eat mass quantities of organic matter and do not require a lot of space to burrow.
    - Night crawlers require large spaces to burrow and aerate soil by producing tunnels.
- **How many worms?** Purchase about a 1000 worms for a standard bin.
- **Where to place worms?** Place the worms in the prepared bedding inside the bin.

- **How to feed worms:** Worms like organic materials like vegetable and fruit peelings, grains, coffee grounds and filters, newspaper. Try not to overload bins with citrus in order to avoid a toxic amount of d-limonene, which occurs naturally in citrus. To speed up vermicomposting, you may puree fibrous foods such as broccoli stocks, potato peels, and carrots. Please note that meat, dairy, and oily materials are not recommended because they produce strong odors that can attract undesirable critters, such as mice or rats.

Codes/Standards

Check local and state regulations. Permits may be required depending on the size and scope of the composting process.

Benefits

There are several benefits to composting, which include:

- Reductions in disposal costs;
- Conservation of community landfill space; and
- Hands-on science education.
- The benefits of using compost include:
- Fertilization of lawns and landscape plants, thereby reducing the need for chemical applications.
- Loosening of soil, allowing water and air to enter and help roots grow.
- Increasing soil moisture, reducing the need to water.
- Reducing soil erosion and water pollution.

Costs

Set up and operations costs can be supplemented by city and county funds, as well as agency grants and donations.

Monitoring/Controls

Bins must be monitored regularly to ensure that proper conditions exist.

Resources

California Integrated Waste Management Board. *A District-wide Approach To Recycling: A Guide For School Districts*, 1994. http://www.ciwmb.ca.gov/.

California Integrated Waste Management Board. Organic Materials Management, http://www.ciwmb.ca.gov/Organics/

School Composting: A Manual for Connecticut Schools. State of Connecticut, Department of Environmental Protection: 79 Elm Street, Hartford, CT 06106-5127. Website: http://dep.state.ct.us. Or, CT DEP Recycling Program at (860) 424-3239 or Ginny Walton, Mansfield Recycling Coordinator at (860) 429-3333. Website: http://dep.state.ct.us/wst/compost/schmanual.pdf.

Guideline ED5: Indoor Pest Management -- Rodents

Recommendation

Regularly monitor areas for signs of rodent activity. According to the University of California Integrated Pest Management program, the three following strategies are key for rodent control: proper sanitation, exclusion, and population control.

The house mouse is found both indoors and outdoors in most climate zones in the continental United States.

(Photo credit:: UC Statewide IMP Program)

Description

Rodents can cause numerous problems at school sites, including damage to walls, books and wiring; increased health risks; and poor indoor environmental quality.

When dealing with a rodent problem, it is important to know whether you are dealing with mice or rats, since control strategies differ somewhat between the two.

Mice

The house mouse (*Mus musculus*) is one of the most commonly found rodents in the United States. Very adaptable, this species is found in homes and buildings in all climates, as well as in fields and other outdoor areas. Signs of house mice include droppings, gnaw marks and tracks. In general, house mice are nocturnal animals, but daytime sightings are possible. House mice tend to nest in sheltered locations and give off a musky odor, which can help locate an infestation.

Mice are excellent jumpers and can climb non-smooth vertical surfaces. They can pass through openings about 1/4 inch across, making it easy for them to nest in small, hard to access areas.

Other mice species that are common to California are the deer mouse and the white-footed mouse. While less frequently found inside schools, these species have been known to sometimes infiltrate buildings.

Rats

The two most common rat species in California are the roof rat (*Rattus rattus*) and the Norway rat (*Rattus norvegicus*). Like mice, both these rat species are very good climbers, especially roof rats. Rats are nocturnal and rarely seen during the day. Norway rats are the larger of the species, living in burrows near building foundations, woodpiles, and moist garden areas. Roof rats are smaller than Norway rats and have tails that are longer than their bodies. Roof rats prefer nests above ground and live in areas such as shrubs, ivy, attics, walls, cabinets and false ceilings. Roof rats prefer warmer, marine climates.

Mice vs. Rats

Characteristic	House mouse	Roof rat	Norway rat
General appearance	Small, agile	Sleek, agile	Large, robust
Color of belly	Same as entire body; light brown to gray	Gray to white	Mostly gray
Body weight	0.5 ounces	5 to 10 ounces	7 to 18 ounces
Tail	About 3 to 4 inches in length; no fur; all dark	Extends at least to snout; black; fine scales	Shorter than body; dark above; pale below; scales
Head	Muzzle pointed	Muzzle pointed	Muzzle blunt
Ears	Large ears relative to head size	Long enough to reach eyes if folded over	Do not reach eyes
Habitat	Throughout the 48 contiguous United States	Warmer, ocean-influenced climates	Throughout the 48 contiguous United States
Climbing ability	Excellent	Excellent	Moderate
Droppings	Rod-shaped and pointed	Pointed and curved	Capsule-shaped and pointed
Nest location	Near/in stored material	Walls, attics, trees	Mainly in burrows

(Sources: University of California Statewide IPM Program and the Virginia School IPM Program)

Pest Prevention – Sanitation

Good sanitation is an important requirement for controlling rodents. Ensure rodents cannot access sources of nesting, food and water within the school. Proper handling and storage of food supplies and garbage will reduce the attraction for rodents. While proper sanitation alone may never eliminate the presence of house mice (due to their ability to survive on sparse amounts of food) or rats, it can help make the building less inviting to rodent populations by removing easy food and shelter sources. Poor handling of waste and food will only invite rodents to thrive.

For mice, be sure to monitor and/or eliminate sheltered, hidden areas where they can nest.

For rats, use good sanitation techniques to make their potential habitats less hospitable. For instance, store boxes, crates, and gardening equipment off the ground to reduce places for rats to nest. All garbage and composting areas should have secure covers, and trash should be cleared regularly. Regularly thin climbing plants like ivy, jasmine and honeysuckle to help control roof rats. Also cut back tree limbs that are within 3 feet of the roof to make access more difficult.

Pest Prevention – Exclusion

The most successful rodent control technique is to ensure that rodents have no points of entry into the building. Recommended practices:

- Seal any openings larger than ¼ of an inch in foundations, roofs, walls, pipes, drains, and vents.
- Fix any doors or window screens that do not close tightly. Cover edges with sheet metal to prevent possible gnawing.
- Use durable materials such as concrete, sheet metal, steel wool and wire mesh to close any openings or cracks. Plastics or wood materials should not be used since rodents can easily chew threw them.
- Identify if overhead utility wires and/or building cables could be service as a pathway to the roof of the school. Pest control companies or the utility may be able to recommend strategies to deal with this.

Pest Prevention – Population Control

While good sanitation in combination with rodent-proofing the building can provide effective rodent prevention, sometimes a small, existing population of rodents needs to be removed. Many techniques for this exist, including trapping, baits, and electronic mechanisms. Use non-chemical means for rodent population control whenever possible. Rodent traps to be used in schools should be carefully selected. Several types of traps exist, each with various pros and cons. Be sure to select the trap that is most appropriate to the specific infestation location.

- **Snap traps:** Very effective, provided that the trigger is set lightly to spring easily. Selecting the proper bait is also important. Peanut butter works well for mice, but rats can often eat it without triggering the trap. Nuts, dried fruit or bacon are more effective bait for rats.
- **Glue board traps:** Rats or mice get stuck in the glue when walking through this trap. Because of size differences, this trap is more effective for mice than rats. These traps can be problematic because the rodent may not die quickly in the trap. This type of trap is generally not recommended for schools.
- **Live capture traps:** These mechanisms that trap the rodent alive can be single or multiple-capture traps. The significant downside to these traps is that the live rodent must either then be killed or released by staff, which should be a significant factor when considering using these traps.

With all traps, it is vital that children cannot access them. Traps should be placed in areas where rodents travel and nest. For mice, the best locations are close to walls, on ledges, or in other areas of known mouse activity. Since mice stay close to shelter and food supplies, place traps no more than 10 feet apart. For Norway rats, place traps close to walls and in dark corners. Along walls, set the traps at right angles, with the trigger end close, but not touching, the wall. If placed parallel to the wall, set traps in pairs. For roof rats, traps should be placed in areas to capture the animals as they leave their nests, such as ledges, fences, overhead beams and pipes. To prevent other animals or birds from getting caught in the trap, put the device in a box or other barrier. Place traps for rats about 10 to 20 feet apart.

When disposing of dead rodents, never use bare hands and take all necessary safety precautions based on state of decomposition. Secure the dead rodents in plastic bags and place them in the trash. Be sure to wash hands and equipment thoroughly when handling traps (even if they haven't been triggered).

Except for large outdoor rat infestations, toxic baits should only be used as a last resort indoors or in emergency situations, and should be used by licensed professionals if dealing with larger infestations. Types of toxic baits include anticoagulant and nonanticoagulant baits. Anticoagulant baits cause death in the rodent by internal bleeding and come in meal, pellet, kernel or block form. They are available in either single- or multiple-feeding doses. Some multi-feeding anticoagulants are approved for outdoor use, but single-feeding types should only be used indoors. Anticoagulant baits will cause death in the rodent about two to six days after a lethal dose is ingested. Nonanticoagulant baits work more rapidly via toxins, often killing the rodents within 12 hours of ingestion.

Be sure to abide by all appropriate state and local regulations for chemical pest control at the school site. (See Applicable Codes and Standards section). With all baits, it is important to follow the instructions carefully and ensure that children will not be able to access the bait. Keep detailed records of chemical use on the school grounds.

Electronic rodent control devices, which use sound or magnetic waves to keep rodents out of buildings, have not proven to be significantly effective for schools and are not recommended.

Applicable Codes and Standards

The Healthy Schools Act of 2000 requires annual written notification to school staff and parents of all the pesticides expected to be used at the school site in the upcoming year. Schools must also post warning signs at each area where pesticides will be used, both before and after applications. Records of pesticide use must be kept and reports of pesticide use by licensed pest control professionals on school grounds must be submitted to the California Department of Pesticide Regulation (DPR) annually.

There are several types of pesticides that are exempt from these notification requirements, including self-contained baits and traps. For a full list of exempt pesticides, visit http://www.cdpr.ca.gov/cfdocs/apps/schoolipm/school_ipm_law/26_exempt_text5.pdf

Exempt or not, the California DPR recommends that schools keep complete records of all pest management activities, chemical or not, as part of an effective integrated pest management program.

For more information on the Healthy Schools Act, visit http://www.cdpr.ca.gov/cfdocs/apps/schoolipm/school_ipm_law/main.cfm?crumbs_list=1,4

Benefits

- Healthier school
- Better indoor environmental quality
- Protects building and equipment from costly damage

Costs

Diligent monitoring and preventive rodent control through sealing points of entry and good sanitation techniques will be much more cost effective for a school district than dealing with the extermination costs and property damage of a large infestation.

Monitoring/Controls

Regular monitoring of buildings and grounds for signs of rodents is a key to effective control.

Common Retrofit Opportunities

N/A.

Verification/Commissioning

N/A.

References/Additional Information

- California Department of Pesticide Regulation, California School IPM, School IPM Kit for Administrators, http://www.cdpr.ca.gov/cfdocs/apps/schoolipm/school_admin/main.cfm?crumbs_list=1,11#School.
- US Environmental Protection Agency, Integrated Pest Management for Schools: A How To Manual, http://www.epa.gov/pesticides/ipm/schoolipm/index.html.
- University of California IPM Online Statewide Integrated Pest Management Program. How to Manage Pests – Rats. http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn74106.html.
- University of California IPM Online Statewide Integrated Pest Management Program. How to Manage Pests – House Mouse. http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn7483.html.
- Virginia School IPM Program, Schools Integrated Pest Management (IPM) for Rats and Mice http://schoolipm.ento.vt.edu/pages/rats.pdf.

Cleaning Practices and Products

Overview

Cleaning is one of the most effective means of achieving a high level of environment quality in school. Studies have shown that cleaning, maintenance, and restoration when consistently implemented are cost effective and can lead to measurable environmental improvements and better student and teacher performance (EPA, Indoor Air Quality & Student Performance, August 2003).

According to the Environmental Protection Agency, indoor air quality can be 100 times worse than outdoor air quality. An EPA sponsored study named "The Total Building Cleaning Effectiveness Study" demonstrated how an organized program contributes to reductions in particles, volatile organic compounds (VOCs), and biological pollutants in excess of 50%-90%.

The cleanliness of schools is an important aspect of school environments. Clean schools reduce the threat of the spread of illness and convey a caring message to students. Indoor air quality (IAQ) is an important issue in schools. Some of the health problems caused by poor IAQ include headaches, nasal congestion, breathing problems, eye-nose-throat irritation, coughing, thermal discomfort, and rashes.

Custodial staff is the first line of defense to promote a high quality, sustainable, healthy and safe environment. Providing high quality training to custodial staff in the emerging technologies and skills are some of the most cost effective ways to achieve a high quality indoor environment in schools.

A school with a well-run "Green Cleaning" program in place will be a healthier school. This is true because a "Green" school encourages cleaner healthier facilities, enhances professionalism of the custodial and maintenance staff, improves building occupant morale and productivity, and creates safer conditions for students and occupants. A "green" school reduces viral and bacterial transmission, minimizes exposures to toxic chemicals, and potentially can reduce chemical, equipment and supply budgets in a relatively short period of time.

- Cleaning Maintenance Plan (Guideline CP1)
- Cleaning Products and Equipment (Guideline CP2)
- Carpet (Guideline CP3)
- Resilient Floors (Guideline CP4)
- Food Areas: Cafeterias/Kitchens/Breakrooms (Guideline CP5)
- Restrooms (Guideline CP6)
- Furniture (Guideline CP7)
- Window Coverings (Guideline CP8)
- Chalkboards/Whiteboards (Guideline CP9)
- OSHA Bloodborne Pathogen Standard (Guideline CP10)

Guideline CP1: Cleaning Maintenance Plan

Recommendation

Develop a cleaning maintenance plan that outlines the goals, tasks and schedules for the custodial staff. The plan should also outline staff training, safety guidelines, and supply information.

Description

Managing a school building is a complex and important responsibility. The impact on health and the quality of life of the people that occupy the building has a significant impact on their lives. There are ten Stewardship Principles that must become part of a shared responsibility by all school occupants and visitors. The head custodian, principal, teachers, students, visitors and other users of the school need to be made aware of and need to uphold the 10 Stewardship Principles. Caring for a building imvolves far more than performing mechanical operations.

The 10 Stewardship Principles are:

1. Commit to people, education, and communications. A successful green custodial program should involve both the cleaning personnel and building occupants. Get everyone involved. Celebrate and communicate successes. For example: use school bulletin boards, newsletters, websites and notes sent home to parents to get the word out. This can best be achieved through the use of well-established process management principles.
2. A clean building will be healthy to people and to the environment. It is important to clean to protect the health and the environment first, then for appearance. It is not necessarily what is seen that is the real area of concern. Even buildings that appear clean can be extremely unhealthy and dirty due to contamination by pesticides, bacteria, viruses, chemicals and other pollutants. By cleaning for health and the environment the appearance will be addressed at the same time. For example, maintaining the handwashing areas so that children can wash their hands will reduce the transmission of colds and flu.
3. Clean and maintain the building as a whole, not just as separate components. Begin with the entryways. Schools in particular need to have entryway mat systems that remove and retain soil and contaminants, and moisture. Mats should be designed to dry quickly, be treated with fire-retardant or made from fire resistant materials, and must not promote bacterial or other biological growth. A maintenance program for these mats must be established and implemented at the time of purchase. This is one example of how cleaning and maintenance in one area of a building can have a major impact on other areas. For another example, the fumes from the stripping and recoating of a floor in one area can contaminate adjacent areas or even the entire building through the ventilation system. Appropriate actions must take place to protect the health and safety of occupants throughout the building. To address this issue some floor product manufacturers are currently developing new products that will eliminate the stripping and recoating process.
4. Schedule and carry out all routine maintenance. Scheduled maintenance that is frequent and thorough is the most efficient and effective method for building maintenance. Concise plans and records are a must. For example, scheduled maintenance can be improved with pressure spraying, high efficiency vacuuming and other emerging technologies.
5. Develop a response plan for foreseeable incidents and accidents. Specific procedures need to be developed and practiced to address accidents. Plans should address weather-related problems, as well as common spills, water leaks, smoke, or air contamination by a noxious chemical reaction. For example, ask the local emergency responders or fire department to conduct a joint training exercise during a routine fire drill at the school. This will familiarize school staff with the process, and give responders an opportunity to simulate an actual event.

6. Minimize human exposure to harmful contaminants and cleaning residues. Workers should always use the appropriate personal protective equipment, including appropriate hand, foot, eye, ear, body, face and respiratory protection, in all areas where hazardous work is taking place. Provide adequate ventilation in accordance with OSHA and AHRAE rules and standards. For example work schedules should be established to minimize exposure to building occupants, and products used should be independently certified to meet health and environmental standards or the least hazardous to accomplish the task.
7. Minimize the chemical, particle, and moisture residue when cleaning. Products that are used for cleaning can contribute to a building's problem if used incorrectly. For example, incorrectly diluted concentrated products can leave excessive residues on desks, floors or other surfaces which can cause eye or skin irritation, increase the potential for slip/fall accidents and other potential problems.
8. A comprehensive program to protect the health and safety of students, teachers, other building staff and visitors should be in place in every school at all times. For example, the school district or regional risk manager or insurance carrier should work with the school to develop a plan and train school staff on their appropriate roles.
9. Minimize the amount of pollutants entering the building, while maximizing the amount of pollutants extracted. It is significantly more effective in terms of both time and money to keep contaminants out of the building, than to try to remove them once they have entered. For example, keep entryways and sidewalks clean and provide walk off mats at key entryways. Mats should be as wide as the entryway and at least 15' long. These mats will pay for themselves in short order by reducing time spent vacuuming, mopping and cleaning floor systems throughout the school. They will also make the school healthier, prevent slip and fall injuries, and improve the visual appearance of the school hallways and classrooms.
10. Dispose of cleaning waste in environmentally safe ways. For example, contact local sanitary sewer districts, solid waste departments and others to ensure proper practices are current, well-known to all staff and students, and followed. Posting proper disposal practices near sinks and providing recycling and proper hazardous waste disposal containers is another example.

Roles and Responsibilities of School Staff

Every member of the school staff plays an important role in the success of a cleaning program. Key staff and their related roles and responsibilities are shown in the table below.

Role	Responsibility
District Custodial Supervisor	▪ Custodial recruiting, screening, and selection. ▪ Custodial staff training and development. ▪ District-wide technical administration and evaluation of custodians. ▪ Determination of custodial staffing requirements by conducting a task/time/work standards analysis. ▪ Design of custodial work schedules at school sites in conjunction with the principal and head custodian. ▪ Hiring, managing, and training of substitute custodians. ▪ Maintenance of custodial equipment. ▪ Research of new equipment and supplies. ▪ Management of district custodial supplies inventory. ▪ Sanitation and environmental control. ▪ Twenty-four hour availability for emergency situations. ▪ Custodial maintenance projects. ▪ Communication and support both internally to principals and head custodians on custodial operations, as well as preparation of external communications to parents and the community at-large.
Supervisor of Maintenance and Operations	▪ Installation of equipment and supplies in new facilities ▪ Schedule the work of head custodians and custodial staff, including: ▪ Daily, biweekly, and weekly tasks. ▪ Nonscheduled time to be used at principal's discretion ▪ Tasks to be performed when the principal has not made assignments utilizing nonscheduled time. ▪ Schedule as much of the routine work as possible during the evening or during school vacations. ▪ Assist the District Custodial Supervisor as needed in training the custodial personnel, as needed. ▪ Evaluate custodians after consultation with District Custodial Supervisor and the principal. ▪ Hire custodians, with principal acting in an advisory capacity, if the principal desires. ▪ Reassign custodial personnel after consultation with the principals involved. ▪ Review custodial schedule with principals to clarify procedures, identify problems, and inspect plant. ▪ Use suggestions and experience of custodians and principals to improve the custodial program. ▪ Communications with District Custodial Supervisor and principal, as well as the development of site-based communications as necessary and as approved by the appropriate individuals.

School Principal	▪ Evaluate the cleanliness of the school and notify the custodial supervisor of maintenance and operations of any concerns. ▪ Consult with the supervisor of maintenance and operations regarding evaluation of personnel as it relates to conduct with other school personnel and students, cooperation, and work habits. ▪ Act as a consultant to the supervisor of maintenance and operations in the selection of custodians for their school. ▪ Refrain from working custodians out of job classification (particularly in the supervision of students). ▪ Inform staff of custodial problems and costs and offer suggestions to teachers as to how they and their students can assist in making the custodial program less costly and more efficient. ▪ Communications with appropriate district personnel, as well as site specific communications with teachers, school nurse, custodians, parents and community groups using the specific school.
Custodial Staff	▪ Carry out and document assigned work responsibilities. ▪ Notify the principal, or the principal's designee, of any hazardous conditions. ▪ Offer suggestions to the supervisor of maintenance and operations for program improvement. ▪ Transmit work-related concerns to the supervisor of maintenance and operations, who will resolve the problems in consultation with principal or other staff members. ▪ Make a daily maintenance inspection of the buildings and grounds. When maintenance problems are found, correct them as appropriate. Notify the maintenance department by phone in emergency situations and in writing for routine items. ▪ Communications with supervisors, teachers and students.
Teachers	▪ Assist and cooperate with custodians in the interest of maximum custodial efficiency and building cleanliness. ▪ Channel unusual requests for service through the principal's office. ▪ Discuss routine matters and problems directly with the custodians involved. ▪ Respect custodians as an important part of the school. ▪ Communications relative to cleaning needs and requirements with the appropriate personnel and students.

Staff Training

- Establish a goal to develop the highest professional knowledge, behavior, and performance from the custodial staff.
- Train your staff to view themselves as the first line of defense against illness and injury to students and staff. Help them understand their role as health and environmental managers. This will help to elevate their self-image and help them and others appreciate the important value of their work. View custodians as stewards of the building environment.
- Establish an ongoing program to teach procedures that meet established health and environmental guidelines for cleaning.

- The school should establish a cleaning training program for the custodial staff. Develop cleaning programs that capture and remove dust and other particles. Purchase new and effective cleaning equipment, and repair or replace equipment that is ineffective or inefficient.
- Evaluate custodial closets and provide adequate lighting, storage and ventilation. Closets need to be properly maintained and organized. The training program should teach the purpose of each product and piece of equipment, and instruct the custodians on proper use and personal safety.
- The head custodian must be trained in the latest science and technologies to clean effectively and to provide similar training programs to incoming staff. The head custodian is in a leadership position that requires regular checks (audits) on the custodial staff and their performance. Documenting staff performance, correcting mistakes, and setting a good example is part of an effective program. Each school should have a custodial program developed which is site-based, specific to the needs of the schools, and which maximizes existing resources with minimum negative impacts on human and environmental health.
- The cleaning supplies in the custodial closet need to be examined for effectiveness, cleanliness, and safety. With regular inspections, the entire school building will benefit. The head custodian should be responsible for these inspections. All types of inspections should not only point out problems, but direct staff to learning resources and provide specific guidance and suggestions for possible improvements.

Custodial Schedules

An orderly custodial schedule should be developed that lays out in writing what tasks are done, estimates the amount of time needed, and prioritizes them in case a conflict or unforeseen event arises. Schedules may call for some custodians to begin work early in the morning before staff and students arrive, while other custodians begin after school has let out for the day. The schedule should permit flexibility and meet the needs of special situations.

Each custodian should have a written schedule that specifies the day's work and identifies where the custodian is working at given times. These daily schedules should be specific for each day of the week as it is often necessary to perform different duties each day to insure that all cleaning requirements, including immediate (daily), interim (weekly to monthly) and deep (bi-monthly to annually) cleaning are accomplished.

Schedules are also important because they can serve as an inspection checklist and are extremely helpful to orient and train new and substitute custodians. Schedules also serve as an audit tool for custodial managers.

The first step to developing a schedule involves identifying tasks and the appropriate green cleaning equipment and supplies necessary to perform the tasks. After this is done estimating the time required to perform each task should be done. Typical times for cleaning school classrooms and other areas can be found at International Sanitary Supply Association (ISSA) 458 Cleaning Standards. This can also be a collaborative project involving the building principal and the supervising custodian. Tasks, equipment, supplies and schedules can vary depending on the school's size, construction, floor plan, number of students, and building types.

Custodians should arrive early in the morning to open the building, make sure that the heating, air-conditioning systems and utilities are operating properly, check for vandalism or safety problems, prepare entryways and student drop-off areas. During school hours, the custodian will focus activities on cleaning food preparation and service areas, maintaining entryways, insuring that restrooms are adequately stocked, handling spills, and can perform minor maintenance operations.

The night custodians are more involved in the thorough or "deep" cleaning of restrooms, classrooms, hallways, libraries, administration and other areas after the students, staff and community groups have departed for the day. The night custodians should do the sweeping and cleaning necessary to put the building in order for the following school day. Custodians are responsible to lock the building as well. Custodians may be expected to work a split shift in smaller schools.

The custodians should work with teachers and students during the day, as well as sports teams, extra-curricular school groups, community groups and others who may use the schools during the nights to pickup crayons, large pieces of papers, educational and other materials to allow for efficient vacuuming and mopping of classrooms and other areas.

In addition, policies should be considered that foster stewardship and shared responsibility whereby occupants assist with organizing and policing areas to allow the custodial force to focus their resources on more extensive cleaning activities. For example, students can stack chairs or place them on desks to expedite cleaning because it will take 30 students only two minutes to stack a classroom of chairs, while it will take a single custodian 10 minutes to perform the same task. Other examples include students collecting trash or recyclables into a central location. These activities encourage students to be "stewards" and teaches them the value of picking up after oneself", while allowing critical cleaning resources to be applied to more critical cleaning focused on protecting health.

A clear policy needs to be developed on what work orders are handled by the day and night custodial staff and a clear statement of responsibilities will maximize custodial staff efficiency.

Applicable Codes and Standards

See the Applicable Codes and Standards sections in the subsequent guidelines.

Benefits

A well-developed cleaning maintenance plan that incorporates green cleaning practices, products and procedures can lower absenteeism, illness, and injury by focusing on pollution prevention strategies and specific opportunities that modify traditional practices to ones that reduce impacts on health and the environment.

Costs

By improving indoor environmental quality, reducing absenteeism, illnesses and injuries to students and others, a well-run "Green Cleaning" program is, dollar for dollar, the single best investment a school can make with their maintenance budget. (ISSA High Performance Healthy Cleaning Seminar October, 2003).

Monitoring/Controls

As mentioned above, documenting staff performance, correcting mistakes, and setting a good example is part of an effective program. Regular monitoring of school cleanliness ensures that the cleaning plan is being implemented properly.

Common Retrofit Opportunities

N/A.

Verification and Commissioning

N/A.

References/Additional Information

Green Seal, http://www.greenseal.org.

Commonwealth of Pennsylvania, "Pennsylvania Green Building Maintenance Manual: A Manual for the Commonwealth of Pennsylvania on Environmentally Preferable Building Operations and Maintenance." April 1, 2002.

Guideline CP2: Cleaning Products and Equipment

Recommendation

Carefully select cleaning products according to an environmentally preferable purchasing (EPP) strategy. Standardize their usage to improve safety and lead to more consistent cleaning.

Adopt a portion control system for concentrated cleaning chemicals using pre-measured packets or automatic mixing and dispensing units to eliminate mistaken measurements.

Communicate with all building employees, students and other building users about the "Green Cleaning" program in the school, since teachers and staff will at times bring cleaning products to school. While a school may not want to discourage this action, it may want to establish clear guidelines for all users regarding what is and is not preferred or allowed for school use.

Description

Assessing the Needs of the Facilities

The first step in developing a Green Cleaning Strategy is to assess the overall needs of the facilities. This entails looking at the size and age of the facility, the floor and wall coverings, and the condition of each area. Special attention should be paid to the resources available versus the amount of space to be cared for, and the complexity of each task to be performed. It is very important to use cleaning products that contain less-toxic ingredients and to eliminate all products that put custodians and occupants at high risk.

Environmentally Preferable Purchasing (EPP)

The main focus of an EPP strategy is to reduce the impacts of a product or service on both health and the environment compared to similar products and services used for the same purpose. EPP is a simple recognition of the enormous technological advances found in many industries, including those which supply products used for cleaning schools by increasing the importance of health, safety and environmental attributes when making a "best value" purchasing decision. It also recognizes that many schools are currently using 50+ year old technologies, and while these products are not "bad" or placing people at imminent risk, there are newer, safer, better technologies available.

EPP is an important opportunity especially for schools and other buildings with sensitive populations (i.e. young children, asthmatics and those with chemical sensitivities), or where the product users because of language and other training barriers may find it important to increase the level of safety.

A more comprehensive definition of EPP can be found in Executive Order 13101, located at: http://www.ofee.gov/eo/13101.htm or the Center for a New American Dream at: http://www.newdream.org/procure/.

"Green" Janitorial Equipment

Schools use janitorial equipment, such as vacuum cleaners, floor buffers and burnishers to maintain carpeting and hard flooring materials. Studies have shown that the soils being removed by these pieces of equipment can be contaminated with toxic materials including lead, pesticides, VOCs, mold spores and other materials that can affect health. Unfortunately, some commonly used equipment can actually contribute to these problems.

Some of the problems which can be caused by these pieces of equipment include vacuum cleaners with poor quality cloth bags containing no inner liners that inadequately capture fine particles and can actually contribute to indoor air quality problems as they pull contaminants that would otherwise be trapped in a carpet and make them air-borne. Another example is high speed burnishers without filter attachments which grind floor finish off the floor and send them into the air to be inhaled and resettle as dust on furnishings and other services. Specifying and utilizing janitorial equipment that not only create a good appearance, but more importantly capture and remove dust is essential for maintaining a healthy school.

Schools should keep a log for all powered janitorial equipment. The log should identify the date of purchase and all repair and maintenance activities. Include vendor cut sheets for each type of equipment in use in the logbook.

Equipment shall meet these requirements:

- Vacuum cleaners shall meet Carpet & Rug Institute Green Label Program. Information on the Green Label Program can be found at: http://www.carpet-rug.com. It is desirable that vacuums exceed the minimum requirements of the Green Label Program in the following ways:
    - Higher ability to capture and contain fine/respirable particles (capture 96% of particulates 0.3 microns in size)
    - Powerful air flow (>90 CFM) and suction (static lift of >80 inches) for enhanced cleaning performance
    - Durable to reduce impacts on resources and disposal (manufacturer's warranty on parts and labor >2 years)
- Carpet extraction equipment shall be capable of removing sufficient moisture such that carpets can dry in less than 24 hours.
- Powered floor maintenance equipment should be equipped with vacuums, guards and/or other devices for capturing fine particulates, and shall operate with a sound level less than 70dBA.
- Propane-powered floor equipment shall have high-efficiency, low-emission engines.
- Automated scrubbing machines shall be equipped with variable-speed feed pumps to optimize the use of cleaning fluids.
- Battery-powered equipment shall be equipped with environmentally-preferable gel batteries.
- Where appropriate, active micro fiber technology shall be used to reduce cleaning chemical consumption and prolong life of disposable scrubbing pads.
- All powered equipment including those for both hard floor and carpet care shall be ergonomically designed to minimize vibration, noise and user fatigue. Additionally, consider weight, ease of motion, tools and accessories, and profile of equipment when evaluating ergonomically designed equipment.
- Equipment shall have rubber bumpers to reduce potential damage to building surfaces.

"Green" Cleaners

Approximately 5 billion pounds of chemicals are consumed in the US each year to clean and maintain institutional and commercial buildings, of which schools are a significant portion. They majority of these products are derived from non-renewable natural resources and for the vast majority of the 70,000+ ingredients used to make these products, little testing has been conducted to evaluate their long-term affects on children or in the environment.

One way to find safer and environmentally preferable chemicals is to purchase products that have been Green Seal Certified, or have equivalent specifications. Executive Order 13101 provides a definition that is useful. The three Environmentally Preferable Products Purchasing "wizards" produced by U.S. General Services Administration are helpful and can be found at:
http://www.epa.gov/oppt/epp/cleaners/select/matrix.htm

Specific to standards for cleaning products, Green Seal a non-profit, consensus-based standards setting organization has produced widely adopted industry standards for sustainable, healthy and safe materials, cleaning supplies and their proper use. The Green Seal Standard for Industrial and Institutional Cleaners (see GS-37) address health, environmental & performance attributes.

By using Green Seal Standard 37, or an equivalent set of specifications, it is much easier to develop a cleaning product program for the needs of each school and school district as compared to a school district trying to develop its own unique specification addressing health, safety, environmental,

performance and other criterion. Furthermore, when purchasing Green Seal Certified products a school can be confident that the product meets the health, environmental and performance requirements because Green Seal audits the manufacturer's facility to insure that they are doing what they claim. More information on Green Seal's Standard 37 can be found at http://www.greenseal.org/standards/industrialcleaners.htm.

It can also be helpful to find out what other cities, states, and other agencies are buying, but this may simply reflect temporary local vendor promotions or long-standing business practices. Another route is to evaluate and test the products onsite.

The typical custodial contractor buys its chemical products from a number of sources and keeps an inventory sufficient to cover about a month's consumption. Custodians working for a site also buy from a variety of sources, but can keep more supplies on hand. Some school districts purchase each fall enough supplies for an entire year. One desirable goal in purchasing is to establish a single source of compatible, environmentally friendly products that carry the Green Seal label. This is not just safe and healthy, but also good business, since buying in quantity allows for lower costs per unit volume purchased.

Chemical Control

Carefully selecting products and standardizing their usage can improve safety and lead to more consistent cleaning. Reducing the number of different cleaning chemicals can save money, simplify training and reduce the potential for product misuse.

Adopt a portion control system for concentrated cleaning chemicals using pre-measured packets or automatic mixing and dispensing units to eliminate mistaken measurements. The appropriate dilution of concentrated cleaning chemicals can significantly reduce product consumption by 30% to 65%, save money and reduce environmental impacts.

Controlling chemicals also involves communicating with all building employees, students and other building users about the "Green Cleaning" program in the school as teachers and staff will at times bring cleaning products to school. While a school may not want to discourage this action, it may want to establish clear guidelines for all users regarding what is and is not preferred or allowed for school use.

Types of Cleaners

Green Seal provided the following definitions:

- **Bathroom cleaners.** This category includes products used to clean hard surfaces in a bathroom such as counters, walls, floors, fixtures, basins, tubs, and tile. It includes products that are required to be registered under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), such as disinfectants and sanitizers, but does not include products specifically intended to clean toilet bowls.
- **Concentrate.** This is a product that must be diluted by at least eight parts by volume water (1:8 dilution ratio) prior to its intended use.
- **Dispensing-system concentrates.** These are products that are designed for use in dispensing systems that cannot be easily accessed by users. It is suggested that the building water pressure be accurately tested to ensure compatibility with dispensing system manufacturer's requirements. If this is not done, problems can occur, such as improper dilution of the concentrates.
- **General-purpose cleaners.** This category includes products used for routine cleaning of hard surfaces including impervious flooring such as concrete or tile. It does not include cleaners intended primarily for the removal of rust, mineral deposits, or odors. It does not include products intended primarily to strip, polish, or wax floors, and it does not include cleaners intended primarily for cleaning toilet bowls, dishes, laundry, glass, carpets, upholstery, wood, or polished surfaces. This category does not include any products registered under FIFRA, such as those making claims as sterilizers, disinfectants, or sanitizers.
- **Glass cleaners.** This category includes products used to clean windows, glass, and polished surfaces. This category does not include any products required to be registered under FIFRA, such as those making claims as sterilizers, disinfectants, or sanitizers. Some manufacturers have

developed a single product that will clean glass and also serve as a general purpose cleaner. This promotes easy use and save custodial staff time.

- **Ingredient.** Any constituent of a product that is at least 0.01% by weight of the product.
- **Ozone-depleting compounds.** An ozone-depleting compound is any compound with an ozone-depletion potential greater than 0.01 (CFC 11 = 1). Typically, these compounds are found in aerosols.
- **Product as used.** This is the most concentrated form of the product that the manufacturer recommends for a product's intended use. For example, if a manufacturer recommends a product be diluted 1:64 or 2:64 for use as a general-purpose cleaner, the product shall meet the environmental and performance requirements at a dilution of 2:64. Note the comment under “concentrates” above regarding matching the dispensing system to the available water pressure.
- **Primary packaging.** This packaging is the material physically containing and coming into contact with the product, not including the cap or lid of a bottle.
- **Recyclable package.** This package can be diverted from the waste stream through available processes and programs, and can be collected, processed, and returned to use in the form of raw materials or products.
- **Undiluted product** This is the most concentrated form of the product produced by the manufacturer for transport outside its facility.

Product Ingredients

Preferable Ingredients

There are two critical elements in deciding when a product is environmentally preferable. The first critical element is choosing a product that has comparatively fewer human health and safety risks than others. The second critical element is to minimize or eliminate negative environmental impacts as much as possible. These elements form a decision-making model and can be developed using a decision matrix which takes advantage of the opportunity to reduce health risks to humans, create fewer environmental impacts, and allow custodians to perform their work more safely.

Incorporating environmentally preferable products into purchasing decisions requires a comparison based on health and environmental factors.

Ingredients to Avoid

According to the Pennsylvania Green Building Maintenance Manual, all-purpose cleaners consist of a broad array of possible formulations. The following are some of the specific issues to compare for this product category:

- pH: Prefer those with a neutral pH (closer to 7) as compared to those with extreme pH (closer to 1 or 14)
- Biodegradability: Prefer those that are readily biodegradable as compared to those that are slower to degrade. Unfortunately, many older formulations contain excellent performing ingredients that have been found to have serious environmental and health concerns.
- Dyes and fragrances: Prefer those with no or low levels of dyes and fragrances compared to those products that are heavily dyed or fragranced. If dyes are necessary use those that are approved for foods and cosmetics (F&C).
- VOCs: Prefer those that have no or low VOCs as compared to alternatives with higher levels. Consider detergent-based products compared to those containing solvents.
- Surfactants: More preferable surfactants are those containing terms such as lauryl, amides, and glycosides as they are sustainably derived from biobased and renewable resources.

- Less preferable ingredients: Nonyl Phenol Ethoxylates, NTA, EDTA, glycol ethers, sodium hydroxide, potassium hydroxide, sodium metasilicate, and phosphates as these common ingredients each have some significant adverse health or environmental impact.

Product must NOT contain:

- Persistent, bioaccumulative, and toxic chemicals.
- Carcinogens, mutagens, and teratogens.
- Ozone-depleting compounds.
- High volatile organic compounds.
- Hazardous waste designators.

Minimize Product Use

- Before using a product, an analysis must first be done as to whether the task for which the product is needed is a task that should be performed at all.
- Find out which products contain the most dangerous ingredients and focus on changing those first.
- Do research to find out the alternative products that are available. Figure out how to perform the same work with fewer chemicals.
- Initially restrict the use of highest risk chemicals using a sign-out system to control inventories. Be sure to train custodians on how to minimize chemical use.
- Eliminate highest risk chemicals by shifting from the old products after finding, testing, and introducing preferable substitutes.
- NOTE: The strategies listed above that apply to Product Use can be adapted to supplies and equipment in many cases.

Safe Chemical Use and Disposal

Safety Practices

- Read the label and directions for use, storage, and disposal. Hazard warning labels must include a description of the hazard(s), personal protection information and first aid for accidental exposure.
- Watch for signal words such as CAUTION, WARNING, and DANGER. Avoid the use of products that are labeled “danger”, and minimize the use of products labeled “warning” in routine school cleaning operations. A “caution” label represents a lower level of hazard.
- Avoid skin and eye contact. Use appropriate PPE.
- Never mix products or different brands of the same product. Follow the instructions on the label.
- Keep products in their original containers if possible. If not, be sure that containers are properly labeled, and use a different color for each chemical to prevent accidental misuse of cleaning solutions.
- Buy the appropriate products for the job, in the appropriate quantity. Use non-hazardous or less hazardous products as described above.
- Provide adequate ventilation. For example, mixing of solutions or dilution procedures should take place in a well-ventilated area, negatively pressurized area, or outdoors.

Disposal of Chemical Products

The recommended disposal for cleaning products is to use them as they were intended to be used. Read the label for information on safe use, storage and disposal. Contact the manufacturer by calling the consumer toll-free number given on many products. If these disposal options are not possible, some common disposal solutions are set forth below.

Recommendations for safe use, storage and disposal can change depending on product formulations. If you are unsure about use, storage and disposal methods, seek more information about the product from the retailer or manufacturer. Ask for a copy of the Material Safety Data Sheet. However, bear in mind that MSDS sheets are sometimes difficult to interpret and do not always provide all the information necessary to make an informed decision, for a variety of reasons. A library of MSDS sheets is available at the Cornell University website. Other trusted sources of information about products include: NIOSH; www.greenseal.org

***Caution*:** When flushing any chemical down a drain to enter the sewage treatment system, flush only a small quantity and thoroughly rinse before adding any other chemicals such as a toilet bowl cleaner. Chemicals will interact and sometimes produce toxic chemicals or gases.

Aerosols

In most situations the use of aerosols indoors is not a sustainable, healthy or cost effective practice. The negative effects of most propellants and/or the high relative cost per unit of volume can be easily demonstrated in most cases. If they exist or are used, dispose of the empty containers in the trash—do not burn or put them into a trash compactor where s they may rupture or explode. Some aerosol cans that are steel or aluminum are recycled in some areas of the U.S. Contact the local health department or refuse disposal facility to learn more about what can be done in your area. Pump products are a non-aerosol alternative to most aerosol formulations.

- **Aluminum cleaners.** Although most schools do not purchase these types of cleaners, if they are used, treat them as follows: If they contain phosphoric acid and only a small quantity remains, they can be discarded in the septic system. Pour the product down a drain (not a storm sewer—some garage drains may empty into the storm sewer) and flush with plenty of water. Rinse the container and throw it away.
- **Ammonia.** DO NOT MIX WITH CHLORINE BLEACH. The product can be discarded in small quantities in the septic system, in the same method as aluminum cleaners.
- **Bleach.** DO NOT MIX WITH AMMONIA. The product can be discarded in small quantities in septic system, in the same method as aluminum cleaners.
- **Detergents.** The product can be discarded in small amounts down a sanitary drain, in the same method as aluminum cleaners.
- **Drain openers.** If the product contains a solvent (organic solvent), take it to a household hazardous waste collection program. In most cases, allowing the volatile solvents to evaporate is not recommended. State, and local rules and insurance policies should be carefully checked before considering evaporation, and if evaporation of solvents is allowed, it is only recommended in a ventilated chemical laboratory hood. Many types of chemical disposal programs for schools are becoming more common nationwide. Contact risk management, health agencies and environmental authorities for local guidance on disposal programs and facilities that will accept organic solvents from schools for proper disposal. If it does not contain a solvent, the product may the discarded in the same method as aluminum cleaners. Wear eye protection when discarding drain cleaners.
- **Floor care products.** If the product contains an organic solvent, it can be disposed of in the same method as either aerosols or drain openers. If the product does not contain a solvent, it can be discarded in the same method as aluminum cleaners.
- **Furniture polish.** The product can be disposed of in the same method as aerosols or by evaporating in the same method as drain openers.
- **General home liquid cleaners.** If the product contains a solvent, it can be disposed of in the same method as aerosols or drain openers. If the product does not contain a solvent, it can be discarded in the same method as aluminum cleaners.
- **Germicides/disinfectants.** If the product contains a solvent, it can be disposed of in the same method as aerosols or drain openers. If the product does not contain a solvent, it may be able to be discarded in the same method as aluminum cleaners. Save the product for a hazardous waste

collection if "germicide or disinfectant" is listed in the ingredients. Technically, disinfectants or germicides fall under pesticide labeling regulations. Try to avoid disposal in septic systems.

- **Metal polish with solvent.** The product may be evaporated in the same method as aluminum cleaners.
- **Oven cleaner.** If the product contains a solvent, it can be disposed of in the same method as aerosols or drain openers. If the product does not contain a solvent and is not an aerosol, it can be discarded in the same method as aluminum cleaners.
- **Rug upholstery cleaners.** If the product contains a dry-cleaning solvent, it can be disposed of in the same method as aerosols or drain openers. If the product does not contain a solvent, it can be discarded in the same method as aluminum cleaners.
- **Toilet, tub, and tile cleaners.** The product may be discarded in the septic system, in the same method as aluminum cleaners.
- **Window cleaner.** The product may be discarded in the septic system, in the same method as aluminum cleaners. If the product contains a solvent, dispose of through evaporation.

Applicable Codes and Standards

While it is recommended that all schools purchase “green” cleaning products, several cities and schools districts have adopted policies requiring the purchase of environmentally preferable janitorial products. Verify any regulations in your area.

Benefits

If schools collectively use a significant amount of janitorial paper, chemical cleaning products and equipment, the implementation of green practices and products will positively impact the environment and promote improved conditions for students, faculty, and custodians.

Costs

There are no known additional or unusual costs associated with purchasing environmentally preferable products as recommended by the International Sanitary Supply Association.

Reducing the number of different cleaning chemicals can save money. Also, appropriate dilution of concentrated cleaning chemicals can significantly reduce product consumption by 30% to 65%, save money and reduce environmental impacts.

Monitoring/Controls

N/A.

Common Retrofit Opportunities

N/A.

Verification and Commissioning

N/A

References/Additional Information

California Integrated Waste Management Board, Environmentally Preferable Purchasing, http://www.ciwmb.ca.gov/WPIE/Purchasing/.

Green Seal, http://www.greenseal.org.

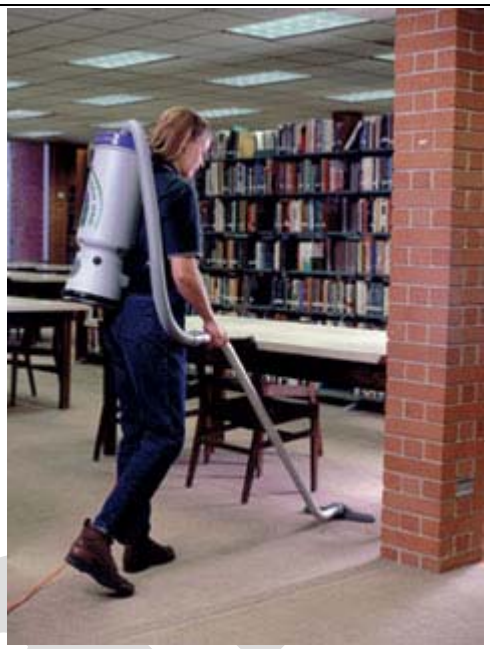
Commonwealth of Pennsylvania, “Pennsylvania Green Building Maintenance Manual: A Manual for the Commonwealth of Pennsylvania on Environmentally Preferable Building Operations and Maintenance.” April 1, 2002.

U.S. Environmental Protection Agency, Database of Environmental Information for Products and Services, http://yosemite1.epa.gov/oppt/eppstand2.nsf.

Guideline CP3: Carpet

Recommendation

- Combine regular vacuuming with walk-off mats to prevent dirt from being tracked into the carpet.
- For spot and extraction cleaning, use the least amount of moisture and chemicals possible.
- When chemical cleaners are used, select products that are biodegradable, and contain low amounts of dyes, fragrances, and VOCs.
- Carpet cleaning should be scheduled as part of the overall preventative maintenance plan.



Vacuuming is the most effective and economical way to keep carpet clean. Photo reprinted with permission from the Carpet and Rug Institute, http://www.carpet-rug.com.

Description

Measures for carpets should focus on the following areas:

Pollution prevention

Keep entryways clean to prevent dirt from being tracked onto the carpet. Entryway spot vacuuming and cleaning must be done as soon as significant soiling is noticed, throughout the day. The importance of maintaining these relatively small areas cannot be over-emphasized, since keeping dirt, oil pesticides, sand and other pollutants from being tracked through the whole building prevents the spread of airborne pollution and saves the cost of having to clean the whole building as frequently. It also prolongs the life of building floor surfaces of all types and improves the building's appearance in the halls and elsewhere. Place appropriately sized walk-off mats at all exterior doors to capture dirt and moisture from shoes. Walk-off mats, in good condition, should be provided at school entrances. Mats should have beveled edges to prevent them from becoming turned up, which could lead to a "trip/fall" injury. Mats should be as wide as the doorway and extend approximately 15-25 feet inside the building, if possible. (http://www.psbait.org/Newsletters/SafetySense/inss0303.html)

- In general, the mats should be long enough for a person's shoes to touch the mat several times and remove dirt from the sole. Use grit mats to trap sand and soil at entrances near playgrounds and unpaved, highly soiled areas, etc. Frequent changing of mats is generally a more effective maintenance technique than constantly cleaning the same mat. During the winter season when moisture tracking is high, swap out mats twice a week. At other times, changing mats every one or two weeks is generally sufficient. A number of different mats heavy traffic mats and anti-slip mats for entryways can be found by searching for "Walk-off mats" online using conventional Internet search engines. Mats that are used in high traffic areas can be hung outside, hosed off and allowed to air dry in many cases, under the school eaves or soffits. Mats soiled with grease and oil can be taken to a local car wash and cleaned with detergents, brushes and pressure washers. Be sure to consult the manufacturer before implementing these practices to avoid problems with mat warranties.
- Adhere to carpet manufacturers' recommendations regarding carpet maintenance.
- Keep resilient floors near high traffic areas clean in order to reduce transfer of dirt to surrounding carpeted areas.

- Limit eating and drinking outside of the cafeteria and breakroom areas to reduce damage to classroom and hallway flooring and time spent cleaning up spills. As part of a comprehensive program of shared responsibility, work with the student council and school administration to limit or eliminate the use of chewing gum on campus. It is important that students and staff be made aware that gum is one of the most difficult substances to remove, and requires time and special cleaning procedures, sometimes involving the use of highly volatile and toxic cleaners. In any case the importance of limiting foods, beverages and chewing gum and candy from classrooms and other hard to clean areas in the school is a **shared responsibility** that will only succeed if there is 1) awareness of the problems created and 2) buy-in to any proposed solutions.
- Locate trashcans throughout the school to encourage the proper disposal of litter.
- Proper ventilation is also important to preventing the build up of harmful materials in carpets. Replace air filters monthly, and inspect air ducts frequently for buildup of contaminates.

Vacuuming

- Establish a regular schedule for vacuuming carpets and entry mats.
- Focus on high traffic areas, such as classrooms, entrances, corridors, break areas, and other congested areas, which should be vacuumed at least once per day, or more and every day after school.
- Areas with less activity, like conferences rooms, offices, and auditoriums, should be vacuumed as needed base on soiling, with extra attention being paid to areas in those rooms with the most foot traffic.
- Select a vacuum with high airflow (suction) for more effective soil removal.
- Consider a vacuum with a high efficiency particulate air (HEPA) or near-HEPA filter air filtration system to prevent dust and other materials from passing through the vacuum bag back into the air. Filtration is the key element in school carpet soil removal. There is no need in most schools to use rotating brushes or “power heads” on vacuums, In fact with modern institutional carpets this can be counter-productive. The crucial elements to vacuum cleaning are having a strong vacuum suction in combination with a high efficiency filter. This combination is the key to capturing dust, pollutant particles and pathogens that can become airborne if not vacuumed and filtered properly.
- Use disposable vacuum bags, and replace them before the bag is half full. This will increase vacuuming particle removal efficiency and help to prevent spills and leaks.

Spot cleaning

- Clean up spills immediately or as soon as possible. Spills and stains are much easier to clean while they are fresh.
- For **dry spills**, use a vacuum to remove surface residue. Do not use any type of liquid on dry spills this will make the problem worse.
- For **wet spills**, blot spill with an absorbent cloth or white paper towel.
- Many spills can be removed with warm water and blot until the towel stops picking up moisture. See the Cleaning products section below for additional cleaning solutions. The use of non-commercial “household” cleaners or other home remedies in schools, however appealing they may appear, are not recommended in schools and other commercial settings for safety, health, warranty and quality control reasons. Only about 30% of the ingredients used in household cleaners have been evaluated for human health effects. There are numerous effective, inexpensive and appropriate spill removers available to schools, and they should be used instead. The use of “Green Seal” labeled products is recommended.
- When commercial cleaning products are used, do not apply the solutions using a fine mist. Use a stream or coarse spray to minimize the amount of chemicals released into the air.

- Limit access to carpet until it is completely dry to prevent slips, falls, and resoiling. Carpets can be checked for moisture percentage using a simple pin hygrometer. (http://www.inspectortools.com/pinmoismet.html)

Extraction cleaning

- Schedule extraction cleaning as needed during the school year: Cleaning the carpets before classes begin in the Fall is generally recommended. Follow the carpet manufacturers recommendations on cleaning in all cases, and spot clean often to avoid the need to schedule additional extractions during the Winter break unless the carpets become visibly soiled.
- Use the least toxic products appropriate for the carpet and minimize the amount of cleaner used. Excess cleaner can lead to rapid resoiling of the carpet. Once again, follow the manufacturer's instructions to avoid warranty issues.
- Before starting, ensure that the equipment works properly. Leaks in the attachments may decrease suction. The equipment should extract the maximum amount of moisture from the carpet possible. Moisture left in the carpet from extraction cleaning can lead to serious IAQ problems from mold and mildew growth.
- Ventilate the space using fans and natural ventilation (if weather permits) for approximately 48 hours to properly dry the carpet. Carpets should be dry within 24 hours to prevent the growth of mold and other harmful organisms. Flush out the space with fresh air prior to reopening to students and staff.
- Properly dispose of all cleaning solutions in accordance with state and local laws and ordinances.

Cleaning products

As mentioned in the previous guideline, select products that:

- Have a neutral pH (near 7) rather than an extreme pH (near 1 or 14).
- Are biodegradable.
- Contain no or low levels of dyes and fragrances.
- Have no or low volatile organic compounds (VOCs).

For carpets, look for products with surfactant ingredients containing lauryl, amides, and glycosides. Avoid products with the following ingredients: Nonyl Phenol Ethoxylates, NTA, EDTA, glycol ethers, sodium hydroxide, potassium hydroxide, sodium metasilicate, phosphates. Follow the carpet manufacturer's recommendations whenever possible.

Applicable Codes and Standards

See Applicable Codes and Standards for Guideline CP2: Cleaning Products and Equipment.

Also, check the carpet manufacturer's recommendations of preferred cleaning methods to prevent invalidation of applicable warranties for your carpet.

Benefits

Proper and frequent carpet cleaning can protect indoor air quality, by removing dirt and preventing the growth of mold and other bacteria.

Dirt and other harmful materials can become ground into carpet backing. Once these substances get into the backing, they are extremely difficult to remove and damage the carpet fibers, ultimately resulting in the carpet having to be replaced. Proper carpet cleaning extends the life of the carpet.

Costs

Look for durability in a vacuum cleaner to reduce long-term costs of maintaining or replacing the equipment, rather than selecting a machine based only on first cost. Cleaning efficiency can deteriorate

quickly with low quality vacuums, and equipment maintenance or replacement costs are high. The poor performance of equipment will also impair the environmental quality and health condition of your school.

Monitoring/Controls

N/A.

Common Retrofit Opportunities

When replacing carpet, select a product that has low-VOC emissions; is durable; is made with recycled content; is easy to clean; prevents liquids from penetrating the backing layer; can removed without chemicals; can be easily replaced; and absorbs sound. It is critical that the carpet backing completely stop moisture from flowing through to contaminate or soak the pad and/or sub-flooring.

When possible, select a carpet and pad that is recyclable at the end of its service life.

To reduce waste during installation, consider carpet tile rather then broadloom, if possible.

For more information, see "IS1: Carpeting" in Vol. II of the CHPS Best Practices Manual.

Verification and Commissioning

N/A.

References/Additional Information

Carpet and Rug Institute, "Carpet in Schools" web site. Site contains information on carpet maintenance and indoor air quality for schools. http://www.carpet-schools.com.

Commonwealth of Pennsylvania, "Pennsylvania Green Building Maintenance Manual: A Manual for the Commonwealth of Pennsylvania on Environmentally Preferable Building Operations and Maintenance." April 1, 2002.

Green Seal, "Standard 37: Industrial and Commercial Cleaners". October 2000. Available at http://www.greenseal.org.

Green Seal, "General Purpose Cleaners." Choose Green Report. March 1998. Available at http://www.greenseal.org.

Guideline CP4: Resilient Floors

Recommendation

- Sweep, dust mop, or vacuum daily to prevent dirt from being ground into the resilient floor.
- Wet mop the floor using non-toxic and environmentally safe products once a week.
- Depending on the color of the floor and/or the amount of dirt, the floor may have to be wet mopped more frequently.

Burke Mercer Flooring Products: http://www.burkemercer.com/rubber.html

Description

Pollution prevention

- Keep entryway mats clean, dry, and in good condition. Maintaining entryway mat systems are the first line of protection for all flooring systems.
- Ensure that dust mops are made of micro-fiber materials and properly treated to capture dust.
- Make sure mopping solutions are kept clean using the correct amount of cleaning chemical. Do not overuse concentrated cleaning chemicals. Remix solutions as necessary and dispose of used solutions appropriately.

Cleaning Techniques

Apply cleanser using appropriate techniques recommended by the manufacturer. Do not use sponge mops. After the soil deposits have been loosened from the floor, mop up excess detergent and water. Rinse with clean, warm water to remove all residues. Any detergent film remaining on the floor will cause stickiness and trap tracked-in dirt.

Excess water may harm floor seals and adhesives. Keep off the floor until dry.

Cleaning Products

When choosing a floor detergent, look for products that are low foaming, general detergents that may be used in automatic scrubbers. A good detergent will also have neutral pH to remove dirt and protect polish and be highly concentrated to allow for low dilution ratio. An all-purpose cleaner from Green Seal or Pennsylvania is recommended.

Scuffs and marks

- Periodic buffing with a slow speed buffer will remove most scuffmarks and light scratches. Buffing also will add luster while dislodging dirt and blending touch-up spots.
- Difficult scuffmarks that aren't removed by mopping or buffing can be removed using a nylon scouring pad. Use a solution of neutral floor cleaning detergent, rub gently, and rinse well afterward.
- To prevent damaging the floor, equip movable chairs, tables, desks and other objects that dig into the floor with appropriate floor guards or casters on the bottoms of each leg to prevent deep scuffs, cuts and scratches.

Floor finish and luster

- Over time, high traffic areas will lose their luster and gloss. Touch up worn areas before the finish film wears away completely to prevent permanent damage or staining to the floor surface.

- Be sure floors are thoroughly cleaned and dried before applying finish. Never apply a finish to a dirty floor because it will trap the dirt under the surface. .
- Good floor finishes contain high-performance acrylics with different solid percentages. High solids content alone means nothing. The quality of the polymer which makes up the solids is what is crucial. Using high solids means that fewer coats will need to be applied, however. If a high quality, high-solids product is used, it will allow for easy application, excellent leveling and buffing results, and dry bright without buffing. Schools may use low, medium or high solids products that are compatible, depending on the circumstances. Pick an appropriate low maintenance coating with a high gloss finish. Products that are designed specifically for ultra-high speed buffing machines are relatively soft and will show foot traffic and wear patterns more readily.
- Once the floor is thoroughly cleaned, apply a light coat of polish to restore luster. To apply, pour liquid into a clean, shallow pan. Use a microfiber mop to apply an even finish.
- Apply finish to the floor by mopping in one direction to ensure a thin, even coat on the floor. Most finishes dry in about 30 minutes. To apply additional coats, make sure the first layers are completely dry.
- Do not force-dry the floor. This can lead to a “powdering” of the finish.

Removing build up

- Select floor strippers or other products that are ammonia-free, fast-acting and detergent-enhanced (allowing the chemicals to strip efficiently without harming the floor).
- Dilute stripper solutions as directed and mop onto the floor. After application wait for several minutes and agitate the area with proper floor tools to remove the solution and any unwanted build-up of cleaning materials. Then rinse, allow the floor to fully dry, and apply additional coats, as needed.
- Never use the same equipment, mops or buckets for applying finish as you have used for removing it. Even small traces of stripper will prevent the new finish from adhering properly. Color-coding mops and other tools is an effective way to manage these pieces of equipment.

Selecting finishes and strippers

Floor finishes must be durable and appropriate for the prescribed maintenance method, but they typically contain heavy metals. New technologies include ultraviolet floor finishes that eliminate the burnishing process. Burnishing creates airborne contaminants (refer to Infectious Control Today, August 2003). It is important that the floor finish is compatible with the stripping solution. Here are specific issues to consider:

- Durability: Prefer finishes that are more durable to reduce the need for additional buffing, restoring, and recoating.
- Heavy Metals: Prefer non-metal cross-linked polymers as compared to those containing heavy metals. Another significant benefit of non-metal polymer formulas is that frequently they can be removed with less hazardous floor strippers.
- More Preferable Ingredients: Metal-free polymers.
- Less Preferable Ingredients: Metal cross-linked polymers.

Floor strippers typically have extreme pH, solvents and ammoniated compounds necessary to remove metal cross-linked floor finishes. Floor stripper must be compatible with floor finish. The following issues should be considered:

- pH: Prefer those with a neutral pH (closer to 7) as compared to those with extreme pH (closer to 1 or 14)
- VOCs: Prefer those that have no or low VOC as compared to alternatives with higher levels. Consider detergent-based products compared to those containing solvents.

- Bio-Based/Renewable Resources: Prefer products that use oils derived from renewable resources as compared to oils from non-renewable resources.
- More Preferable Ingredients: d-Limonene and methyl esters from soy and corn.
- Less Preferable Ingredients. Glycol ethers in general, 2-butoxyethanol, ethylene glycol mono-butyl ether, and sodium hydroxide.

Applicable Codes and Standards

See Applicable Codes and Standards for Guideline CP2: Cleaning Products and Equipment.

Benefits

Frequent cleaning not only maintains the condition of the resilient floor, but can reduce the transfer of dirt to the surrounding carpet.

Costs

Proper cleaning is essential to maintaining the long life of most resilient flooring. If neglected, flooring can degenerate to a state where cleaning requires significant expense, or complete replacement.

Monitoring/Controls

N/A.

Common Retrofit Opportunities

When selecting new resilient flooring, look for products that are material efficient (i.e., contain recycled content and/or are recyclable) and non-polluting. Use low-toxic adhesives and coatings to reduce the health risk for installers and to protect IAQ in the school.

For more information, see “IS2: Resilient Flooring” in Vol. II of the CHPS Best Practices Manual.

Verification and Commissioning

N/A.

References/Additional Information

Resilient Floor Covering Institute: 401 E. Jefferson St., Suite 102; Rockville, MD 20850. For Info call (301) 340-8580 or fax (301)340-7283. Online at: http://www.rfci.com.

Right Cleaning Equipment, Optimized Way of Cleaning (Part 1) by Rajiv Ranjan (rmcldel@satyammail.com);http://www.ipfonline.com/content/General/Management/MG210920021.jsp.

Guideline CP5: Food Areas: Cafeterias/Kitchens/Breakrooms

Recommendation

- Food preparation areas and eating tables should be cleaned after each food preparation or eating period. Cleaning should include the undersides as well as the tops of the tables. Good mechanical cleaning (scrubbing with soap and water) physically reduces the numbers of germs from the surface. Wiping cloths used for cleaning tables should not be the same materials used for cleaning restrooms or floors.
- Wash the floors in these areas daily. Carpets and fabrics should be vacuumed daily and deep cleaned monthly or sooner as needed. Walls, ceilings and vents should be routinely inspected and cleaned as required. Be sure to identify any food scraps, proteins, and standing wastewater that can become overgrown by fungi and bacteria. Check for these under sinks, washers, refrigerators and trashcans.
- If there is a restaurant or a mid to high volume food preparation area, perishable refuse should be picked up daily. Insure that trash containers are covered and that pest control is effective. (See the Recycling and Waste Management chapter for additional information.)

Description

Pollution prevention

- Regularly clean and sanitize floors, tables, and other food surface contact areas.
- Separate recyclables from trash and make sure recyclable areas are kept clean.
- Make sure that occupants understand how to properly separate trash and recyclables and properly dispose of each. (See the chapter on Recycling and Waste Management for more information.)
- Make sure that waste containers are covered and emptied at least once a day.
- Some items and surfaces require sanitizing to kill germs after cleaning with soap and rinsing with clear water. Items that can be washed in a commercial grade dishwasher with a hot cycle for sanitizing do not have to be chemically disinfected because these machines use water that is hot enough for a long enough period of time to kill germs and other organisms of public health significance.
- The disinfection process uses chemicals that are stronger than soap and water. Disinfection also usually requires soaking or drenching the item for several minutes to give the chemical time to kill the remaining germs. Commercial products that meet NSF or CDC standards are suitable for this purpose.
- Pay careful attention to food waste, trash receptacles containing food debris, recyclables, and other objects that contain food residues, which can attract pests. Making effort to eliminate those things that attract pests is critical to protecting occupant health by reducing or eliminating the need for pesticides inside the building.
- Rinse out food and drink containers before placing in recyclable collection. Refrigerators used by occupants for their personal use should be emptied and cleaned periodically by the occupants. A school Integrated Pest Management (IPM) policy should be adopted and followed.

Cleaning products

All purpose cleaners

All Purpose Cleaners consist of a broad array of possible formulations. The following are some of the specific issues to compare for this product category:

- pH: Prefer those with a neutral pH (closer to 7) as compared to those with extreme pH (closer to 1 or 14)
- Biodegradability: Prefer those that are readily biodegradable as compared to those that are slower to degrade. Unfortunately, many older formulations use excellent performing ingredients that have been found to have serious environmental and health concerns.
- Dyes and Fragrances: Prefer those with no or low levels of dyes and fragrances compared to those products that are heavily dyed or fragranced. If dyes are necessary use those that are approved for foods and cosmetics (F&C).
- VOCs: Prefer those that have no or low VOC as compared to alternatives with higher levels. Consider detergent based products compared to those containing solvents.
- More Preferable Ingredients: Surfactants containing terms such as lauryl, amides, and glycosides.
- Less Preferable Ingredients: Nonyl Phenol Ethoxylates, NTA, EDTA, glycol ethers, sodium hydroxide, potassium hydroxide, sodium metasilicate, phosphates.

General degreasers

General degreasers are typically heavy-duty cleaners that include solvents for removing oil-based soils. Traditional solvents are typically derived from a non-renewable sources, can be flammable, have a high degree of VOCs, which can cause respiratory irritation and contribute to environmental pollution and some have sever health impacts. The following are some of the specific issues to look for:

- Bio-Based/Renewable Resources: Prefer products that use oils derived from renewable resources as compared to oils from non-renewable resources.
- Flashpoint: Prefer products that have a high flashpoint compared to those with a low flashpoint.
- More Preferable Ingredients: d-Limonene and methyl esters from soy and corn.
- Less Preferable Ingredients. Glycol ethers in general, ethylene glycol mono butyl ether, and sodium hydroxide.

Applicable Codes and Standards

See Applicable Codes and Standards for Guideline CP2: Cleaning Products and Equipment.

Disinfection products used in these areas should meet NSF or CDC standards.

Benefits

Unsanitary food areas can pose many health and environmental issues. Proper and frequent food area cleaning can protect indoor air quality by removing germs and bacteria.

Costs

N/A.

Monitoring/Controls

Monitor areas regularly for signs of pest and rodent infestation.

Common Retrofit Opportunities

N/A.

Verification and Commissioning

N/A.

References/Additional Information

All Family Resources: PRACTICES TO REDUCE DISEASES AND INJURY; PO Box 5338 Novato, CA 94948-5338; Tel.: 415-209-0502; http://www.familymanagement.com/childcare/practices/practice.index.html.

Pennsylvania Department of Environmental Protection: Pennsylvania Green Hotels and Motels

POLLUTION PREVENTION & COMPLIANCE ASSISTANCE Address: 16th Floor, Rachel Carson State Office Building P.O. Box 2063; Harrisburg, PA 17105-2063. http://www.dep.state.pa.us/dep/deputate/pollprev/pollution_prevention.html.

Guideline CP6: Restrooms

Recommendation

- Clean restrooms daily (see Description section below), focusing on trash removal, surface cleaning, cleaning urinals, toilets, sinks, and spills and disinfecting.
- Supplies need to be replaced as needed, which may more or less than once per day depending on the dispensing equipment.
- Once a week, a more extensive cleaning should occur that focuses on deep stain and soil removal, such as scrubbing walls, doors, tiles, as well as graffiti removal (see Description section below).
- More frequent cleaning may be required based on weather and level of use.
- Staff should wear appropriate personal protective equipment (PPE). Product labels contain recommendations for proper handling and personal protection. Gloves and wet-splash goggles should be available when using cleaning products, especially when working with disinfectants. Mild, non-acidic products should be used when possible.
- Minimize the use of chlorine bleach solutions in schools. Substitute products that will sanitize with less environmental and human health impact where possible. Follow local and state public health laws and regulations that require bleach solutions in certain cases.

Description

Regular Daily Cleaning

Daily restroom cleaning should be part of the school's overall preventative maintenance plan.

The cleaning process should include the following activities:

- Emptying trash;
- Refilling paper towel, toilet paper, and soap dispensers;
- Cleaning mirrors and glass surfaces;
- Cleaning toilets & urinals with a non-acid bowl cleaner;
- Cleaning showers with a non-acid soap remover;
- Disinfecting all surfaces and fixtures; and
- Microfiber mopping floor and wet mopping with a cleaner/disinfectant.

Weekly Cleaning

A more through restroom cleaning should occur once a week. Restrooms with high use and/or highly soiled conditions may need more frequent cleaning.

The weekly cleanings generally include the same tasks as the daily cleanings, but often involve more "elbow grease" with brushes and scrub pads to remove stains and soils. While the same chemicals can be used, it may be necessary to mix them at higher concentrations to remove certain soils, including graffiti, tile deposits, and toilet stains.

Lime and rust stains are two of the more common stubborn soils that plague toilets. These stains generally can not be removed using the daily cleaner, and instead must be tackled using a powdered cleaner and scrub pad, or with cleaners recommended by Green Seal.

Because of the harmful nature of many acid cleaners, they should be used sparingly and with caution:

- Use acid cleaners only on porcelain toilet bowls, since acid corrodes metal.

- Custodial staff should always use gloves and goggles.
- Prevent splashes by pouring the acid cleaner close to the water. Avoid creating splashes when using a scrub brush.
- Flush the toilet twice after cleaning to rinse away excess cleaner.

Product Selection

Select mild cleaners for daily restroom cleaning. Such products are reasonably safe to use, and have little environmental impact. Follow the manufacturer's dilution directions.

Combination cleaner/disinfectant products only effectively work on relatively clean surfaces. For heavily soiled areas, clean the surface first and then apply a disinfectant. Let the disinfectant sit on the area in accordance with manufacturer's recommendations.

An institutional grade disinfectant product can generally be used daily hard surface cleaning. Milder sanitization grade products may be used in toilet bowls where the goal is to reduce germs to a safe level (typically 0.1%), rather than completely eliminate them.

It should be noted that disinfectants do pose a health risk, and the following steps should be taken to use these products effectively:

- Select a product that contains the specific EPA-registered ingredients needed to kill common restroom germs. Using the wrong disinfectant wastes time and money.
- Plan "smart" disinfection. The most commonly used surfaces will need the most disinfection. An ultraviolet light can reveal how soon germs reappear after cleaning. Schedule disinfection work accordingly. Also, the U.S. EPA, Centers for Disease Control, and other agencies publish guidelines for disinfection that are useful.
- Dilute solutions according to directions. Using full strength disinfectants not only wastes chemicals, but is much more dangerous for the custodial staff. Therefore, make sure that disinfectants are diluted according to the manufacturer's directions. Typical dilutions are 1:64 to 1:256 of concentrated product to water.
- Don't skimp on process. For disinfectants to work properly, make sure the surface is clean of dirt, grease, and oil. The disinfectant should be left in place for 10 minutes. It may be necessary to do the work in a new sequence to allow this longer contact time. For example, consider doing a pre-cleaning the surfaces and applying the disinfectant throughout a restroom, and then go on to empty the trash and refill paper dispensers.

Glass Cleaners are cleaners that have ingredients added to reduce streaking and to evaporate quickly. Traditional glass cleaners can contain alcohol and other solvents or ammonia. The following are some of the specific issues to compare for this product category:

- pH: prefer those with a neutral pH (closer to 7) as compared to those with extreme pH (closer to 1 or 14)
- Biodegradability: Prefer those that are readily biodegradable as compared to those that are slower to degrade. Unfortunately, many older formulations use excellent performing ingredients that have been found to have serious environmental and health concerns.
- Dyes and Fragrances: Prefer those with no or low levels of dyes and fragrances compared to those products that are heavily dyed or fragranced. If dyes are necessary use those that are approved for foods and cosmetics (F&C).
- VOCs: Prefer those that have no or low VOC as compared to alternatives with higher levels. Consider detergent based products compared to those containing solvents.
- More Preferable Ingredients: surfactants containing terms such as lauryl, amides, and glycosides.
- Less Preferable Ingredients: ammonia, alcohols, propylene glycol, ethylene glycol and other glycol ethers.

Important Safety Tips

- Train the custodial staff on the proper use of cleaning chemicals, and if possible, have staff work in teams of two when using stronger chemicals.
- Staff should always wear goggles and gloves when using acids, caustics or products containing glycol ethers or ethanolamines.
- Properly ventilate the restroom while cleaning.
- Avoid mixing incompatible cleaning products. Rinse out cleaning buckets between different types of use or when the solution becomes excessively soiled. Cleaning equipment should be put away clean.

Applicable Codes and Standards

See Applicable Codes and Standards for Guideline CP2: Cleaning Products and Equipment.

Benefits

According to the Federal Center for Disease Control, a thorough cleaning of sinks, toilets, doorknobs, and other hard surfaces that people frequently touch is the first and most important step in preventing the spread of disease.

Frequent regular cleaning can prevent larger problems later.

Costs

There are no known additional or unusual costs associated with purchasing environmentally preferable products as recommended by the International Sanitary Supply Association.

Monitoring/Controls

Restrooms should be regularly monitored for cleanliness.

Common Retrofit Opportunities

N/A.

Verification and Commissioning

{Some commercial buildings have signoff sheets for restroom cleaning….is that common in schools as well?}

References/Additional Information

National Clearinghouse for Educational Facilities. 1090 Vermont Ave., NW Suite 700, Washington, D.C. 20005. Toll free: 888-552-0624 · (202) 289-7800 http://www.edfacilities.org/rl/cleaning.cfm

Guideline CP7: Furniture

Recommendation

- Use a high filtration vacuum, or if this is not possible, use a dampened micro-fiber or treated dust cloth – not a feather duster – to remove dust from shelves, desks, tables, blinds, and other hard surfaces.
- Dusting should occur as needed when dust accumulates.
- Doorknobs, light switches and other surfaces that frequently come in contact with hands should also be cleaned with a disinfectant cleaner.

Photo: BOORA

Description

Protecting Indoor Environmental Quality

Eliminating or minimizing dust is very important for staff and students with asthma and/or allergies. Proper dusting on a regular schedule protects occupants from this irritant.

Do not allow old, dusty furniture such as sofas, loveseats, stuffed chairs or other fleecy furniture in school classrooms or elsewhere in schools.

Furniture that has been in storage or unused for long periods of time should be cleaned and sanitized using appropriate International Sanitary Supply Association techniques and equipment.

Soiling Factors

- Dirt and soil. — Walk-off mats can prevent a great deal of dirt and soil from reaching school floors and furniture. Furniture is exposed to a far higher degree of human body oils, which require thorough preconditioning with specialty furniture preconditioning products. In most cases, furniture preconditioners are blends of solvents and moderate pH detergents. Upholstery preconditioner has a lower, safer pH, with a higher solvent content to break down body oils.
- Perspiration — Perspiration stains are difficult to remove and may damage many fiber types. Yellowish discoloration on the arms of furniture may be from oxidized body oils, perspiration, or both. Best results come with the use of oxidizing agents, enzymes, and/or aggressive furniture preconditioning formulas.
- Hair — Human and animal hair are deposited on carpet and upholstery, but can be more difficult to remove from woven fabrics as hair is held more tightly within these fiber constructions. Hair can be extremely difficult to remove if the cleaning staff does not use lint rollers, brushes, and vacuums before applying any cleaning agents.
- Cosmetics — Most cosmetics (make up, eye liner, eye shadow, lipstick, nail polish) need to be removed with volatile or nonvolatile spotters. Solvent spotters may damage back coatings on fabric, so be sure to inspect and test carefully before beginning any spotting procedures.

Cleaning Products

Use cleaning products that are Green Seal approved.

Use care when selecting a furniture polish. Many products contain petroleum distillates, which are poisonous and a non-renewable resource. Use the following guidelines when selecting a furniture polish:

- No or low VOCs.

- Oils derived from renewable resources.
- Contain citrus oils.
- Avoid products with petroleum distillates.

Applicable Codes and Standards

See Applicable Codes and Standards for Guideline CP2: Cleaning Products and Equipment.

Benefits

According to a committee formed by the Institute of Medicine (IOM), Washington, DC, at the request of the US Environmental Protection Agency, dust and other indoor irritants contribute to asthma. Regular cleaning of furniture protects indoor air quality and contributes to a healthy school environment.

Costs

Minimal.

Monitoring/Controls

N/A.

Common Retrofit Opportunities

N/A.

Verification and Commissioning

N/A.

References/Additional Information

Healthy Buildings, Inc. Address: 5424 Ballard Ave N.W. #300; Seattle, WA 98107. For more information: http://www.healthybuilding.com/index.html.

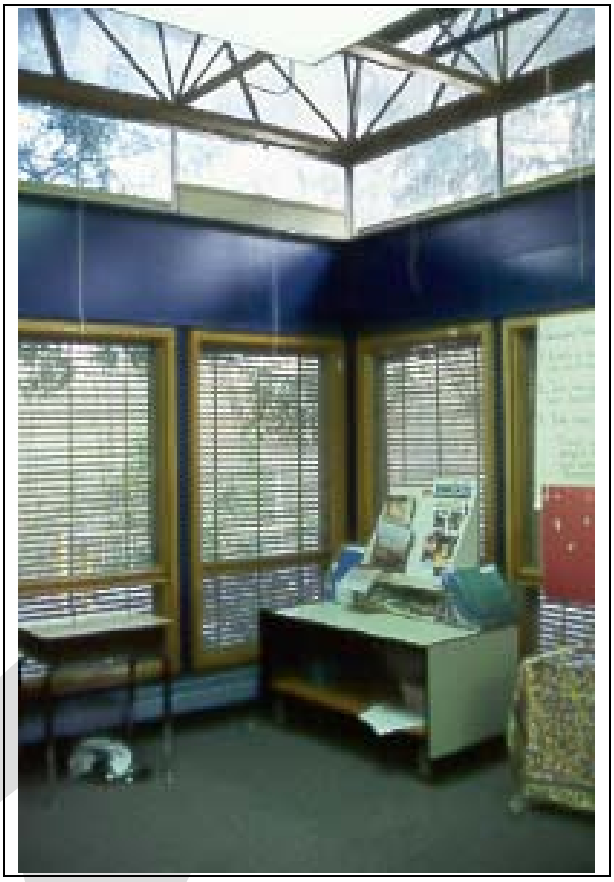
International Sanitary Supply Association, http://www.issa.com

POLLUTION PREVENTION & COMPLIANCE ASSISTANCE Address: 16th Floor, Rachel Carson State Office Building P.O. Box 2063; Harrisburg, PA 17105-2063. http://www.dep.state.pa.us/dep/deputate/fieldops/sw/hpsp/appendix_2.htm.

Guideline CP8: Window Coverings

Recommendation

Combine regular vacuuming (using brush attachment) and dusting to prevent mold infestations. When using detergent or other chemical cleaners, use the least amount of product possible and select mild detergents and products that are least toxic (biodegradable, and contain low amounts of dyes, fragrances, and VOCs).



Description

Blinds and other window coverings tend to attract a large amount of dust particles, contributing to IAQ problems, including dust mites and mold growth.

Regular cleaning of blinds, drapes and curtains should be scheduled as part of the overall preventative maintenance plan. Measures for window coverings should focus on the following areas:

Aluminum Blinds

Monthly Dusting

- Vacuum blinds using the brush attachment, first with slats tilted up and then with slats tilted down.
- Finish using a soft, moist cloth to wipe down both sides of the slats (starting from the top and working towards the bottom of each side).

Annual Washing

- Use a damp sponge or cloth with mild detergent to wipe down the blinds, making sure that excessive water does not damage window sills or the floor. Do not use hot water to dampen sponge or cloth, as it may cause paint to peel.

Wood Blinds

Monthly or Weekly Dusting

- Do not wash wood blinds to prevent damage and discoloration.
- Use a clean, soft dust cloth a vacuum brush attachment to remove dust. Start from the top of slats tilted up, then wipe down the other side (slats tilted down). (Follow instructions per manufacturer.)
- Finishing with a light wood treatment/oil is optional.

Blind Repairs

Replacing Wand Tilter

- Take down the blind from the window.
- Slide the horizontal axle shaft out of the tilter mechanism.
- Remove the wand from the tilter by unsnapping the tilter from the head rail.

- Replace the new tilter in the same position, making sure to line up the with the shaft notch.
- Slide axle back into position, attach tilt wand, and test tilter.
- Reinstall blind.

Replacing Slats (Aluminum and Plastic Blinds)

- Expose and pull out (slightly) the end of the cords by removing end caps from the bottom rail.
- Cut the cord above the knot and pull the cord up through the last damaged slat.
- Remove the slats and replace them with the new ones, making sure to insert the slats so that route holes are aligned with the existing slats.
- Weave the cords through the route holes and bottom rail, securing with new knots.
- Replace the end caps.

Shades, Curtains, and Drapes

Monthly or Weekly Dusting

- Lightly vacuum, using brush attachment.
- Finish by wiping down with a moist cloth.

Spot Cleaning

- Moisten a sponge or cloth with lukewarm water and a mild detergent and lightly rub onto the soiled area. Do not use hot water to dampen the cloth and be extra careful when cleaning blackout shades, to avoid creasing.

Applicable Codes and Standards

See Applicable Codes and Standards for Guideline CP2: Cleaning Products and Equipment.

Benefits

Keeping window coverings clean can prevent mold, dust mites and other contributing factor to poor IAQ, while contributing to the overall cleanliness and health of the building. Window coverings provide shading, prevent glare, and some insulation.

Costs

Aluminum blinds are inexpensive and fairly easy and cheap to maintain. Wood blinds have a more expensive initial cost, but have relatively low maintenance costs.

Monitoring/Controls

N/A.

Common Retrofit Opportunities

Blinds are generally recommended for renovation projects over curtains because they allow flexibility in light level adjustments.

Verification/Commissioning

N/A.

References/Additional Information

Levolor Inc., Troubleshooting Guide, http://www.levolor.com/main.taf?p=0,3,3

No Brainer Blinds, Inc., http://www.nobrainerblinds.com/about/

Guideline CP9: Chalkboards/Whiteboards

Recommendation

Daily cleaning of chalkboards and whiteboards should be part of the school's shared green cleaning responsibility and should be assigned to students by classroom teachers as needed.

The custodial staff should focus on more hazardous and critical areas of cleaning. This policy also helps prevent accidental erasure of classroom materials or assignments.

Significant cleaning of chalkboards/whiteboards with green cleaning products should be scheduled for periodic times during the school year, preferably during student vacations. Teachers should be notified in advanced of these scheduled cleanings, so that they can copy down any important material from the boards.

Source: http://www.virtualflint.com/student/project/whiteboard

Regular cleaning of erasers are vital to keeping chalkboards clean. Begin cleaning chalkboards by vacuuming up all chalk dust. Then clean them with a microfiber cloth. .

Description

Whiteboards

Markers

Use whiteboard markers that are considered nontoxic under Federal Hazardous Substances Act Regulation, Title 16, Part 1500.

Markers containing methyl isobutyl ketone (MIBK) or xylene can release vapors that result in dizziness, nausea, and headaches. A 1987 study by the Environmental Protection Agency (EPA), found that occupational exposure to 100 parts per million (ppm) of ketones causes headaches, nausea, and respiratory tract irritation. This level is rarely found, but precautions should be taken to minimize any exposures. However, most markers have been tested and shown to be considered nontoxic under Federal Hazardous Substances Act Regulation, Title 16, Part 1500. These products are considered safe when used under normal conditions.

Whiteboard Cleaning

Whiteboard cleaners may contain alcohols and ethers, such as isopropyl alcohol. Do not clean surface of whiteboard with unsuitable chemicals such as turpentine, methylated spirits, grease, oil, wax, aerosol sprays or acetone.

After applying the cleaner, rinse with clear water and dry. Some manufacturers recommend using a sponge and squeegee to ease cleaning. However, be sure to avoid using harsh, abrasive materials that will permanently damage the whiteboard, such as paper towels, etc.

A mild solvent can remove crayon, scotch tape, etc. from the whiteboard surface. To prevent damage to the whiteboard, verify that the specific solvent is safe for such surfaces.

Avoid wiping or erasing whiteboards with the fingers. The skin's natural oils may cause permanent residue on the surface of the board, resulting in poor quality and appearance.

Chalkboards

Erasers

Use felt or sponge rubber erasers in classrooms. Clean erasers frequently – weekly is recommended – to maintain their effectiveness. Rubber erasers can be easily rinsed in a water faucet. Felt erasers must be vacuumed or dusted to remove chalk dust. Here is another opportunity for students and teachers to get hands-on experience in protecting their own indoor environment as part of the school's environmental stewardship policy.

Chalkboard Cleaning

Use a dry cloth as frequently as necessary to apply a chalkboard cleaner that meets Green Seal Standard 37.

See: http://www.greenseal.org/standards/industrialcleaners.htm Dustless or low-dust chalk should be used on chalkboards. (See: ASTM D-4236) Do not wash the entire surface at once time since the sections washed first will dry and leave a gray film. If the chalkboard is not cleaned to satisfaction using water, use a suitable cleaner recommended by the chalkboard manufacturer. Avoid using household cleaners or other cleaners that may contain toxic and non-biodegradable ingredients. Less than 30% of ingredients used in household cleaners have been tested for toxic effects on humans according to the US Environmental Protection Agency. Avoid use of harsh abrasives such as scouring powder or strong cleaning chemicals.

Chalkboards may require periodic cleaning to remove material that has accumulated, including tape and pencil marks, effects of hard chalk, colored chalk, crayons, fingerprints and stains. Colored chalk is especially difficult to remove, and hard chalks are damaging because the clay (or binder) in this type of chalk tends to fill the pores (or tooth) of the chalkboard stone, leaving a shiny surface that diminishes the board's usefulness.

Wash a small section at a time using clear water; if results are unsatisfactory, use a mild detergent in solution to clean. The section should be immediately rubbed dry with a lint free cloth. Do not wash the entire surface at once time as the portions washed first will dry and leave a gray film on the surface. After rinsing, dry the board. A dehumidifier left in the room over a weekend can help.

These cleanings may not remove stubborn marks and stains, such as colored chalk, tape, hard chalk, fingerprints and crayons. To remove these marks, rub gently with a damp, soft cloth and fine-grade dental pumice (available at pharmacies). Such abrasive material may be used as a last resort, but should be applied gently and sparingly.

Applicable Codes and Standards

See Applicable Codes and Standards for Guideline CP2: Cleaning Products and Equipment.

Federal Hazardous Substance Act Regulations of the Occupational Safety and Health Administration (OSHA).

The American Society of Testing Materials ASTM-D4236.

Benefits

The benefits of clean whiteboards and chalkboards include:

- Aesthetic appearance.

- Regular cleaning of chalkboards means less chalk dust that can aggravate allergies and unnecessary chalk inhalation. As mentioned above, dustless chalk that complies with ASTM D-4236 should be used. For more information: http://www.greenseal.org/
- Regular cleaning of whiteboards can prevent stains that might require abrasive and toxic cleaning products.

Costs

Maintenance costs are minimal.

Monitoring/Controls

N/A.

Common Retrofit Opportunities

Recently whiteboards are rapidly replacing chalkboards. There are pros and cons for both choices. For instance, whiteboards can help prevent chalk-dust exposures for teachers and students. Also, chalk dust can damage computers, by causing keyboard keys to stick.

However, whiteboards also can produce harmful effects. Many marker fumes can cause dizziness, nausea, and headaches. In addition, whiteboard cleaning solutions usually contain alcohols and ether and are extremely flammable.

Verification and Commissioning

N/A.

References/Additional Information

Clive, Michelle, "Markers To Be Replaced", Nov. 12, 1998; http://www.mbhs.edu/silverchips/nov98/news/markers.html

"FAQ's About EXPO Markers" answers provided by the makers of Sanford EXPO products; http://shop.store.yahoo.com/mywhiteboards/faqabexmar.html.

Green Seal, http://www.greenseal.org/

Osu College of Biological Sciences MSDS File, *Sanford -- EXPO Dry Erase Markers Chisel Tip, Black Material Safety Data Sheet*; http://www.biosci.ohio-state.edu/~jsmith/MSDS/SANFORD%20--%20EXPO%20DRY%20ERASE%20MARKERS%20CHISEL%20TIP.htm.

Guideline CP10: OSHA Bloodborne Pathogen Standard

Recommendation

- Blood and other potentially infectious material (OPIM) spills should be dealt with immediately.
- Follow the OSHA procedure for handling of blood and OPIM spills.
- According to OSHA standards, always assume that the material is infectious with HIV, HBV, or other bloodborne pathogens.

Description

OSHA has issued a final rule, known as the Blood-Borne Pathogen Standard (29 CFR 1910.1030), that requires employers to provide employees with a training program on safe work practices and personal protective equipment when occupational exposure to blood or other potentially infectious materials is reasonably anticipated.

Clean-Up Procedure

- Put on appropriate Personal Protective Equipment including gloves, goggles and aprons as necessary Gloves and a fluid-resistant gown must be worn during clean-up of a spill. Blood/body fluid should be wiped up using paper towels.
- For a small spill (less than 100 mls.), blot up with paper or Turkish toweling, or any of the various powders (plaster of paris) on the market, is appropriate. Place all materials in a biohazard bag for disposal. Dispose of biohazard bag according to local regulations.

  For a large spill (larger than 100 mls.), add appropriate TB effective disinfectant to the spill and allow sufficient contact time before performing the absorption process as stated above. Place all materials in a biohazard bag for disposal. Dispose of the biohazard bag according to federal and/or local regulations.
- After removal, the area must be disinfected. For a small spill (less than 100 mls.), spray area of the spill with TB effective disinfectant spray. and allow several minutes of contact time as noted on the product label. Allow the surface to air dry.

  For a large spill, mop area of spill with appropriate TB effective disinfectant such as Quik Fill 960, allow 10 minutes of contact time, remove any remaining mixture with mop and bucket, and discard mixture. Allow surface to air dry. Launder mop heads using hot wash/dry cycles.
- If single use gloves are used, at this point remove the gloves and place them in the biohazard bag and seal the biohazard bag. Wash hands immediately using antimicrobial hand soap. If a wash station is not immediately available, sanitize hands in accordance with BBP protocols. . After sanitizing, wash hands again using hand soap and warm water for 20-30 seconds..
- If reusable gloves are used, wash the gloves while they are on, using an appropriate hand soap . If the gloves were visibly contaminated with blood or OPIM, dip in a use-solution of the germicide as specified in Step 3 above before removal. Wash hands as specified above.
- Follow up with normal cleaning procedure (mop and bucket, autoscrubber, etc.) using daily cleaning/disinfection solution. When the liquid has been absorbed, the entire spill site should be cleaned with an appropriate disinfectant such as a 1:10 dilution of common liquid bleach solution. All disposable contaminated materials must be discarded as infectious waste.

Hygiene Practices

- Handwashing is one of the most important (and easiest) practices used to prevent transmission of bloodborne pathogens. Universal Precautions should be followed by anyone who has been potentially exposed. Hands or other exposed skin should be thoroughly washed as soon as possible following an

exposure incident. Use antibacterial soap, and disinfect with a mild bleach solution.. Avoid harsh, abrasive soaps, as these may open fragile scabs or other sores. Hands should also be washed immediately (or as soon as feasible) after removal of gloves or other personal protective equipment.

- For more details see: http://www.osha.gov/SLTC/bloodbornepathogens/compliance.html and see: http://www.hc-sc.gc.ca/hpb/lcdc/publicat/ccdr/98pdf/cdr24s8e.pdf
- Because handwashing is so important, staff should be familiar with the location of handwashing facilities. Laboratory sinks, public restrooms, custodial closets, and so forth may be used for handwashing if they are normally supplied with soap. If no such facilities are available, you may use an antiseptic cleanser in conjunction with clean cloth/paper towels or antiseptic towelettes. If these alternative methods are used, hands should be washed with soap and running water as soon as feasible.
- If in an area where a reasonable likelihood of exposure exists, **never**:
    - Eat
    - Drink
    - Smoke
    - Apply cosmetics or lip balm
    - Handle contact lenses
- No food or drink should be kept in refrigerators, freezers, shelves, cabinets, or on counter tops where blood or potentially infectious materials are present.

Decontamination and Sterilization

- All surfaces, tools, equipment and other objects that come in contact with blood or potentially infectious materials must be decontaminated and sterilized as soon as possible. Equipment and tools must be cleaned and decontaminated before servicing or being put back to use.
- Decontamination should be accomplished by using:
    - EPA-registered tuberculocidal disinfectant. Check the label of all disinfectants to make sure they meet this requirement.
    - A solution of 5.25% sodium hypochlorite (household bleach) diluted between 1:10 and 1:100 with water. The standard recommendation is to use at least a quarter cup of bleach per one gallon of water. If using bleach use extreme caution as it is a respiratory irritant, can burn eyes and skin, and if inadvertently mixed with other common cleaning products will produce a poisonous gas.
    - If cleaning up a spill of blood, carefully cover the spill with paper towels or rags, then gently pour your 10% solution of bleach over the towels or rags, and leave it for the time specified in the reference materials provided above. This will help ensure that the bloodborne pathogens are killed before wiping the material up. Covering the spill with paper towels or rags decreases the chances of causing a splash when pouring bleach.
    - If decontaminating equipment or other objects (be it scalpels, microscope slides, broken glass, saw blades, tweezers, mechanical equipment upon which someone has been cut, first aid boxes, or whatever), leave the disinfectant in place for at least 10 minutes before continuing the cleaning process.
    - Any materials used to clean up a spill of blood or potentially infectious materials must be decontaminated immediately, as well. This includes mops, sponges, re-usable gloves, buckets, pails, etc.

Cleaning Products

Required products include:

- Intermediate grade disinfectant that is tuberculocidal (kills HBV).
- Specific dilution of chlorine bleach (sodium or calcium hypochlorite, or dilute bromine solution).

Applicable Codes and Standards

Directive Number: CPL 2-2.69

Effective Date: November 27, 2001

Subject: Enforcement Procedures for the Occupational Exposure to Bloodborne Pathogens

Paragraph (d)(4)(i). Cleaning schedules and methods will vary according to the factors outlined in this paragraph. While extraordinary attempts to disinfect or sterilize environmental surfaces such as walls or floors are rarely indicated, routine cleaning and removal of soil are required.

The particular disinfectant used, as well as the frequency with which it is used, will depend upon the circumstances in which the housekeeping task occurs.

Benefits

Each of the disinfectants required by OSHA are proven to be effective in killing both HBV and HIV 1 (AIDS).

Costs

N/A.

Monitoring/Controls

N/A.

Common Retrofit Opportunities

N/A.

Verification and Commissioning

N/A.

References/Additional Information

Summary of OSHA's Bloodborne Pathogen Standard: Fact Sheet No. OSHA 92-46. U.S. Department of Labor Program Highlight: Occupational Safety & Health Administration
200 Constitution Avenue, NW, Washington, DC 20210.
http://www.osha.gov/SLTC/bloodbornepathogens/compliance.html

International Sanitary Supply Association, http://www.issa.org/

Landscaping

This section provides information on how to develop and execute a successful landscape management plan by implementing safety and sanitary measures that reduce negative environmental impacts, while ensuring healthy and beautiful plant-life. The use of toxic pesticides, which are particularly harmful to youngsters, can be reduced or eliminated without risking the quality of your landscape or drastic increases in cost.

- Landscaping Maintenance Plan (Guideline LP1)
- Turf/Grass (Guideline LP2)
- Trees (Guideline LP3)
- Ornamentals (Guideline LP4)
- Hardscape (Guideline LP5)
- Playgrounds (Guideline LP6)
- Irrigation Systems (Guideline LP7)
- Outdoor Pest Management (Guideline LP8)

Guideline LP1: Landscaping Maintenance Plan

Recommendation

Develop a landscaping management plan that outlines the goals, tasks, schedules and responsibilities for the grounds staff. This plan should cover all aspects of grounds maintenance including hardscape care, plant maintenance, and pesticide use.

Description

The purpose of planning out a landscape management program is to work towards providing the necessary nutrients to sustain healthy plant materials and working to prevent and eradicate both pests and the use of toxic materials. It is best to identify the situations that allow pests to flourish and form strategies to prevent such situations. An example of this is making frequent soil improvements. The key steps for ensuring a successful landscape management program are easy to follow on a regular basis and consist of: prevention; monitoring; and nontoxic pest control methods. Sometimes nontoxic methods fail, and this is when the next step is to identify least toxic pesticides, which include boric acid, silica gels, and diatomaceous earth.

Should your schools decide to have in-house staff to apply pesticides, obtain a business license that documents local and state requirements. Or hire someone that is certified in the application of pesticides and herbicides.

Overarching Objectives

The objectives of a landscape management plan are to ensure that school landscape areas are clean, neat, safe, functional and aesthetically pleasing. Typical daily landscaping processes include maintaining paved surfaces, such as parking lots, playgrounds, courts and play surfaces clean, as well as maintaining plant culture by regular mowing, watering and pruning. Such daily tasks should be documented clearly and systematically in the landscape management plan to ensure the quality of the landscape.

Gathering Supporting Data

The first step to developing a successful landscape management plan is to identify and assess the components and layout of the landscape, taking into account critical factors, such as the geographic location of the campus to determine the types of vegetation endemic to the ecology of the landscape. Assessment and identification can involve taking inventory of trees, shrubs, ornamentals and even turf. A careful assessment of the ecology also provides information on the strengths and weaknesses of the landscape, such as determining the amount of runoff that contributes to water pollution. It is also very important to identify and distinguish maintenance zones, noting exactly the areas that require high maintenance and those that receive less traffic and are less visible. Identification and assessment are extremely important because they will help determine the associated costs related to landscaping.

Devising the Plan

After gathering important information about the landscape, get ready to devise a plan. Once your landscaping needs have been identified, make a list of overarching goals and organize them into an action plan that prioritizes each of the landscaping needs. Include measures to:

- Maximize use of native plants.
- Maximize the efficiency of irrigation practices.
- Minimize the presence of disease and pests.
- Minimize the use of pesticides using integrated pest management techniques.
- Maximize the health of soil and plants through selective pruning, composing and mulch, and controlled fertilizer use.

- Maximize the safety and cleanliness.
- The main focus of the plan should be centered on:
- Operating an effective grounds maintenance organization.
- Accomplishing economy of operations.
- Recruiting and training highly proficient personnel.
- Developing and implementing effective, functional, and safe procedures and methods.
- Selecting and employing the most safe and effective supplies and equipment.

Revising the Plan

Make sure to allow stakeholders and interested parties to contribute to developing and revising the plan to ensure the quality of the landscape management program.

Here is a list of important questions to ask when developing a landscape management plan:

- Does the plan acknowledge the importance of selecting material and equipment that contributes to efficient grounds operations?
- Does the district budget provide for the necessary funds to execute the details of the plan?
- Are annual budgets able to cover the costs of maintaining and replacing old equipment?
- What are the costs related to executing each of the tasks in your proposed plan?
- How much will it cost to train staff or to hire knowledgeable groundskeepers, based on the specific landscape needs?
- Once these numbers are calculated, is there enough budget to set aside to pay for these needs?

Minimize Pesticide Use

- Create a list of environmentally preferable products, including least toxic pesticides, and eliminate or reduce products that have been deemed as highly toxic.
- Begin treating disease and pest control with least toxic pesticides first. Only use more toxic pesticides as a last resort and in minimal quantities.
- Keep records of all pest control methods.
- Whenever possible, control pest employing organic options.

Grounds Staff

It is imperative to hire grounds staff that have been properly trained and educated in the procedures set forth in the landscape management plan, as well as basic training in conducting themselves in a friendly, courteous manner. Consider requiring grounds staff to wear uniforms and maintain a well-groomed appearance. Develop a policy that requires all equipment to be immediately stored away after use, away from the reach of students.

Roles and Responsibilities

Several members of the maintenance and operations staff play an important role in the success of a landscaping program. Larger districts may hire different individuals to fulfill each of the roles listed below.

- Director of Maintenance and Operation
- Supervisor of Grounds Maintenance Services
- Head Groundskeeper
- Lead Groundskeepers
- Grounds Crew

- Sprinkler Repair Crew
- Chemical Application Groundskeepers
- Field Turf Mowing Groundskeepers
- Refurbishment Crew Groundskeepers
- Grounds Equipment Maintenance Persons
- Site Groundskeepers

Applicable Codes and Standards

The Healthy Schools Act of 2000 requires annual written notification to school staff and parents of all the pesticides expected to be used at the school site in the upcoming year. Schools must also post warning signs at each area where pesticides will be used, both before and after applications. Records of pesticide use must be kept and reports of pesticide use by licensed pest control professionals on school grounds must be submitted to the California Department of Pesticide Regulation (DPR) annually.

There are several types of pesticides that are exempt from these notification requirements. For a full list of exempt pesticides, visit
http://www.cdpr.ca.gov/cfdocs/apps/schoolipm/school_ipm_law/26_exempt_text5.pdf

Exempt or not, the California DPR recommends that schools keep complete records of all pest management activities, chemical or not, as part of an effective integrated pest management program.

For more information on the Healthy Schools Act, visit
http://www.cdpr.ca.gov/cfdocs/apps/schoolipm/school_ipm_law/main.cfm?crumbs_list=1,4

Benefits

Schools and districts are encouraged to come up with landscaping strategies that focus on improving student health and safety, especially because children and adolescents are most vulnerable to toxicity. The other great thing about establishing landscaping strategies is that they can save districts lots of money by ensuring that turf, physical education fields, playgrounds and irrigation systems are properly maintained and avoidable pest outbreaks are suppressed. Not to mention, well-maintained and healthy landscapes provide a beautiful setting for schools serving as a great source of pride for students, staff, and the community.

Costs

A strong landscaping maintenance plan will lower costs through more efficient use of staff time, lower water use, extended plant life, and reduced chemical pesticide purchases.

Monitoring/Controls

N/A.

Common Retrofit Opportunities

N/A.

Verification/Commissioning

N/A.

References/Additional Information

California Integrated Waste Management Board, School Waste Reduction – Maintenance and Operations, http://www.ciwmb.ca.gov/Schools/WasteReduce/Maintenance/

California State Department of Education, Administration of Maintenance and Operations in California School Districts: A Handbook for School Administrators and Governing Boards, 1986.

Guideline LP2: Turf/Grass

Recommendation

Focus on a pest and weed prevention strategy that combines routine mowing with monitoring for harmful pests and weeds before implementing any measures, such as aerating, fertilizing and pesticide application. When monitoring indicates that fertilizers and pesticides are needed, make sure to use only the exact amount needed and performing only spot treatments.

North Canyon High School – Football Stadium

Proper fertilization program is the backbone of any good maintenance program. A proper nitrogen program should be based on the requirements of your turf on your field, your location, the soil texture, and lastly your budget.

Photo source:
http://www.smarturf.com/09_05_03_services%20flyer.pdf

Description

Conducting a soil texture analysis at the onset of a landscaping project will provide insight into the soil's texture and nutrient deficiencies, thereby allowing you to determine the best strategies to improve and maintain turf. A soil texture analysis is performed to provide the soil content in terms of the proportions of sand, silt and clay particles existing in the soil. Soil texture determines almost all processes in the soil, such as the ability to absorb and distribute moisture and nutrients to plants.

Turf monitoring should be scheduled as part of the overall preventative maintenance plan. Measures for maintaining turf should focus on the following areas:

Pests and Pollution Prevention

- Maintain soil at proper moisture levels to prevent distressing turf.
- Use calibrated measurement tools to measure the appropriate amount of chemicals needed and to prevent excess fertilizer from seeping into environment as a pollutant. In general, do not apply Nitrogen fertilizers to turf more than three times a year and never apply more 250 lbs/ac Nitrogen at one time.
- Conduct spot treatments when applying chemicals. Apply fertilizer only to areas that desperately need it. Applying fertilizer to areas where plants do not grow increases weeds.
- Mow athletic fields once every week and mow lawns at least once every two weeks. Bag and recycle clippings from lawns that are only mowed every two weeks.
- Monitor turf for weeds, thatch, and pests when mowing the lawns. Consider keeping a record of turf problems.
- Aerate lawns when needed to alleviate compaction and reduce thatch.
- Use proper, working equipment and safety gear for protection.

Mowing

- Frequent mowing of turf can prevent thatch, stress, and weeds. It is important to establish a regular schedule for turf care, as follows.

  - High traffic areas, such as athletic fields, break areas and other congested areas should be mowed once every week after school or during class.
  - Areas with less activity, like between classrooms, should be mowed every two weeks.

- Select a rotary mower to cut cool season grass, such as marathon grass. Cut cool season grasses to about three-four inches. Cool season grasses prefer cool to warm temperatures, flourish in the spring and fall, and while they are dormant in the summer and winter, they have a relatively high winter tolerance.
- Select a reel mower to cut warm season grass, such as Bermuda grass. Cut warm season grasses to about 1 inch. Warm season grasses prefer warm to hot temperatures and grow best in the summer, but they have a poor winter and shade tolerance.
- Leave clippings in the ground when mowing is scheduled every week. Bag and recycle clippings when mowing is scheduled every two weeks. The longer you wait to mow, the more clippings you will need to bag and recycle.
- Monitor turf condition and moisture levels when mowing to determine if aerating, nutrients, or other measures are needed. Keep a record of findings.

Aerating

- Aerate compacted turf to improve nutrient and water uptake. Aerate turf once or twice a year, as needed. Schedule aerating in the early spring and/or late fall to aid in capturing the natural precipitation during non-weed germination periods.
- Aerate turf if the thatch is one-half inch or more.
- Water the turf the day before aeration to soften the soil. Turf that is too dry is difficult to aerate.
- Make enough passes with the aerator to make plug holes at **two-inch** intervals. Leave the plugs on the lawn surface for a few days to allow rain and irrigation water to wash the soil from the plugs. The remaining plugs can then be picked up, if desired.
- Core-aerate turf to get the most out of the labor put in. Core-aerators are more expensive, but turn out to be more cost-effective in the long run.
- Consider landscape layout and be careful not to puncture shallow irrigation systems when aerating.

Fertilizing

- Use fertilizer only when needed to correct or prevent nutrient deficiencies.
- Determine the nutrients that are deficient before applying amendments by performing regular soil tests and monitoring the color of the turf when mowing. Turf that is nitrogen deficient will demonstrate poor color, restricted growth, and poor density. Iron deficiencies can be detected by the yellowing of young turfgrass leaves. Phosphorous deficient grass has a dull blue-green color.
- Schedule fertilizer applications according to climate, location, and turfgrass species. Warm season grasses grow well in the summer and lay dormant in the winter. Cool season grasses grow well in spring, fall, and winter.
- Apply the minimum recommended amount of fertilizer needed to restore health. Over-application burns leaves and might lead to water pollution.
- Modify soil as needed, prior to fertilizing, to improve nutrient uptake.
- Split up applications of slow-release fertilizer to minimize the risk of nutrients leaching into groundwater or running off in surface water.
- Properly irrigate turf following fertilization to help grass utilize applied nutrients, but avoid excessive irrigation and washing away fertilizer.

Seed and Soil Amendments

- Schedule seed and soil amendment applications on an as-needed basis for correcting or preventing nutrient deficiencies in the soil. When installing turf, the data from soil tests will determine the types of amendments necessary for growing healthy turf.

Product Purchasing

In general, select products that:

- Contains only the nutrients or amendments that is needed.
- Last longer, such as slow-release chemical fertilizers.
- Are made of natural organic materials, including sewage sludge, animal manures, compost, or other by products containing plant nutrients. (These tend to be more expensive and bulky, however some municipalities and water districts may offer free supplies of sludge or compost.)

Applicable Codes and Standards

The Healthy Schools Act of 2000 requires annual written notification to school staff and parents of all the pesticides expected to be used at the school site in the upcoming year. Schools must also post warning signs at each area where pesticides will be used, both before and after applications. Records of pesticide use must be kept and reports of pesticide use by licensed pest control professionals on school grounds must be submitted to the California Department of Pesticide Regulation (DPR) annually.

There are several types of pesticides that are exempt from these notification requirements. For a full list of exempt pesticides, visit
http://www.cdpr.ca.gov/cfdocs/apps/schoolipm/school_ipm_law/26_exempt_text5.pdf

Exempt or not, the California DPR recommends that schools keep complete records of all pest management activities, chemical or not, as part of an effective integrated pest management program.

For more information on the Healthy Schools Act, visit
http://www.cdpr.ca.gov/cfdocs/apps/schoolipm/school_ipm_law/main.cfm?crumbs_list=1,4

Benefits

Beautiful, healthy turf is the product of successful turf maintenance practices, such as routine mowing, monitoring, and irrigating. Infrequent mowing and monitoring of turf causes thatch, compaction, and nutrient deficiencies to escalate into irreparable turfgrass, creating unwanted labor and high cost. Proper maintenance of turf results in an attractive lawn, with good color, density and uniformity. The environmental benefits of healthy turf are numerous, as healthy turf contributes to the preservation and protection of soil, air and water resources.

Costs

Equipment Costs

Look for durability in a mower—some can last over 30 years—to reduce long-term costs of maintaining or replacing the equipment, rather than selecting a machine based only on first cost. Save costs by applying chemicals and amendments only where needed, meaning performing spot treatments.

According to data from the 32nd annual M&O Cost Study, the national mean cost for grounds maintenance is $20.71 per student.

Monitoring/Controls

As mentioned above, routine monitoring can prove to be extremely cost-effective because it allows you to prevent the occurrence of escalated damage levels caused by pests or nutrient deficiencies and allows

you to pinpoint the areas that need help, so you only have to purchase and apply treatments for the specific areas in need.

Common Retrofit Opportunities

Consider installing advanced irrigation systems to control runoff, erosion and sediment contamination.

Verification/Commissioning

N/A.

References/Additional Information

Green Industries of Colorado, Best Management Practices for the Conservation and Protection of Water Resources, http://www.greenco.org/bmp_list.htm.

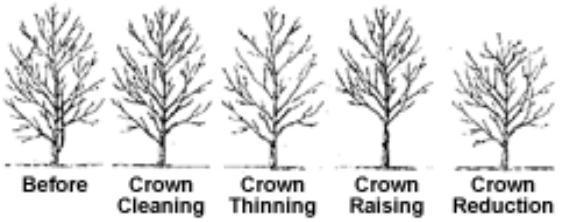
University of Massachusetts, Plant Culture and Maintenance, http://www.umassgreeninfo.org/fact_sheets/plantculture.html

U.S. Environmental Protection Agency, Integrated Pest Management (IPM) in Schools, http://www.epa.gov/pesticides/ipm/index.htm

Guideline LP 3: Trees

Recommendation

- Schedule routine maintenance procedures vital for the health and aesthetic quality of trees, including regular monitoring for stress, as well as proper pruning, irrigation, fertilization and disease/pest control.
- Focus on weed and pest prevention strategies that combine routine pruning with monitoring for weeds and other pests to determine if measures such as fertilizing techniques are required. Use fertilizers and pesticides only when absolutely necessary and make sure to use only the exact amount needed, following labels carefully.



Mature trees should require very little regular pruning. It is important to maintain an even distribution of foliage along large limbs and in the lower portion of the crown.

Graphic taken from the International Society for Arboriculture, http://www.treesaregood.com/treecare/pruning_mature.asp

Description

Make sure to closely follow tree maintenance guidelines (as set forth by the International Society for Arboriculture) to keep up with the changing needs of trees, which depend on the season, age and species of tree, site conditions, etc.

Monitoring for stress, disease and pests should be scheduled as part of the overall preventative maintenance plan. Focus tree maintenance strategies to ensure healthy and beautiful trees, as stated in the following:

Pests and Pollution Prevention

- Monitor trees to identify strengths and weaknesses of existing landscape to eradicate weeds and other pests. Consider keeping a record of observations.
- Maintain proper moisture and pH levels of the soil to ensure healthy trees. Adjusting pH levels is important because specific plants grow best within a certain range of pH and also because pH affects the availability of both major and minor nutrients.
- Use calibrated measurement tools to measure the appropriate amount of chemicals needed and to prevent excess fertilizer from seeping into environment as a pollutant. Focus fertilizer applications to areas that desperately need it. To prevent weeds, do not apply fertilizer to tree trunks or to areas where plants do not grow.
- Maintain a buffer zone along waterways where chemicals are not applied in accordance with product labels, local ordinances and state and federal regulations to keep chemicals out of surface water-bodies.

Watering

Determine the specific water needs of each type of tree in your landscape and follow the watering guidelines available. Watering trees regularly is a simple and vital measure to maintain the life and health of trees. Typically, irrigation systems do not provide adequate water for trees.

Pay close attention to young trees, as they require adequate watering applied directly to roots.

Mulching

Mulching is an inexpensive measure that improves root growth and soil structure, while reducing soil erosion, compaction and tree trunk and root damage. Organic mulches, which are made up of (organic materials) wood chips, shredded leaves, etc., to improve soil structure and protect trees from weeds and

similar pests. Inorganic mulches, made up of crushed rock, gravel, etc., for a longer lasting mulch effect. Note that inorganic mulches do not decompose into nutrients, like organic mulch, however they last longer and protect better against weeds and disease.

- Before using mulch make sure that you aware of the ingredients, as some mulches can create adverse reactions.
- Do not apply mulch directly to the base of the tree's trunk. Leave a space between 6 in. – 12 in. in diameter around the tree trunk.
- According to Journal of Arboriculture[5], a rule of thumb for how much mulch to use is 2 feet of mulch per inch of trunk (in diameter).
- When using organic mulches, make sure to monitor closely in drought conditions, as they are prone to burn in dry conditions.

Pruning

Pruning trees restores and maintains health; reduces risk of limb falling; improves aesthetic quality; and enhances views.

- Schedule frequent pruning to maximize plant health. It is important to establish a regular arbor care schedule to promote healthy and lush trees.
- Keep leaves, grass clippings, and other ornamental wastes cleared off the sidewalks and streets so they don't wash into storm drains and ultimately into streams and ponds. Power blowers should be used to blow clippings onto grass, not into the gutter.
- Frequently remove dead or dying plants and all weeds that compete with healthy plants for available water. Clean up plant litter and remove weeds before they go to seed.
- Schedule regular pruning according to the specific design and species of the landscape.
- Use proper handling of equipment and utilize safety gear for protection. Perform routine inspections of equipment to determine when maintenance and repair are needed.
- Physically pull weeds out by hand, digging or cultivation, before resorting to chemical use.
- Properly prune young trees to develop structures so they are well suited to the site and their intended landscape function.
- Mature trees require little regular pruning. Improper pruning of mature trees can cause irreversible damage to trees. Limit pruning of large trees to the removal of dead or potentially hazardous limbs.
- Prune trees to remove dead, broken, insect-ridden and diseased branches to maximize plant health and to minimize pest invasion. For branches that are heavily infested with scale insects, pruning can be effective management strategy.

Fertilizing

- Use fertilizer only when needed for correcting or preventing nutrient deficiencies; establishing newly planted trees and shrubs; or enhancing foliage color and plant appearance
- Schedule fertilizer applications according to climate, location, and plant species. In general, fertilizers are best applied in late August through September when root absorption of nutrients is very efficient. Nitrogen absorbed in the fall is stored and converted to forms used to support the spring flush of growth. The next best time to fertilize woody plants is early spring prior to initiation of new growth.
- Apply the minimum recommended amount of fertilizer. Over-application burns leaves and may lead to water pollution.

5 Gilman, E.F. 2002. Trees for urban and suburban landscapes: an illustrated guide to pruning. 2nd ed. Albany, NY: Delmar Publishers. 330 p.

- Modify soil as needed, prior to fertilizing, to improve nutrient uptake.
- Utilize split applications of slow-release fertilizer to minimize the risk of nutrients leaching into groundwater or running off in surface water.
- Properly irrigate soil following fertilization to help grass utilize applied nutrients, while avoiding excessive irrigation, washing away fertilizer.

Seed and Soil Amendments

Schedule seed and soil amendment applications on an as needed for correcting or preventing nutrient deficiencies in the soil.

Product Purchasing

In general, select products that:

- Contains only the nutrients or amendments that is needed.
- Last longer, such as slow-release chemical fertilizers.
- Are made of natural organic materials, including sewage sludge, animal manures, compost, or other by products containing plant nutrients. (These tend to be more expensive and bulky, however some municipalities and water districts may offer free supplies of sludge or compost.)

Applicable Codes and Standards

Prune tress in accordance to the International Society for Arboriculture (ISA) Standards.

Benefits

Proper maintenance of soil fertility and attention to plant nutritional requirements is at the heart of an effective plant health care program.

Costs

According to data from the 32nd annual M&O Cost Study, the national mean cost for grounds maintenance is $20.71 per student.

Monitoring/Controls

N/A.

Common Retrofit Opportunities

N/A.

Verification/Commissioning

N/A..

References/Additional Information

Green Industries of Colorado, Best Management Practices for the Conservation and Protection of Water Resources, http://www.greenco.org/bmp_list.htm.

International Society of Arboriculture, Tree Care Information, http://www.treesaregood.com/treecare/treecareinfo.asp

University of Massachusetts, Plant Culture and Maintenance, http://www.umassgreeninfo.org/fact_sheets/plantculture.html

Guideline LP 4: Ornamentals

Recommendation

Focus on weed and pest prevention strategies that combine routine pruning with monitoring for weeds and other pests to determine if measures such as proper aerating and fertilizing techniques are required. When fertilizers and pesticides are needed, make sure to use only the exact amount needed, following labels carefully.

Proper fertilization is the backbone of any good maintenance program. Photo source: http://bestplants.chicago-botanic.org/

Description

Conducting a soil texture analysis at the onset of a landscaping project will provide insight into the soil's texture and nutrient deficiencies, thereby allowing you to determine the best strategies to improve and maintain ornamentals.

Monitoring should be scheduled as part of the overall preventative maintenance plan. Measures for ornamentals should focus on the following areas:

Pests and Pollution Prevention

- Maintain proper moisture and pH levels of the soil to ensure healthy ornamentals. Adjusting pH levels is important because specific plants grow best within a certain range of pH and also because pH affects the availability of both major and minor nutrients.
- Use calibrated measurement tools to measure the appropriate amount of chemicals needed and to prevent excess fertilizer from seeping into environment as a pollutant. Focus fertilizer applications to areas that desperately need it. To prevent weeds, do not apply fertilizer to areas where plants do not grow.
- Use compost, well-rotted manures and sewage sludge to fertilize woody plants. When purchasing bulk quantities of these organic materials, always request a nutrient analysis of the product.
- Incorporate phosphorous, potassium and limestone according to a soil test report. Avoid placing water-soluble nitrogen fertilizer directly in the planting hole to avoid injury to roots.
- Monitor ornamentals to identify strengths and weaknesses of existing landscape to eradicate weeds and other pests. Consider keeping a record of observations.
- Maintain a buffer zone along waterways where chemicals are not applied in accordance with product labels, local ordinances and state and federal regulations to keep chemicals out of surface water-bodies.
- Before moving directly to utilizing chemicals to control weeds.

Pruning

- Frequent pruning of ornamentals is key to maximizing plant health. It is important to establish a regular ornamental care schedule to promote healthy and lush plants, shrubs, trees and flowers.
- Keep leaves, grass clippings, and other ornamental wastes cleared off the sidewalks and streets so they don't wash into storm drains and ultimately into streams and ponds. Power blowers should be used to blow clippings onto grass, not into the gutter.
- Frequently remove dead or dying plants and all weeds that compete with healthy plants for available water. Clean up plant litter and remove weeds before they go to seed.

- Schedule regular pruning according to the specific design and species of the landscape.
- Use proper handling of equipment and utilize safety gear for protection. Perform routine inspections of equipment to determine when maintenance and repair are needed.
- Leave clippings in the ground when mowing at least once a week. Bag and recycle clippings when mowing every two weeks.
- Physically pull weeds out by hand, digging or cultivation, before resorting to chemical use.
- Properly prune young trees to develop structures so they are well suited to the site and their intended landscape function.
- Prune trees to remove dead, broken, insect-ridden and diseased branches to maximize plant health and to minimize pest invasion. For branches that are heavily infested with scale insects, pruning can be effective management strategy.

Organic Substitutes

- Use mulches to exclude weeds.
- Consider using specific insects and plant pathogens to control weeds.

Fertilizing

- Use fertilizer only when needed for correcting or preventing nutrient deficiencies; establishing newly planted trees and shrubs; or enhancing foliage color and plant appearance
- Schedule fertilizer applications according to climate, location, and plant species. In general, fertilizers are best applied in late August through September when root absorption of nutrients is very efficient. Nitrogen absorbed in the fall is stored and converted to forms used to support the spring flush of growth. The next best time to fertilize woody plants is early spring prior to initiation of new growth.
- Apply the minimum recommended amount of fertilizer. Over-application burns leaves and may lead to water pollution.
- Modify soil as needed, prior to fertilizing, to improve nutrient uptake.
- Utilize split applications of slow-release fertilizer to minimize the risk of nutrients leaching into groundwater or running off in surface water.
- Properly irrigate soil following fertilization to help grass utilize applied nutrients, while avoiding excessive irrigation, washing away fertilizer.

Seed and Soil Amendments

- Schedule seed and soil amendment applications on an as needed for correcting or preventing nutrient deficiencies in the soil.

Product Purchasing

In general, select products that:

- Contains only the nutrients or amendments that is needed.
- Last longer, such as slow-release chemical fertilizers.
- Are made of natural organic materials, including sewage sludge, animal manures, compost, or other by products containing plant nutrients. (These tend to be more expensive and bulky, however some municipalities and water districts may offer free supplies of sludge or compost.)

Applicable Codes and Standards

Prune tress in accordance to the International Society for Arboriculture (ISA) standards.

Benefits

Proper maintenance of soil fertility and attention to plant nutritional requirements is at the heart of an effective plant health care program.

Costs

According to data from the 32nd annual M&O Cost Study, the national mean cost for grounds maintenance is $20.71 per student.

Monitoring/Controls

N/A.

Common Retrofit Opportunities

N/A.

Verification/Commissioning

N/A.

References/Additional Information

Green Industries of Colorado, Best Management Practices for the Conservation and Protection of Water Resources, http://www.greenco.org/bmp_list.htm.

University of Massachusetts, Plant Culture and Maintenance, http://www.umassgreeninfo.org/fact_sheets/plantculture.html

Guideline LP 5: Hardscape

Recommendation

Focus on a pollution prevention strategy that combines routine inspections with cleaning of hazardous wastes, graffiti, and trash along fields and exercise paths; PE/recreation areas; courts, sidewalks, parking lots, bike paths and similar hardscape areas.

Hoover School, Redwood City, CA.

Source: http://www.rcsd.k12.ca.us/depts/const/measureb_schools/hoover.htm

Description

Conducting daily hardscape inspections will prevent exposure to hazardous materials and allow early detection of cracks.

Measures for maintaining hardscape should focus on the following areas:

Pollution prevention

- Conduct daily inspections of hardscape for hazardous materials and picking up waste.
- Schedule routine cleaning.
- Conduct daily inspections for graffiti and immediately submit request for removal.
- Dispose of trash at the end of each school day.
- Hose areas where liquid materials have been spilled.

Inspections for Hazardous materials

- Inspect field and exercise paths once everyday, disposing any debris that is found.
- Sweep and empty trashcans placed in PE areas once everyday.
- Inspect play structures and areas for hazardous materials and pick up wastes once everyday.
- Inspect courts and hardscape once every day for hazardous materials, condition of equipment, all the while picking up litter that is found.
- Dispose trash at the end of each school day.
- Conduct daily inspections for graffiti and remove as soon as possible.

Applicable Codes and Standards

N/A. See the Recycling and Waste Management chapter for information on trash removal for these areas.

Benefits

Hardscape maintenance is important because it ensures that students are protected from exposure to hazardous wastes and that your outdoor environment is clean and beautiful.

Costs

According to data from the 32nd annual M&O Cost Study, the national mean cost for grounds maintenance is $20.71 per student.

Monitoring/Controls

N/A.

Common Retrofit Opportunities

Consider pervious options when major repairs are needed.

Verification/Commissioning

N/A.

References/Additional Information

California Integrated Waste Management Board, School Waste Reduction – Maintenance and Operations, http://www.ciwmb.ca.gov/Schools/WasteReduce/Maintenance/

City of Santa Monica, Elementary School Playground Access Program Plan, http://www.santa-monica.org/ccs/current_park_projects/playplan.htm

Firehouse.com, Safe Kids: Playground Injury, http://www.firehouse.com/safekids/factsheets/play_inj.html

National Program for Playground Safety/University of Iowa, Equipment Maintenance Guidelines for Playgrounds, http://www.uni.edu/playground/tips/SAFE/equipment_guidelines.html

Guideline LP 6: Playgrounds

Recommendation

Avoid placing asphalt, concrete, grass and soil surfaces under playground equipment for younger children. Acceptable loose-fill materials include hardwood fiber mulch or chips, pea gravel, fine sand and shredded rubber. Surfacing should be maintained at a depth of 12 inches and should extend a minimum of 6 feet in all directions around stationary equipment. Rubber mats, synthetic turf and other artificial materials also are safe surfaces and require less maintenance.

Focus on risk prevention strategies that combine routine comprehensive inspections and cleaning of playground areas and equipment.

Fairmont Elementary School, Denver, CO.

Photo taken from http://fm.dpsk12.org/psphotos_pgs/pages/frmnt35.htm

Description

Conduct daily playground inspections to prevent exposure to hazardous materials and for early detection of cracks.

Measures for maintaining playgrounds should focus on the following areas:

Planning

- Set and enforce daily, monthly and annual playground maintenance schedules.
- Ensure that equipment are age-appropriate and well-maintained, and that trained supervisors are present at all times when children are on the playground.
- Maintain separate play areas for children under age 5.
- Send letters to parents outlining playground rules, such as removing hood and neck drawstrings from all children's outerwear. Never allow children to wear necklaces, purses, scarves or clothing with drawstrings while on playgrounds.

Risk prevention

- Conduct daily inspections of playgrounds for broken equipment, hazardous wastes and cracks in the pavement.
- Conduct daily inspections for graffiti and immediately submit request for removal.
- Hose areas where liquid materials have been spilled.

Inspections for Hazardous materials

- Conduct a comprehensive inspection of all playgrounds at the end and/or beginning of each day.
- Report any playground safety hazards to the administration or district.

Weekly Inspections

- Inspect the depth of loose-fill cushioned surfacing, such as wood chips or pea gravel that might have been displaced because of use.
- Place 12" of loose-fill surfacing under and around the playground equipment.

- Sweep and remove debris from accessibility paths such as rubber mats or poured-in-place surfaces, such as sand, dirt or any loose-fill surfaces.
- Inspect for trash, protruding glass, can lids, sharp rocks, metal and other items, that should be removed immediately.
- Inspect equipment for damage.
- Inspect for vandalism and report occurrences immediately.
- Pay close attention to playground equipment that receives the most or high usage for hazards like broken or missing handrails, guardrails, steps or signs.

Monthly, Quarterly or Annual Inspections

- Monitor for compaction or deterioration of loose-fill surfacing materials such as wood chips, pea gravel or sand.
    - Add as much additional material needed to provide adequate cushioning of surfaces under playground equipment. The recommended level of loose-fill is about 12 inches.
- Inspect playground equipment for broken, loose, worn or missing parts.
    - Check for sharp points, corners or edges.
    - Do an up-close inspection of bolts, welding points and moving parts.
    - Check swings for severe wear, openings on S-hooks and wear of bearing hangers.
    - Check merry-go-rounds for wear of gear boxes and governors regulated for speed.
    - Verify that protective caps or plugs on equipment, such as ladders and climbers, are in place and replace if needed.
    - Conduct general a walk-through to reveal trip hazards, such as exposed concrete footings or anchoring devices, rocks, roots or uneven surfacing materials.
    - Inspect wooden equipment for splinters, large cracks and deterioration.
    - Apply wood preservative once a year to help prevent deterioration (preservatives should meet both CPSC guidelines and ASTM standards.
    - Inspect metal equipment and pieces for rust or deterioration.
    - Repaint metal equipment that is in need of painting. Use paints or similar finishes that contain no more than 0.06% lead by dry weight.
    - Test for lead paint on equipment purchased before 1978 unless manufacturer documentation states that non-lead paint was used.
    - Inspect drainage in the playground areas:
    - Check that water does not collect under or near equipment, especially under slide and swing areas.

General Safety Points

- Make sure that openings on playground are smaller than 3½ inches or larger than 9 inches in areas where a child's head or body could be trapped.
- Make sure that there are not any v-shaped openings or open areas close to the top of slides, where strings or ropes could get caught and cause strangulation.
- Make sure that cushioning is placed under or near the fall zone for play equipment.
- Do not place more than two swings in a bay or support structure and make sure that swings are placed at least 24" apart at the base and 30" from the side supports.

- Make sure that all S-hooks on equipment are closed, such as on teeter-totters, where fingers could get pinched.
- Remove all hard animal swings that can ram into a child.

Applicable Codes and Standards

The National Program for Playground Safety recommends compliance with U.S. Consumer Product Safety Commission (CPSC) playground safety guidelines in its *Handbook for Public Playground Safety*. Playgrounds, whether they are old, recently installed or just a few years old, need to be inspected. Manufacturer's recalls, warnings or updates should be observed. CPSC warnings should be taken into consideration.

Benefits

Most maintenance of equipment involves making sure the equipment's surfaces and mechanical workings are safe for children to use. Protecting students from danger on playgrounds is extremely important and easily managed by abiding by maintenance and general safety tips and schedules.

Costs

According to data from the 32nd annual M&O Cost Study, the national mean cost for grounds maintenance is $20.71 per student.

Monitoring/Controls

N/A.

Common Retrofit Opportunities

N/A.

Verification/Commissioning

N/A.

References/Additional Information

California Integrated Waste Management Board, School Waste Reduction – Maintenance and Operations, http://www.ciwmb.ca.gov/Schools/WasteReduce/Maintenance/

City of Santa Monica, Elementary School Playground Access Program Plan, http://www.santa-monica.org/ccs/current_park_projects/playplan.htm

Firehouse.com, Safe Kids: Playground Injury, http://www.firehouse.com/safekids/factsheets/play_inj.html

National Program for Playground Safety/University of Iowa, Equipment Maintenance Guidelines for Playgrounds, http://www.uni.edu/playground/tips/SAFE/equipment_guidelines.html

U.S. Consumer Product Safety Commission, http://www.cpsc.gov/

Guideline LP 7: Irrigation Systems

Recommendation

Focus on strategies that maximize irrigation system performance and efficiency. Sustain the landscape by updating irrigation systems according to the dynamic water needs of turf and ornamentals. Incorporate evapotranspiration (ET) and precipitation data in irrigation scheduling. Develop an efficient irrigation by using previous data from audits or future audits.

Photo reprinted with permission from Rain Bird Sprinkler Mfg. Corp.
http://www.rainbird.com/rbturf/products/xeri/xeri.htm

Description

Irrigation systems should be scheduled to operate on a regular basis, according to the specific watering needs of turf, ornamentals, and other plant life. Perform regular tests and checks to determine the amount of water that is needed to maintain the health and quality of your landscape.

The following areas should be focused on when managing irrigation systems:

Prevention

- Perform regular inspections to optimize irrigation equipment:
- Equipment maintenance should be performed on a weekly basis, which includes checking equipment for damage, such as leaks, or adjustments and then performing the adjustment or repair necessary.
- Perform in-depth inspections of irrigation systems after annual activation in the spring, and bring systems up to specified operating conditions.
- Prioritize future irrigation system improvements by maintaining a record of repairs that are needed, especially for large irrigation systems.
- Check the backflow prevention device to make sure it works properly.
- Hire a certified landscape irrigation auditor at least once every five years to conduct a thorough and comprehensive efficiency check for properties that are one acre or larger.
- If and when irrigation water runs onto hardscape, such as sidewalks, streets, or driveways, immediately shut off irrigation systems and adjust. Look for signs of leakage, such as overgrown or particularly green turf areas, soggy areas around spray heads and aboveground hoses, jammed spray heads and torn hoses.
- Adjust water pressure as needed. Make sure that water pressure is properly set to minimize wind effects. Make sure that the water supply and pressure meet design specifications. Differences in the sprinkler system's required design operating pressure and actual water pressure can affect operation and efficiency. Install pressure reducing valves (PRVs) where needed to stop misting due to excessive pressure.
- Perform regular and annual inspections of system components to confirm that equipment and equipment components meet the original criteria for efficient operation and uniform distribution of water, including:
    - Water valves: 1) Adjusted for proper flow and operation and 2) To ensure proper shutdown of valves.

  - Sprinkler heads: 1) Adjusted properly and 2) Cleaned to remove debris that might cause blockage or buildup.
  - Sensors: 1) Adjusted properly and 2) Calibrated according to specifications.
- When possible, use originally specified materials to repair or replace broken hardware and pipes. Make sure to test all repairs.
- Upon plant maturation, add or relocate system components as needed to maintain uniform distribution of water. When performing system modification, do not exceed the system watering capacity.
- Select a reliable irrigation maintenance contractor that is licensed, experienced and reputable.

Updating Plant Water Needs

- Regularly update and adjust the irrigation system in response to the changing/seasonal landscape water needs using specific measures, which include:
- Modify and inspect automatic controllers according to the seasonal needs of plants.
- Understand and use a reliable source for reference evapotranspiration rates. Appropriately modify the reference evapotranspiration to calculate local water needs for the needs for the various plant materials and turfgrass in the landscape.
- Periodically verify that plant material is healthy and that soil moisture is adequate. Use a soil probe to visually inspect root depth, soil structure and moisture.
- The irrigation system is a management tool and cannot replace the sound judgment of trained professionals. The best-designed irrigation system will fail without regular maintenance.

Applicable Codes and Standards

Properties one acre or larger must employ a certified landscape irrigation auditor at least once every five years to conduct a thorough and comprehensive check for efficiency of water application.

Benefits

Taking good care of irrigation systems can save districts lots of money, in terms of water bills and labor. Properly maintained irrigation systems also conserve water and keep landscapes looking beautiful and healthy.

Costs

Establish a water budget based upon system performance and plant water requirements. Then measure and compare actual water usage to the amount of water needed.

Monitoring/Controls

N/A.

Common Retrofit Opportunities

CHPS suggests updating and retrofitting existing irrigation systems and water catch equipment to take advantage of new water-saving technology, such as rain shut-off devices, drip irrigation.

Verification/Commissioning

N/A.

References/Additional Information

Green Industries of Colorado, Best Management Practices for the Conservation and Protection of Water Resources, http://www.greenco.org/bmp_list.htm.

University of Massachusetts, Plant Culture and Maintenance, http://www.umassgreeninfo.org/fact_sheets/plantculture.html

Guideline LP 8: Outdoor Pest Management

Recommendation

Focus on a pest prevention strategy that combines regular monitoring and record keeping with measures to keep pest numbers low enough to prevent serious damage or annoyance. When chemical controls are needed, minimize risk by applying spot treatments and using the least-toxic formulation that is effective.

The goal of a school IPM program is to ensure student health by suppressing harmful pests.

http://www.pestworld.org/

Description

Pesticide treatments should be scheduled an as-needed basis. Measures for pest management should focus on the following areas:

Pest Management

- Monitor regularly pest populations and relevant factors that contribute to pests.
- Accurately identify pests that have been discovered.
- Determine injury and action levels that trigger treatments.
- Time treatments according to data obtained from monitoring.
- Implement spot treatments of chemicals to minimize human exposure and costs.
- Implement strategies that are least disruptive.
- Evaluate effectiveness of treatments to better future actions.
- Educate all people involved with the pest problem.

Monitoring

- Frequent monitoring of areas where pest problems might occur includes both regular observation and recording. It is important to establish a regular schedule for monitoring.
- Plants and their pests: Observe and record the condition of the plant; the kind and abundance of pests; the amount of plant damage; and management activities, such as pruning, and their effects on the plant pest population.
- Monitor plants beginning in spring, when plants put out new leaves, until autumn, when leaves fall. Incorporate monitoring into routine grounds maintenance activities, such as weekly mowing.
- Keep records when you are monitoring to prevent erroneous conclusions and to best manage pest. When recording, include the identification of the pest, the location, the time and the name of the person monitoring.

Criteria for Selecting Strategies

- Select chemicals that are least hazardous to human health, as children are particularly vulnerable toxics.
- Choose chemicals that do not disrupt the settings of your landscape by killing non-target organisms and natural enemies that aid in pest control.
- Find treatments that are most likely to have permanent effects.
- Take measures to prevent recurrence:

- Educate students and staff on how their actions affect pest management.
- Caulk cracks and crevices to reduce insect harborage and entry.
- Institute sanitation measures to reduce the amount of food available to ants, cockroaches, flies, rats, etc.
- Clean gutters and direct their flow away from the building to prevent moisture damage.
- Install a sand barrier around the inside edge of a foundation to prevent termites from crawling up into the structure.
- Use an insect growth regulator to prevent fleas from developing in an area with chronic problems.
- Apply pesticides that are relatively simple and safe to carry out.

Applicable Codes and Standards

The Healthy Schools Act of 2000 requires annual written notification to school staff and parents of all the pesticides expected to be used at the school site in the upcoming year. Schools must also post warning signs at each area where pesticides will be used, both before and after applications. Records of pesticide use must be kept and reports of pesticide use by licensed pest control professionals on school grounds must be submitted to the California Department of Pesticide Regulation (DPR) annually.

There are several types of pesticides that are exempt from these notification requirements. For a full list of exempt pesticides, visit
http://www.cdpr.ca.gov/cfdocs/apps/schoolipm/school_ipm_law/26_exempt_text5.pdf

Exempt or not, the California DPR recommends that schools keep complete records of all pest management activities, chemical or not, as part of an effective integrated pest management program.

For more information on the Healthy Schools Act, visit
http://www.cdpr.ca.gov/cfdocs/apps/schoolipm/school_ipm_law/main.cfm?crumbs_list=1,4

Benefits

Regular inspection will allow staff to identify and respond to any pest problems before the infestation becomes significant. Reduced use of chemical pesticides protects the environment and the health of staff and students.

Costs

According to data from the 32nd annual M&O Cost Study, the national mean cost for grounds maintenance is $20.71 per student.

Monitoring/Controls

N/A.

Common Retrofit Opportunities

N/A.

Verification/Commissioning

N/A.

References/Additional Information

Green Industries of Colorado, Best Management Practices for the Conservation and Protection of Water Resources, http://www.greenco.org/bmp_list.htm.

U.S. Environmental Protection Agency, Integrated Pest Management (IPM) in Schools, http://www.epa.gov/pesticides/ipm/index.htm

Snow Management and De-Icing

Winter brings with it a multitude of variables and modifications to operations within a school district. Costs are always a factor in operating in and dealing with areas of snow and ice. Budgets at school districts throughout the country and within various areas of California are stretched to the limit, as districts contending with these additional expenses are sometimes expected to use the same funds and calculations as districts without harsh winter conditions.

Conditions vary greatly between districts contending with snow and ice. They differ in severity, temperature variables, terrain, and duration. While this section provides recommended best practices for managing snow and ice at school sites, the unique conditions at an individual location should always be taken into account.

- Snow Management Plan (Guideline SI1)
- Contracting vs. In-house Staffing and Equipment (Guideline SI2)
- Snow Removal for Parking Areas/Bus Lanes (Guideline SI3)
- Snow Removal for Walkways/Doorways (Guideline SI4)
- Snow Removal for Roofs (Guideline SI5)
- Winterizing Equipment and Grounds (Guideline SI6)

Guideline SI1: Snow Management Plan

Recommendation

Always plan for at least a *moderate winter* season when considering in-house personnel and equipment needs, but plan for *severe winters* with regards to materials (such as rock salt, de-icers, sand). Materials costs are not usually excessive, and carry-over inventory is beneficial since the next year will likely bring increased cost for the same materials

Base the snow management plan on a needs assessment, which includes understanding the potentials for changing conditions; researching the conditions and needs faced during prior years; evaluating current equipment conditions, repair histories and costs; reviewing personnel that operate equipment of all types; and determining training needs.

Glenshire Elementary School, CA.
(source: Tahoe Truckee Unified School District)

Description

Planning and implementation is necessary for an effective winter operations program. It is important that the plan addresses many different scenarios, including condition changes within one storm or event.

Planning should include:

- In-house personnel staffing, hours, operational hours in equipment, rest periods, time to ramp, store, and prepare for additional snow deposits.
- Timing of snow removal in relation to school start times, bus departures and arrivals, staff arrival times, sanding needs and timing, and conditions and duration of any given storm.
- Wind-driven drift locations, snow storage locations, vehicle arrival times and parking plans for removing hazards and promoting safety.
- Fueling, including capacities, provisions for refueling, and fuel storage.
- Providing for leased equipment, blades, and chains.
- Preparation timeline for winterizing owned equipment, such as chains, tires, blade turns or replacements, antifreeze, and indoor parking.
- Snow staking, debris removal, surface inspection and repair, sanding operation coverage in relation to needs as opposed to areas of negative impact.
- Refresher training in equipment operation, proper lifting and shoveling techniques, chemical and fuel acquisition, use, handling, storage, and disposal.
- Material purchasing, handling, storage, and distribution.
- Communications procedure as they relate to call out, on-call, emergencies, school closures, road closures, and delayed starts.

Later guidelines address some of these areas in more detail, as each relates to the overall plan and a successful snow management operation.

Potential Contingencies

Contingencies should be accounted for in any well-laid plan. Contingencies can come in many forms:

- Severity, duration, timing, and direction of a storm as differing from weather forecasts.
- Equipment breakdowns.
- Contractor and / or in-house personnel no-shows or late starts.
- Frozen fuel lines and hydraulics.
- Visibility issues and white-outs.
- Accidents.
- Communications breakdowns.
- Transportation (bus) impacts.

Note:

With removal of snow often at the heart of decisions to open school or have the notoriously student-pleasing "Snow-Day", it is incumbent for staff to plan for the worst (within economics and staffing), and hope for the best. To assist in dealing with possible breakdowns, overload, and understaffing on any given day, provisions for backup services should be made in as many areas as possible. An example would be to contract out services, strictly on a backup basis should in-house staff become overwhelmed. In an hourly arrangement, this is usually possible at no cost until services are used. However, remember that first in line for service may not be available in these instances.

The potential for a series of storms is also of great concern in preparing for one round of removal after another. As storms track across the ocean -- especially onto the west coast -- a pattern often develops bringing in storm after storm for extended periods that can last for weeks at a time. Resources and storage capacities can be stretched to capacity very easily. Planning and ongoing preparation can alleviate much of this problem.

The best defense in dealing with weather contingencies is to have reliable weather information. Informational web sites provide excellent information on up-to-the-minute changes in weather patterns and conditions. See the Resources section below for useful weather websites.

Time is of the Essence

Schools are a breed unto themselves in the world of snow removal operations. They offer distinct and difficult issues compared other property or business anywhere in the country.

Removal operations must coincide with site openings. The start of this activity is one of the most difficult scheduling problems faced by the maintenance and operations director. Not knowing when, how much, or how long a storm will last can create stressful situations for hours or days at a time. Multiple sites create a need to remove in conjunction with the opening schedules, which may not be in order of proximity. Removal in these instances must be viewed closely with regard to equipment, contractor(s), and minimizing costs.

These questions, along with whether or not roads will be open to allow school crews to get to removal equipment to start the clearing, often pose challenging and sleepless nights. Ultimately, the most important aspect is the safety of students and staff at the school site.

Clearing bus and transportation department locations must be completed even earlier than clearing at the school sites. The buses must be accessible if school is to open in areas where they are the main source of student transportation.

After School / Weekends / Holidays / Facility Users

Scheduling snow removal can be difficult enough when just dealing with school days. However, there are other schools use needs that require even more planning and communication.

Weekends and holidays when school is not being used require no snow removal except for fire lanes, which should be clearly communicated to staff and contractors. When events are scheduled for school sites during non-school hours, it is vital that this information is relayed to maintenance staff as early as possible so that snow removal can be scheduled if necessary. As long as the policy is agreed upon beforehand with the group leading the event, it may be possible to bill that organization for snow removal services performed for that after-hours meeting.

Note:

There is often a need for facility users to have snow removal services performed prior to their events. Users providing their own snow removal, and / or contracting out service, or volunteer member removal with or without equipment should be expressly prohibited unless additional insurance is involved, contracts reviewed and approved by the district, and repairs to damage are addressed.

To assist the users, and help prevent problems through litigation, damages, etc., it is for the most part, best to prearrange removal with established procedures already in place and offer hourly removal costs to the facility users.

Applicable Codes and Standards

N/A.

Benefits and Costs

Without understanding and planning for what is needed for operations, contingencies, emergencies, and resultant variables, an organization will most often operate in an emergency mode, which is inefficient and costly.

Monitoring/Controls

N/A.

Common Retrofit Opportunities

N/A.

Verification/Commissioning

N/A.

Resources

California Highway Patrol Traffic Incident Information Page. This site contains information on road conditions, accidents, chaining requirements, and weather related issues. http://cad.chp.ca.gov/.

National Weather Service, Internet Weather Source. This site features radar and weather maps for U.S. and international locations. http://weather.noaa.gov

San Francisco State University, Meteorology Department. This webpage shows daily jetstream information for the western and central U.S. http://squall.sfsu.edu/gif/jetstream_pac_init_00.gif.

Unisys Corporation, Enhanced Infrared Satellite Image Website, This site shows satellite weather images for all regions of the U.S. and Canada. http://weather.unisys.com/satellite/sat_ir_enh_west_loop-12.html.

Weather Underground Inc. This website allows users to search on weather, wind, humidity, heat index, and visibility conditions throughout the U.S. and the world. http://help.wunderground.com/

Guideline SI2: Contracting vs. In-house Staffing and Equipment

Recommendation

Carefully evaluate whether or not in-house staff and equipment are sufficient or if an outside snow removal contractor is needed for the larger site areas such as parking lots, playgrounds, and outdoor commons. While those are the largest areas of concern, this analysis should also take into account the labor needs of other areas such as roofs, walkways, doorways, and staircases.

This mid-sized snow blower is helpful for removing snow from roads and parking areas. School districts need to evaluate whether to contract out removal services for these larger campus areas.
(source: Tahoe Truckee Unified School District)

Description

When considering contracting vs. in-house resources, focus on the following questions:

- Are in-house personnel able to remove snow efficiently in the majority of situations, prior to the need for school opening?
- Is in-house equipment of sufficient size, power, and operational condition (i.e., dependability) to perform the work necessary for the task in the time frame needed?
- Are the sites being considered along with others in sufficient proximity as to make them part of the equation in time and ability?
- In multiple site situations, are any of the sites far enough away as to prohibit roading a piece of equipment to it when needed? Consider equipment size, dimensions of the blade or other accessories, road lighting, potentially severe road conditions, and danger to other drivers in this analysis.
- What pricing would a contractor provide as a comparison to committing in-house equipment and staff to the removal site?
- Will an outside contractor provide services to the location in a timely manner, prior to staff arrival and school opening? Will they provide verbiage in the contract that addresses this and guarantees the site will be priority on their list and not in-line with other removals? Are they also able to provide emergency service removals, if necessary? Will they provide fire-lane removal services when needed during long storms to both save costs and comply with fire access requirements?
- Will a contactor backup their services with additional equipment or piggyback the agreement to cover the site should the allocated equipment fail?
- Do the school start times vary enough within the district to allow sufficient time for in-house staff to address the snow removal needs, or is a contractor needed to support the operation?
- When considering areas of service, start times, allocation of funds for equipment, repairs, replacement costs, condition of equipment, and staffing requirements; is it economically feasible to cover any particular location?

In addition to in-house staff and contracting with outside contractors, there are some public agencies that may provide services for school district. (See Emergency Staffing Resources section below.). This

service can come in the form of no compensation, trade-offs, or direct reimbursement for services. All require a written agreement with insurances in place.

Contract Nuances

When entering into a contract for snow removal services, the basics of contractual agreement are no different than those of any other construction contract. However, there are several areas of concern that should be reviewed and either integrated into the contract or dismissed if not pertinent.

First, consider the manner in which the contract originates. Is it acceptable to sign a contract provided by the contractor, or should the district issue the contract? Some snow removal contractors refuse to do business unless their contract is in place. This is not an acceptable or desirable practice for a district to take unless there are no other options. If this is the only option, an attorney for the district should review the document for acceptability.

The contract should flow from the district to the contractor and include the following information:

- The exact location (address) and areas of removal to be performed. Provide a map of the locations included in the removal.
- The time by which the removal must be accomplished.
- The depth of snow that triggers removal, and a provision that unless that depth is met, removal will be considered unauthorized and non-compensative.
- A list of the equipment that is to be used in the removal, including backup equipment and the rates per hour at which they will be charged.
- A list of the marking of obstructions and areas of concern that must be done by the contractor, with a note to provide stakes that do not include PVC piping. (This is discussed in more detail in the guideline on Snow Removal in Parking Lots.)
- Language stating that damage to unmarked areas and property will be repaired at the expense of the contractor, unless pavement is in disrepair and is damaged during normal operations. Include a time frame for repairs keeping in mind safety issues developing from damage.
- Proof of insurances and workers' compensation policy, which will be provided prior to the contract taking effect.
- Requirements for fingerprinting process and approvals to be in place prior to employees working on school sites while school is in session, should that occur.
- Provisions for fire lanes to be plowed as necessary during holidays, weekends, and days when school is called off. Specify location and provide a map of the areas with minimum width to be cleared. California requires twenty feet in width; however check with local fire department for any special requirements.
- Verbiage relating to school late starts in regards clearing that may affect a contractor's ability to perform after the normal removal times.
- Requirements that snow to be stored and/or piled for removal at the discretion of the contractor should be clear of buildings, playing fields, and parking lots, and in no way creating a hazard to persons or property.
- Request for a copy of contractor's license and list of employees that will be performing removal operations.
- Verbiage mandating that the use of heavy equipment and removal operations halt when children are present. Special approval may be obtained in circumstances in which this is necessary.

Emergency Staffing Resources

Some snow removals can be planned, given certain pre-arranged conditions and potentials for additional snowfall. Sometimes emergency conditions arise where it is necessary to suddenly or immediately remove snow and existing resources cannot meet that need. In such situations, workforces must be identified and prearranged to take action under the most adverse conditions. The following are some of the potential workforces and labor pools that are available.

- **Contractors with removal crews for hire.** Contractors with removal crews for hire may provide additional or main support, depending on the number of individuals that sign up in-house, or even qualify for the work. It may be necessary to contract with several different contractors to provide the workforce needed or anticipated. Contracting with these companies prior to winter is sound practice to provide an available workforce with a fixed rate per hour per individual and a clause permitting the district to specify the size of the workforce at any given time prior to and during the removal operations. Contract verbiage should be specific to allow charges for this service to commence only when services are rendered and not charged for the arrangements only. Damage clauses should be included, and all insurances must be on file prior to the season commencing. This will permit smoother initiation of the actual work process when needed. In most cases, removal operations will occur after school hours on weekends and snow-days. However, specific employees of the contractor that may be asked to perform snow removal operations during school hours must be identified and processed to work while students are on premises according to statute and Ed Code.
- **California Department of Forestry and California Conservation Department.** Department of Forestry and Conservation may be called in an emergency; however it should be noted that these agencies often use convicted criminals on work programs. Arrangements for non-school hour work, special supervision and accounting must be instituted prior to arranging for resources of this type to be used. Regardless of the constraints placed on the agencies and the precautionary measures in place, the public, parents, and students will need to be informed of the activities as well as the security and safety arrangements. A public relations announcement is always a good, preemptive way to averting potential backlash and concerns.
- **Local municipality staff.** Local municipality contracting should be viewed in the same light as outside contractors. Contracts and specific requirements and expectancies should be reviewed and noted. It should also be remembered that if the district is in need of emergency snow removal services, conditions in the area are also likely to be straining local resources to the limit and may not be readily available.
- **Outside labor force through advertisement.** Outside labor for through advertising is accomplished in the same manner as temporary employees and should go through the usual pre-employment hiring process. This requires no set hours with only call out work as necessary with pre-established rates, bargaining unit approval and possible contract verbiage. This type of process is usually only permitted with bargaining unit members taking a first right of refusal status or when the in-house staff numbers have been exhausted.

Applicable Codes and Standards

Insurance as it relates to contracting removal services should be incorporated into the signed agreement, with notification of liability with limits (check with legal counsel for amounts) and workers' compensation coverage. It's also important to know if the contractor will be sub-contracting out all or part of the services, as additionally insured, liability, and workers' compensation insurance are also required of the subs.

All individuals who will be working on-site while school is in session must be identified and processed to work according to the regulations outlined in the Education Code.

Benefits

Contracting out the snow removal can ease the demand on in-house staff (especially in smaller districts) and can allow more areas to be cleared in shorter time periods. Cost and quality of service can vary.

Cost

IF a district decides that outsourcing snow removal services is beneficial to its operations, contracts should be obtained no later that September to assure that contractors have a place for first in line for removal. There are two distinct contract arrangements in snow removal.
The first type is based on an **hourly rate charged** against various types of equipment used. An example would be:

- John Deere 644 Articulating Loader with sixteen foot blade = $95.00 per hour.
- John Deere 624 Articulating Loader with twelve foot blade = $85.00 per hour.
- Ten-yard International Dump with Case 544 Skip-loader = $90.00 per hour plus associated dump charges for snow hauling from site.

This type of contract provides exact costing for time actually used and is more beneficial to the contractor than the district. It does not provide a very good prospectus for what the total costs will be for the season, since final costs are dependant on the severity of the winter among other factors. The district will be in a better position in a light winter, a poor position in a heavy winter.

The second contract type is based on **a seasonal flat rate**. In this type, a contract is provided for the entire season at a specified cost. It is important to cover a few additional items in this type of contract:

- Identify when the removal contract and the season begins and ends. Include dates in the verbiage.
- Include an explicit section on the numbers of times out and how that relates to additional times of removal per day.
- Request the inclusion of snow storage and ramping if necessary within the scope of the contact at no additional charge.

This type of contract is specific in its benefits to both sides depending on the severity of the winter and the number of times storms require removal be performed. In a heavy winter, or one in which snowfall demands removal many times at minimal depths, the district should benefit, since it is assumed that at an hourly rate, the contractor would have been charging more.
In a light winter, the district is placed in a position of paying for more than the actual work performed and the contractor is in the more advantageous position. These assumptions are based on the district being able to negotiate a contract that does not contain contingency funds to cover the contractor in the event of a heavy winter.

Monitoring/Controls

In the “hourly rate” type of snow removal contract, for the most part, it is not the severity of the winter itself that increases the cost, rather the number of time a contractor arrives to remove snow at the minimum depth. A winter that produces many minimal depth removal snow falls will be much more expensive than one that contains a smaller number of major depths.

To assist in curtailing this, it is imperative to be sure to keep in contact with contractors during storms that are long lasting, that close schools or delay openings, and on weekends and holidays. Canceling a removal that can wait until the storm is over or holding off until a weekend or holiday storm is finished can reduce the number of times a contractor comes out to remove, and can result in a savings. This scheduling strategy should be weighed against the much larger storms that may result in a longer time frame to remove if waiting too long to commence operations.

Common Retrofit Opportunities

N/A.

Verification and Commissioning

Attorneys for the district should review all contracts prior to signing. In most cases, once a snow removal contract is developed, it should suffice for many years. If designed correctly, minor modifications can be made easily to accommodate specific needs in special locations at any given time.

Resources

Tahoe Truckee Unified School District, http://www.ttusd.org

Guideline SI3: Snow Removal for Parking Areas/Bus Lanes

Recommendations

Schedule snow removal to accommodate school opening times for staff and student arrival. Arrange for parking areas for staff to be cleared first, so that, especially if snow removal goes longer than anticipated or scheduled, staff can park out of the way of the balance of the operations.

Pickup truck with blade.
(source: Tahoe Truckee Unified School District)

Select equipment that can cover the areas to be removed in the most efficient manner, while avoiding property damage and wear on staff. On larger lots, front-end loaders and plow trucks are the preferred method of removal. When conditions become severe, snow depths become overpowering for that type of equipment and edges of parking areas need to be pushed out to bring back useable parking spaces and surfaces. In these situations, larger snow blowers (similar to those used by road crews) may be used. Backup-services for equipment are advisable in all removal scenarios, whether in-house or contractors are used.

Ensure that sufficient lighting exists for work crews. Since snow removal -- for the most part -- is accomplished prior to school opening, work crews are often required to work in the dark. Equipment lighting only is not adequate to perform removal in a safe and efficient manner. Lighting parking lots in addition to equipment lights is imperative, especial when considering adverse weather conditions that may be encountered. Visibility is reduced significantly during snowstorms, and lighting can make the difference in safe removal operations.

Removing snow during in-session school, bus and vehicle drop off times, and after-hours events should not be a part of normal operations.

Description

Parking areas vary in size, shape, wind-drift areas, building and other obstacle interferences, slopes, drainage, conditions, proximity to storage, actual storage availability, and materials. All play a role in making the right decision in selecting and using snow removal equipment.

Parking lots are mainly made of two main surface materials: asphalt and concrete. (There may be some larger areas or overflow parking locations that are constructed on base material or gravel.)

- Asphalt is a much easier surface on equipment blades and is also easier to replace or repair if damaged. Unfortunately, asphalt is also much *easier* to damage, is in need of annual sealing and repair, and is less durable as concrete over longer periods of time.
- Concrete, while a more durable material, is hardest on machinery, blades, and operators since it is not forgiving when hit by the equipment.

Removal strategy can vary based on the material. For instance, floating a blade may be a more efficient technique on asphalt, since it absorbs heat faster than concrete, which allows a thin layer of surface snow to melt faster on its own. This process can -- at times -- save blade and surface wear.

Melt mats or hydronic systems should be not be used in parking lots since they are much too costly for areas of this size.

Operations should be worked into off hours, evenings, weekends, holidays and any time prior to school opening or after closing to reduce the chance of incident to vehicles or people. This is sometimes difficult depending on storm conditions and times, however should always be the first and foremost plan of attack.

It should also be remembered that loader and snow removal equipment operations during in-school session hours may be a distraction to students in classrooms and noise levels may interfere with classroom education. Always check with site staff for feedback and recommendation should these operations become necessary.

Vehicle and equipment operations may also be in areas other than normal vehicle traffic and for longer periods of time. Exhaust from snow removal equipment is often at different elevations and in different locations than other vehicles.

In all cases, review of these areas for air handler and fresh-air intakes should be performed and schedules adjusted for operations of equipment in order to prevent intake of exhaust fumes that may be drawn into ducting and subsequently into occupied building areas.

Marking and Signage

Marking parking lots is also called “staking”. Whether performed by in-house or contractors, snow pole staking is necessary for protection of sensitive areas, drainage systems, conveyance devices, electrical boxes and transformers, landscaping, poor surface conditions, etc.

Snow poles should be constructed of galvanized steel pipe and placed in pre-installed sleeves in the ground or parking surface areas. Do not use of plastic or PVC pipe, as they can be damaged very easily and can cause injury to students playing with them.

Installation of markers should be accomplished prior to freezing weather causing permafrost and/or before the first snowfall. All other forms of marking such as signage should also be in place prior to adverse weather. Any areas with surface marking should have alternative signage visible in winter months, as pavement markings may be covered for extended periods of time from snowfall.

Note:

The standard staking color code used by state, county, and municipal snow removal departments on roadsides are recommended for use on school sites as well:

- Green = indicates a drain – DI - catch basin.
- Blue = indicates a hard immovable object.
- Orange = indicates that a snow blower is not to blow snow in that direction.
- White = indicates a regular snow pole delineating road side edges.
- Red = indicates a fire hydrant.
- Yellow and Orange = indicates high voltage area or a transformer.

Parking area signage is reflective of conditions in any given location. Sloped areas that pose no hazard during non-winter months may be treacherous during icy conditions. Posting signs in these locations warning of these conditions should be done at a minimum. Signage indicating that these specific parking areas or stalls are not to be used during the winter season with specific dates is an even more proactive approach. There may even be a need to eliminate entire parking areas during adverse conditions and temporary signage could be necessary in addition to barricades.

Snow Storage and Hauling

After removing snow from parking areas, the question becomes what to do with it in order to make room for the next storm's snow. Areas for storage should be made and maintained by snow removal crews. Ramping of snow may be necessary to gain more room for additional snow in storage locations. This practice can be hazardous depending on weather, conditions of the surface of the snow-pack, and the equipment used, so it should only be performed by seasoned and well-trained personnel.

Packing and ramping of snow to make more room in storage areas adds expense to removal costs. Since In-house staff or contractors must return after removal and during lulls in storms to perform this task, it adds hours/costs and is considered another call-out (if using a contractor).

Hauling is an aspect of snow removal operations that should be avoided at all costs. It can become one of the most expensive operations in the program. The need to haul snow comes from a few different areas:

- Roof snow clearing from the perimeter of buildings.
- Areas in need of removal that have inadequate storage locations.
- Large amounts of snowfall that overpower storage areas.

Hauling involves heavy equipment operators, dump trucks, and front-end loaders or tractors. Costs vary with hourly rates, time to perform the process, the distance of the transfer point, and the potential costs for using an off-site transfer location (if there is no available space on district property).

Sand vs. Salt vs. Deicers:

Sand, as mentioned before, is an abrasive that finds its way into buildings through foot traffic. It can destroy or significantly reduce the life of carpets, vinyl floors and other types of flooring. It is also devastating on vacuum cleaning equipment.

It does however, have its place in the battle against ice, as it is relatively inexpensive to purchase, and is effective in helping prevent slip-falls. There is always controversy over which product or material to use in any given location, how often to apply, and how much to apply.

This section does not provide comments on which product works better than another, but addresses the advantages and disadvantages of each, so that individual districts can determine which best meets their own needs.

	Sand	Rock Salt	De-icers
Pros	- Inexpensive - Moderate to excellent in reducing slip-falls and accidents in parking areas.	- Moderately inexpensive - Easy to apply; - Melts ice rapidly within a specific temperature range - Packaged in bags that are relatively easy to handle	- Easy to apply, depending on brand - Melts moderately fast (usually within a tighter range of temperatures than rock salt) - Can be environmentally friendly - Can be less irritating than rock salt to skin - Packaged in bags and containers that are relatively easy to handle.
Cons	- Abrasive to floor coverings - Damages vacuum equipment - Tracks into buildings creating additional cleanup	- Destructive to metal ramps and thresholds - Damages alkaline intolerant concrete and masonry materials; - Stains wood and other materials when melted ice is left in contact with them; - Harmful to vegetation from runoff - Can irritate and burn skin and eyes - Tracks into buildings and can damage floor coverings	- Expensive in comparison to rock salt - Can be irritating to skin and eyes depending on brand. In some instances breathing vapor from a newly opened container can cause temporary dizziness and possibly other effects.

For the most part there is a use and a place for all of the materials noted above. It is incumbent upon the user to place the material in the proper locations for each and provide common sense in quantities. Always survey the effectiveness of the material used, the damage it may be causing, and how much to apply. The least amount of material used, while still maintaining safety, will help prevent environmental problems, damage, and injury.

There are other products on the market that spray down on asphalt and concrete surfaces prior to snow or ice developing. These products are usually used by larger organizations with massive areas to cover, such as county and state highway snow removal crews.

These products are expensive when not purchased in bulk quantities and require additional vehicle equipment to spread them in an efficient manner. They also are specific in their purpose and fine-lined in their usefulness with various traffic, temperature, and weather changes affecting their ability to perform. They are mentioned here as information only.

Sanding and deicing operations on larger parking areas is usually at the direction of temperature, moisture, time of day, and known areas of concern. These locations should be identified and placed on a schedule to be addressed under specific conditions.

Areas that remain in shade for longer periods than others may continue to be ice for much greater periods than locations in the sun. Driveway and parking lot curves, as well as stopping areas, necessitate additional applications to assist in preventing accidents.

The larger areas mentioned in this section do not usually pose a problem for damage to interior surfaces from tracking, however they should be reviewed periodically to minimize any of this potential.

Applicable Codes and Standards

California requires twenty feet in width clearance for fire lanes; however check with local fire department for any special requirements.

In some locations, tire ice studs are illegal. Check with local authorities for legal use and dates of the year in which these can be used. On school property there are no restrictions unless the district has imposed them. However, tire ice studs can damage certain surfaces and should be used only on appropriate surfaces.

Check with your liability and vehicle insurance providers for proper coverage on snow removal equipment, especially those that will be traveling on public highways and roads.

Also, check for local ordinances relating to where snow can be stored or pushed. Many areas of the country are now being viewed with an eye to environmental considerations. Regional Water Control Boards are aware of bituminous deposits, salt, deicers, and asphalt that are scraped up and melt out of snow that has been removed from parking areas. More and more, limits are being paced on where snow can be removed to, driving costs up.

Benefits

Timely snow removal from parking lots and fire lanes will ensure safe and timely access for staff and students. Planning removal techniques that are appropriate for the area/material will help prevent damage to both equipment and surfaces.

Costs

Equipment purchasing or leasing from heavy equipment loaders, plow trucks, sanders, and blowers, to personnel snow blowers, spreaders, snow shovels, and roof sleds, all have associated initial costs and, in some cases, reoccurring costs in the from of leases or rentals. Replacement costs based on damage and useful life expectancy are also a part of this area. These costs on the surface are some of the most expensive, in conjunction with labor and contracts, but by no means are they the only ones.

Incidental costs to the equipment come in the form of insurance premiums, coverage for accidents, failures necessitating repairs, regularly scheduled maintenance, and the routine fluids and other products used on almost a daily basis to keep them operating at the highest efficiency and dependability possible.

Another consideration is that workers' compensation claims are more prevalent in winter due to strains and lifting problems. Dehydration is also a factor more in the winter than in the summer. To reduce these increased costs, training (which does have some associated cost) should be provided in the proper use of shoveling and lifting.

Other costs from improper snow management include:

- Damage to buildings, curbs, sign-posts, drain grates, etc. from weather, equipment, and tracking.
- Cleanup from winter operations, inclusive of drainage and catch basin cleanout, sweeping operations to clear sand applied over the winter.

Monitoring/Controls

N/A.

Common Retrofit Opportunities

During construction planning for new buildings and additions, it is important that snow removal operations crews are involved and provide their input. All projects have the potential to drive up costs, operational time, and create difficulties and safety concerns beyond the normal ones usually looked for.

Verification/Commissioning

Signage should also be reviewed for damage on a regular basis by snow removal operators to be reported and replaced as soon as possible. Review of these signs at the end of the season is also necessary in order to provide time to replace or repair in preparation for the next winter season.

Damaged or badly worn asphalt can be easily dug up with loaders and blades, creating potholes and voids that can cause safety problems and add to the potential for damage to equipment and vehicles. Heavy equipment and even smaller plow trucks using snow blades and scrapers can dig up asphalt, tear into concrete and asphalt curbs and destroy objects not clearly marked. Snow staking areas to help prevent damage is an integral part of the operation. Inspection and repair of some kind should be made during the winter season as damage occurs, as costly repairs could be in order after months of waiting.

The weight of built up snow can easily damage buildings.

(Source: Tahoe Truckee School District)

Pre-walks with contractors and in-house staff over all removal areas to provide a clear picture of areas that may require a lighter touch of the heavy equipment to prevent damage and surface tear out, may assist in reducing damage and stretching pavement replacement. These pre-walks, with an eye to heaving concrete walkways and pavement, can save blades on equipment from damage and undue wear. Hitting a slightly raised concrete lip can damage blades, hydraulic systems, as well as injure equipment operators.

Permit snow chains only on surfaces that can handle the wear and tear. Install chains just prior to need and remove as soon as possible at the end of the season. Use cables on lighter snow removal vehicles where possible. Install tire ice studs with the same considerations as chains. Only install studs on vehicles that absolutely need them such as pickup-truck sander units. (See Applicable Codes and Regulations section above for more information.)

Damage from excess snow weight should also be monitored for in large areas, including parking lots and play areas. Two main areas of consideration are playgrounds and vegetations. Snow can damage event he most hardy of plants, and sturdiest of playground equipment. Inspection to prevent accident and injury is an important responsibility.

Property damage from excessive snow weight.

(Source: Tahoe Truckee School District)

References

TO COME

Guideline SI4: Snow Removal for Walkways/Doorways

Recommendations

Remove snow with manually operated snow blowers, small tractors with either plow blades or blower attachments, and shovels. Larger equipment may be appropriate on some walkways and commons areas; however care should be taken that these locations have been designed to accept the weight, wear and tear of this type of equipment.

Operate power equipment when pedestrians and others are not present or in proximity to the operation. Sizing this equipment is also as important as with larger snow removal equipment.

Freeze marker, indicating freezing temperatures to warn of icy conditions on walkways and parking lots.

Description

As with parking areas, there are two distinct types of surfaces used for walkways: concrete and asphalt. Snow and ice are prone to melt faster on asphalt than concrete due to coloration and heat retention. With this understanding, concrete walkways should be viewed more scrutiny in the application of deicers and removal schedules.

Raised surface edges may pose a potential for damage to equipment of all types. Walks and doorways should be inspected prior to each winter, looking for possible areas that may affect removal. These areas should be marked so as to be identifiable when covered with snow.

Curbs along walkways are of concern in regards to slip potential. Asphalt curbs are susceptible to damage from removal operations. Concrete curbs become slippery and can cause equipment damage if in disrepair. Curbs with metal angles embedded to help prevent snow removal equipment damage can become very slick if not designed with anti-skid grooves or material application. All of these areas are in need of additional attention from staff.

Doors and thresholds should be cleared often and thoroughly not only for access and slip-fall prevention, but also from a maintenance standpoint. Metal thresholds, weather stripping, door sweeps, automatic operators, and hinges all receive unusual strain and stress with ice and snow left to lift and jam mechanisms. These conditions not only create additional maintenance and costs, but can lead to energy conservation issues.

Marking and Signage

As discussed in the guideline for parking areas, marking parking lots is also called “staking”. To a lesser degree, walkways should also be marked or staked as necessary. Longer and/or meandering walks are of greater concern, however all pathways should be taken into consideration. Curbs are also an area that may need addressing and should be considered in the overall marking plan.

Installation of markers should be accomplished prior to freezing weather causing permafrost, and before the first snowfall. All other forms of marking areas such as signage should also be in place prior to adverse weather.

Any areas marked for specific purposes on the surface that are necessary to be seen in the winter, should be provided with signage or other means, as pavement markings may be covered for extended periods of time from snowfall. Walkways should also contain appropriate verbiage, delineating potential dangerous or hazardous locations and conditions. Posting signs in specific locations to warn of these conditions is a minimum need, and ramps and sloping walks are particularly of concern.

Signage should also be reviewed for damage on a regular basis by snow removal operators to be reported and replaced as soon as possible. Review of this signs at the end of the season is also necessary in order to provide time to replace or repair in preparation for the next winter season.

Snow pole staking may be necessary to help prevent damage by or to equipment. This staking should be scheduled for a specific time annually, prior to the onset of freezing temperatures or permafrost conditions. Snow poles should be constructed of galvanized steel pipe and placed in preinstalled sleeves in the ground. The use of plastic or PVC pipe is discouraged, as they can be damaged very easily, and also cause injury to students playing with them.

Sanding/Deicing

Sanding and deicing of walkways and doorways falls under the heading of obligation-to-open. These areas are not to be left in a condition that would allow occupants to be placed in harms way should they be exiting the building under any circumstances, especially in an emergency.

Larger ground surface areas in need of automatic and continual deicing, such as entries to buildings, asphalt or concrete handicap ramps, landings, and heavily trafficked walkways can be kept clear with melt mats. These are located just under the covering surface, are thermostatically controlled and are electric in nature.

Note:

The use of chemicals, de-icers, and salt all pose a hazard to those that may come in direct contact with them, just as the users of these products. Care should always be taken in handling and using, and the same reasoning for that care must be followed through for possible contact by others. Hazards include but are not limited to ingestion, inhalation, skin burn, and eye irritation.

Inform occupants of the egress points that are kept clear so they understand it is safe to exit by means of that particular exit point. It would be unfortunate, to say the least, if occupants were able to escape harm from a dangerous situation within the building, only to be injured during the exiting process from something other than the original danger. This potential injury could also cause an exit to become blocked from further use, creating yet another life threatening hazard.

Shady areas may continue to be icy for much longer periods than locations in the sun. Interior surfaces may become damaged or prematurely destroyed from tracking of deicers and sand. Use of these chemicals and materials should be reviewed for each particular area and potential for harm.

Applicable Codes and Standards

Fire code requires that all egress points in a building be clear of obstruction during all hours and times of occupancy. Occupancy is defined as whenever there is human presence in a building, including personnel opening the facility. Timing the start of removal operations with weather conditions is crucial in providing a safe building for students and staff to begin the school day. The obligation to open also continues throughout the day, and requirements to keep exits clear continue until all occupants have left the building.

Also, check for local ordinances relating to where snow can be stored or pushed. Many areas of the country are now being viewed with an eye to environmental considerations. Regional Water Control Boards are aware of bituminous deposits, salt, deicers, and asphalt that are scraped up and melt out of

snow that has been removed. More and more, limits are being paced on where snow can be removed to, driving costs up.

Note:

Unleaded fuels are not meant to be stored for more than three months and remain useful. Fuels stored for more than three months that have not received additives to accommodate storage longevity should be discarded and replaced as they may produce inadequate results and cause harm to machinery. Always store flammables in appropriate storage containers and lockups. Do not store equipment with fuel in fuel tanks, in locations not meant for flammables.

Benefits

Repair costs, down time, wear and tear, and timelines may all be compromised with inadequately sized equipment.

Costs

A smaller horse powered snow blower; purchased to save in the initial purchase price will quickly lose its value and usefulness as it is overworked in an area that required a larger machine. Time spent in removal operations may also become a factor, as staff is required to exhaust additional time with less than adequate equipment.

Incidental costs to the equipment come in the form of insurance premiums, coverage for accidents, failures necessitating repairs, regularly scheduled maintenance, and the routine fluids and other products used on almost a daily basis to keep them operating at the highest efficiency and dependability possible.

Workers' compensation claims are more prevalent in winter due to strains and lifting problems and dehydration is also a factor more in the winter than in the summer. To reduce these increased costs, training should be provided in the proper use of shoveling and lifting. These have associated costs also.

Other costs from improper snow management include:

- Dual pane window seal repairs.
- Damage to buildings, curbs, sign-posts, drain grates, etc. from weather, equipment, and tracking.
- Ground cover replacement from weather, equipment, and applied materials.

Monitoring/Controls

N/A.

Common Retrofit Opportunities

N/A.

Verification/Commissioning

Annual training should be a requirement for any potential operators of power equipment. Lifting and shoveling training should also be a part of the pre-season safety training process. This equipment, especially powered or rotating blade machinery is in need of inspection, repair, service, and necessary adjustments at scheduled times. Inspection of this equipment should be performed prior to each operator use.

Pre-walks with contractors and in-house staff over all removal areas to provide a clear picture of areas that may require a lighter touch of the heavy equipment to prevent damage and surface tear out, may assist in reducing damage and stretching pavement replacement. These pre-walks, with an eye to heaving concrete walkways and pavement, can save equipment blades from damage and undue wear. Hitting a slightly raised concrete lip can damage blades, hydraulic systems, and operators.

Safety for walks and doors relates to pedestrian traffic. Removing snow during in-session school, bus and vehicle drop off times, and after-hours events is often necessary, but should be curtailed as much as possible.

After the winter season, it is always necessary to prepare equipment of this nature for the long period of non-operation. Fuel draining or additive application, and storage considerations are appropriate as a part of the maintenance of equipment that will be expected to operate as the next winter comes around.

References

TO COME

Guideline SI5: Snow Removal for Roofs

Recommendations

Consider the depth of the snow, moisture content, size of the area to be removed, and the configuration of the roof when selecting equipment for roof snow removal. Parapits, roof jacks, ventilation units, cooling towers, antennas, crickets, and weather instrumentation packages, all present barriers and areas of potential damage, if care is not taken to consider how and what equipment to use in the removal.

Use shovels with plastic blades as a first resort for roof snow removal since they help prevent damage to roofing material. They are also the equipment of choice in gaining initial access to the roof and making room on the roof for any needed additional personnel and equipment by clearing the perimeter of the building roof first. Once room has been made for more equipment and personnel, light snow blowers, sleds, skids, and dollies can be brought in to aid in the removal process

Gutters must be made of heavy gauge steel and connected to buildings properly. Heat tapes will help prevent freeze, damage, and premature replacement..

(source: Tahoe Truckee Unified School District)

Regular snow blowers are not recommended without careful consideration, professional operators, and a specific plan for gaining access to the roof, safe operations for the user and others, a great knowledge of the roof layout, and a means to remove the blower safely. If they are used for roofs, they should have track drive (not wheel drive), be lightweight, and have adequate depth adjustment in order to provide at least two inches of clearance between the roof and blades. Metal guides should be wide and optimally constructed of polypropylene or rubber material. In some cases of extreme depth, snow blowers may be used to remove in layers.

A “deck blower” may also be used if the snow is not too dense from moisture. These blowers are very lightweight, can be lifted and maneuvered easily, and have rapidly oscillating plastic louvers rather than rotating metal blades.

Sleds (plastic or metal toboggan-like devices that can be pulled and slid along the surface of snow) or skids (plastic or metal devices constricted with handles similar to a two-wheeled dolly) may be used to bring snow greater distances from the roof to the perimeter to be dumped over the edge. When snow depths become greater than shovels and conventional methods of removal can accommodate, snow can be cut into blocks of various sizes with saws or a taut string line, which works exceptionally well to prevent damage to roof membranes from errant saw cuts. Blocks of snow, (sometimes refrigerator sized) are then pulled or pushed (depending on the configuration of the sled or skid) to the edge of the roof for removal. This method is most efficient for greater depths and should be accomplished by leaving at least six to 12 inches of snow on the roof to be used for the sleds and skids to navigate over, thus preventing damage to the roof.

Description

Roof areas are without doubt, the most important locations to monitor conditions, especially in high snow load areas. This guideline focuses on flat roofs due to the commonality found in their design and often

pervasive need for removal, as opposed to that of a sloped roof. (Sloped roofs in need of snow removal vary in pitch and material, making them difficult to address in generalization.)

Note:

It should be remembered that with all sloped roofs, greater care and additional safety equipment must be used in the removal process.

Roof Surfaces

There are many different types of roof surfaces that may be encountered in the process of roof snow removal. Some that are most typical in snow country are metal, composition, build-up, and foam.

Metal roofs are usually installed on sloped-roof building and most often are not in need of addressing in the removal process, as they shed snow very well in most instances. Of note, however, are those mild slope roofs and/or those containing snow dams at intervals down the long axis of the roof to control the amount of snow drop from the edges. In these cases, snow may build up, and in all cases these roofs should be placed in line with the ongoing measurement system the district has in place.

Foam roofs are the most susceptible to damage from snow removal operations and are in need of the most snow left behind on the deck to prevent damage from shovels, etc. To prevent damage, snow should never be removed down to the surface on a foam roof.

Build-up roofs are the most common on a flat or cricketed roof, and can be of many different layers and materials. Many roofs today are being upgraded with elastomeric acrylic material overlays that are cool in nature, as well as provide energy savings in the warmer summer months and moisture intrusion protection.

These types of coverings also come with another advantage in snow-country. They provide added protection from damage by removal operations, and most importantly provide for efficient and cost effective repair to damaged surfaces and protrusions.

Composition roofs are installed on sloped roofs similarly to metal roofs. They are more apt to be in need of snow removal than metal however, as they do not shed easily even with a substantial roof pitch. Care should be taken in removal operations with these roofs to not lift or damage shingles. Working from the top down will help prevent this damage.

Marking and Signage

Marking or staking, as referred to in this section, is of paramount important on roofs that have been known to need snow removal. Projections that are comprised of, but not limited to, roof jacks, vent pipes, air handler exhausts and intakes, antennas, weather vanes and monitoring equipment, and satellites are all subject to damage if they do not protrude more than the highest level of snow that can be expected.

Check records, if available, to determine what was the maximum depth on a particular roof that was attained prior to the need for removal operations in the past. If seven feet of snow was encountered just before removal operations, it would be appropriate to install snow poles or other markers on anything that could be damaged of less than seven feet in height from the surface of the roof.

These stakes would provide visual indication of obstacles under the snow, and should also be provided around the perimeters of any larger area objects such as roof hatches, etc. to indicate overall dimensions. It is also advisable to install snow poles on roofs of building perimeters that have no visible sight delineator when approaching the edge of the building.

Large open fields with no trees on the side of a building would be an example of this, as snow, regardless of elevation changes from roof to ground, tends to blend into the horizon making it difficult to differentiate between them and thus creating a potential walk-off hazard. Snow poles can be marked or taped with various bright colors indicating different types of hidden objects. This can be helpful even for regular maintenance needs in locating a specific unit or object on the roof that may be in need of repair or adjustment.

To reduce the effort and manpower needed to perform staking and marking each year (since it is appropriate to remove markers during non-snow months), telescoping snow poles may be used. These can be permanently attached to roof objects, easily lowered instead of removed, and raised again in the fall in preparation for winter.

Example of a falling snow warning sign.
(source: Tahoe Truckee Unified School District)

Signage is required in several locations. As indicated in previous sections, there are specific areas that must be identified by snow removal operations personnel and addressed with appropriate signage.

These include, but are not limited to:

- Roof snow shed locations.
- Cornice removal areas.
- Obstacle markings and locating signage.
- High voltage signage indicating potential overhead wires and electrical roof-jacks.
- Signs indicating roof or overhang heat tape location.

It is important to remember that each building and each situation is different, indicating a need for scrutiny and discussion to afford the best possible signage and markings for safety and damage control.

Cornices

Roof overhangs and eaves can create snow and ice cornices of varying sizes and danger. As snow melts on a roof, including flat roofs, the water that develops under the remaining snow, carries the snow to the edges of the building where most roofs drain to scuppers and roof drains. As the snow migrates past the heated main building edges to the unheated overhangs and eaves, depending on temperatures, it can again freeze. This is the process that forms icicles and snow and ice dams, including cornices of snow that can become very large and imposing.

Cornices can develop at any time when conditions are right, however they are most notable in the early morning hours after the prior day's thaw and evening freeze. For this reason, it is of utmost importance to investigate all roof edges from the ground each morning and perform removal operations prior to school opening, if needed.

Locations of primary importance are doorways, exits, entrances, and windows that may become damaged should the cornices become large enough to break off and fall. As cornices develop and grow, they tend to roll underneath and towards the main building walls, due to the heat from the building attracting moisture toward them. This rolling in creates a problem for windows, should they be allowed to

develop to this extent. Less danger and work is created when cornices are handled prior to reaching this stage.

Smaller cornices, and those on single story buildings, can be mitigated from the ground using long telescoping or fixed length poles with affixed blades. Blades of heavy-duty plastic are recommended to reduce damage potential.

On larger cornices and multiple story buildings, ground operations may not be appropriate. In cases where roof access and removal is necessary, it is important to note the inherent dangers. Knowing exactly where building edges are located is an absolute necessity. Removal should always be performed, standing several feet back from the edge using a tool to reach the edges. The ice and snow forming the cornice may extend back from the edge by up to three feet or more creating a means by which an individual may be swept off the building edge with the falling cornice.

To provide the safest operation in cornice removal from the roof, at least two people should perform the roof top operation with one observing the other performing the removal and providing physical support with tie offs if necessary, and a third person on the ground protecting passers-by from falling object harm.

It is also advisable to perform this operation prior to building occupancy to reduce potential for injury. Signs indicating the danger are also appropriate, including in areas where cornices and falling or shedding snow are know to be a potential hazard for pedestrians or vehicles.

Ground-Level Operations

With many roof removal processes there is a need to remove the same snow twice: once from the roof, and again from the sides of the building from which the snow originated.

The following areas should be taken into consideration:

- Window protection from falling snow due to roof removal operations.
- Landscape and other structure protection from falling snow.
- Staking of items that may be covered by falling removed snow.
- Appropriate equipment, i.e., loader operations, to remove snow dropped from roof operations.
- Safety of pedestrians and ground crew operators through barricades, signage, and additional personnel tasked with only safety duties.
- Storage for large amount of snow from the roof removal.
- Removal of snow from building walls to prevent moisture and frost, and possibly subsequent interior wall mold damage.
- Coordination with teaching and coaching staff with outdoor student activities and removal operations should they occur during school hours.

Emergencies

There are always emergencies, even with the best-laid plans. These are accommodated by planning and practice for the most part.

Emergency roof removal operations may be necessary at any given time during the winter from severe storms and/or a continued series of storms offering little or no time in between to address removal. In these instances, when snow loads are deemed to necessitate emergency removal, it is wise to proceed after discussion of closing school until after weight has been reduced, work forces have been removed from the site, and any danger to occupants from snow loads has diminished.

Safety

It may go without saying, however it will be said here -- safety is the most important factor in approaching roof snow removal. All areas of the operation must be considered and addressed from this aspect.

To be summarize these areas, the following is meant to offer a list of addressable operations with which to develop safety preparations:

- Roof top access with and without equipment.
- Falling snow and ice from cornices and the resultant removal operations.
- Falling snow and ice from roof removal operations.
- Ground operations for pedestrians and removal crews.
- High voltage and other electrical equipment and devices on and above the roof.
- Overhead and hidden electrical for ground crews, especially with regard equipment operations.
- Use of power equipment on roof.
- Ongoing load measurements with regard to building occupancy prior to removal and during operations.

In-house staff should be required to sign up for the roof snow removal program prior to the winter season. Each employee should be required to be tested for ability to perform strenuous work, perform lifting requirements, and work at raised elevations.

They should also be trained to use shovels and be afforded professional training on lifting procedures for shovels along with the use of the appropriate shovel for the specific task. Occupational Health Services are a good resource for this training and evaluation process. This process is an annual event, and should not contain roll-over provisions.

In-house personnel also require pre-arranged rates for this type of work, bargaining unit approval and possible contract verbiage, continuous hours of work verbiage, supervision provisions, and sign in and out sheet. This work force may or may not be sufficient to remove snow during and emergency or urgent need. Often, it's numbers that provide the necessary timeframe of removal.

Heat Tapes / Melt Mats:

Roof eaves, overhangs, gutters, and downspouts freeze solid without some means of prevention. Heat tapes are one way to provide a somewhat reliable manner in which to accomplish this. They do not come without their costs and problems. The trade-off in costs is the purchase, installation, and replacement of the units as opposed to the repair and/or replacement of building components. Frozen rooflines and gutters may pose other threats to buildings with potential water intrusion under roofing materials and into exterior wall surfaces.

Gutters and downspouts should always be kept clear of ice whenever possible to prevent subsequent damage not only from the freezing and expanding pipes, but also from when thawing ice seeps into the building structure.

Heat tapes come in various lengths, energy draws, and configurations. A thermostatically operated heat tape is the most efficient and safest to use. Always provide a dedicated circuit for supplying electricity, with a ground fault interrupt breaker.

Downspouts should always empty into either an underground conveyance device or into areas that will not contribute to melting snow black-ice conditions or slip-fall surface areas.

Melt mats also come in the form of hydronic heating, in which pipes carry heated water containing a non-freezable liquid such as glycol, under the ground surface. Water is heated by means of a hot water tank or boiler. When constructed properly, the boiler for the building can serve as the heart source.

Either type of melting system is costly to install and especially to replace. They are efficient, however once damaged underground, necessitate a major project to replace. There is always the cost savings from salt, the resultant damage to interior floor surfaces, and injury reductions when they are operating optimally.

Applicable Codes and Standards

Check for local ordinances relating to where snow can be stored or pushed. Many areas of the country are now being viewed with an eye to environmental considerations. Regional Water Control Boards are aware of bituminous deposits, salt, deicers, and asphalt that are scraped up and melt out of snow that has been removed from parking areas. More and more, limits are being paced on where snow can be removed to, driving costs up.

Benefits

Timely roof snow removal with attention paid to surfaces and equipment will prevent damage to the roof.

Costs

Equipment purchasing or leasing from heavy equipment loaders, plow trucks, sanders, and blowers, to personnel snow blowers, spreaders, snow shovels, and roof sleds, all have associated initial costs and in some cases reoccurring costs in the from of leases or rentals. Replacement costs based on damage and useful life expectancy are also a part of this area. These costs on the surface are some of the most expensive, in conjunction with labor and contracts, but by no means are they the only ones.

Incidental costs to the equipment come in the form of insurance premiums, coverage for accidents, failures necessitating repairs, regularly scheduled maintenance, and the routine fluids and other products used on almost a daily basis to keep them operating at the highest efficiency and dependability possible.

Workers' compensation claims are more prevalent in winter due to strains and lifting problems and dehydration is also a factor more in the winter than in the summer. To reduce these increased costs, training should be provided in the proper use of shoveling and lifting. These have associated costs also.

Monitoring/Controls

As previously mentioned, roofs come in a variety of types and in a variety of roof live loads. This is the loading factor in pounds provided by the original engineer that the building will take per square foot of surface area.

In snow country, these loading factors are much greater than in areas that do not receive snow. An example of this would be non-snow country roof load rated at forty to sixty pounds per square foot, while some snow country roofs may be rated at over two hundred and fifty pounds per square foot.

Note:

Another method of measuring load on a roof is available at this time through a patented instrument that continually monitors weight and transmits the calculated weight to either an LED readout or to a building's automated monitoring system that can be configured to send out an alarm when the weight reaches a pre-determined percentage of the rated load in order to gain valuable time in beginning removal operations.

Older buildings may have snow loads that are under rated and out of date with more modern structure loading factors. It is important for the district to identify these buildings and provide monitoring that is respective of the various load capacities.

Different buildings on one site may have different ratings. Also different sections of a building may also sport different ratings if additions have been performed over the years and rating upgraded for each addition. Weight on a roof therefore is of major consequence and importance to monitor and regulate. Weight of snow is variable not only from the depth of the roof, but is also greatly changeable from moisture content and compaction. These variables provide a challenging and intriguing process of monitoring and record keeping.

It also means that a one-foot depth of snow may weigh considerably more than two, three, or even four feet of snow. It also indicates that while measurements provide a safe reading for weight on the roof from one storm for several feet of snow, another more wet snow fall of just one or two feet on top of the lighter snow, may take the load quickly to near or over the rated weight applicable for that particular roof.

This necessitates continual monitoring and inspection of roofs using tools designed to measure the actual weight of the roof snow at any given point. This is accomplished by actually gaining access to the roofs in need of inspection, taking snow samples by use of the weighing instruments, and calculating the weight of the snow using a specific formula.

These measurements must be taken at all different snow load rated roof areas, recorded and kept available for inspection and future reference. The measurement will also provide a means to calculate the percentage at which the weight snow is compared to the engineered maximum live load rating and give indication as to when removal should be considered or how important it is to perform the removal process.

Engineering Factors/Tolerances

Buildings, as mentioned previously, are rated for roof live load by structural engineers during the structural design phase, prior to actual construction. Engineers usually calculate a percentage into the load, over and above the actual weight that is considered to be the true load rating.

This overage provides an added safety factor to the load tolerance, and may offer added time in removal operations, however it should not be considered as a normal safety valve of removal operations as those levels are approached.

In contrast, it should be noted that age and previous loading on the roof structure may attribute to deceased structural tolerances. Record keeping becomes very important in this process, as it can provide information relating to possible overloading in previous years.

Overloading may create stress and reduced weight tolerance, thus potentially reducing the live load factor to some degree. This may be compensated for, by reducing the percentage or actual weight compared to original live load rating in which removal commences. Should decreased live load be suspected however, a structural engineer should be employed to provide a more actuate analysis and possible recommendations.

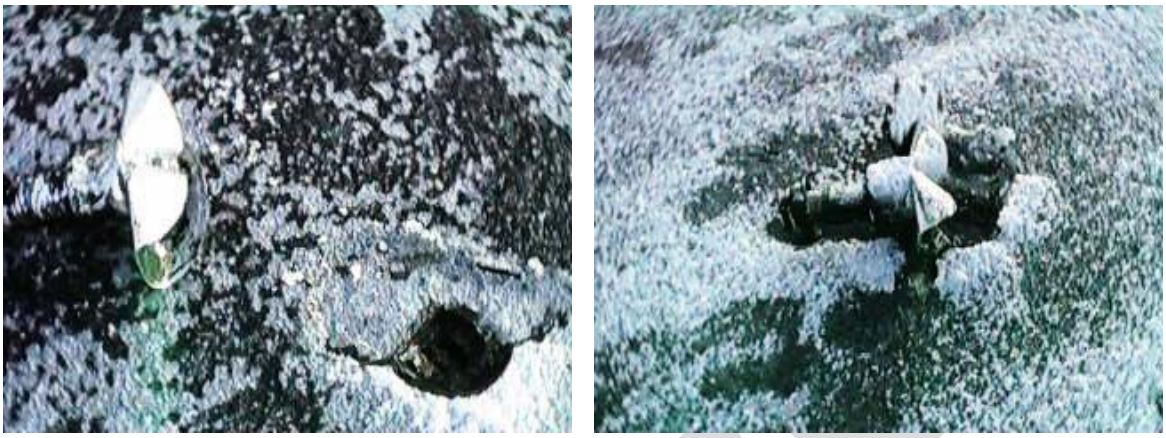
In severe cases of overloading and possible stress, it as advisable when discovered through historic recording, to perform inspections of building structures, columns, beams, etc. in-house and through contracted qualified engineers.

Common Retrofit Opportunities

N/A.

Verification/Commissioning

Damage can occur to roof membranes, parapit walls, seals around roof projections, windows, exterior wall coverings, gutters, downspouts, and a number of other items, both from snow and ice buildup and removal operations.



Examples of roof damage.
(Source: Tahoe Truckee Unified School District)

Protection comes in the form of marking and staking in addition to well-trained personnel performing removal operations. Protection of windows from damage due to falling snow during operations can be afforded through installation of plywood or other covering prior to the removal.

Prevention also is affording with various remedies. Heat tapes for gutters, downspouts, and roof eaves and overhangs may prevent ice buildup and subsequent damage to systems and possibly other building components.

Training and continued refresher courses in removal operations in combination with personal pre-winter walks of the roof areas by authorized removal personnel and contractors can assist in preventing future damage. First hand knowledge of conditions and roof components is always a good defense.

References

TO COME

Guideline SI6: Winterizing Equipment and Grounds

Recommendation

Prepare vehicles, equipment, school buildings and grounds for the oncoming winter *prior* to the onset of freezing temperatures and/or any long lasting snow accumulation.

Snow chains.
(source: Tahoe Truckee Unified School District)

Description

Vehicles & Equipment

Prior to and during winter, the following should be considered in vehicle preparation and use:

- All vehicles should be equipped with snow chains.
- All vehicle and equipment windows and windshields must be clean and free of obstruction prior to use. This also means fogging and ice.
- Vehicles should have snow removed from top and outside of vehicles before leaving any location. (See Applicable Codes and Standards section below.)
- During days where snow removal operations vehicles must be cleared of snow and moved to allow for snow cleanup in the parking areas. This must be accomplished when arriving to work in the morning.
- Vehicle and equipment walk-around inspections must be performed each day of use by any individual about to use the equipment or vehicle. This includes shift change or vehicle sharing. Each person must inspect the vehicle and report any problems or discoveries of importance **prior to use.**
- All district vehicles must be inspected prior to use each day. Including fluid levels (all), fan belts, tire condition, and tire pressure.
- All district vehicles must be warmed up for a minimum of five minutes in warm weather, and 15 minutes during cold weather before driving.
- Diesel with plug ins during winter months should be plugged in at the end of work shift for the night. This will aid in the starting procedure and eliminate unnecessary wear and tear on starting, charging systems, and reduce the chance of internal engine wear.
- GFI receptacles are provided for the above plug ins. If an extension cord is needed, use one that will accommodate the plug in of the vehicle.
- Whenever vehicles are unplugged, cords should be rolled up and not left on the ground or touching the ground. This will to facilitate snow removal operations and reduce the potential of a trip hazard.
- For vehicles with locking hubs, hubs should only be locked in when conditions warrant 4-wheel drive use.
- Four-wheel drive is to be used only during slippery conditions. Even short duration use of 4-wheel drive on dry pavement will result in accelerated wear, drive line and/or transmission component damage and breakage.

- Window washer fluid/antifreeze should be filled daily as needed.
- Before shutting vehicles off after use, be sure all accessories are in the off position. This is most important for windshield wipers that will operate immediately upon switching key to the on position. Damage will occur if snow, ice or wipers are frozen to windshield. If you do turn your key on and the wipers are on, immediately turn the key off, remove snow and or unstuck wipers from windshield (simply turning off the switch will not shut the wiper motor off because of the wiper positioning sensor which requires the wiper to complete a wipe cycle before it parks and power is disconnected from the motor.)

Equipment, equipped with blades and cutting edges, should be inspected for wear and possible turning. Chains should also be inspected, repaired or replaced.

Signage for loaders and snow removal equipment should be reviewed and replaced as necessary including verbiage to stay back and not follow snow removal equipment.

Buildings

Valves and exterior faucets should be winterized by whatever means appropriate for the situation.

Marking, parking controls, and falling snow signs should be installed and implemented. Sand, deicers, and salt should be procured and stored in the appropriate locations.

Boilers and heating systems should be inspected, adjusted, and tested to assure optimal operation when needed.

Fields & Grounds

Sprinkler systems, field house and pump station equipment, and plumbing should be evacuated, drained, and prepared for freezing temperatures. Winterizing fertilizers and dressings should be applied to fields and landscape areas.

Areas that are not to be accessed during winter months should be barricaded and taken out of service. Picnic tables and other outdoor furniture that is susceptible to damage from winter conditions should be removed and stored.

Playground equipment should be taken out of service if not useable during snow months. This equipment should also be placed on an annual inspection process in the spring to assure safe conditions of use. Damage to equipment and playgrounds during winter months can come in the form of structural damage from snow weight and compaction of ground fall material from snow weight also.

Applicable Codes and Standards

Accumulation of four inches of snow on the top or outside of a moving vehicle is illegal, dangerous, and is subject to citation by the California Highway Patrol. After the hood and windshield are clean enough to drive safely, move vehicle to snow storage areas to remove the remaining majority of snow from the rest of the vehicle. Snow must be removed from windows, mirrors, front and rear lights, safety lights, wiper blades, and vents prior to operation. Snow **in excess of four inches**, or in a condition which may cause the snow to blow off the vehicle, must be removed from hood and roof prior to operation.

Benefits

Proper preparation prior to winter and regular care of equipment during harsh condition can prevent damage and keep costs lower.

Costs

Fuel consumption increases from idling vehicles longer for warm-up. Colder engines start harder resulting in greater fuel consumption and added wear, reducing engine longevity. In fact, most mechanical working components of a vehicle are subject to greater and more rapid wear inclusive of bodies and chassis. These costs must be accounted for in replacement factors with greater turn-around than in other climates.

- Accidents and the resulting repairs to vehicles.
- Additional tires (snow vs. regular), studs, chains.
- Clearing snow and ice from vehicles and buses is time consuming and costly.

Monitoring/Controls

See above.

Common Retrofit Opportunities

N/A.

Verification/Commissioning

See above.

References

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