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NYSERDA

August 19, 2008

ENERGY EFFICIENCY STUDY

Sandy Creek Central School District
Sandy Creek, New York

New York State Energy Research and
Development Authority
17 Columbia Circle
Albany, New York 12203-6399

Any questions regarding this report or questions concerning other programs and services offered by NYSERDA, should be directed to Joanna Gomez at (518) 862-1090, extension 3220 or by email at jag@nyserda.org. We hope the findings of this report will assist you in making decisions about energy efficiency improvements in your facility. Thank you for your participation in this program.

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Exhibit A-1

PROJECT SUMMARY SHEET

Participant's Name and Address: Sandy Creek Central School District
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STRATEGY OF ENERGY SAVINGS

Measure Description	Measure Status (See notes)	Fuel Type Saved (See notes)	Demand Reduction (kW)	Energy Saved (MMBTU or kWh)	Annual Dollars Saved	Estimated Costs for Implementation	Simple Payback Period
1. Task 1: Installation of Electric Demand Limiting	R	Elec	46.9 kW	-	$9,370	$5,000	0.5 years
2. Task 2: Daylight Harvesting Control	R	Elec	-	6,889 kWh	$613	$5,700	9.3 years
3. Task 2: Occupancy Sensors	R	Elec	-	Varies	Varies	$340/Space	4.7 to 57.8 years
4. Task 2: Gym Complex Lighting	R	Elec	9.2 kW	47,774 kWh	$5,784	$18,100	3.1 years
5. Task 2: Library Lighting	R	Elec	1.0 kW	7,317 kWh	$814	$10,200	12.5 years
6. Task 2: Elementary Gym Lighting	R	Elec	3.6 kW	18,904 kWh	$2,288	$13,500	5.9 years
7. Task 3: Walk-in Cooler/Freezer Condensing Unit Ventilation	RS	Elec	-	1,119 kWh	$100	$1,900	19.1 years
8. Task 3: Kitchen Exhaust Hood Control	R	Elec, NGas	-	11,443 kWh, 1,109 MMBTU	$15,435	$1,000	0.1 years
9. Task 4: Modified Boiler Operation	R	NGas	-	Varies	Varies	$0	0 years
10. Task 5: Installation of Condensing Water Heater	RS	NGas	-	23.4 MMBTU	$304	>$15,000	50+ years
11. Task 5: Reduction of Tank Storage Temperature	R	NGas	-	10.3 MMBTU	$134	$0	0 years
12. Task 5: Installation of Additional Tank Insulation	R	NGas	-	8.3 MMBTU	$108	$1,000	9.3 years

Measure Description	Measure Status (See notes)	Fuel Type Saved (See notes)	Demand Reduction (kW)	Energy Saved (MMBTU or kWh)	Annual Dollars Saved	Estimated Costs for Implementation	Simple Payback Period
13. Task 6: Auditorium Demand Controlled Ventilation	R	Elec, NGas	-	1,330 kWh, 669 MMBTU	$8,919	$2,000	0.2 years
14. Task 7: Improved Vending Machine Control	R	Elec	-	7,229 kWh	$643	$2,180	3.4 years
15. Task 7: Modified Desktop Computer Shutdown Procedure	R	Elec	-	Up To 239,500 kWh	Up To $21,307	$0	0 years
16. Task 7: Reduced Plug Loads	R	Elec	-	Varies	Varies	$0	0 years
17. Task 8: Re-circuit Exterior Lighting	RS	Elec	-	20,903 kWh	$1,860	$65,000	35 years
18. Task 8: Disconnect Unnecessary Exterior Lights	R	Elec	-	Varies	Varies	$0	0 years
19. Task 9: Bus Garage Lighting Disconnect Unnecessary Exterior Lights	RS	Elec	-	0 kWh	n/a	n/a	n/a
20. Task 9: Bus Engine Block Heater Control	R	Elec	-	39,900 kWh	$3,551	$2,820	0.8 years

Notes: Please fill in applicable boxes.
Measure Status: Implemented (I); Recommended (R); Further Study Recommended (RS)
Fuel Saved: Elec, NGas, Oil2, Oil4, Coal, LPG, Propane MMBTU = 1,000,000 BTU

SUMMARY

Sandy Creek Central School District is a public school located in Sandy Creek, New York in Northern Oswego County. The District has a total enrollment of approximately 1,150 students and facilities including a 267,000 square foot main building, a small bus storage/maintenance garage and a small grounds maintenance building. The District is interested in exploring alternative approaches to reduce both thermal and electrical energy consumption throughout the facility. Nine opportunities are being evaluated under the New York State Energy Research and Development Authority (NYSERDA) FlexTech Technical Assistance Program using various energy modeling tools and methods. Each task will be evaluated for total savings and total project cost, with a resulting simple payback calculation. The New York State Education Department requires a payback of less than 18 years for energy performance contract projects. Therefore, a payback of 18 years will be used as the cut-off for a recommendation to proceed with each project in this study. Energy costs of $0.089 per kWh of electrical consumption, $16.65 per kW of electrical demand and $1.30 per therm of natural gas consumption were utilized for the purpose of this energy assessment.

Task 1 – Evaluate Upgrade of Energy Management System (EMS)

The existing energy management system is an Invensys NW8000 system with a user interface running on a Windows 98 platform. Task 1 focused on the capabilities of the energy management system pertaining to control of HVAC and lighting systems. Additional functions could be incorporated into the existing energy management system to improve the operational control. These features include electric demand limiting, optimum start/stop, additional scheduling capability, and duty cycling.

Electric demand limiting would reduce the total electric demand to the facility by managing non-essential electric loads at peak demand periods. An additional benefit of the Invensys electric demand limiting module is its ability to monitor electrical energy consumption and show historical trending of this consumption. It was estimated that the addition of electric demand limiting control could reduce the District's electrical demand by approximately 47 kW per month, resulting in an estimated annual savings of $9,370. The estimated cost to implement this control is $5,000. With an estimated payback period of 0.5 years, it is recommended that the District proceeds with implementation of the electric demand limiting EMS module. The District is also recommended to carefully manage and/or replace other loads with high electric demands such as the dishwasher booster heater and the art kilns.

Optimum start/stop would modify the way the EMS transitions between occupied and unoccupied periods. The implementation of optimum start/stop will ensure that the HVAC systems are transitioning between occupancy periods in the most energy efficient manner by monitoring the zone temperatures and outdoor temperature and then adjusting the length of these occupancy transition periods appropriately. Calculating the actual energy savings based on implementation of a control algorithm like optimum start/ stop requires extensive building modeling, which is well beyond the scope of this assessment. However, with a small implementation cost of approximately $3,000 for software programming, a small savings would result in favorable payback. Additionally, because this is a building-wide control, small percentage savings are significant. For example, with a $175,000 annual natural gas bill, a 0.25 percent reduction in natural gas consumption would result in $438 annual savings and a 6.9 year payback.

Task 2 – Evaluate Upgrade of Interior Lighting Fixtures

There are approximately 15 areas throughout the building, including both hallways and stairwells with large window and/or glass block wall areas that allow a significant quantity of sunlight into the space. These circuits can be modified to allow automatic control based on a light sensor in the space, turning off only those fixtures in the well-lit areas during periods of sunshine. This upgrade would achieve annual savings of approximately 6,889 kWh and $613. With an estimated upgrade cost of $5,700 and a simple payback period of 9.3 years, it is recommended that the District proceeds with implementation of daylight harvesting control in these areas.

Occupancy sensors could be installed to allow the lights in a space to turn-off when there are no occupants in the room. These sensors would be installed to allow use of the existing circuit wiring, keeping upgrade costs low. Typical spaces were defined and the energy savings was then calculated for each of these spaces, based on 1, 2, 3 and 4 hours of unoccupied time (and therefore, lights off) per day. The analysis shows that installing occupancy sensors would provide payback periods under the 18 year cutoff required by the NY State Education Department in many spaces. In these cases, it is recommended that the District proceeds with implementation of this energy saving strategy.

The Gym Complex floor lighting consists of forty 400 watt metal halide hanging fixtures. The lighting is on from 6:15 a.m. to 11:00 p.m. during school days from September to June. The gym complex metal halides could be upgraded to high efficiency T5HO fluorescent fixtures to save energy while maintaining or improving light levels and providing many other tangible benefits. Additionally, occupancy control and daylight harvesting could be implemented to reduce the number of hours that the lights are on during building occupied periods. The analysis shows an annual savings of 47,774 kWh, 9.2 kW and $5,784. With an estimated upgrade cost of $18,100 and a simple payback period of 3.1 years, it is recommended that the District proceeds with the upgrade of the Gym Complex lighting.

The Library lighting consists of fifteen 250 watt metal halide hanging bowl fixtures. The lighting is on from 7:00 a.m. to 11:00 p.m. during school days from September to June. The Library lighting could be upgraded from the existing 250 watt metal halide fixtures to high efficiency T5HO fluorescent fixtures to save energy while improving light levels and providing many other tangible benefits. Additionally, occupancy control could be implemented to reduce the number of hours that the lights are on during building occupied periods. The analysis shows an annual savings of 7,317 kWh, 1.0 kW and $814. With an estimated upgrade cost of $10,200 and a simple payback period of 12.5 years, it is recommended that the District proceeds with the upgrade of the Gym Complex lighting.

The Elementary Gym lighting system consists of thirty-two 175 watt metal halide hanging fixtures. The lighting is on from 6:15 a.m. to 11:00 p.m. during school days from September to June. The Elementary Gym metal halides could be upgraded to high efficiency T8 fluorescent fixtures to save energy while maintaining or improving light levels and providing many other tangible benefits. Additionally, occupancy control and daylight harvesting could be implemented to reduce the number of hours that the lights are on during building occupied periods. The analysis shows an annual savings of 18,904 kWh, 3.6 kW and $2,288. With an estimated upgrade cost of $13,500 and a simple payback period of 5.9 years, it is recommended that the District proceeds with the upgrade of the Elementary Gym lighting.

Task 3 – Evaluate Kitchen Ventilation Systems

The kitchen area has one walk-in cooler and one walk-in freezer, each with an outdoor condensing unit installed in the ceiling space above the walk-in units. This ceiling space has poor ventilation which could be improved by installing a ducted make-up air path from the outdoors to the condensing unit space. The analysis shows that upgrading the ventilation in this space results in an annual savings of 1,119 kWh and $100. With an estimated upgrade cost of $1,900 and a simple payback period of 19.1 years, which is longer than the 18 year cutoff required by the NY State Education Department, this measure would not be recommended for implementation solely for a reduction in energy consumption.

The exhaust hood in the kitchen area is a Caddy Model SHC acting as the primary collection of cooking vapors and residues. Two air handling units provide make-up air to the kitchen. The exhaust hood is currently operating continuously, 365 days/year because it is interlocked with main natural gas shutoff valve serving the kitchen appliances under the hood. The District has been told this operation is required due to the pilot flame in use on the appliances. Discussions with the lead Fire Protection Engineer with the New York State Department of State Building Codes Division have determined that this is not a code requirement. Removing this interlock will allow the exhaust hood to be turned off when its use is not needed, without extinguishing the pilot flames on the kitchen appliances. The cost of upgrade has been estimated at approximately $1,000 to allow review of the existing controls and any implementation of modifications required to accomplish the removal of this interlock. With an estimated annual savings of $15,435 and a simple payback period of 0.1 years, it is recommended that the District proceeds with the removal of the interlock between the exhaust hood and the main gas valve.

Task 4 – Evaluate Improvements to the existing Hot Water Boiler System

The existing central heating plant for the Main Building is a low pressure hot water system consisting of two standard efficiency cast iron boilers and five high efficiency condensing boilers. The standard efficiency boilers are Weil-McLain, Model 2094, cast iron sectionals with power burners. The high efficiency boilers are Fulton, Model PHW-1400 condensing hot water boilers, direct vented with a pulse burner design. All seven boilers operate with natural gas as the primary fuel. The hot water boiler system is currently being operated based on the proper sequence of operations for high efficiency condensing boilers. However, the following items deserve mention for continued operation at the highest possible efficiency:

- The cast-iron sectional boilers should only be operated when the condensing boilers can not handle the steady-state heating load.
- Size future heating coils with a large heating water delta-T to reduce the return water temperature to the boilers. Ensure the overall return water temperature does not decrease to a point that results in an unsuitably low temperature for the cast-iron sectional Weil-McLain boilers.
- Optimize the slope of the outdoor reset curve and the design day supply water temperature to keep the supply water temperature as low as possible throughout the year, while still satisfying all heating loads. Ensure the overall return water temperature does not decrease to a point that results in an unsuitably low temperature for the cast-iron sectional Weil-McLain boilers.

Task 5 – Evaluate Improvements to the Domestic Hot Water System for Gym Complex

The domestic hot water system for the Gym Complex consists of two AO Smith Conservationist Burkay water heaters and a 750 gallon insulated storage tank installed during the 2001 renovation. Based on discussions with Facilities staff and estimated diversity factors for each plumbing fixture, it is estimated that the wing requires 220 gallons of 100°F hot water per day and an average of 10 gallons of 140°F hot water per day. Energy use on the existing system has been estimated to total approximately 470 therms per year, at a cost of $611 per year.

Installation of a smaller, high-efficiency, condensing, tank-type water heater will both reduce the losses due to water heater inefficiency and the standby losses through the storage tank wall. This new system would result in an annual energy demand of 236 therms at a cost of $307 per year. The annual savings over the baseline case is approximately $304. At an estimated construction cost of over $15,000 the simple payback for this strategy will be at least 50 years. With a payback longer than the 18 year cutoff required by the NY State Education Department, this measure would not be recommended for implementation solely for a reduction in energy consumption.

It was determined that 140°F water is actually not required in the Gym Complex. Reducing the hot water tank storage temperature from 150°F to 110°F would result in a reduction in standby losses of 103 therms per year, for an estimated annual savings of $134. There is no cost associated with this modification, so the payback is immediate and it is recommended that the District proceeds with lowering the hot water tank storage temperature.

The existing storage tank has fiberglass insulation with an R-value of 5.2. Increasing the tank insulation will reduce the standby losses associated with this hot water storage. The analysis shows that installing additional insulation on the Gym Complex domestic hot water storage tank could result in a savings of up to 83 therms per year and $108 per year. With an estimated upgrade cost of $1,000 and a simple payback of approximately 9.3 years, it is recommended for the District to proceed with installation of additional faced blanket insulation.

Task 6 – Evaluate Implementation of DCV Control - Auditorium AHU

The Main Building includes an auditorium of approximately 4,500 ft^2 and a stage of approximately 1,800 ft^2, served by two 6,000 CFM rooftop units. The admittance of outdoor air into the space is currently on scheduled control during conditioning periods and economizer control during economizing periods.

There is no ability to modulate outdoor air flow based on actual space occupancy. Demand control ventilation (DCV) is a method of control that allows modulation of the flow of outdoor air to the space based on real-time occupancy. A common and effective method of estimating the real-time occupancy, based on the principles of human physiology, is to measure the actual concentration of carbon dioxide in the space air. One or more carbon dioxide sensors would be installed in the space and the reported concentrations would be compared to the concentration reported by a sensor located outdoors. The flow of outdoor air would then be controlled to maintain the desired space carbon dioxide level. The analysis shows that the implementation of carbon dioxide based DCV control for the auditorium and stage ventilation would result in an annual savings of 1,330 kWh, 6,693 therms and $8,919. With an estimated upgrade cost of $2,000 and a simple payback of approximately 0.2 years, it is recommended for the District to proceed with installation of carbon dioxide based DCV control for the auditorium and stage areas.

Task 7 – Facility Wide Audit of Plug Loads

A plug load audit was performed, estimating the types and quantity of equipment powered by 120V electrical receptacles throughout the District's facility. Task 7 analyzes the estimated electrical energy consumed by these devices and provides recommendations for energy reduction. The annual operation of each piece of equipment was estimated based on the District schedule and discussions with Facilities staff.

Improved vending machine control could be installed to reduce the hours/day that the vending machines are operating, but still allow the machine to power on when a potential customer enters the area. Installing this control would provide an estimated annual savings of 7,227 kWh and $643. With an estimated upgrade cost of $2,180 and a simple payback of approximately 3.4 years, it is recommended for the District to proceed with installation of improved vending machine control.

Computers and monitors should be turned off when not in use for extended periods (e.g. weekends, overnight). Ensuring that all monitors and computers are powered off at night and during off-days will provide significant savings over the cost of continuous operation. Eliminating this consumption and instituting the same practice to 500 computers over 190 days per year could result in total annual savings of approximately 213,750 kWh and $19,000, with no implementation cost. With this immediate payback period, it is recommended that the District proceeds with implementation of this energy saving strategy. The District also has approximately 100 laptop computers in use and by following the same strategies discussed for the desktop computers, similar percent reductions in energy consumption can be achieved.

Setting all computers to enter standby and all monitors to enter sleep mode after a short period of inactivity could save an estimated additional 25,650 kWh and $2,300 per year (assuming each computer/monitor enters this standby/sleep mode for 2 hours of the 9 hour day), with no implementation cost. With this immediate payback period, it is recommended that the District proceeds with implementation of this energy saving strategy.

As new monitors are purchased for the District, upgrading from CRT monitors to LCD monitors will save additional energy. Upgrading the monitors at all workstations from CRT to LCD could save an additional 30,875 kWh and $2,748 per year, which amounts to approximately $5.50 savings for each computer. Payback on this will vary as the cost of LCD monitors comes down. If the upgrade cost from CRT to LCD is $30, the payback is approximately 5.5 years. When purchasing new monitors, the District should evaluate the additional cost required to upgrade to LCD monitors and proceed with LCD if the payback is less than the expected life of the monitor.

Each compact refrigerator requires approximately 321 kWh per year to operate, costing approximately $29 year. The elimination of the estimated 15 compact refrigerators would result in an annual savings of approximately $429, assuming there is open space in the existing common area refrigerators and additional refrigerators do not need to be added. It is recommended that the District evaluate compact refrigerator use on a case-by-case basis and eliminate loads not providing enough benefit to warrant the cost of operation.

Each small microwave requires approximately 66 kWh per year to operate, costing approximately $6 each per year. About 2/3 of this energy is consumed while the microwave is in standby (estimated 5 watts of power required) and the other half is used when in heating mode. Removal of the estimated 5 small microwaves will eliminate the standby energy use, estimated to be 44 kWh per year for each microwave, or about 219 kWh per year total. The energy used in heating mode will still be required but will simply shift to a common area microwave, so the total energy reduction will be approximately 219 kWh per year, for an annual savings of $19. Therefore, the elimination of each small microwave will save approximately $4 per year in standby energy use (assuming it is left plugged in 365 days/year). It is recommended that the District evaluate small microwave use on a case-by-case basis and eliminate loads not providing enough benefit to warrant the cost of operation.

A residential size single burner coffee maker requires approximately 86 kWh per year to operate, costing approximately $8 per year. The elimination of the estimated 8 coffee makers will result in a cost reduction of approximately $61 per year. It is recommended that the District evaluate small coffee maker use on a case-by-case basis and eliminate loads not providing enough benefit to warrant the cost of operation.

A 1,500 watt space heater consumes approximately 13.5 kWh if run constantly over a 9 hour day, at a cost of approximately $1.20 per day. Assuming the heaters are operated when the outdoor temperature is below 35°F (about 670 occupied hours per year), each heater will consume approximately 1,005 kWh per year, at a cost of $89. The elimination of the estimated ten space heaters will result in a cost savings of approximately $894 per year. It is recommended that the District eliminates the use of electric space heaters and utilize installed HVAC equipment for all space conditioning needs.

It is recommended that the District ensures operating practices include powering down printers, projectors, smartboards and copiers during off periods (nights, weekends, etc) and setting up the equipment to enter sleep/standby modes during periods of inactivity, as the equipment allows. There is no implementation cost for these modifications, so the payback is immediate. Additionally, when evaluating future equipment purchases, the District should consider total energy consumption of the equipment, as well as the availability of energy saving features such as standby mode.

Task 8 – Evaluate Exterior Lighting

The academic building has six circuits of exterior wall lights that were considered in Task 8 for re-circuiting to reduce the total annual energy consumption. The existing operation calls for all circuits to be energized throughout the night. Each circuit includes multiple 250 watt high pressure sodium wall-mounted fixtures. Re-circuiting the exterior lights to allow the lights to be controlled on two separate schedules would result in annual savings of approximately 20,903 kWh and $1,860. An estimated upgrade cost of $65,000 gives a simple payback of approximately 35 years. With a payback longer than the 18 year cutoff required by the NY State Education Department, this measure would not be recommended for implementation solely for a reduction in energy consumption.

If there are lights that are not required to operate at all (including the evening hours), it is recommended that the District remove these light bulbs or disconnect these fixtures from the circuit for an annual savings of approximately $115 per deactivated fixture.

Task 9 – Evaluate Bus Garage Lighting and Block Heater Control

The bus garage includes a 20'x84' repair bay, a 76'x84' six-bay storage area and approximately 1,000 square feet of additional storage and office space. There are sixty-three 32 watt T8 fixtures throughout these spaces. The T8 fluorescent fixtures currently installed in the bus garage facility are considered high efficiency lighting and after reviewing the efficacy (i.e., measure of light output per unit of energy input) of these fixtures there are no options that will result in energy savings significant enough to warrant fixture replacements. With no suitable upgrade options for energy savings, no action is recommended at this time.

The bus garage parking area has provisions for powering 14 engine block heaters in the school bus fleet. The circuits are energized at all times, so the heaters are in operation at all periods during which they are plugged in. To reduce the annual hours of operation, the bus engine block heater circuits would be wired through contactors controlled by a timeclock. Bus garage personnel would be able to program the system to energize the circuits only when necessary. The analysis shows that the installation of an automated control system for the bus engine block heaters would result in annual savings of approximately 39,900 kWh and $3,551. With an estimated upgrade cost of $2,820 and a simple payback of approximately 0.8 years, it is recommended for the District to proceed with implementation of this energy saving strategy.

SANDY CREEK CENTRAL SCHOOL DISTRICT
ENERGY CONSERVATION STUDY

SECTION 1
BACKGROUND

Sandy Creek Central School District Background Information

Sandy Creek Central School District is a public school located in Sandy Creek, New York in Northern Oswego County. The District is bordered by Lake Ontario to the West and the Tug Hill Plateau to the East and encompasses the villages of Sandy Creek and Lacona. Total enrollment is approximately 1,150 students from pre-kindergarten through twelfth grade. The District's facilities include a 267,000 square foot main building, a small bus storage/maintenance garage and a small grounds maintenance building. The main building was constructed first, followed by succeeding additions and major renovations in recent years. Typical to a public school, the facility incorporates classrooms, cafeterias, auditorium, gymnasium, administrative offices and other utility/miscellaneous areas.

The facility utilizes a variety of HVAC systems that include central air handling units (AHU's), roof top units (RTU's), packaged terminal air conditioners (PTAC's), unit heaters and exhaust fans. Heating is primarily supplied by gas-fired hot water boilers or by indirect-fired natural gas heating sections in the RTU's. Where utilized, cooling is by direct-expansion refrigerant coils in conjunction with air-cooled condensing units.

The District is interested in exploring alternative approaches to reduce both thermal and electrical energy consumption throughout the facility. Nine opportunities are being evaluated under the New York State Energy Research and Development Authority (NYSERDA) FlexTech Technical Assistance Program using various energy modeling tools and methods. Each task will be evaluated for total savings and total project cost, with a resulting simple payback calculation. The New York State Education Department requires a payback of less than 18 years for energy performance contract projects. Therefore, a payback of 18 years will be used as the cut-off for a recommendation to proceed with each project in this study.

Sandy Creek Central School District Annual Energy Costs

Electric utility information provided by the District and National Grid indicates an annual consumption of 1,877,400 kWh of electrical energy with an average peak demand of 469 kW (April 2007 to March 2008 basis). The current cost for electrical energy usage, on an incremental basis, is $0.089 per kWh. The current cost for electrical energy demand, on an incremental basis, is $16.65 per kW. These electrical costs were utilized for the purpose of this energy assessment.

Natural gas utility information provided by the District indicates annual natural gas consumption of 134,579 therms at a total cost of $174,810 (October 2006 to September 2007 basis). The resulting estimated unit cost is $1.30 per therm. This natural gas cost was utilized for the purpose of this energy assessment.

SANDY CREEK CENTRAL SCHOOL DISTRICT
ENERGY CONSERVATION STUDY

SECTION 2
ENERGY CONSERVATION TASKS

TASK 1 – EVALUATE UPGRADE OF ENERGY MANAGEMENT SYSTEM (EMS)

Field Findings

The existing energy management system is an Invensys NW8000 system with a user interface running on a Windows 98 platform. This task will focus on the capabilities of the energy management system pertaining to control of HVAC and lighting systems. The EMS includes operational control, monitoring and scheduling of these systems. Scheduling capability for the lighting systems is spread out across approximately 14 zones and is primarily performed on a wing-by-wing basis (three zones) for the HVAC systems.

The District staff is extremely diligent in monitoring and adjusting the variable control parameters and schedules to conserve energy, while continuing to meet the needs of the building occupants. However, manual adjustments cannot accomplish the same level of optimization and cannot adapt to real-time information that advanced EMS features can. This task will address several advanced features that are available.

Analysis

Additional functions could be incorporated into the existing energy management system to improve the operational control. These features include electric demand limiting, optimum start/stop, additional scheduling capability and duty cycling.

Electric Demand Limiting

Electric demand limiting is a feature that allows the EMS to monitor the real-time electric demand of the facility and prevent the operation of non-critical equipment when the operation of that equipment will cause the electric demand to climb above a pre-set limit. An analog input to the EMS would be installed from the existing demand meter to provide this real-time electric demand information. The system operator would define an electric demand limit, which is essentially the largest kW draw that the EMS will allow at any given time, and the EMS would then control to this setpoint. Each of the substantial electrical loads in the facility would be identified with parameters including type of load, criticality, shed priority and various time limits. As the electric demand climbs towards the preset value, all systems would continue to run based on their defined sequence of operations. When the electric demand limit is reached, and another electrical load needs to start, the system will "shed" non-essential loads to keep the electric demand below the limit. The EMS will determine which load(s) to shed based on the parameters entered for each load and then shed the least critical load(s). For example, the EMS may disable the air-conditioning unit for the zone that is closest to its setpoint temperature. Over time, as the electric load decreases below the limit, additional non-essential loads will be allowed to come back on-line. The operation of this feature smoothes the peaks and valleys of the electric demand profile which can result in substantial savings.

The magnitude of the kW demand reduction is completely controllable by the operator of the system; with the limiting factors being the total demand of essential loads and the occupant comfort levels related to non-essential loads (e.g., cooling). Depending on the state of the existing operation, similar facilities average approximately 10-15 percent reduction in kW demand without extensive discomfort from occupants. The National Grid utility bill from March 2008 showed an average billed demand of 469 kW over the last twelve months. If the average peak demand was reduced by 10 percent the resulting reduction would be 46.9 kW. At a current demand charge of $16.65 per kilowatt, this results in a monthly savings of approximately $781 and an annual savings of approximately $9,370.

Based on a budgetary estimate from Building Controls & Services, the implementation of electric demand limiting would cost the District approximately $5,000. This would include the installation of a sensor to input the actual real-time kilowatt demand to the EMS and the necessary programming required for the electric demand limiting module to operate properly. At an estimated annual savings of $9,370, the simple payback for this upgrade is approximately 0.5 years.

An additional benefit of the Invensys electric demand limiting module is its ability to monitor electrical energy consumption and show historical trending of this consumption. This will provide the District's Facilities staff the information needed to accurately measure reductions in consumption, in addition to reductions in peak demand, resulting from improved operations and equipment.

Not directly related to the energy management system, but closely tied to the concept of demand limiting is the electric booster heater for the dishwasher in the cafeteria area. The dishwasher is a Jackson MSC Model AJ-66CE and it requires a final rinse flow of 3.9 GPM at 180°F. The installed booster heater is a Hatco Model C-45 that is powered by a 480V/3Ø electrical supply, is rated at 45.0 kW and can supply a 7.5 GPM flow of 180°F water when fed with a 140°F supply (the existing drawings indicate a 140°F water supply to the dishwasher). As stated, the actual required flow to the dishwasher is about 3.9 GPM, so the heater is oversized by approximately 90 percent. A properly sized booster heater for this application would be 24.0 to 27.0 kW to supply 4.0 to 4.5 GPM of 180°F water with a 140°F water supply to the heater. Installation of a 27.0 kW heater booster heater would result in an electric demand reduction of 18.0 kW during the school months bring down the annual average by 15.0 kW per month (10 out of 12 months for the year). The resulting savings could approach $250 per month and $3,000 per year (if the heater is running at the peak demand time for each of the 10 school months). A new 27.0 kW electric booster heater could be installed for approximately $2,600 for a simple payback period of 0.9 years. Additional electric demand reduction, as well as reduced electrical consumption, could be achieved by switching to a natural-gas fired appliance for this water heating requirement.

Other large electrical loads in the facility should be closely monitored, including the kilns in the Elementary and High School art rooms. The Elementary art room kiln is a 208 volt, single-phase unit rated at 11,438 watts and the High School art room kiln is a 208 volt, three-phase unit rated at 14,300 watts. Each of the kilns is used approximately 30 times per year, for 18 hours per run. If these kilns are being operated during the middle of the day on weekdays, savings could be achieved by simply altering the schedule of operation to avoid the maximum demand period for the facility. If the kilns are run during the week, they should be started in the very late afternoon to complete the run by mid-morning. As an example, if both of these kilns were actually operated during the peak electrical demand period for each month (September to June), the additional annual demand charge could be over $4,000, as illustrated in the calculation below. This illustrates a worst case, but shows how much the cost of energy can be affected simply by running an art appliance at the wrong time of the day.

Additional Monthly Demand Charge (for 10 months/year) = 25.7 kW * $16.65 = $428
Effect on Avg Monthly Demand Charge (due to 10 months/year operation) = $428 * 10/12 = $357
Additional Annual Demand Charge = $357 * 12 months = $4,284 per year

The analysis of the dishwasher booster heater and the art kilns were not part of the original scope of this report, but were included due to the large impact that they can have on the electrical demand charges. There are other electric water heaters throughout the facility (also not part of the scope of this report), that should be considered for electric demand reduction. Where practical, these heaters could be replaced with natural-gas fired units if they must run during peak electrical demand periods. If their use is limited and not critical, they can be tied in with the EMS electric demand limiting module to prevent their operation during peak periods.

Scheduling

The existing lighting control is across 14 separate lighting zones. The interior zones all have similar schedules because of similar occupancy schedules, which include time required by the cleaning staff in the evening hours. Therefore, individual space controls (e.g., occupancy sensors, daylighting control) will be reviewed and addressed in Task 2. For exterior lighting, additional zones could be added to reduce the number of fixtures that are operating throughout the night. These modifications will be addressed in Task 8.

Optimum Start/Stop

The HVAC systems are controlled to maintain occupied and unoccupied setpoints based on schedules maintained by an operator. At the end of each occupied or unoccupied period, the system should operate to prepare the space(s) for the new setpoint(s) in the most energy efficient manner. For example, when transitioning from unoccupied to occupied setpoints in heating mode, the unit should run for a period of time at the end of the unoccupied period to achieve the occupied setpoint before occupancy. Depending on the building load, this warm-up period can vary greatly. It may take one hour to raise the building temperature on a 0°F day, but only 20 minutes on a 50°F day. A fixed warm-up period will therefore result in wasted energy on all but the coldest days of the year. Similar situations are present at all transitions between occupied and unoccupied periods, in both heating and cooling mode.

The implementation of optimum start/stop control will ensure that the HVAC systems are transitioning between occupancy periods in the most energy efficient manner by monitoring the zone temperatures and outdoor temperature and then adjusting the length of these occupancy transition periods appropriately. Calculating the actual energy savings based on implementation of a control algorithm like optimum start/ stop requires extensive building modeling, which is well beyond the scope of this assessment. However, with a small implementation cost of approximately $3,000 for software programming, a small savings would result in favorable payback. Additionally, because this is a building-wide control, small percentage savings are significant. For example, with a $175,000 annual natural gas bill, a 0.25 percent reduction in natural gas consumption would result in $438 annual savings and a 6.9 year payback.

Duty Cycling

Another EMS feature is duty cycling, which allows for electrical loads (such as pumps and fans) to be turned off for adjustable periods of time to save on the electrical energy consumption required for their operation. The implementation of a duty cycling feature will not have as significant of an impact on District's energy cost as the other features being discussed because of the types of electrical loads present. The majority of the fans in the District (if not all of them) are running to satisfy a ventilation requirement and could not be shut off with duty cycling. Circulating pumps would not be a candidate for duty cycling, as they should be controlled to simply turn off when the zone(s) that they are serving are not requiring flow. The energy required to run air conditioning compressors would not be reduced because of the nature of air conditioning operation. The thermal energy transfer must still be accomplished, if the compressors were shut off for 15 minutes out of the hour, the unit would just work harder for the remaining 45 minutes to accomplish the same cooling.

Recommendation

Electric Demand Limiting

The analysis shows that the implementation of electric demand limiting would result in a simple economic payback period of approximately 0.5 years. With this favorable payback period, it is recommended that the District proceeds with implementation of this energy saving strategy. It is also recommended for the District to work to reduce electrical demand in other ways, including installation of gas-fired appliances and operational control of high electrical demand appliances, such as art kilns.

Scheduling

See Task 2 for interior lighting and Task 8 for exterior lighting.

Optimal Start/Stop

The analysis shows that the implementation of optimal start/stop control would result in an estimated simple economic payback period of less than 10 years. With this favorable payback period, it is recommended that the District proceeds with implementation of this energy saving strategy.

Duty Cycling

The District should consider duty cycling operation if they encounter future significant electrical loads that 1) run continuously, 2) are not required to run continuously and 3) lack a parameter to control part-time operation.

TASK 2 – EVALUATE UPGRADE OF INTERIOR LIGHTING FIXTURES

Field Findings

Daylight Harvesting Control

There are approximately 15 areas throughout the building, including both hallways and stairwells with large window and/or glass block wall areas that allow a significant quantity of sunlight into the space. The fixtures in these areas are either two lamp luminaires with 32 watt T8 lamps or two lamp luminaires with 40W Philips PL-L lamps. A summary of these circuits and their fixture counts can be found in Table 2.1, in the analysis section.

Occupancy Sensors

The occupancy sensor analysis will be based on a typical spaces and will show the payback when these typical spaces are left unoccupied for various periods of time.

Gym Complex Lighting

The Gym Complex floor lighting consists of forty 400 watt metal halide hanging fixtures. The lighting is on from 6:15 a.m. to 11:00 p.m. during school days from September to June.

Library Lighting

The Library lighting consists of fifteen 250 watt metal halide hanging bowl fixtures. The lighting is on from 7:00 a.m. to 11:00 p.m. during school days from September to June.

Elementary Gym Lighting

The Elementary Gym lighting system consists of thirty-two 175 watt metal halide hanging fixtures. The lighting is on from 6:15 a.m. to 11:00 p.m. during school days from September to June.

Analysis

Daylight Harvesting Control

The circuits that have been identified as having a significant amount of sunlight can be modified to allow automatic control based on a light sensor in the space. The circuits would be rewired to allow only those fixtures in these well lit areas to turn-off during periods of sunshine. Based on National Weather Service climatological data from 2005 through 2007, Syracuse, New York receives an average of approximately 2,200 hours of sunshine per year, which is approximately 50 percent of the total hours of daylight throughout the year. Multiplying this number by 5/7 (weekdays only), results in an average of 1,570 hours of sunshine on weekdays per year. For this analysis, it is assumed that the hallway lighting is energized on weekdays throughout the year, including the summer.

Table 2.1 summarizes the 15 circuits, the number of fixtures in each circuit and the watts per fixture. The total wattage on each circuit was then multiplied by 1,570 hours of sunshine to achieve the estimated annual energy savings in kilowatt-hours. Finally the energy savings across all circuits was totaled to reach an estimated average annual savings of 6,889 kWh and $613. The estimated cost to upgrade these circuits to allow daylight harvesting control is approximately $5,700 for an estimated simple payback of 9.3 years.

Table 2.1
Daylighting Analysis

Circuit #	Location	Fixture	Fixture Count	Watts/ Fixture	kWh Saved
Circuit #1	Elem. Ground Floor	2 Lamp, 48", 32W T8	5	58	455
Circuit #2	Elem. Ground Floor	2 Lamp, 48", 32W T8	5	58	455
Circuit #3	Elem. Ground Floor	2 Lamp, 48", 32W T8	4	58	364
Circuit #4	Elem. Ground Floor	2 Lamp, 48", 32W T8	2	58	182
Circuit #5	Elem. Ground Floor	2 Lamp, 40W Philips PL-L	11	72	1,243
Circuit #6	HS Ground Floor	2 Lamp, 48", 32W T8	3	58	273
Circuit #7	HS Ground Floor	2 Lamp, 48", 32W T8	4	58	364
Circuit #8	HS Ground Floor	2 Lamp, 48", 32W T8	3	58	273
Circuit #9	HS Ground Floor	2 Lamp, 48", 32W T8	3	58	273
Circuit #10	HS Second Floor	2 Lamp, 48", 32W T8	4	58	364
Circuit #11	HS Second Floor	2 Lamp, 48", 32W T8	5	58	455
Circuit #12	HS Stairwell	2 Lamp, 40W Philips PL-L	5	58	455
Circuit #13	HS Stairwell	2 Lamp, 40W Philips PL-L	5	58	455
Circuit #14	HS Stairwell	2 Lamp, 40W Philips PL-L	7	58	637
Circuit #15	HS Stairwell	2 Lamp, 40W Philips PL-L	7	58	637
				Total Annual Energy Savings (kWh)	6,889
				Total Annual Monetary Savings	$613

Occupancy Sensors

Occupancy sensors could be installed to allow the lights in a space to turn-off when there are no occupants in the room. These sensors would be installed to allow use of the existing circuit wiring, keeping upgrade costs low. All spaces are assumed to have all fixtures on a single circuit.

Typical spaces (with fixture type and fixture count) were defined in Table 2.2 and Table 2.3 along with estimated days of operation per year. The energy savings was then calculated for each of these spaces, based on 1, 2, 3 and 4 hours of unoccupied time (and therefore, lights off) per day. The resulting total energy savings, monetary savings and simple payback is shown.

Table 2.2
Occupancy Sensor Analysis
Fixture Type: 3 Lamp, 48", 32W T8

Fixture Count	Watts/ Fixture	Circuit On (Days/Yr)	Unoccupied (Hrs/Day)	Energy Savings (kWh)	Monetary Savings	Cost of Upgrade	Simple Payback (Years)
12	90	190	1	205	$18	$340	18.6
12	90	190	2	410	$37	$340	9.3
12	90	190	3	616	$55	$340	6.2
12	90	190	4	821	$73	$340	4.7
6	90	190	1	103	$9	$340	37.2
6	90	190	2	205	$18	$340	18.6
6	90	190	3	308	$27	$340	12.4
6	90	190	4	410	$37	$340	9.3

Table 2.3
Occupancy Sensor Analysis
Fixture Type: 2 Lamp, 48", 32W T8

Fixture Count	Watts/ Fixture	Circuit On (Days/Yr)	Unoccupied (Hrs/Day)	Energy Savings (kWh)	Monetary Savings	Cost of Upgrade	Simple Payback (Years)
12	58	190	1	132	$12	$340	28.9
12	58	190	2	264	$24	$340	14.4
12	58	190	3	397	$35	$340	9.6
12	58	190	4	529	$47	$340	7.2
6	58	190	1	66	$6	$340	57.8
6	58	190	2	132	$12	$340	28.9
6	58	190	3	198	$18	$340	19.3
6	58	190	4	264	$24	$340	14.4

Gym Complex Lighting

The Gym Complex metal halides could be upgraded to high efficiency T5HO fluorescent fixtures to save energy while maintaining or improving light levels. Replacing all forty existing 400 watt metal halide fixtures with 4 lamp, 54W T5HO fixtures will result in a reduction in annual electrical consumption. Electrical demand reductions will also be realized because these lamps are operated during the day throughout the school year. The T5HO fixtures provide many other benefits over the HID fixtures including: instant on starting (hot and cold), optional emergency lighting (for egress), improved color rendition, longer lamp life, no lamp noise and improved light level maintenance (the HID lamp provides greatly reduced light level as it ages).

Additionally, the installation of occupancy sensor/photocell control will allow the lights to be turned off when the space is not occupied and when natural light levels are high enough to suit the occupants. It is estimated that the occupancy based control will allow the lights to be turned off for an average of 4 hours per day and that the daylight harvesting control will allow the lights to be turned off for approximately 50 percent of the remaining hours. For the purpose of this assessment, a low voltage control system was priced which will provide common control to all fixtures on each circuit.

Table 2.4 details the fixture wattage and operation of the existing and upgraded cases, along with the associated electrical consumption reduction, electrical demand reductions, total savings, upgrade cost and simple economic payback.

Table 2.4 Gym Complex Lighting Analysis		
Item	**Existing**	**Upgrade**
Fixture and Operation Details		
Fixture Type	400W Metal Halide	4 Lamp, 54W T5HO
Fixture Quantity	40	40
Input Watts	465	235
Building Occupied - Lights On (hrs/yr)	3,180	1,210
Building Occupied - Lights Off (hrs/yr)	0	1,970
Energy Consumption Reduction and Savings		
Energy Consumption (kWh/yr)	59,148	11,374
Reduced Energy Consumption (kWh/yr)		47,774
Associated Annual Monetary Savings		$4,252
Electrical Demand Reduction and Savings		
Electrical Demand (kW)	18.6	9.4
Reduced Demand (kW)		9.2
Associated Annual Monetary Savings		$1,532
Total Savings, Upgrade Cost and Simple Payback		
Total Annual Monetary Savings		$5,784
Upgrade Cost		$18,100
Simple Payback (years)		3.1

Library Lighting

The Library lighting could be upgraded from the existing 250 watt metal halide fixtures to high efficiency T5HO fluorescent fixtures to save energy while improving light levels. Replacing all 15 existing 250 watt metal halide fixtures with fifteen 4 lamp, 54W T5HO fixtures (in a new layout) will result in reductions in both electrical consumption and electrical demand. Additionally, the light levels in the Library will improve with the new fixtures and layout, providing a higher quality space for the occupants. The T5HO fixtures also provide many other benefits over the HID fixtures including: instant on starting (hot and cold), optional emergency lighting (for egress), improved color rendition, longer lamp life, no lamp noise and improved light level maintenance (the HID lamp provides greatly reduced light level as it ages). A good example of the fluorescent benefit is the way in which they handle a power outage. The new fixtures can include battery powered lighting for egress. Additionally, when the power returns the fluorescent will restart instantly, while the HID fixtures may take 10-15 minutes to restart when hot.

The installation of fixture mounted occupancy sensors would allow only the fixtures in occupied areas of the library to be energized. A substantial portion of the occupied hours during the day are after the students have left the building and during this time janitorial staff is only periodically in the space. Fixture mounted sensors would only turn on fixtures when the janitorial staff is in the space and would only turn on the fixtures that the staff is near (the remainder of the space would remain off). For the purpose of this assessment, it is estimated that the occupancy based control will allow the lights to be turned off for an average of 6.5 hours per day.

Table 2.5 details the fixture wattage and operation of the existing and upgraded cases, along with the associated electrical consumption reduction, electrical demand reductions, total savings, upgrade cost and simple economic payback.

Table 2.5
Library Lighting Analysis

Item	**Existing**	**Upgrade**
Fixture and Operation Details		
Fixture Type	250W Metal Halide	4 Lamp, 54W T5HO
Fixture Quantity	15	15
Input Watts	300	235
Building Occupied - Lights On (hrs/yr)	3,040	1,805
Building Occupied - Lights Off (hrs/yr)	0	1,235
Energy Consumption Reduction and Savings		
Energy Consumption (kWh/yr)	13,680	6,363
Reduced Energy Consumption (kWh/yr)		7,317
Associated Annual Monetary Savings		$651
Electrical Demand Reduction and Savings		
Electrical Demand (kW)	4.5	3.5
Reduced Demand (kW)		1.0
Associated Annual Monetary Savings		$162
Total Savings, Upgrade Cost and Simple Payback		
Total Annual Monetary Savings		$814
Upgrade Cost		$10,200
Simple Payback (years)		12.5

Elementary Gym Lighting

The Elementary gym metal halides could be upgraded to high efficiency T8 fluorescent fixtures to save energy while maintaining or improving light levels. Replacing the thirty-two existing 175 watt metal halide fixtures with 4 lamp, 32W T8 fixtures will result in reductions in both electrical consumption and electrical demand. A second lighting option was also evaluated using T5HO fixtures; however, the 2 lamp T5HO fixtures resulted in similar lighting levels and slightly higher energy use than the 4 lamp T8 fixtures. The fluorescent fixtures also provide many other benefits over the HID fixtures including: instant on starting (hot and cold), optional emergency lighting (for egress), improved color rendition, longer lamp life, no lamp noise and improved light level maintenance (the HID lamp provides greatly reduced light level as it ages).

Additionally, the installation of occupancy sensor/photocell control will allow the lights to be turned off when the space is not occupied and when natural light levels are high enough to suit the occupants. It is estimated that the occupancy based control will allow the lights to be turned off for an average of 4 hours per day and that the daylight harvesting control will allow the lights to be turned off for approximately 50 percent of the remaining hours. For the purpose of this assessment, a low voltage control system was priced which will provide common control to all fixtures on each circuit.

Table 2.6 details the fixture wattage and operation of the existing and upgraded cases, along with the associated electrical consumption reduction, electrical demand reductions, total savings, upgrade cost and simple economic payback.

Table 2.6 Elementary Gym Lighting Analysis		
Item	Existing	Upgrade
Fixture and Operation Details		
Fixture Type	175W Metal Halide	4 Lamp, 32W T8
Fixture Quantity	32	30
Input Watts	230	124
Building Occupied - Lights On (hrs/yr)	3,180	1,210
Building Occupied - Lights Off (hrs/yr)	0	1,970
Energy Consumption Reduction and Savings		
Energy Consumption (kWh/yr)	23,405	4,501
Reduced Energy Consumption (kWh/yr)		18,904
Associated Annual Monetary Savings		$1,682
Electrical Demand Reduction and Savings		
Electrical Demand (kW)	7.4	3.7
Reduced Demand (kW)		3.6
Associated Annual Monetary Savings		$606
Total Savings, Upgrade Cost and Simple Payback		
Total Annual Monetary Savings		$2,288
Upgrade Cost		$13,500
Simple Payback (years)		5.9

Upgrading the existing lighting to higher efficiency systems not only reduces the electrical energy consumption and electrical demand for the lighting system, but it also has interactive effects on the HVAC systems. The higher efficiency lighting will result in lower heat gain to the space when the lighting is energized. In heating mode this will result in a slightly higher energy requirement to provide the additional heating. In cooling mode (in spaces that are cooled) the result is a slight reduction in electrical energy required to maintain desired space temperature. For spaces that are not cooled, the higher efficiency lighting will result in slightly lower space temperatures, increasing occupant comfort.

Recommendation

Daylight Harvesting Control

The analysis shows that installing daylight harvesting control on identified circuits in the hallways and stairwells throughout the Elementary and High School wings results in a simple economic payback period of approximately 9.3 years. With this favorable payback period, it is recommended that the District proceeds with implementation of this energy saving strategy.

Occupancy Sensors

The analysis shows that installing occupancy sensors would provide payback periods under the 18 year cutoff required by the NY State Education Department in many spaces. In these cases, it is recommended that the District proceeds with implementation of this energy saving strategy.

Gym Complex Lighting

The analysis shows that upgrading the Gym Complex lighting results in a simple economic payback period of approximately 3.1 years, along with many other tangible benefits. With this favorable payback period, it is recommended that the District proceeds with implementation of this energy saving strategy.

Library Lighting

The analysis shows that upgrading the Library lighting results in a simple economic payback period of approximately 12.5 years, along with many other tangible benefits including improved light levels for the students. With this favorable payback period, it is recommended that the District proceeds with implementation of this energy saving strategy.

Elementary Gym Lighting

The analysis shows that upgrading the Elementary Gym lighting results in a simple economic payback period of approximately 5.9 years, along with many other tangible benefits. With this favorable payback period, it is recommended that the District proceeds with implementation of this energy saving strategy.

TASK 3 – EVALUATE KITCHEN VENTILATION SYSTEMS

Field Findings

Walk-in Cooler/Freezer Condensing Units

The kitchen area has one walk-in cooler and one walk-in freezer, each with an outdoor condensing unit installed in the ceiling space above the walk-in units. The total area of the ceiling space is approximately 12'x20'. The walk-in cooler condensing unit is a Heatcraft Model CHT010H2CF with a capacity of 8,380 BTU/hr at 95°F ambient temperature and 7,260 BTU/hr at 105°F ambient temperature. The walk-in freezer condensing unit is a Heatcraft Model CZT045L6CF with a capacity of 16,290 BTU/hr at 95°F ambient temperature and 15,315 BTU/hr at 105°F ambient temperature. The condensing unit capacities were estimated from manufacturer data.

A 500 CFM exhaust fan pulls air from this ceiling space with no provisions for make-up air. The District Facilities staff has removed ceiling tiles from the kitchen's drop ceiling in an effort to improve air circulation to this area.

Kitchen Exhaust Hood

The exhaust hood in the kitchen area is a Caddy Model SHC acting as the primary collection of cooking vapors and residues. The hood measures approximately 12.5'x10', in a double island canopy arrangement, and is sized to provide an exhaust flow of 5,000 CFM. Two air handling units provide make-up air to the kitchen. Located in the basement, supplying make-up air to kitchen area diffusers, is a Trane Model GSND020, with a 200 MBH input, 160 MBH output, 80 percent efficient indirect fired natural-gas heating section. Located on the roof, supplying make-up air to the kitchen exhaust hood, is a Trane Model GRBA50, with a 500 MBH input, 400 MBH output, 80 percent efficient indirect fired natural-gas heating section. The exhaust hood is currently operating continuously, 365 days/year because it is interlocked with main natural gas shutoff valve serving the kitchen appliances under the hood. The District has been told this operation is required due to the pilot flame in use on the appliances. An Ansul R-102 liquid agent system is installed for fire suppression.

Analysis

Walk-in Cooler/Freezer Condensing Units

As the ambient temperature increases, the capacity of the walk-in cooler and walk-in freezer condensing units decrease. The units must then run for a longer period to obtain the same amount of heat transfer. The following analysis estimates the required annual run-time hours of these condensing units based on an ambient temperature in the condensing unit location of 95°F and 105°F.

The walk-in cooler and the walk-in freezer were modeled to determine the heat transfer through the unit walls. The following assumptions were used in the model:

- *Exterior Surface Areas:* 500 ft^2 each for freezer and cooler
- *Exterior Surface Insulation:* 4" urethane foam, for a total R-value of 31 (hr- ft^2-°F)/BTU and u-value of 0.032 BTU/(hr- ft^2-°F)
- *Average Room Temperature:* 70°F
- *Average Freezer Temperature:* -10°F, for a delta-T of 80°F
- *Average Cooler Temperature:* 38°F, for a delta-T of 32°F

Simple conductive heat transfer across the freezer and cooler walls results in the following energy gains in the cooler and freezer space:

- Freezer Conductive Heat Gain = 500 ft^2 * 0.032 BTU/(hr-ft^2-°F) * 80°F = 1,280 BTU/hr
- Cooler Conductive Heat Gain = 500 ft^2 * 0.032 BTU/(hr-ft^2-°F) * 32°F = 512 BTU/hr

When applied across the entire year, the result is:

- Freezer Conductive Heat Gain = 1,280 BTU/hr * 8760 hours/year = <u>11,212,800 BTU/yr</u>
- Cooler Conductive Heat Gain = 512 BTU/hr * 8760 hours/year = <u>4,485,120 BTU/yr</u>

When the freezer and cooler doors are opened during breakfast and lunch preparation, additional heat is gained in the cooler and freezer that must be rejected. It is assumed that during peak breakfast and lunch preparation periods, the condensing units must run for an additional hour each (in the current configuration at 105°F ambient temperature):

- 2 Hours of Freezer Unit Running at 105°F Ambient = 30,630 BTU/day
- 2 Hours of Cooler Unit Running at 105°F Ambient = 14,520 BTU/day

Applied across 190 school days results in the following:

- Freezer Air Transfer Heat Gain = 30,630 BTU/day * 190 days/year = 5,819,700 BTU/yr
- Cooler Air Transfer Heat Gain = 14,520 BTU/day * 190 days/year = 2,758,800 BTU/yr

Table 3.1 sums the air transfer heat gain and the conductive heat gain to show the total heat rejection required. The total condensing unit run time, in hours per year, is then calculated for both 105°F ambient and 95°F ambient, based on the different condensing unit capacities at these temperatures. Based on the condensing unit electrical power, the annual energy consumed and the resulting cost of operation was then calculated. Finally, the energy and monetary savings is shown as the difference between the two operating conditions.

Table 3.1 Condensing Unit Energy Analysis		
Item	Walk-in Freezer	Walk-in Cooler
Operation at 105°F Ambient Temperature		
Total Heat Rejection Required (BTU/year)	17,032,500	7,243,920
Condensing Unit Capacity (BTU/hour)	15,315	7,260
Total Condensing Unit Run-Time (hours/year)	1,112	998
Total Condensing Unit Electrical Power Required (kW)	8.6	4.1
Total Electrical Energy Consumed (kWh/year)	9,564	4,091
Cost of Electrical Energy Consumed ($/year)	$851	$364
Operation at 95°F Ambient Temperature		
Total Heat Rejection Required (BTU/year)	17,032,500	7,243,920
Condensing Unit Capacity (BTU/hour)	16,290	8,380
Total Condensing Unit Run-Time (hours/year)	1,046	864
Total Condensing Unit Electrical Power Required (kW)	8.6	4.1
Total Electrical Energy Consumed (kWh/year)	8,992	3,544
Cost of Electrical Energy Consumed ($/year)	$800	$315
Savings, Cost of Upgrade & Simple Payback		
Energy Savings (105°F vs 95°F Ambient) (kWh/year)	572	547
Monetary Savings (105°F vs 95°F Ambient) ($/year)	$51	$49

The existing 500 CFM exhaust fan has the capability to remove approximately 5,400 BTU/hour from the condensing unit space when the outside air temperature is 85°F and the space temperature is 95°F, based on the following calculation:

- Heat Removal = Fan CFM * 1.08 * Delta-T = 500 * 1.08 * 10 = 5,400 BTU/hr

The average hourly heat rejection is well below this number (it is approximately 2,800 BTU/hr), so the fan would be able to maintain the required 95°F ambient temperature for most of the year, assuming sufficient make-up air is present from the outdoors. Therefore, the upgrade would be to install a ducted make-up air path from the outdoors to the condensing unit space. This would consist of an intake louver on the exterior wall and approximately 20 feet of ductwork to bring the air from the exterior wall to the condensing unit space. A thermostat would be installed in the space to only run the exhaust fan when the space temperature climbs above the setpoint.

Table 3.2 shows the total savings, estimated upgráde cost and simple payback.

Table 3.2 Cost of Upgrade and Simple Payback	
Item	**Walk-in Freezer/Cooler**
Total Annual Savings	$100
Cost of Upgrade	$1,900
Simple Payback (years)	19.1

Kitchen Exhaust Hood

NFPA 96, the Standard for Ventilation Control and Fire Protection of Commercial Cooking Operation, provides the code requirements for kitchen exhaust hood operation. Article 4.1.1 of this Standard states "Cooking equipment used in processes producing smoke or grease-laden vapors shall be equipped with an exhaust system that complies with all the equipment and performance requirements of this standard." Furthermore, Article 4.1.2 states "All such equipment and its performance shall be maintained in accordance with the requirements of this standard during all periods of operation of the cooking equipment." Discussions with the lead Fire Protection Engineer with the New York State Department of State Building Codes Division has determined that the active pilot flame on the appliance does not constitute "operation of the cooking equipment". Therefore, the use of this pilot flame does not result in a requirement for the exhaust system to be in operation.

The kitchen exhaust hood is currently operating 24 hours per day, 365 days per year due to this incorrectly applied gas valve interlock. Removing this interlock will allow the exhaust hood to be turned off when its use is not needed, without extinguishing the pilot flames on the kitchen appliances. The exhaust hood is only required to be in operation when the appliances are in operation. However, this hood is also serving as general exhaust for the kitchen area so the exhaust hood should remain in operation during occupied periods to balance the 100 percent outdoor air supplied by the make-up air units for ventilation and space conditioning. This new schedule will result in fan operation only during occupied periods, from approximately 6:30 a.m. to 2:00 p.m. This new operation will significantly reduce the electrical energy required for fan operation. Table 3.3 illustrates the estimated total reduction in electrical energy consumption based on these reduced hours of operation.

The make-up air units are currently being operated during occupied periods for ventilation, from approximately 6:30 a.m. to 2:00 p.m. Therefore the modified operation will not reduce the electrical energy consumption of the make-up air unit fans. However, with the exhaust fans running at all hours in the current configuration, approximately 5,000 CFM of air is still being exhausted from the building. This means that an additional 5,000 CFM of air will be introduced into the building at all times, either through mechanical make-up or infiltration. Regardless of the source, this air must be conditioned to maintain space temperatures. With the 80 percent efficient make-up air units not operating throughout the night, it has been assumed that this additional load is handled by the 86 percent efficient hot water boiler system. Table 3.3 shows the reduced heating load resulting from the exhaust fan being turned off during unoccupied periods (nights, weekends and holidays). The space was modeled in Carrier's Hourly Analysis Program (HAP) to calculate this reduced heating load. It should be noted that the space is not cooled, so electrical energy savings due to reduced cooling load is not applicable.

Finally, Table 3.3 summarizes the total savings, cost of upgrade and simple payback. The cost of upgrade has been estimated at approximately $1,000 to allow review of the existing controls and any implementation of modifications required to accomplish the removal of this interlock. With an estimated annual savings of $15,435, the result is simple payback period of 0.1 years.

Table 3.3 Kitchen Exhaust Hood - Analysis of Modified Operation		
Item	**Existing Operation**	**Modified Operation**
Exhaust Fan Energy Savings		
Estimated Brake HP Required for 5,000 CFM Exhaust	1.75	1.75
Estimated kW Input to Exhaust Fan (84% Efficient Motor)	1.56	1.56
Hours of Operation per Year	8,760	1,425
Total Electrical Energy Consumed (kWh/year)	13,666	2,223
Total Annual Reduction in Electrical Energy Consumption (kWh)	11,443	
Make-up Air Energy Savings		
Estimated Total Heating Load (kBTU/year)	1,197,770	244,085
Reduced Heating Output - Existing to Modified Operation (kBTU/year)	953,685	
Reduced Heating Input Required (kBTU/year)	1,108,936	
Reduced Heating Input Required (therms/year)	11,089	
Savings, Cost of Upgrade & Simple Payback		
Monetary Savings Due to Reduced Electrical Energy Consumption	$1,018	
Monetary Savings Due to Reduced Natural Gas Consumption	$14,416	
Total Annual Monetary Savings	$15,435	
Cost of Upgrade	$1,000	
Simple Payback (years)	0.1	

Recommendation

Walk-in Cooler/Freezer Condensing Units

With an estimated payback of approximately 19.1 years, which is longer than the 18 year cutoff required by the NY State Education Department, this measure would not be recommended for implementation solely for a reduction in energy consumption.

Exhaust Hood

The analysis shows that removing the gas valve/exhaust fan interlock and modifying the hours of exhaust hood operation will result in a simple economic payback period of approximately 0.1 years. With this favorable payback period, it is recommended that the District proceeds with implementation of this energy saving strategy.

TASK 4 – EVALUATE IMPROVEMENTS TO THE EXISTING HOT WATER BOILER SYSTEM

Field Findings

The existing central heating plant for the Main Building is a low pressure hot water system consisting of two standard efficiency cast iron boilers and five high efficiency condensing boilers. The standard efficiency boilers are Weil-McLain, Model 2094, cast iron sectionals with power burners. The Weil-McLain boilers have a manufacturer rated gross input of 6,856 MBH and a gross output of 5,520 MBH, for an efficiency of approximately 80.5 percent. The high efficiency boilers are Fulton, Model PHW-1400 condensing hot water boilers, direct vented with a pulse burner design that eliminates the need for a power burner during normal operation (only required during pre and post-purge). The Fulton boilers have a manufacturer rated gross input of 1,400 MBH and a gross output of 1,204 MBH, for an efficiency of approximately 86 percent (at 120°F return water temperature and 140°F supply water temperature). At full fire, 180°F supply and 160°F return, the efficiency is approximately 85 percent. The efficiency of these boilers will increase significantly at lower firing rates and lower return water temperatures.

All seven boilers operate with natural gas as the primary fuel. Additionally, one of the Weil-McLain boilers is dual-fuel capable (natural gas and no. 2 fuel oil). The current sequence of operation calls for the condensing boilers as the primary heat source at the cast iron sectional as the secondary heat source. The condensing boilers start at low fire when there is a call for heat and, if the heating demand is not satisfied, additional boilers continue to come on-line until all five are running at low fire. Further heating demand will result in all five boilers modulating up to higher firing levels as a group, until all five are running at full fire. The cast iron sectional that is online alternates each week and provides secondary heat when required.

The hot water system is operated with an outdoor reset control to reduce the supply water temperature as the outdoor air temperature increases, which is indicative of a decreasing heating load.

Analysis

The hot water boiler system is currently being operated based on the proper sequence of operations for high efficiency condensing boilers. However, the following items deserve mention for continued operation at the highest possible efficiency:

- *Operation of Secondary Boilers:* The Weil-McLain boilers are currently operated only as a secondary heat source, when the Fulton boilers (the primary heat source) can not keep up with the load. To achieve the highest system efficiency, the secondary boilers should only be operated when this is actually the case. For example, morning warm-up may be able to be accomplished faster with the Weil-McLain boilers, but it will be at the cost of additional energy.
- *Future Equipment Sizing:* Select future heating coils with a large heating water delta-T to reduce the return water temperature to the hot water boiler system. These condensing boilers operate on an inverse efficiency curve (when plotting efficiency versus return water temperature), meaning the efficiency increases as the return water temperature decreases. This approach, however, must ensure the overall return water temperature does not decrease to a point that results in an unsuitably low temperature for the cast-iron sectional Weil-McLain boilers.
- *Outdoor Reset Curve Optimization:* There may be opportunity for optimization of the outdoor reset curve to allow a lower average supply water temperature across the operating year, which will equate to a lower average return water temperature across the operating year. As previously discussed, this results in increased efficiency. The slope on the outdoor reset curve should be increased as much as possible while still allowing the heating system to satisfy the heating loads. The supply water temperature on the coldest day of the year can also be decreased as much as possible while still allowing the heating system to satisfy the heating loads. This optimization must be performed on a trial-result basis. Again, this approach must ensure the overall return water temperature does not decrease to a point that results in an unsuitably low temperature for the cast-iron sectional Weil-McLain boilers.

Recommendation

Continue operating with the current sequence of operations. Ensure the following practices are occurring:

- The cast-iron sectional boilers should only be operated when the condensing boilers can not handle the steady-state heating load.
- Do not operate the cast-iron sectional boilers simply to achieve minor reductions in morning warm-up period.

- Size future heating coils with a large heating water delta-T to reduce the return water temperature to the boilers. Ensure the overall return water temperature does not decrease to a point that results in an unsuitably low temperature for the cast-iron sectional Weil-McLain boilers.
- Optimize the slope of the outdoor reset curve and the design day supply water temperature to keep the supply water temperature as low as possible throughout the year, while still satisfying all heating loads. Ensure the overall return water temperature does not decrease to a point that results in an unsuitably low temperature for the cast-iron sectional Weil-McLain boilers.

Table 5.1 Gym Complex Estimated Daily Domestic Hot Water Use							
Fixture	Count	Est. # Used (Each Day)	Est. Fixture GPM	Est. Fixture HW GPM	Est. Fixture Min/Day	Est. Total Gal 100°F HW/Day	Est. Total Gal 140°F HW/Day
Column Shower (6 Head)	30	10	2.5	2	5	100	0
Handicap Shower	5	1	2.5	2	5	10	0
Lavatory	26	20	1	1	3	60	0
Sink (Training Room)	1	1	3	2	5	10	0
Mop Basin	2	2	3	2	10	40	0
Washing Machine	1	1	-	-	-	0	10
Hot Water Usage (Gallons/Day)						220	10

Table Notes:

(1) Washing machine operated twice per week, 25 gallons of HW per load, estimated as 10 gallons HW per school day.

Energy use on the existing system can be broken down into three categories:

- *Energy Required to Raise the Domestic Water Temperature:* Raising the temperature of 220 gallons of water from 45°F to 100°F requires approximately 100,900 BTU of energy. Raising the temperature of 10 gallons of water from 45°F to 140°F requires approximately 7,900 BTU of energy. Multiplying the total of 108,800 BTU/day across 190 days and converting to therms results in a total of 207 therms per year.

- *Efficiency Losses:* The manufacturer of the installed water heaters claims the efficiency of each unit is approximately 82.3 percent. Therefore, to accomplish the transfer of 108,800 BTU of heat into the domestic water, the unit consumes approximately 132,100 BTU. The estimated daily loss is therefore 23,300 BTU. Multiplying across 190 days and converting to therms results in 44 therms per year.

- *Standby Losses:* The existing tank stores water at about 150°F, has an insulation value of R5.2 and an estimated surface area of 126 ft^2. Assuming an average room temperature of 65°F, conductive heat loss through the tank wall equates to approximately 2,060 BTU/hr. The water heater inefficiency means that 2,500 BTU/hr of energy must be consumed to make up this loss. Multiplying across 8,760 hours/year and converting to therms results in 219 therms per year. Losses through the insulated piping and the water heaters are assumed to be negligible (it was previously mentioned that the water heaters have no appreciable storage of hot water).

Summing these categories gives a total annual energy use of approximately 470 therms, at a cost of $611 per year. The total system efficiency is approximately 44 percent (470 therms consumed for 207 therms of useful heating). This low system efficiency is mostly due to the very small quantity of domestic water that is actually consumed each year, resulting in the standby loss becoming the largest use of energy.

<u>*Installation of Condensing, Tank-Type Water Heater*</u>

Installation of a smaller, high-efficiency, condensing, tank-type water heater will both reduce the losses due to water heater inefficiency and the standby losses through the storage tank wall. A tank-type water heater, with 100 gallon storage capacity, R12.5 insulation and 95 percent thermal efficiency will reduce both standby losses and efficiency losses.

- *Efficiency Losses:* A 95 percent efficient heater would require a daily input of approximately 114,500 BTU to accomplish the required 108,800 BTU of water heating for an estimated daily loss of 5,700 BTU. Multiplying across 190 days and converting to therms results in 11 therms per year.
- *Standby Losses:* A new 100 gallon tank-type heater with R12.5 insulation and a storage temperature of 110°F would lose approximately 200 BTU/hr through the tank wall. The water heater inefficiency (95 percent efficient heater in this case) means that 210 BTU/hr of energy must be consumed to make up this loss. Multiplying across 8,760 hours/year and converting to therms results in 18 therms per year.

Combining these losses with the previously determined 207 therms required to heat the water results in a total annual energy demand of 236 therms, at a cost of $307 per year. Therefore, the annual savings over the baseline case is approximately $304. At an estimated construction cost of over $15,000 the simple payback for this strategy will be at least 50 years.

Reduction of Tank Storage Temperature

The existing hot water system in the Gym Complex has 140°F hot water piped to the washing machine in Training Room C105. The installed washing machine is a large capacity residential grade unit that does not require 140°F to operate. A Facilities Engineer with the NY State Education Department was contacted and was not aware of any requirement for 140°F water to be used in this application. Reducing the tank storage temperature from 150°F to 110°F will reduce the standby losses associated with the tank. The standby losses at 110°F tank temperature are approximately 1,090 BTU/hr. The water heater inefficiency means that 1,324 BTU/hr of energy must be consumed to make up this loss. Multiplying across 8,760 hours/year and converting to therms results in 116 therms per year. This is a reduction in standby losses of 103 therms per year, for an estimated annual savings of $134. There is no cost associated with this modification.

Installation of Additional Tank Insulation

The existing storage tank has fiberglass insulation with an R-value of 5.2. Increasing the tank insulation will reduce the standby losses associated with this hot water storage. Assuming a storage temperature of 110°F, the following table illustrates the annual standby losses for various levels of insulation, in addition to the existing R-5.2. The reduced natural gas cost, savings, upgrade cost and simple payback is shown.

Table 5.2
Analysis of Increased Insulation on Domestic Hot Water Storage Tank

Insulation	Total R-Value	Energy Loss (therms /year)	Energy Input (therms /year)	Annual Savings (therms)	Annual Savings ($)	Upgrade Cost	Simple Payback (years)
Existing	5.2	95.5	116	-	-	-	
+1.5" Insul. (R-5.2)	10.4	47.8	58	58	$75	$700	9.3
+2" Insul. (R-7)	12.2	40.7	49	67	$87	$800	9.2
+3" Insul. (R-10)	15.2	32.7	40	76	$99	$900	9.1
+4" Insul. (R-13)	18.2	27.3	33	83	$108	$1,000	9.3

Recommendation

Installation of Condensing, Tank-Type Water Heater

The analysis shows that the installation of a high-efficiency water heater to serve the Gym Complex results in a simple economic payback period of 50+ years, which is longer than the 18 year cutoff required by the NY State Education Department. Therefore, this measure would not be recommended for implementation.

Reduction of Tank Storage Temperature

The analysis shows that reducing the tank storage temperature from 150°F to 110°F results in an annual savings of approximately $134, with no upgrade cost. With this immediate payback, it is recommended that the District proceeds with implementation of this energy saving strategy.

Installation of Additional Tank Insulation

The analysis shows that installing additional insulation on the Gym Complex domestic hot water storage tank results in a simple payback of approximately 9.3 years, independent of insulation thickness. With this favorable payback period, it is recommended for the District to proceed with installation of additional faced blanket insulation (thickness as allowed by physical constraints).

TASK 6 – EVALUATE IMPLEMENTATION OF DCV CONTROL – AUDITORIUM AHU

Field Findings

The Main Building includes an auditorium of approximately 4,500 ft^2 and a stage of approximately 1,800 ft^2, served by two 6,000 CFM rooftop units (RTU's), manufactured by Trane. Each RTU is the "high efficiency" version of the Trane Voyager model line, with an EER of 11.5. Each unit includes packaged DX cooling with a nominal cooling capacity of 15 tons, an R-22 refrigerant circuit, a factory installed economizer, a 5 HP supply fan and a 3/4 HP exhaust fan. Unit electrical power is 460 volt, 3Ø. Heating is provided by a duct-mounted hot water coil downstream of the unit discharge. The admittance of outdoor air into the space is currently on scheduled control during conditioning periods and economizer control during economizing periods. There is no ability to modulate outdoor air flow based on actual space occupancy.

Analysis

Demand control ventilation (DCV) is a method of control that allows modulation of the flow of outdoor air to the space based on real-time occupancy. A common and effective method of estimating the real-time occupancy, based on the principles of human physiology, is to measure the actual concentration of carbon dioxide in the space air. The indoor measurement of carbon dioxide concentration provides a real-time indicator of the balance between carbon dioxide generation (by individuals in the space) and the admittance of outdoor air with atmospheric concentrations of carbon dioxide.

One or more carbon dioxide sensors would be installed in the space and the reported concentrations would be compared to the concentration reported by a sensor located outdoors. As the concentration of carbon dioxide in the space climbs above that of the outdoor air, the outdoor air damper modulates open to maintain the carbon dioxide concentration at an acceptable level. When the concentration falls to an acceptable level, the damper modulates closed reducing outdoor airflow and saving energy. This control significantly reduces the volume of outdoor air that is admitted to the space during periods of reduced occupancy, while maintaining adequate fresh air supply when occupancy levels are high. Trane offers a carbon dioxide sensor kit for the Voyager rooftop units as a field installed accessory.

To determine the energy savings associated with implementation of carbon dioxide based DCV, the auditorium and stage spaces were modeled in the Carrier Hourly Analysis Program (HAP) with the following assumption and parameters:

- Auditorium: floor area 4,420 ft^2, design occupancy 663 people
- Stage: floor area 1,770 ft^2, design occupancy 124 people
- Unit Operating Capacity (each RTU): 190,000 MBH at 18.0 kW electrical input
- Constant Volume Control – Occupied Schedule:
    - September-June, Monday-Friday, 8AM-4PM
    - 52 events per year, 11AM-5PM (6 hours/event)
- DCV Control – Estimated Space Occupancy:
    - September-June, Monday-Friday, 8AM-4PM, *Average 10 percent Occupied*
    - 52 events per year, 11AM-5PM (6 hours/event), *First 2 Hours at 20 percent Occupancy (Setup), Middle 3 Hours at 90 percent Occupancy (Event), Final Hour at 10 percent Occupancy (Cleanup)*

The results of the analysis are summarized in Table 6.1.

Table 6.1
Auditorium DCV Analysis and Simple Payback

Item	Constant Ventilation	DCV
Estimated Annual Cooling Loads and Inputs		
Ventilation Cooling Load (kBTU/year)	20,921	5,681
Electrical Input for Cooling (kWh/year)	1,848	518
Energy Savings (kWh/year)	1,330	
Estimated Annual Heating Loads and Inputs		
Ventilation Heating Load (kBTU/year)	721,200	132,219
Boiler Output Required (therms/year)	7212	1,322
Average Boiler Thermal Efficiency	87%	87%
Input Required (therms/year)	8290	1,520
Energy Savings (therms/year)	6,770	
Estimated Cost of Energy Consumed and Saved		
Annual Cost for Electricity	$164	$46
Annual Cost for Natural Gas	$10,777	$1,976
Annual Total Energy Cost	$10,941	$2,022
Total Annual Savings	$8,919	
Estimated Construction Cost for Upgrades	$2,000	
Simple Payback (Years)	0.2	

Recommendation

The analysis shows that the implementation of carbon dioxide based DCV control for the auditorium and stage ventilation results in a simple economic payback period of approximately 0.2 years. With this favorable payback period, it is recommended that the District proceeds with implementation of this energy saving strategy.

TASK 7 – FACILITY WIDE AUDIT OF PLUG LOADS

Field Findings

A plug load audit was performed, estimating the types and quantity of equipment powered by 120V electrical receptacles throughout the District's facility. This task will analyze the estimated electrical energy consumed by these devices and provide recommendations for energy reduction. Table 7.1 summarizes the estimated quantity of the identified equipment:

Table 7.1
Estimated Quantities of Select Equipment Powered by 120V Receptacles

Appliance	Estimated Quantity	Notes
Vending Machines	8	All machines are chilled drink and/or snack
Desktop Computers	500	With 17" CRT monitor
Laptop Computers	100	-
Refrigerators	15	Compact, estimated avg. volume of 4 cu. ft.
Microwaves	5	Residential grade, compact, estimated avg. volume of 0.7 cu. ft.
Coffee Makers	8	Residential grade, single burner
Space Heaters	10	Ceramic, 1500 watt

Analysis

The annual operation of each piece of equipment was estimated based on the District schedule and discussions with Facilities staff. The electrical requirement for each piece of equipment was estimated from typical values for the appliance or from sources referenced in the table notes. Table 7.2 summarizes this data and calculates the current total annual cost based on the estimated number of appliances from Table 7.1.

Table 7.2 Estimated Annual Energy Use and Cost to Operate Select Electrical Equipment						
Appliance	**kWh/Day (/ unit)**	**Days/Yr (/ unit)**	**kWh/Yr (/ unit)**	**Est. Annual Cost (/ unit)**	**Est. Quantity**	**Existing Energy Cost (Total)**
Vending Machines (1)	5.50	365	2,008	$179	8	$1,429
Desktop Computers (2)	3.60	190	684	$61	500	$30,438
Laptop Computers (3)	0.96	190	182	$16	100	$1,623
Refrigerators (4)	0.88	365	321	$29	15	$429
Microwaves (5)	-	-	66	$6	5	$29
Coffee Makers (6)	0.45	190	86	$8	8	$61
Space Heaters (7)	-	-	1,005	$89	10	$894

Table Notes:

(1) 5.50 kWh/day based on ENERGY STAR Refrigerated Beverage Vending Machines - New Machine Product List

(2) 3.60 kWh/day based on 150 watts, 24 hrs/day (70W Computer, 80W Monitor)

(3) 0.96 kWh/day based on 40 watts, 24 hrs/day

(4) 0.88 kWh/day estimated from FTC's "EnergyGuide" Appliance Label

(5) 66 kWh/yr est. from 700 watt microwave operated 10 min/day, 190 days/yr and 5 watts standby 24 hrs/day, 365 days/yr

(6) 0.55 kWh/day est. from 900 watt brewing for 10 min/day and 100 watt warming 3 hrs/day

(7) 1,230 kWh/yr est. from 1500 watt heater for 670 hrs/yr

Vending Machines

The vending machines currently operate 24 hours per day to maintain the required internal temperature and to keep the machines in a state that allows dispensing product to customers. The building's occupied schedule results in the need to maintain this state of readiness only about 25 percent of the time but the machines lack the control capability to take advantage of this schedule, as they only have manual on/off control. Installation of control equipment that will allow the machine to power down when the space is not occupied will result in a significant reduction in energy consumption. Occupancy based systems allow the machine to turn off when there are no individuals in the vicinity and power on when a potential customer enters the area. During unoccupied periods the machine would periodically restart, according to a user adjustable schedule, to maintain merchandise temperature. Independent testing has verified average savings of approximately 35-55 percent using this technology, with savings variation based on the occupancy levels in the space. For the purpose of this study, an average savings of 45 percent will be used. Therefore, based on a current annual cost of approximately $1,429, the total annual savings is estimated at $643. An approximate implementation cost of $2,180 results in an estimated simple payback period of 3.4 years.

Desktop Computers

An average desktop computer and CRT monitor uses approximately 150 watts of electricity while in use (estimated 80 watts for the CRT monitor and 70 watts for the computer). Allowing the computers and monitors to remain powered on for 24 hours/day, 190 days/year will result in the energy consumption detailed in the Baseline Case in Table 7.3. Allowing the computers to stay powered on during weekends, school breaks, etc will significantly increase the energy use estimated in the Baseline Case.

Computers and monitors should be turned off when not in use for extended periods (e.g. weekends, overnight). Ensuring that all monitors and computers are powered off at night and during off-days will provide significant savings over the cost of continuous operation. A typical computer and monitor running overnight, from 4:00 p.m. to 7:00 a.m. (not in sleep mode), consumes approximately 2.25 kWh of electrical energy, costing approximately $0.20. Eliminating this consumption and instituting the same practice to 500 computers over 190 days per year would result in total savings of approximately $19,000, which can be seen in the difference in energy cost between Baseline Case and Strategy #1 in Table 7.3.

Setting all computers to enter standby and all monitors to enter sleep mode after a short period of inactivity would save an estimated additional $2,300 per year (assuming each computer/monitor enters this standby/sleep mode for 2 hours of the 9 hour day). This is illustrated in the additional reduction in energy cost between Strategy #1 and Strategy #2 in Table 7.3.

Finally, as new monitors are purchased for the District, upgrading from CRT monitors to LCD monitors will save additional energy. Strategy #3 in Table 7.3 shows an estimated energy cost if all 500 computers are switched from CRT to LCD, which amounts to approximately $5.50 savings for each computer. Payback on this will vary as the cost of LCD monitors comes down. If the upgrade cost from CRT to LCD is $30, the payback is approximately 5.5 years. If users are not diligent about turning off computers when not in use, this strategy will payback even faster.

Table 7.3 Desktop Computer Energy Reduction Strategies						
Appliance	**kWh /Day (/unit)**	**Days /Yr (/unit)**	**kWh /Yr (/unit)**	**Est. Annual Cost (/unit)**	**Est. Quantity**	**Annual Cost (Total)**
Baseline [(1)]	3.60	190	684	$61	500	$30,438
Strategy #1 - Shut-Downs [(2)]	1.35	190	257	$23	500	$11,414
Strategy #2 - Standby/Sleep [(3)]	1.08	190	205	$18	500	$9,131
Strategy #3 - LCD Monitor [(4)]	0.76	190	143	$13	500	$6,384

Table Notes:

(1) Baseline from Table 7.2

(2) 1.35 kWh/day based on 150 watts, 9 hrs/day (70W Computer, 80W Monitor)

(3) 1.08 kWh/day based on 150 watts, 7 hrs/day and 15 watts for 2 hrs/day (Computer in Standby, CRT Monitor in Sleep Mode)

(4) 1.10 kWh/day based on 105 watts, 7 hrs/day and 10 watts for 2 hrs/day (Computer in Standby, LCD Monitor in Sleep Mode)

Laptop Computers

The District also has approximately 100 laptop computers in use and by following the same strategies discussed for the desktop computers, similar percent reductions in energy consumption can be achieved. Looking at the estimated energy cost in Table 7.2 (assuming the laptop is left powered on 24 hours/day, 190 days/year) it is evident that the opportunity for monetary savings is much smaller than with the desktop computers. However, modifying computer use practices has an implementation cost of $0 and is an easy area to reduce energy consumption.

Refrigerators

As shown in Table 7.2, compact refrigerators require approximately 321 kWh per year to operate, costing approximately $29 year. The elimination of the estimated 15 compact refrigerators will result in an annual savings of approximately $429, assuming there is open space in the existing common area refrigerators and additional refrigerators do not need to be added.

Microwaves

As shown in Table 7.2, each small microwave requires approximately 66 kWh per year to operate, costing approximately $6 each per year. About 2/3 of this energy is consumed while the microwave is in standby (estimated 5 watts of power required) and the other half is used when in heating mode. Removal of the estimated 5 small microwaves will eliminate the standby energy use, estimated to be 44 kWh per year for each microwave, or about 219 kWh per year total. The energy used in heating mode will still be required but will simply shift to a common area microwave. Therefore, total energy reduction will be approximately 219 kWh per year, at a savings of $19.

Coffee Makers

As shown in Table 7.2, a residential size single burner coffee maker requires approximately 86 kWh per year to operate, costing approximately $8 per year. The elimination of the estimated 8 coffee makers will result in a cost reduction of approximately $61 per year.

Space Heaters

A 1,500 watt space heater consumes approximately 13.5 kWh if run constantly over a 9 hour day, at a cost of approximately $1.20 per day. Assuming the heaters are operated when the outdoor temperature is below 35°F (about 670 occupied hours per year), each heater will consume approximately 1,005 kWh per year, at a cost of $89. The elimination of the estimated ten space heaters will result in a cost savings of approximately $894 per year.

Other Equipment

The District also has the following essential equipment:

- Large Desktop Printers: 100
- Projectors and Smartboards: 40, with future addition of 80-90
- Large Copiers: 6
- Large Server Racks: 9
- Uninterruptible Power Supplies: 20

The printers, projectors, smartboards and copiers should be powered down during off periods and setup to enter standby mode (as the equipment allows). Significant savings can be achieved by following these practices and will be dependent on the equipment in question.

Recommendation

Vending Machines

With an estimated simple payback period of 3.4 years, it is recommended that the District installs occupancy based vending machine control on all vending machines.

Desktop Computers and Laptop Computers

With potential savings ranging up to $20,000 per year (depending on the actual existing operation) and no cost of implementation, it is recommended that the District proceeds with reducing computer operating time. This includes ensuring all computers and monitors are shut down during off periods (nights, weekends, etc.) and setting up monitors/computers to enter sleep/standby modes during periods of inactivity. Additionally, when purchasing new monitors, the District should evaluate the additional cost required to upgrade to LCD monitors and proceed with LCD if the payback is less than the expected life of the monitor.

Refrigerators

The elimination of each compact refrigerator will save the District approximately $29 per year. This is assuming that there is room available in the common area refrigerators and that additional refrigerator space is not needed. It is recommended that the District evaluate compact refrigerator use on a case-by-case basis and eliminate loads not providing enough benefit to warrant the cost of operation.

Microwaves

The elimination of a small microwave will save approximately $4 per year in standby energy use (assuming it is left plugged in 365 days/year). It is recommended that the District evaluate small microwave use on a case-by-case basis and eliminate loads not providing enough benefit to warrant the cost of operation.

Coffee Makers

The elimination of a coffee maker will save approximately $8 per year. A small portion of this savings may be lost due to increased use of common area coffee makers. It is recommended that the District evaluate small coffee maker use on a case-by-case basis and eliminate loads not providing enough benefit to warrant the cost of operation.

Space Heaters

The elimination of a space heater will save approximately $1.20 per 9 hour day of constant run-time. With an estimated 10 space heaters running for an estimated 670 hours per year, the total savings is approximately $894. It is recommended that the District eliminates the use of electric space heaters and utilize installed HVAC equipment for all space conditioning needs.

Other Equipment

It is recommended that the District ensures operating practices include powering down printers, projectors, smartboards and copiers during off periods (nights, weekends, etc) and setting up the equipment to enter sleep/standby modes during periods of inactivity. There is no implementation cost for these modifications, so the payback is immediate. Additionally, when evaluating future equipment purchases, the District should consider total energy consumption of the equipment, as well as the availability of energy saving features such as standby mode.

TASK 8 – EVALUATE EXTERIOR LIGHTING

Field Findings

The academic building has six circuits of exterior lights that will be considered in this task for re-circuiting to reduce total annual energy consumption. The six circuits are divided into four exterior lighting zones, each controlled by a lighting contactor on a schedule. The existing operation calls for all circuits to be energized throughout the night. Each circuit includes multiple 250 watt high pressure sodium wall-mounted fixtures, see Table 8.2 for details.

Analysis

The lights around the perimeter of the building could be re-circuited to allow the lights to be split and controlled on two separate schedules. All of the lights would remain on from sunset until 11:00 p.m., but a certain number of lights could be turned off after 11:00 p.m., providing the light levels remain high enough for safety and security.

Table 8.1 illustrates the total number of nighttime hours (sunset to sunrise) in one year and the total number of annual hours between sunset and 11:00 p.m.

Table 8.1
Evening/Night Hours

Month	Average Sunrise	Average Sunset	Dusk-to-Dawn Hours /Day	Evening Hours/ Day	Dusk-to-Dawn Hours /Month	Evening Hours/ Month
Jan	7:34 AM	4:55 PM	14.7	6.1	454	189
Feb	7:03 AM	5:35 PM	13.5	5.4	377	152
Mar	7:16 AM	7:12 PM	12.1	3.8	374	118
Apr	6:22 AM	7:48 PM	10.6	3.2	317	96
May	5:41 AM	8:22 PM	9.3	2.6	289	82
Jun	5:25 AM	8:46 PM	8.7	2.2	260	67
Jul	5:39 AM	8:42 PM	9.0	2.3	277	71
Aug	6:10 AM	8:07 PM	10.1	2.9	312	89
Sep	6:44 AM	7:15 PM	11.5	3.8	345	113
Oct	7:18 AM	6:22 PM	12.9	4.6	401	144
Nov	6:57 AM	4:41 PM	14.3	6.3	428	190
Dec	7:29 AM	4:30 PM	15.0	6.5	464	202
				Total Hours	4,298	1,511

Table 8.2 defines the six circuits in question and the number of fixtures on each circuit. Each circuit was reviewed and the number of fixtures that could be turned off during the late night hours was estimated. The total number of fixtures on each circuit was then split between those that would remain on for the entire night and those that would remain on from sunset until 11:00 p.m. The total energy consumption of the existing operation (all fixtures on throughout the night) and the modified operation (40 percent of the fixtures turned off at 11:00 p.m.) was then calculated. This task is to illustrate the possible energy savings resulting in turning off these fixtures. A lighting level analysis should be performed before implementation of this modification to determine which fixtures can actually be turned off to maintain adequate light levels for safety and security.

Table 8.2
Exterior Lighting Analysis
All Fixtures: 250 Watt High Pressure Sodium

Circuit #/ Location	Total # Fixtures	Fixtures On for Entire Night	Fixtures On for Evening Only	Watts/ Fixture	Energy - Existing (kWh)	Energy - Night/ Evening (kWh)
#1/Elem. Wing North	10	6	4	300	12,894	9,550
#2/Elem. Wing South	11	7	4	300	14,183	10,839
#3/Main Traffic Circle	8	4	4	300	10,315	6,971
#4/HS Wing North	8	5	3	300	10,315	7,807
#5/HS Wing South	12	8	4	300	15,473	12,128
#6/Gym Complex	14	8	6	300	18,052	13,035
Total Annual Energy Consumed (kWh)					81,232	60,330
Total Annual Energy Savings (kWh)						20,903
Total Annual Monetary Savings						$1,860

It was found that the modified operation would save approximately 20,903 kWh per year, resulting in an annual savings of approximately $1,860.

Each exterior circuit would need to be split into two separate circuits to allow this mode of operation. It was estimated that 4,000 feet of circuit wiring and conduit would need to be installed to accomplish this re-circuiting. Four additional lighting contactors would need to be installed and new energy management system controls would be required. At an estimated $15 per linear foot of circuit wiring/conduit and an additional $5,000 in contactors/controls, the total cost of upgrade is approximately $65,000. This results in an estimated simple payback period of 35 years.

If there are lights that are not required to operate at all (including the evening hours), a second option would be to simply remove the light bulb or disconnect the fixture from the circuit. The analysis showed a total cost to of approximately $7,100 to operate all 63 fixtures throughout the year, from sunset to sunrise. Therefore, for each disconnected fixture, the District will save approximately $115 per year.

Recommendation

With an estimated payback of approximately 35 years, which is longer than the 18 year cutoff required by the NY State Education Department, this measure would not be recommended for implementation as an energy reduction measure.

If there are lights that are not required to operate at all (including the evening hours), it is recommended that the District remove these light bulbs or disconnect these fixtures from the circuit for an annual savings of approximately $115 per deactivated fixture.

TASK 9 – EVALUATE BUS GARAGE LIGHTING AND BLOCK HEATER CONTROL

Field Findings

Lighting

The bus garage includes a 20'x84' repair bay, a 76'x84' six-bay storage area and approximately 1,000 square feet of additional storage and office space. There are approximately 33 fixtures throughout the repair bay, the office and the storage areas, with each fixture consisting of two 32 watt T8 lamps. The bus storage bay has approximately 32 fixtures; 30 of which have two 32 watt T8 lamps and two of which have one 32 watt T8 lamp. The lights in both spaces are manually controlled and are normally operated year round, 5 days per week, from approximately 6:00 a.m. to 4:00 p.m.

Block Heater Control

The bus garage parking area has provisions for powering 14 engine block heaters in the school bus fleet. The installed bus engine block heaters are manufactured by Hotstart and are rated at 1,500 watts each. There is a dedicated circuit for each block heater and the circuits are wired to 14 receptacles in the parking lot into which the block heaters are plugged directly. The circuits are energized at all times, so the heaters are in operation at all periods during which they are plugged in. During the winter months, from approximately December through March, the heaters are plugged in each school day afternoon at about 4:00 PM and unplugged each school day morning at about 6:00 a.m. The heaters are on continuously over weekends and vacations.

Analysis

Lighting

The T8 fluorescent fixtures currently installed in the bus garage facility are considered high efficiency lighting and after reviewing the efficacy (i.e., measure of light output per unit of energy input) of these fixtures there are no options that will result in energy savings significant enough to warrant fixture replacements. The total system efficacy varies between fixtures and manufacturers, but the average efficacy across all T5, T5HO and T8 fluorescent fixtures are very similar. Depending on the application, there are benefits for each of these fixtures, but in terms of energy savings alone there are no options for replacement.

Block Heater Control

The existing sequence of operation results in approximately 2,180 hours of runtime per year, based on 50 school days at 14 hours each and 70 off days at 24 hours each. To reduce the annual hours of operation, the bus engine block heater circuits would be wired through contactors controlled by a timeclock. Bus garage personnel would be able to program the system to energize the circuits only when necessary. When controlled by a timeclock, the system could be programmed to run the heaters for approximately four hours per school day, prior to the start of the morning bus routes. This new operation would result in approximately 280 hours of run-time per year.

Table 9.1 details these two scenarios, including energy savings, monetary savings, cost of upgrade and simple payback.

Table 9.1
Bus Engine Block Heater - Timer Control Analysis

Item	Manual Control	Timer Control
Number of Circuits	14	14
Watts per Circuit	1,500	1,500
Annual Hours of Operation (/ circuit)	2,180	280
Total Annual Energy Required (kWh)	45,780	5,880
Total Annual Energy Savings (kWh)	39,900	
Total Annual Monetary Savings	$3,551	
Cost of Upgrade	$2,820	
Simple Payback (years)	0.8	

Recommendation

Lighting

With no suitable upgrade options for energy savings, no action is recommended at this time.

Block Heater Control

The analysis shows that the implementation of improved engine block heater system control results in a simple economic payback period of approximately 0.8 years. With this favorable payback period, it is recommended that the District proceeds with implementation of this energy saving strategy.

Appendix A

Task 1 – Supporting Information

Figure A.1

Construction Cost Estimate for Dishwasher Electric Booster Heater

BARTON & LOGUIDICE, P.C.
CONSTRUCTION COST ESTIMATE

TASK 1 - DISHWASHER ELECTRIC BOOSTER HEATER

PROJECT TITLE:
SANDY CREEK CENTRAL SCHOOL DISTRICT - NYSERDA FLEXTECH STUDY

B&L JOB NO: 1190.001-S

DATE PREPARED: 6/3/2008

LOCATION:
SANDY CREEK, NY

ESTIMATED BY: DCW

ITEM NO.	ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1.	DEMO EXISTING HEATER	1	LS	$100.00	$100.00
2.	ELECTRIC BOOSTER HEATER, 27.0 kW	1	EA	$1,800.00	$1,800.00
3.	PIPING, FITTINGS, VALVES, INSULATION	1	LS	$200.00	$200.00
	CONSTRUCTION SUBTOTAL				**$2,100**
	CONTRACTOR'S OVERHEAD & PROFIT			15%	**$300**
	CONTINGENCIES			10%	**$200**
	ESTIMATED TOTAL CONSTRUCTION COST				**$2,600**

Appendix B

Task 2 – Supporting Information

Figure B.1

Construction Cost Estimate for Daylight Harvesting Control

BARTON & LOGUIDICE, P.C.
CONSTRUCTION COST ESTIMATE

TASK 2 - DAYLIGHT HARVESTING CONTROL

PROJECT TITLE:
SANDY CREEK CENTRAL SCHOOL DISTRICT - NYSERDA FLEXTECH STUDY

B&L JOB NO: 1190.001-S

DATE PREPARED: 7/30/2008

LOCATION:
SANDY CREEK, NY

ESTIMATED BY: DCW

ITEM NO.	ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1.	MC CABLE, #10, 2 WIRE	670	LF	$3.30	$2,211.00
2.	MC CABLE, #12, 2 WIRE	50	LF	$2.40	$120.00
3.	LINE VOLTAGE, CLG MOUNT, DAYLIGHT SENSOR	15	EA	$150.00	$2,250.00
	CONSTRUCTION SUBTOTAL				**$4,581**
	CONTRACTOR'S OVERHEAD & PROFIT			15%	**$690**
	CONTINGENCIES			10%	**$460**
	ESTIMATED TOTAL CONSTRUCTION COST				**$5,731**

Figure B.2

Construction Cost Estimate for Occupancy Sensors

BARTON & LOGUIDICE, P.C.
CONSTRUCTION COST ESTIMATE

TASK 2 - OCCUPANCY SENSORS

PROJECT TITLE:
SANDY CREEK CENTRAL SCHOOL DISTRICT - NYSERDA FLEXTECH STUDY

LOCATION:
SANDY CREEK, NY

B&L JOB NO: 1190.001-S

DATE PREPARED: 7/30/2008

ESTIMATED BY: DCW

ITEM NO.	ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1.	MC CABLE, #12, 2 WIRE	50	LF	$2.40	$120.00
2.	LINE VOLTAGE, CLG MOUNT, OCCUPANCY SENSOR	1	EA	$150.00	$150.00
	CONSTRUCTION SUBTOTAL				$270
	CONTRACTOR'S OVERHEAD & PROFIT			15%	$40
	CONTINGENCIES			10%	$30
	ESTIMATED TOTAL CONSTRUCTION COST				$340

Figure B.3

Construction Cost Estimate for Gym Complex Lighting

BARTON & LOGUIDICE, P.C.
CONSTRUCTION COST ESTIMATE

TASK 2 - GYM COMPLEX LIGHTING

PROJECT TITLE: SANDY CREEK CENTRAL SCHOOL DISTRICT - NYSERDA FLEXTECH STUDY

B&L JOB NO: 1190.001-S

DATE PREPARED: 7/30/2008

LOCATION: SANDY CREEK, NY

ESTIMATED BY: DCW

ITEM NO.	ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1.	4 LAMP, 54W T5HO	40	EA	$175.00	$7,000.00
2.	FIXTURE REMOVAL / INSTALLATION	40	EA	$100.00	$4,000.00
3.	SCISSOR LIFT RENTAL	1	LS	$500.00	$500.00
4.	LOW VOLTAGE WIRING, 3 CONDUCTOR, HIGH INSTALL	600	LF	$1.30	$780.00
5.	OCCUPANCY SENSOR WITH PHOTOCELL OPTION	8	EA	$140.00	$1,120.00
6.	LIGHTING CONTROLLER / POWER MODULE	4	EA	$95.00	$380.00
7.	INTEGRATING NEW LIGHTING CONTROLS	1	LS	$700.00	$700.00
	CONSTRUCTION SUBTOTAL				**$14,480**
	CONTRACTOR'S OVERHEAD & PROFIT			**15%**	**$2,170**
	CONTINGENCIES			**10%**	**$1,450**
	ESTIMATED TOTAL CONSTRUCTION COST				**$18,100**

Figure B.4

Construction Cost Estimate for Library Lighting

BARTON & LOGUIDICE, P.C.
CONSTRUCTION COST ESTIMATE

TASK 2 - LIBRARY LIGHTING

PROJECT TITLE:
SANDY CREEK CENTRAL SCHOOL DISTRICT - NYSERDA FLEXTECH STUDY

B&L JOB NO: 1190.001-S

DATE PREPARED: 7/30/2008

LOCATION:
SANDY CREEK, NY

ESTIMATED BY: DCW

ITEM NO.	ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1.	4 LAMP, 54W T5HO	15	EA	$275.00	$4,125.00
2.	FIXTURE REMOVAL / INSTALLATION	15	EA	$100.00	$1,500.00
3.	MC CABLE, #10, 2 WIRE	275	LF	$3.30	$908.00
4.	FIXTURE MOUNTED OCCUPANCY SENSOR	15	EA	$110.00	$1,650.00
	CONSTRUCTION SUBTOTAL				**$8,183**
	CONTRACTOR'S OVERHEAD & PROFIT			**15%**	**$1,230**
	CONTINGENCIES			**10%**	**$820**
	ESTIMATED TOTAL CONSTRUCTION COST				**$10,233**

Figure B.5

Construction Cost Estimate for Elementary Gym Lighting

BARTON & LOGUIDICE, P.C.
CONSTRUCTION COST ESTIMATE

TASK 2 - ELEMENTARY GYM LIGHTING

PROJECT TITLE:
SANDY CREEK CENTRAL SCHOOL DISTRICT - NYSERDA FLEXTECH STUDY

LOCATION:
SANDY CREEK, NY

B&L JOB NO: 1190.001-S

DATE PREPARED: 7/30/2008

ESTIMATED BY: DCW

ITEM NO.	ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1.	4 LAMP, 32W T8	30	EA	$175.00	$5,250.00
2.	FIXTURE INSTALLATION	30	EA	$85.00	$2,550.00
3.	FIXTURE REMOVAL	32	EA	$15.00	$480.00
4.	SCISSOR LIFT RENTAL	1	LS	$16.00	$16.00
5.	LOW VOLTAGE WIRING, 3 CONDUCTOR, HIGH INSTALL	400	LF	$1.30	$520.00
6.	OCCUPANCY SENSOR WITH PHOTOCELL OPTION	8	EA	$140.00	$1,120.00
7.	LIGHTING CONTROLLER / POWER MODULE	2	EA	$95.00	$190.00
8.	INTEGRATING NEW LIGHTING CONTROLS	1	LS	$700.00	$700.00
	CONSTRUCTION SUBTOTAL				**$10,826**
	CONTRACTOR'S OVERHEAD & PROFIT			15%	**$1,620**
	CONTINGENCIES			10%	**$1,080**
	ESTIMATED TOTAL CONSTRUCTION COST				**$13,526**

sensorswitch

ON/OFF PHOTOCELL SENSOR - FIXTURE & CEILING MOUNT, LINE VOLTAGE

TYPICAL APPLICATIONS

- Daylight Harvesting
- On/Off Lighting Control

FEATURES

- Self-contained Relay, no Power Pack needed
- Capable of finding optimum set-point
- Digitally Programmable via simple push button commands
- No Minimum Load Requirements
- Green LED Activity Indicator
- 100 Hour Lamp Burn-in Timer Mode

AVAILABLE OPTIONS

- Dual Zone Control (-DZ)
- 347 VAC (-3) or 208/480 VAC (-480)
- Low Temp/Hi Humidity (-LT)

SPECIFICATIONS

- Size: CMRB: 3 5/8" x 3 5/8" x 1 1/4" (9.2 cm x 9.2 cm x 3.175 cm)
  CMR: 4.55" Dia., 1.55" Deep (11.56 cm Dia., 3.94 cm Deep)
- Weight: 5 Oz (CMRB), 5 Oz (CMR)
- Sensor Color: White
- CMRB Mounting: 1/2 inch knockout
- CMR Mounting: Round Fixture Box or Single Gang Handy Box
- Relative Humidity: 20 to 90% non-condensing
- Operating Temp: 14° to 160° F (-10° to 71° C)
- Storage Temp: -14° to 160° F (-26° to 71° C)
- Load Rating:
  800 W @ 120 VAC
  1200 W @ 277 VAC
  1500 W @ 347 VAC
  5 Amps @ 208/480 VAC
- 1/4 HP Motor Load
- Frequency: 50/60 Hz
- UL, CUL, and Title 24 Compliant
- 5 Year Warranty
- Made in U.S.A.

LOW TEMP/HI HUMIDITY(-LT)

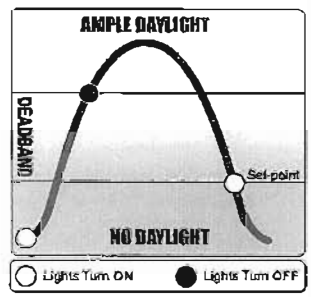
- Conformally coated Circuit Board is corrosion resistant from moisture
- Operates down to -40° F(-40° C)

CMR-PC
CMRB-PC
w/ Dual Zone Option!

The *CMR(B)-PC Series* of On/Off Photocell sensors provide the industry's most intelligent control of lighting for daylight harvesting applications. Ideal for public spaces with windows like vestibules, corridors, or bathrooms; the sensors work by monitoring daylight conditions in a room, then controlling the lighting so as to insure that adequate lighting levels are maintained. The *CMR(B)-PC* has On/Off lighting control; turning off the lights when sufficient daylight is present and turning them on when additional lighting is necessary. The *CMR(B)-PC Series* sensors are line powered and can switch loads directly without the need for a Power Pack. The CMR version sensors are ceiling mounted, while the CMRB versions are specifically designed to mount on the end of a linear fluorescent fixture. To add dimming control to the On/Off control provided by the *CMR(B)-PC*, see the Technical Data Sheet on the CMR(B)-PC-ADC sensor.

CMR(B)-PC ON/OFF OPERATION

The lights turn "On" when the space's overall light level drops below a programmable threshold called a "set-point". The lights turn "Off" when light is above the set-point plus a 10 to 20% safety factor and deadband. The safety factor will prevent the system from cycling when the light level is very near the set-point. The deadband is the level of light contributed by the artificial lights being controlled. This level is tracked so if the lighting conditions change (for example a lamp burns out) the point at which the lights turn off is adapted accordingly. If the photocell is looking up at skylights and can not view the lights being controlled, there is no deadband and the sensor is said to be working "open loop". There is also an adaptive 5-25 minute delay before the photocell turns the lights off to prevent the system from cycling on a cloudy day.



DUAL ZONE (-DZ) OPTION

With the -DZ option, a second independent relay is provided to control an additional zone of lighting according to one of two operational modes. The default mode, referred to as "Duo" operation, is ideal for A/B (also called inboard/outboard) switching applications as it determines the necessary On/Off combination of the zones in order to maintain adequate lighting. The alternate mode uses a relative set-point for the second zone that is a selected percentage higher than the primary zone's set-point. This mode accounts for the fact that daylight contribution diminishes as the distance from the source (windows) increases. Called "Percentage" operation, this second mode is ideal for classrooms with individually controlled parallel rows of lights. A single shared set-point is used by both modes and can be user programmed or automatically determined by the sensor itself.

Note: The -DZ option is not available with the 208/480 VAC option (-480). The -480 option requires both relays in order to switch a 480 VAC load. The -DZ option switches the two relays independently.

Model Numbering System: [SERIES #]-[DUAL ZONE*]-[VOLTAGE]-[TEMP/HUMIDITY]

SERIES #	DESCRIPTION	DUAL ZONE	VOLTAGE	TEMP / HUMIDITY
CMR-PC	On/Off Photocell Sensor - Ceiling Mount, Line Voltage	Blank = Single Zone -DZ* = Dual Zone	Blank = 120-277 VAC -3 = 347 VAC -480 = 208/480 VAC	Blank = 14° to 160°F LT = -40° to 160° F
CMRB-PC	On/Off Photocell Sensor - Fixture Mount, Line Voltage	*Not avail. with -480 option		

LIGHT LEVEL SET-POINT

The sensor functions by comparing the amount of daylight available with a defined acceptable lighting level. This threshold, called the set-point, is utilized in all daylight harvesting lighting control decisions. The sensor can find its optimum set-point via the **Automatic Set-Point Programming** mode. In this mode, the sensor sets the minimum light level to be the amount contributed by the artificial lights being controlled. It is assumed that the space is properly lit by design, however, if this is not the case the set-point may be easily adjusted to the occupant's preferences. All modes and settings are entered digitally via a push button sequence. Once programmed, the exact value of the set-point (in foot candles) can be read out from the sensor via a series of LED flashes.

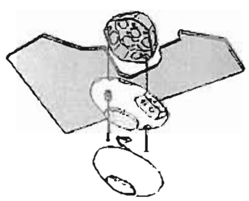
DIGITAL SET-POINT CONTROL

Each sensor contains a microcontroller that enables the user to engage the Automatic Set-Point Programming mode or to manually set / adjust the set-point. The manual process involves calculating and inputting the exact foot-candle value of the desired set-point into the sensor. It is important to note that the set-point is the light level required at the face of the sensor and that this value will be much different than the level required at a work surface. Typically, light levels at the ceiling are 3 to 5 times less than the work surface. For example, if 50 fc is desired at the work surface, the sensor should be set at 10 fc. For best results, measure the levels at both locations using a foot-candle meter before programming the set-point.

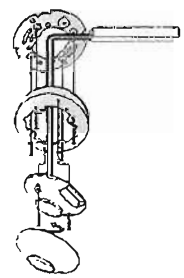
INSTALLATION

The ceiling (CMR) sensor enclosure accommodates mounting to a variety of junction boxes ranging in size from a single gang "Mud Ring" at a 3.28" spacing, up to a Round Fixture Box spacing of 3.5".

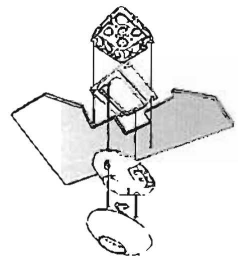
ROUND FIXTURE BOX



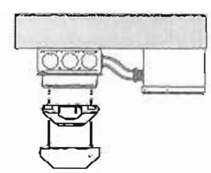
WIREMOLD V5738 FIXTURE BOX



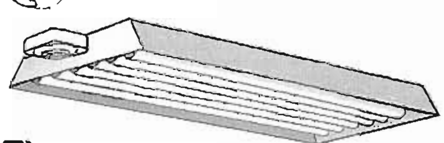
MUD RING WITH 1900 BOX



OFFSET NIPPLE



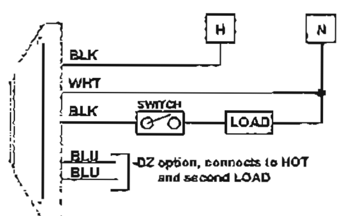
The fixture (CMRB) sensor enclosure provides an extended chase nipple that facilitates mounting to a half-inch knockout hole on the side of a fixture.

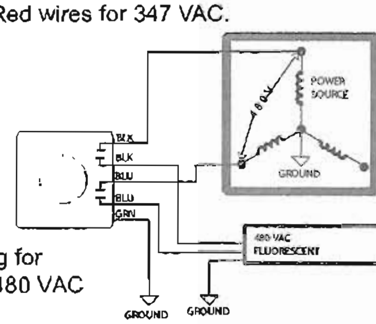


TYPICAL WIRING DIAGRAM (DO NOT WIRE HOT)

The sensor uses Sensor Switch's patented "either/or wiring"; Black to Hot and Black to Load (-DZ option adds a pair of Blue wires for the second zone). For 120, 277, and 347 VAC the White wire connects to neutral. Alternatively, for 208 and 480 VAC the Green wire connects to Ground. Black wires are replaced with Red wires for 347 VAC.

Wiring for 120, 277, and, 347 VAC





Wiring for 208 and 480 VAC

Note: Once installed, the sensor may take a few minutes to become active. Additionally, there is a 45 second delay before switching from "Off" to "On" (this delay is 55 seconds when connected to 50 Hz).

WARRANTY: Sensor Switch, Inc. warrants these products to be free of defects in manufacture and workmanship for a period of sixty months. Sensor Switch, Inc., upon prompt notice of such defect will, at its option, provide a Returned Material Authorization number and a replacement product. **LIMITATIONS AND EXCLUSIONS:** This Warranty is in full lieu of all other representation and expressed and implied warranties (including the implied warranties of merchantability and fitness for use) and under no circumstances shall Sensor Switch, Inc. be liable for any incidental or consequential property damages or losses.

sensorswitch

SENSOR SWITCH, INC.
900 Northrop Rd., Wallingford, CT 06492
(203) 265-2842 info@sensorswitch.com
www.sensorswitch.com

Figure B.7

Product Data: Sensor Switch, CMR-9 (Occupancy Control)

sensorswitch

STANDARD RANGE SENSOR - CEILING MOUNT, LINE VOLTAGE, PASSIVE INFRARED (PIR)

TYPICAL APPLICATIONS
- Office/Conference Room
- Closet/Changing Room
- Private Bathroom (no stalls)
- Concrete/Drywall Ceilings

FEATURES
- PIR Occupancy Detection
- Self-Contained Relay, no Power Pack needed
- Time Delay: 30 sec. to 20 minutes
- No Minimum Load Requirements
- Push-Button Programmable
- Green LED Activity Indicator
- 100 Hr. Lamp Burn-in Timer Mode

DAYLIGHTING OPTIONS
- On/Off Photocell (-P)
- Auto Dimming Cntl. Photocell (-ADC)

SPECIFICATIONS
- Size: Circular, 4.55"Dia., 1.55" Deep (11.56 cm Dia., 3.94 cm Deep)
- Sensor Weight: 6 Ounces
- Sensor Color: White
- Mounting: Round Fixture Box or Single Gang Handy Box
- Relative Humidity: 20 to 90% non-condensing
- Operating Temp: 14° to 160° F (-10° to 71° C)
- Storage Temp: -14° to 160° F (-26° to 71° C)
- Load Rating (1 Phase Only):
  800 W @ 120 VAC
  1200 W @ 277 VAC
  1500 W @ 347 VAC
- 1/4 HP Motor Load
- Frequency: 50/60 Hz (Timers are 1.2 times for 50 Hz)
- UL, CUL, and Title 24 Compliant
- 5 Year Warranty
- Made in U.S.A.

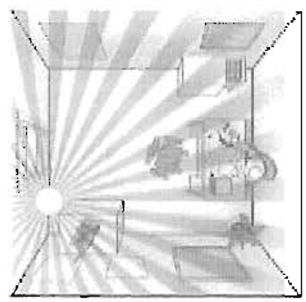
LOW TEMP/HI HUMIDITY(-LT)
- Conformally coated Circuit Board is corrosion resistant from moisture
- Operates down to -40° F(-40° C)

CMR-9 Series
w/ Enhanced Daylighting Control Options!

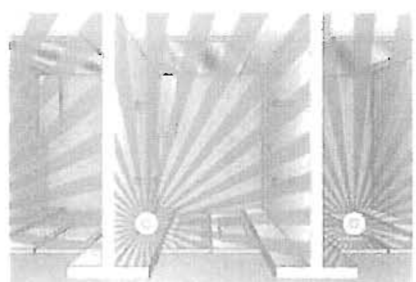
The *CMR-9 Series* incorporates the industry's leading Passive Infra-red (PIR) technology into an attractive line powered ceiling mount occupancy sensor that provides amazing sensitivity to small motions and excellent payback. The *CMR-9* is an economical approach to controlling automatic lighting needs in enclosed areas where a wall switch replacement sensor is not applicable. It is also an ideal choice for retrofitting rooms with concrete or inaccessible ceilings, or new construction with drop ceilings. For rooms with obstructions the CMR-PDT should be considered.

SENSOR OPERATIONS

The sensor detects changes in the infrared energy given off by occupants as they move within the field-of-view. When occupancy is detected, a self-contained relay switches the lighting "On". The sensor is line powered and can switch a large range of line voltages. An internal timer, factory set at 10 minutes, keeps the lights "On" during brief periods of no activity. This timer is selectable at 2.5 minute increments from 30 seconds to 20 minutes, and is reset every time occupancy is re-detected. This state-of-the-art design requires no manual field adjustments.



Small Office
- PIR technology effective in an enclosed unobstructed area
- Best choice for concrete ceiling



Closet/Changing Room
- More cost effective than installing door (plunger type) switches
- Eliminates need for toggle switch
- Adds convenience for user

DAYLIGHTING CONTROL OPTIONS

For spaces with abundant natural light from windows or skylights, this series offers an On/Off Photocell (-P) option and an Automatic Dimming Control (-ADC) Photocell option. The -P option is ideal for public areas like vestibules, corridors, or restrooms; while the -ADC option is perfect for classrooms and private offices. As the daylight levels change in the room, both options insure that an adequate light level is maintained according to a programmable set-point value. The -P option provides two modes of operation; one simply inhibits the lights from turning on, while the other has full On/Off control of the lights. The -ADC option allows the sensor to control a dimmable ballast. It also provides a secondary dim time-out that enables the lights to go to a dim setting after one time-out and then turn fully off after a second time-out. For more detailed information on these daylighting control features, see the CMR-PC-ADC Technical Data Sheet. **Note:** If both the -P and the -ADC options are selected the "Inhibit" mode of the -P option is not available.

Model Numbering System: CMR-9-[DAYLIGHTING CONTROL]-[VOLTAGE]-[TEMP/HUMIDITY]

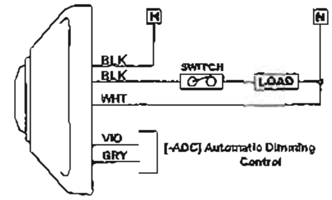
MODEL#	DAYLIGHTING CONTROL*	VOLTAGE	TEMP/HUMIDITY
CMR-9	Blank = None -P = On/Off Photocell -ADC = Auto Dimming Cntl. Photocell *for both options use -P-ADC	Blank = 120-277 VAC -3 = 347 VAC	Blank = 14° to 160° F LT = -40° to 160° F

T014-002-P

TYPICAL WIRING DIAGRAM (DO NOT WIRE HOT)

The sensor uses Sensor Switch's patented "either/or wiring"; Black to Hot and Black to Load. The White wire connects to neutral. Black wires are replaced with Red wires for 347 VAC. The -ADC option adds two low voltage wires for connection to a 0-10 VDC dimmable ballast.

3 MINUTE WARM-UP



INITIAL POWER UP

When power is applied to the sensor, the relay is designed to be in a latched closed position, and the lights should come on. After a 1-3 minute warm-up period, the sensor becomes functional and begins to "time out". ***If the Lights Do Not Immediately Turn On (Initial Installation Only)*** the latching relay is in the open position. When the 1-3 minute warm-up is over the sensor will correct itself and close the relay.

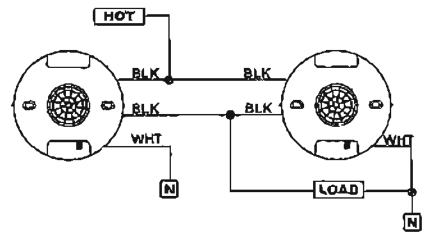
FIELD OF VIEW

The *CMR-9's* dome lens provides a maximum viewing angle of 56° in a complete 360° conical pattern. It is ideal for occupancy detection in unobstructed areas. Place the sensor along the entrance door wall to prevent it from viewing out into the hallway, while still ensuring the sensor can view the entire room from this position.

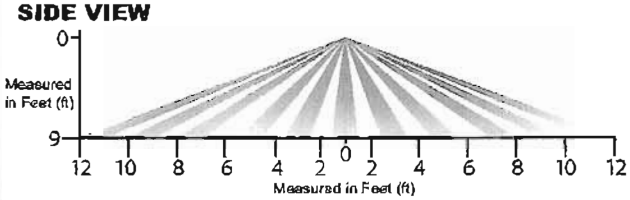
Note: Heat producing sources controlled by the sensor must not be in the view pattern of the sensor. Symptom: Sensor cycles or appears to continually stay "On". Solution: Move sensor or mask lens segments that view the source.

SENSORS IN PARALLEL

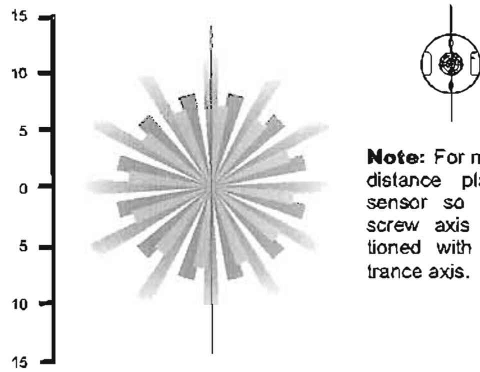
For multiple sensor applications, simply wire sensors in parallel, however the maximum load ratings stay the same. Do not wire sensors with -P or -ADC option in parallel.



SIDE VIEW



TOP VIEW



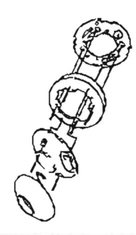
Note: For maximum distance place the sensor so that the screw axis is positioned with the entrance axis.

INSTALLATION

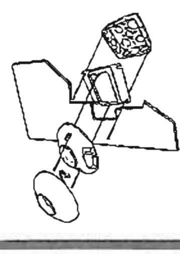
The ceiling sensor enclosure accommodates mounting to a single gang "Mud Ring" at a 3.28" spacing, up to a Round Fixture Box spacing of 3.5". Refer to "Field of View" section to determine orientation of box for maximum coverage. Note that most fixture boxes orientate the sensor 45° differently than a single gang handy box or mud ring on a 1900 box.

ROUND FIXTURE BOX

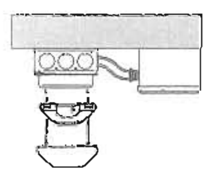
WIREMOLD V5738 FIXTURE BOX



MUD RING WITH 1900 BOX



OFFSET NIPPLE



sensorswitch

SENSOR SWITCH, INC.
900 Northrop Rd., Wallingford, CT 06492
(203) 265-2842 info@sensorswitch.com
www.sensorswitch.com

Figure B.8

Product Data: H.E. Williams, GL T5 (Gym Complex Lighting)

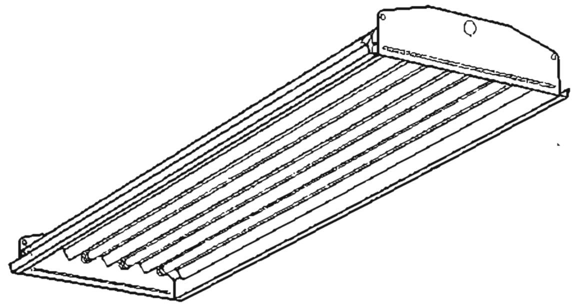
LOW PROFILE **T5 INDUSTRIAL**

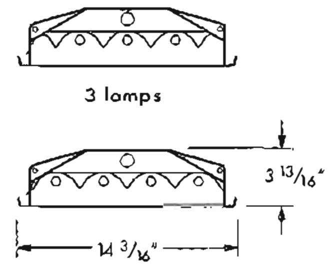
SERIES **GL** 3 or 4 T5

JOB ______

TYPE ______

VOLTAGE ______





SPECIFICATIONS

- HOUSING – .050" die formed aluminum housing
- REFLECTIVE SURFACES – Highly specular anodized MIRO 4™ aluminum reflector
- FINISH – 92% minimum average reflective white powder coat with multi-stage iron/phosphate prepared metal
- ELECTRICAL – Electronic ballast standard, programmed start T5, rated Class P
- LABELS – UL listed to U.S. and Canadian safety standards as fluorescent luminaire suitable for dry or damp locations
- MOUNTING – Pendant mount with VBY hangers and chain, 3" spacer brackets, or single point 3/4" conduit utilizing hub and splice box adapter

FEATURES

- Occupancy sensors are available to instantly turn the lights on only when they're needed — nothing saves energy like lights out!
- Heavy gauge aluminum housing for maximum heat dissipation and extended ballast life
- Easy access to ballast without the removal of lamps or the use of tools
- Unlike HID, T5HO lamps maintain 95% of their original output and provide much better color rendition
- Quick wire access plate in back of fixture housing for easy attachment of incoming power supply
- Shallow fixture depth of less than 4" allows fixture placement near the ceiling for maximum space utilization and reduces damage incurred from material handling equipment
- Consumes 1/2 the energy of 400 watt metal halide and delivers comparable light levels when replaced one for one

ORDERING INFORMATION

Submittal

	SERIES	NOM. LENGTH	TOTAL LAMPS	WATTAGE/ TYPE	OPTIONS	BALLAST	VOLTAGE
EXAMPLE:	GL	4	4	54T5H	OPTIONS	EB4	277

SERIES

GL	Low Profile T5 Industrial

NOMINAL LENGTH

4	4'
8	8'

TOTAL LAMPS

3 or 4	(4' length)
6 or 8	(8' length)

LAMP WATTAGE/TYPE

28T5S	4', 28 watt T5
54T5H	4', 54 watt T5HO

OPTIONS

3SB	3" Spacer Bracket (1 pair)
HA	High Ambient (3 or 4 lamp only, not available with lens option)
HUB 3/4"	Cast iron hub & junction box for single pendant mount (4' unit only)
HUB/HOOK	Mounting hook with safety screw for replacement of HID fixtures (Shipped not attached)

OPTIONS cont'd.

VBY	1 pair VBY hangers (for chain mounting)
OCC SEN	Occupancy Sensor
S7238/B	Cord, 72" length, No. 18 AWG, 3 conductor, black
6CP1/L5-15P/TWLK	6' cord & NEMA Twistlock 120V plug
6CP1/L7-15P/TWLK	6' cord & NEMA Twistlock 277V plug
PSCHA118	Piano hinge steel door frame, 0.118" thick, clear high temperature acrylic glazing (non-prismatic lens)
SCHA118	Steel door frame, 0.118" thick, clear high temperature acrylic glazing (non-prismatic clear lens)
WG11	11 Ga. white powder coat wireguard
REFLWHITE	White reflector
UP5	Uplight apertures — 5% uplight
FP54/41ENC	Encapsulite lamps
ND	Narrow Distribution
WD	Wide Distribution

BALLAST TYPE

EB3	3 lamp electronic ballast
EB4	4 lamp electronic ballast
EB3/3	(2) 3 lamp electronic ballasts
EB4/4	(2) 4 lamp electronic ballasts

VOLTAGE

120	120V
208	208V
240	240V
277	277V
UNV	120 - 277V
347	347V
480	480V
HRV	347/480V

Note: For more options/accessories, ballast combinations, and product details, please consult factory

williams

PHOTOMETRY INFORMATION

STANDARD

Williams Catalog #GL-4-454T5H-EB2/2 Test Report #11759.0, Dated 11/22/02 Ballast Factor: 1.0
Lamp Type: FP54T5HO/835 Lumens: 5000 Lamp Quantity: 4

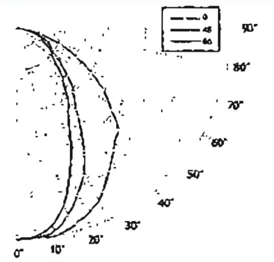
CANDLEPOWER DISTRIBUTION

VERT ANG	HORIZONTAL ANGLE 0	45	90	ZONAL LUMENS
0	11505	11505.	11505	
5	11448.	11435	11376	1090.5
15	11198	10548.	9840.	2990 9
25	10345	8520	6872.	3973 6
35	8822	5678	4811	3979 7
45	7621.	4056	3255	3637 6
55	5527.	2474	2212	2668 3
65	3400	1522	1877	1947.6
75	1483	1004	748.	989 3
85	164	144.	170	177 6
90	0.	0	0	

LUMEN SUMMARY

ZONE	LUMENS	% LAMP	% FIXTURE
0 - 30	8055.	40 3	37 5
0 - 40	12035	60 2	56 1
0 - 60	18341	91 7	85 5
0 - 90	21455	107 3	100 0
90 - 120	0	0.0	0 0
90 - 130	0.	0.0	0.0
90 - 150	0.	0.0	0 0
90 - 180	0.	0.0	0.0
0 - 180	21455	107 3	100 0

TOTAL LUMINAIRE OPTICAL **EFFICIENCY = 100.0%***
SPACING CRITERIA: END = 1.2 DIAG = 1.0 ACROSS = 0.9



NARROW DISTRIBUTION

Williams Catalog #GL-4-454T5H-ND-EB2/2 Test Report #13473.0, Dated 02/22/07 Ballast Factor: 1.0
Lamp Type: FP54T5HO/835 Lumens: 5000 Lamp Quantity: 4

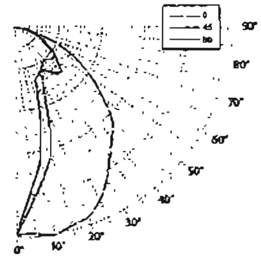
CANDLEPOWER DISTRIBUTION

VERT ANG.	HORIZONTAL ANGLE 0	45	90	ZONAL LUMENS
0	14775.	14775	14775.	
5	14769.	12523.	11610.	1227.2
15	14596.	9229	6305	2709 6
25	13621.	4367.	3714	2963.1
35	11338	3195.	3862	3011.0
45	9488	3232.	4441	3340.5
55	6625	3294	2319.	3015.9
65	3935	2196.	1850	2168.8
75	1591.	1122	900	1157 9
85	136	61	49.	98.9
90	0	0.	0.	

LUMEN SUMMARY

ZONE	LUMENS	% LAMP	% FIXTURE
0 - 30	6900	34.5	35 0
0 - 40	9911	49.6	50 3
0 - 60	16267.	81 3	82 6
0 - 90	19693	98.5	100.0
90 - 120	0	0.0	0.0
90 - 130	0	0 0	0.0
90 - 150	0.	0 0	0 0
90 - 180	0.	0.0	0.0
0 - 180	19693	98 5	100 0

TOTAL LUMINAIRE OPTICAL **EFFICIENCY = 98.5%**
SPACING CRITERIA: END = 1.3 DIAG. = 0.6 ACROSS = 0.4



WIDE DISTRIBUTION

Williams Catalog #GL-4-454T5H-WD-EB2/2 Test Report #13515.0, Dated 03/29/07 Ballast Factor: 1.0
Lamp Type: FP54T5HO/835 Lumens: 5000 Lamp Quantity: 4

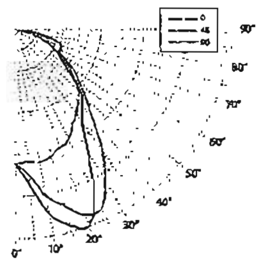
CANDLEPOWER DISTRIBUTION

VERT ANG	HORIZONTAL ANGLE 0	45	90	ZONAL LUMENS
0	5128.	5128	5128.	
5	5081	5541	5924	526 9
15	5004	6966.	7714.	1897 2
25	4646.	7535	6928.	3112.4
35	3937.	5669	4365	3213.4
45	3342.	3745	3515	3144.7
55	2479	2646.	2217.	2391.4
65	1578	1482	1847.	1647 4
75	766.	1246.	1572	1246 7
85	121.	300.	185	269 8
90	0	0	0	

LUMEN SUMMARY

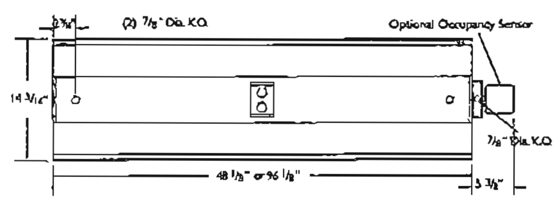
ZONE	LUMENS	% LAMP	% FIXTURE
0 - 30	5537.	27 7	31 7
0 - 40	8750.	43.7	50 1
0 - 60	14286.	71 4	81 9
0 - 90	17450.	87 2	100 0
90 - 120	0.	0 0	0 0
90 - 130	0	0 0	0.0
90 - 150	0	0.0	0 0
90 - 180	0.	0.0	0 0
0 - 180	17450.	87 2	100.0

TOTAL LUMINAIRE OPTICAL **EFFICIENCY = 87.2%**
SPACING CRITERIA: END = 1.2 DIAG = 1.5 ACROSS = 1.4

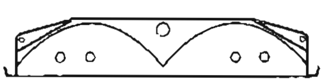


DETAILS

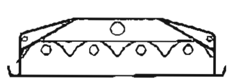
BACK VIEW



DISTRIBUTION



Narrow Distribution



Wide Distribution

ZONAL CAVITY COEFFICIENTS (STANDARD)

EFFECTIVE FLOOR CAVITY REFL = 20

CEILING	.80			.70			.50		
WALL / RCR	.70	.50	.30	.70	.50	.30	.50	.30	.10
0	1.28	1.28	1 28	1.25	1.25	1.25	1 19	1.19	1.19
1	1 19	1.15	1.11	1 16	1 12	1.09	1.08	1.05	1 03
2	1.10	1.03	97	1.08	1.01	95	.97	93	88
3	1.02	.93	.85	1.00	91	84	.88	82	77
4	.95	.83	75	92	.82	75	80	73	.68
5	87	75	66	.85	.74	.66	72	.65	.59
6	.81	.68	60	79	67	.59	65	58	53
7	.75	.62	.53	.73	.61	.53	.60	.52	47
8	70	.56	.48	.68	.56	47	.54	47	.42
9	.65	.51	.43	.63	.50	.42	49	.42	37
10	.60	.47	39	59	.46	.38	.45	.38	.33

* Luminaire efficiency is dependent upon both optical and thermal factors. Under certain circumstances, lamp lumen output can be increased in the luminaire versus lumen output in 25°C air due to increased lamp temperature when operating in the luminaire. As luminaire efficiency is derived from luminaire output versus lamp output in open air, this can result in an efficiency greater than 100%

williams

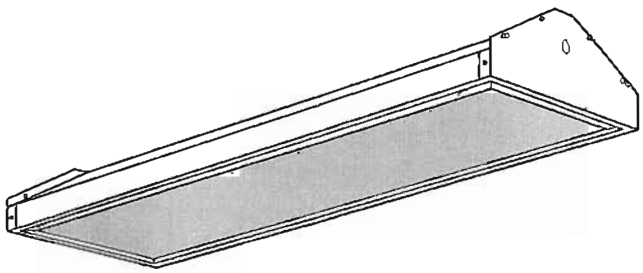
Figure B.9

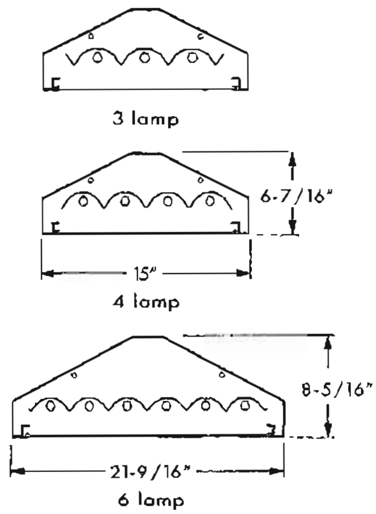
Product Data: H.E. Williams, GLS T5 (Gym Complex Lighting)

SLOPED **T5 INDUSTRIAL**

GLS
T5

SERIES ______
JOB ______
TYPE ______
VOLTAGE ______





SPECIFICATIONS

- HOUSING — .040" die formed aluminum housing
- REFLECTIVE SURFACES — Highly specular anodized MIRO 4™ aluminum reflector standard — optional white reflector available
- FINISH — 92% minimum average reflective white powder coat with multi-stage iron/phosphate prepared metal.
- ELECTRICAL — Electronic ballast standard, programmed start T5, rated Class P
- LABELS — UL/CUL listed as fluorescent luminaire suitable for dry or damp locations
- MOUNTING — Pendant mount with VBY hangers and chain, 3" spacer brackets or single point 3/4" conduit utilizing hub and splice box adapter

FEATURES

- Designed with a sloped top to reduce dust build-up on the fixture
- Designed without flanges to prevent dust build-up along the fixture sides
- Includes double-gasketed lens to reduce, not prevent, dust entry into the fixture*
- High performance MIRO 4™ reflector system standard
- Clear acrylic lens standard, other shielding options available (Consult factory for details)
- Heavy gauge aluminum housing for maximum heat dissipation and extended ballast life
- All parts painted after fabrication to facilitate installation, increase efficiency, and inhibit corrosion

*The GLS is designed to reduce the build-up of dust on the exterior of the fixture (It is not rated as a dust-tight fixture)

ORDERING INFORMATION

Submittal

	SERIES		NOM. LENGTH		TOTAL LAMPS		WATTAGE/ TYPE		FRAME TYPE	SHIELDING		OPTIONS		BALLAST		VOLTAGE
EXAMPLE	GLS	-	4	-	4		54T5H	-	F	CHA118	-	OPTIONS	-	EB4	-	UNV

SERIES

GLS	Sloped T5 Industrial

NOMINAL LENGTH

4	4'

TOTAL LAMPS

3, 4, or 6

LAMP WATTAGE/TYPE

28T5S	4', 28 watt T5
54T5H	4', 54 watt T5HO

DOOR FRAME TYPE

F	White flat aluminum

SHIELDING

CHA118	Clear high temperature acrylic glazing (non-prismatic lens)
A12125	#12 pattern acrylic, .125" thick
PC12125	#12 pattern polycarbonate, .125" thick

OPTIONS

OCC SEN	Occupancy Sensor
S7238/B	Cord, 72" length, No 18 AWG, 3 conductor, black
6CPI/L5-15P/TWLK	6' cord & NEMA Twistlock 15A plug, 120V
6CPI/L7-15P/TWLK	6' cord & NEMA Twistlock 15A plug, 277V
REFLWHITE	White Reflector
VBY	1 pair VBY hangers
VBY-3	1 pair VBY hangers and 2 pieces 3' chain
HUB 3/4"	Cast iron hub & junction box for single pendant mount

BALLAST TYPE

EB3	3 lamp electronic ballast
EB4	4 lamp electronic ballast
EB2/1	(1) 2 lamp & (1) 1 lamp electronic ballast
EB2/2	(2) 2 lamp electronic ballasts
EB3/3	(2) 3 lamp electronic ballasts
EB4/2	(1) 4 lamp & (1) 2 lamp electronic ballast

VOLTAGE

120	120V
208	208V
240	240V
277	277V
UNV	120 - 277V
347	347V
480	480V
HRV	347 - 480V

Specify voltage (not UNV or HRV) if using modular wiring, cord & plug, or occupancy sensor

Note: For more options/accessories, ballast combinations, and product details, please consult factory

williams®

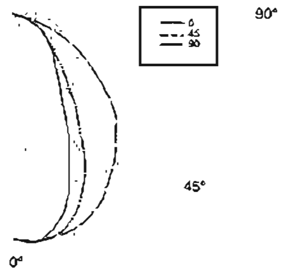
GLS T5 SERIES — PHOTOMETRY INFORMATION

Williams Catalog #GLS-4-454T5H-FCHA118
Test Report #13075.0, Dated 04/28/06

Lamp Type: FP54T5HO/835
Lamp Quantity: 4

CANDLEPOWER DISTRIBUTION

VERT ANG	HORIZONTAL ANGLE 0	45	90	ZONAL LUMENS
0	8363	8363	8363	
5	8466.	8492	8505	809 8
15	8305.	8004	7403	2251.8
25	7656.	6245.	4729.	2888 9
35	6493.	3880.	2913.	2753.2
45	5291.	2338.	2116.	2328 1
55	3592.	1502	1515	1674.2
65	2064.	979	849	1058.0
75	692.	339	182	353.8
85	26	26	26	28.4
90	0.	0.	0	



LUMEN SUMMARY

ZONE	LUMENS	% LAMP	% FIXTURE
0 - 30	5951.	29 8	42.1
0 - 40	8704.	43.5	61.5
0 - 60	12706	63.5	89.8
0 - 90	14146	70 7	100.0
90 - 120	0	0	0.
90 - 130	0	0.	0.
90 - 150	0	0.	0.
90 - 180	0	0.	0.
0 180	14146.	70.7	100.0

TOTAL LUMINAIRE
OPTICAL **EFFICIENCY = 70.7%**
SPACING CRITERIA: END = 1.2 DIAG. = 1.0 ACROSS = 8

ZONAL CAVITY COEFFICIENTS

EFFECTIVE FLOOR CAVITY REFL = .20

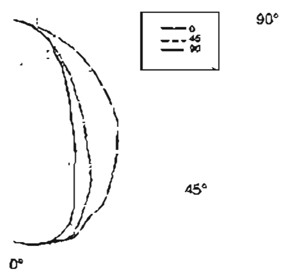
CEILING	.80			.70			.50		
WALL RCR	.70	.50	.30	.70	.50	.30	.50	.30	.10
0	84	84	84	82	82	82	79	79	79
1	79	77	74	77	75	73	72	70	69
2	74	69	66	72	68	65	66	63	60
3	69	63	58	67	62	58	60	56	53
4	64	57	52	62	56	51	54	50	47
5	59	51	46	58	51	46	49	45	42
6	55	47	42	54	46	41	45	41	37
7	51	43	38	50	42	37	41	37	33
8	48	39	34	47	39	34	38	33	30
9	44	36	30	43	35	30	34	30	27
10	41	33	27	40	32	27	32	27	24

Williams Catalog #GLS-4-654T5H-FCHA118
Test Report #13073.0, Dated 04/28/06

Lamp Type: FP54T5HO/835
Lamp Quantity: 6

CANDLEPOWER DISTRIBUTION

VERT ANG.	HORIZONTAL ANGLE 0	45	90	ZONAL LUMENS
0	12392.	12392.	12392	
5	12513.	12526	12580	1196.5
15	12513	12326	11645	3462.3
25	11351.	9855	7799	4518.4
35	9601.	6383.	5114	4403.9
45	7892.	4179.	3632.	3850.7
55	5408	2590.	2564	2798.7
65	3098.	1602	1509	1761.0
75	1055.	600	440	649.2
85	66.	53.	53.	63.1
90	0	0	0	



LUMEN SUMMARY

ZONE	LUMENS	% LAMP	% FIXTURE
0 - 30	9177.	30.6	40.4
0 - 40	13581.	45.3	59.8
0 - 60	20230.	67 4	89.1
0 - 90	22704.	75.7	100 0
90 - 120	0	0.	0.
90 - 130	0.	0	0.
90 - 150	0	0.	0.
90 - 180	0.	0	0
0 - 180	22704	75.7	100 0

TOTAL LUMINAIRE
OPTICAL **EFFICIENCY = 75.7%**
SPACING CRITERIA: END = 1.2 DIAG. = 1.0 ACROSS = .9

ZONAL CAVITY COEFFICIENTS

EFFECTIVE FLOOR CAVITY REFL. = .20

CEILING	.80			.70			.50		
WALL RCR	.70	.50	.30	.70	.50	.30	.50	.30	.10
0	90	90	90	88	88	88	84	84	84
1	84	82	79	82	80	78	77	75	73
2	79	74	70	77	72	69	70	67	64
3	73	67	62	71	66	61	64	60	56
4	68	60	55	66	59	54	58	53	50
5	63	54	49	61	54	48	52	47	44
6	58	50	44	57	49	43	48	43	39
7	54	45	39	53	45	39	44	39	35
8	50	41	35	49	41	35	40	35	31
9	47	37	32	46	37	31	36	31	27
10	43	34	29	43	34	28	33	28	25

BACK VIEW

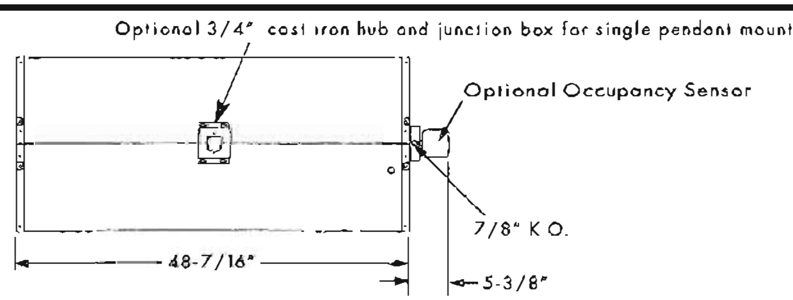


Figure B.10

Product Data: Sensor Switch, CM-6 (Gym Complex Control)

sensorswitch

HIGH BAY 360° SENSOR - CEILING MOUNT
LOW VOLTAGE, PASSIVE INFRARED

TYPICAL APPLICATIONS
- Warehouse
- Gymnasiums
- Racquetball Courts

FEATURES
- PIR Occupancy Detection
- Communicates with Other Sensors
- Up to 45 Foot Mounting
- Push-Button Programmable
- Time Delay: 30 sec. to 20 minutes
- Green LED Activity Indicator
- 100 Hr. Lamp Burn-in Timer Mode

AVAILABLE OPTIONS
- Isolated Low Voltage Relay (-R)
- On/Off Photocell (-P)
- Low Temp/Hi Humidity (-LT)

SPECIFICATIONS
- Size: Circular, 4.55" Dia., 1.55" Deep (11.56 cm Dia., 3.94 cm Deep)
- Sensor Weight: 5 Ounces
- Sensor Color: White
- Mounting: Ceiling Tile Surface, Round Fixture or Junction Box
- Relative Humidity: 20 to 90% non-condensing
- Operating Temp: 14° to 160° F (-10° to 71° C)
- Storage Temp: -14° to 160° F (-26° to 71° C)
- UL, CUL, and Title 24 Compliant
- 5 Year Warranty
- Made in U.S.A.

LOW TEMP/HI HUMIDITY(-LT)
- Conformally coated Circuit Board is corrosion resistant from moisture
- Operates down to -40° F(-40° C)

CM-6 SERIES

Programmable Edition!

The *CM-6* sensor was specifically designed for High Mounting applications (15 - 45 feet). Above 15 feet, the *CM-6* provides Passive Infrared (PIR) detection in a 30 to 40 foot diameter area, making it perfect for warehouses or gymnasiums where the sensors are mounted on a 30 to 40 foot grid pattern. Multiple sensors may be used together to provide coverage as needed. If any one sensor detects occupants, all the lights will turn "On". In Raquetball Courts, it is preferred to locate the sensor near the entrance (furthest from the wall). For freezer applications, use the CM-6-LT for cold temperature and corrosion resistant characteristics. For lower mounting applications, refer to CM-9 or CM-10 Technical Data Sheets.

SENSOR OPERATIONS

The sensor detects changes in the infrared energy given off by occupants as they move within the field-of-view. When occupancy is detected, a DC output goes high and can drive up to 200 mA of connected load. The sensor is powered with 12 to 24 VAC/VDC and typically operates with a PP-20 or MP-20 Power Pack; enabling complete 20 Amp circuits to be controlled. An internal timer, factory set at 10 minutes, keeps the lights "On" during brief periods of no activity. This timer is selectable at 2.5 minute increments from 30 seconds to 20 minutes, and is reset every time occupancy is re-detected. This state-of-the-art design requires no manual field adjustments.

CONTROLLING HID BI-LEVEL LIGHTING

In Gymnasiums or Warehouses where control of HID Bi-Level Lighting is desired, the CM-6 is used with a PP-20-SH Power Pack. This Power Pack provides for a Start-to-High Timer, which brings the lamps to full "On" for up to 20 minutes upon initial power up. The Power Pack must be on the same power circuit as the fixtures to sense the initial power on condition. Some Electronic HID fixtures have this Start-to-High feature built in. In this case, the standard PP-20 or MP-20 Power Pack may be used to switch fixtures from Hi to Low. Consult fixture manufacturer in these cases.

DAYLIGHTING CONTROL OPTIONS (-P)

For spaces with abundant natural light from windows or skylights, this series offers an ***On/Off Switching Photocell (-P)*** option. In a CM-6 sensor this option is most applicable when used in areas where daylight is coming in through High Bay garage doors or windows below the level of the sensor. As the daylight levels change in the room, the sensor insures that an adequate light level is maintained according to a programmable set-point value. The -P option provides two modes of operation; one simply inhibits the lights from turning on, while the other has full On/Off control of the lights. For more detailed information on the daylighting control features, see the CM-PC Technical Data Sheet.

ORDERING INFORMATION

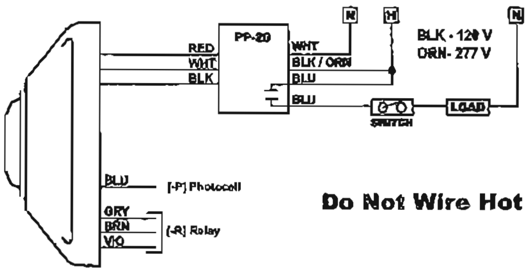
MODEL #	DESCRIPTION	TEMPERATURE	OP. VOLTAGE	CURRENT
CM-6	High Bay 360° Sensor, Low Voltage	14° to 160° F	12 to 24 VAC/VDC	4 mA
Add suffix				
-R	SPDT Relay, 1 Amp			16 mA
-P	On/Off Photocell			4 mA
-RP	Relay & On/Off Photocell			16 mA
-LT	Low Temp/High Humidity	-40° to 160° F		

WIRING INSTRUCTIONS

Wire lead connections are Class II, 18 to 22 AWG.

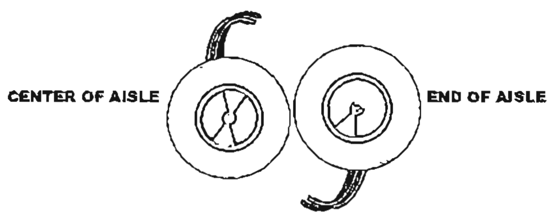
STANDARD CM-9

RED - 12 to 24 VAC/VDC
BLACK - Common
WHITE - Output (HI DC for Occupancy)



MASKING KIT

The sensor views a 360° circular pattern. The kit provided may be used to mask off half of the viewing for end of aisle, or trim the side viewing to create a rectangular pattern for center of aisle. Shown below is the masking for the center of aisle and the end of the aisle.



RELAY OPTION (-R)

GRAY / BROWN - Connected during Occupied state
VIOLET / BROWN - Connected during Unoccupied state
Note: Relay is energized during Unoccupied state

PHOTOCELL OPTION (-P)

BLUE - Photocell output (High: Occupied & Low Light)
Use Blue wire from sensor in place of White wire. For multi-level control, use 2 Power Packs and connect White to primary load and Blue to daylight load.

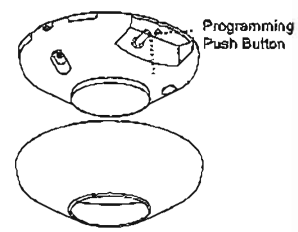
ISOLATED LOW VOLTAGE RELAY OPTION (CM-6-R)

To enable a sensor to interface with a building management system, the -R option provides dry contact closure via a SPDT, 1 Amp, 40 Volt relay. The relay coil is energized and changes state when ALL connected sensors register "Unoccupied". When using multiple sensors, only one sensor per zone needs to have a relay.

Note: Sensor must have power at all times for the relay to function .

MOUNTING CONSIDERATIONS

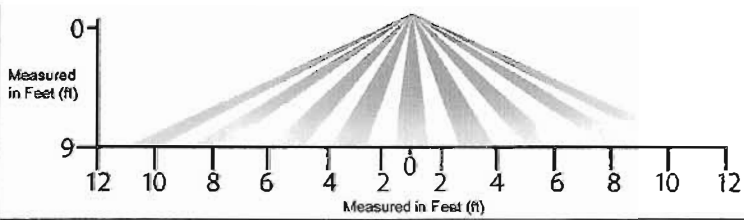
The sensor typically mounts directly to the ceiling tile, or to the metallic grid. However, if desired, the mounting holes are slotted to line up with a standard round, or rectangular box (screws not provided).



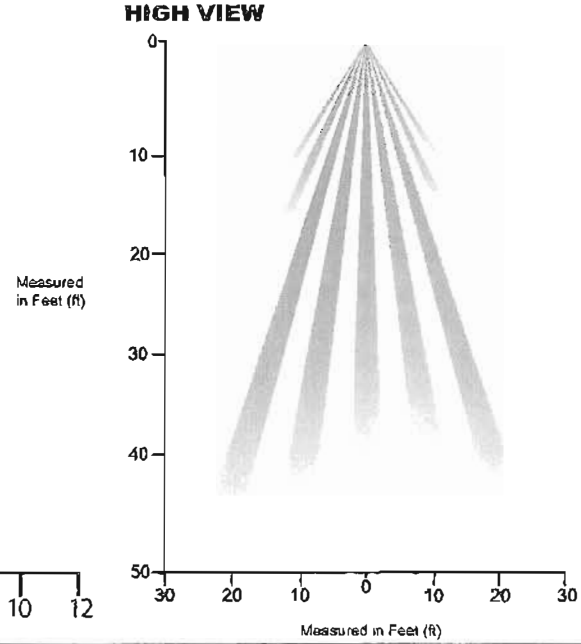
FIELD OF VIEW

The *CM-6* lens views in 5 separate 360° coneshaped patterns. The outermost (fifth) cone viewing at a 54° angle is only effective up to a 12-15 foot mounting height and is therefore not typically considered in High Bay applications. The fourth cone views at a 45° angle and is effective up to 20 feet. The inner three cones viewing at a maximum 30° angle continually maintain their effectiveness. The geometric effect is that the *CM-6* maintains a 15 to 20 foot radius up to a 45 foot mounting height. From 35 to 45 feet, the *CM-6* will generally only detect major motions such as a forklift truck. However, in colder environments, the *CM-6* may maintain very sensitive detection in all cones up to greater heights.

LOW VIEW



HIGH VIEW



WARRANTY: Sensor Switch, Inc. warrants these products to be free of defects in manufacture and workmanship for a period of sixty months. Sensor Switch, Inc., upon prompt notice of such defect will, at its option, provide a Returned Material Authorization number and a replacement product. **LIMITATIONS AND EXCLUSIONS:** This Warranty is in full lieu of all other representation and expressed and implied warranties (including the implied warranties of merchantability and fitness for use) and under no circumstances shall Sensor Switch, Inc. be liable for any incidental or consequential property damages or losses.

sensorswitch

SENSOR SWITCH, INC.
900 Northrop Rd., Wallingford, CT 06492
(203) 265-2842 info@sensorswitch.com
www.sensorswitch.com

revised 08/31/2006

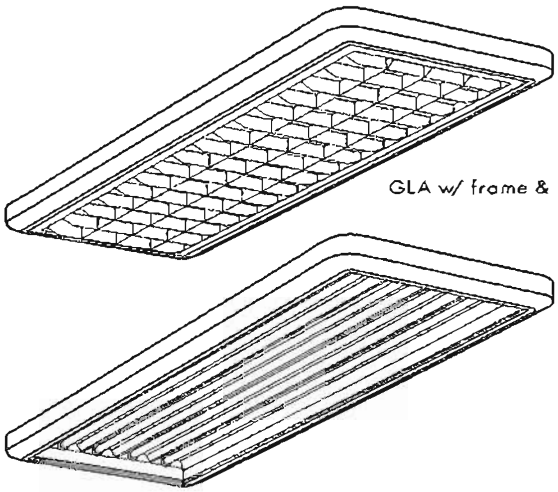
Figure B.11

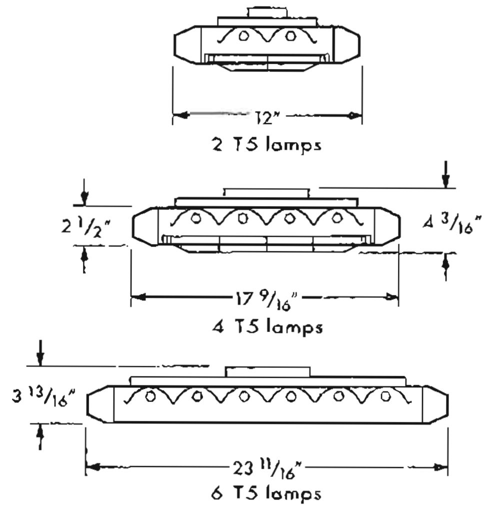
Product Data: H.E. Williams, GLA T5 (Library Lighting)

T5 ARCHITECTURAL HIGH-BAY

GLA T5

SERIES ____ JOB ____ TYPE ____ VOLTAGE ____





SPECIFICATIONS

- INNER HOUSING — 22 gauge die formed C.R.S.
- OUTER HOUSING — .060" thick extruded aluminum sides and ends, die cast aluminum corners
- REFLECTIVE SURFACES — Highly specular anodized MIRO 4˜ aluminum reflector — white reflector optional
- FINISH — Non-glare white polyester powder coated exterior textured finish with multi-stage iron/phosphate prepared metal
- ELECTRICAL — Electronic ballast standard, programmed start T5, rated Class P
- LABELS — UL listed to U.S. and Canadian safety standards as fluorescent luminaire suitable for dry or damp locations
- MOUNTING — Pendant mount with Y-hanger and chain, aircraft cable, or 3/4" conduit utilizing hub and splice box adapter. GLA should be mounted at least 18" from the ceiling for ample access to electrical

FEATURES

- Stylish fixture, less than 4" deep, complements any up-scale architecture
- Optional 1" deep louver follows the contour of the extruded aluminum sides & ends to provide functional lamp shielding and a modern appearance
- Replaces 400 watt HID one-for-one with half the energy
- Mounting options include stem, chain, or aircraft cable
- Extruded aluminum door frame accepts many different types of shielding, up to 1/2" depth — hinges / spring cam latches
- Ideal for any space with medium to high mounting heights
- Uplight apertures provide uplight to illuminate the ceiling
- All parts painted after fabrication to facilitate installation, increase efficiency, and inhibit rusting

ORDERING INFORMATION

Submittal

	SERIES	NOM. LENGTH	TOTAL LAMPS	WATTAGE/ TYPE	OPTIONS	BALLAST	VOLTAGE
EXAMPLE:	GLA	4	4	54T5H	OPTIONS	EB4	UNV

SERIES

GLA	Architectural High-Bay

NOMINAL LENGTH

4	4'

TOTAL LAMPS

2, 4, or 6

LAMP WATTAGE/TYPE

28T5S	4', 28 watt T5
54T5H	4', 54 watt T5HO

OPTIONS

FWSBL2	Frame & louver, white, straight blade, 1" deep, 2 lamp, 2 x 17 cell
FWSBL4	Frame & louver, white, straight blade, 1" deep, 4 lamp, 4 x 17 cell
FWSBL6	Frame & louver, white, straight blade, 1" deep, 6 lamp, 6 x 17 cell

OPTIONS cont'd.

S7238/W	Cord, 72" length, No. 18 AWG, 3 conductor, white
HUB 3/4"	Cast iron hub & junction box for single pendant mount
FCHA118	Clear acrylic lens, .118" thick, high temperature
Y	1 pair "Y" hangers for chain or aircraft cable
UP2	2 rows of uplight apertures, 4-lamp or 6-lamp fixtures only
UP4	4 rows of uplight apertures, 6-lamp fixture only
REFL WHITE	White reflector
6CP1/L5-15P/TWLK	6' cord & NEMA Twistlock 120V plug
6CP1/L7-15P/TWLK	6' cord & NEMA Twistlock 277V plug

BALLAST TYPE

EB4	4 lamp electronic ballast

Consult factory for complete ballast offering

VOLTAGE

120	120V
208	208V (T5H only)
240	240V (T5H only)
277	277V
UNV	120 - 277V
347	347V
480	480V (T5H only)
HRV	347 - 480V (T5H only)

Note: For more options/accessories, ballast combinations, and product details, please consult factory

williams

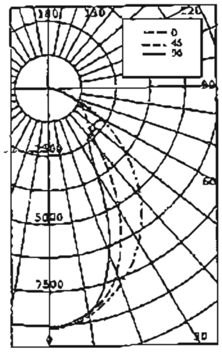
PHOTOMETRY INFORMATION

Williams Catalog #GLA-4-454T5H-WSBL4-EB2/2 — Lamp Type: FP54T5HO/835

Test Report #19713.0, Dated 01/28/05 — Lamp Quantity: 4

CANDLEPOWER DISTRIBUTION

VERT. ANG.	HORIZONTAL ANGLE 0	45	90	ZONAL LUMENS
0	8840.	8840.	8840.	
5	8775.	8719.	8671	836 0
15	8164	7996.	7695.	2212.0
25	7193.	6233.	5074.	2831.0
35	5952.	4014	2650	2620.0
45	4489.	2192.	2303.	2230 0
55	2947.	1705.	2196.	1869 0
65	1524.	1304.	1240.	1291.0
75	569.	571.	565.	598 0
85	139	168	178.	185.0
90	0.	30.	47.	



LUMEN SUMMARY

ZONE	LUMENS	% LAMP	% FIXTURE
0 - 30	5879.	32.7	40.1
0 - 40	8498.	47.2	57 9
0 - 60	12598.	70.0	85.9
0 - 90	14671.	81.5	100.0
40 - 90	6172.	34.3	42.1
60 - 90	2073	11.5	14.1
90 - 180	0.	0.0	0 0
0 - 180	14671	81 5	100.0

TOTAL LUMINAIRE
OPTICAL **EFFICIENCY = 81.5%**
SPACING CRITERIA: END = 1.2 DIAG. = 1.0 ACROSS = 0.9

ZONAL CAVITY COEFFICIENTS

EFFECTIVE FLOOR CAVITY REFL = .20

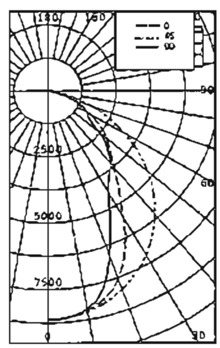
CEILING	.80			.70			.50		
WALL / RCR	.70	.50	.30	.70	.50	.30	.50	.30	.10
0	97	97	97	.95	.95	95	.91	.91	.91
1	90	.87	.84	.88	.86	.83	82	80	.78
2	84	.78	.74	.82	.77	.73	.74	.71	.67
3	.78	.71	65	76	.69	.64	.67	.63	.59
4	.72	.64	.58	.71	.63	.57	61	.56	.52
5	.67	.58	.51	.65	.57	.51	.55	.50	.46
6	.62	.53	.46	.61	.52	.46	.50	.45	.41
7	.58	.48	.42	.57	.47	.41	.46	41	.37
8	.54	.44	.37	.53	.43	.37	.42	.37	.33
9	.50	.40	.34	.49	.39	.33	.38	.33	.29
10	.47	.37	.30	.46	.36	.30	.35	.30	.26

Williams Catalog #GLA-4-454T5H-EB2/2 — Lamp Type: FP54T5HO/835

Test Report #19712.0, Dated 01/28/05 — Lamp Quantity: 4

CANDLEPOWER DISTRIBUTION

VERT ANG	HORIZONTAL ANGLE 0	45	90	ZONAL LUMENS
0	8602.	8602.	8602.	
5	8575	8577	8565.	825.0
15	8247.	8098	7746	2245 0
25	7601	6667	5349	3011.0
35	6656.	4530	3921.	3137.0
45	5457.	3222.	3092.	2910.0
55	4044	2342.	1860.	2240.0
65	2483	1252.	1410.	1529.0
75	1036	691.	424.	696.0
85	87	37	56.	91.0
90	0.	0.	0.	



LUMEN SUMMARY

ZONE	LUMENS	% LAMP	% FIXTURE
0 - 30	6080.	33.8	36 5
0 - 40	9218	51.2	55.3
0 - 60	14368.	79 8	86.1
0 - 90	16684.	92.7	100.0
40 - 90	7466.	41.5	44.8
60 - 90	2316	12 9	13.9
90 - 180	0	0 0	0.0
0 - 180	16684.	92.7	100.0

ZONAL CAVITY COEFFICIENTS

EFFECTIVE FLOOR CAVITY REFL. = 20

CEILING	.80			.70			.50		
WALL / RCR	.70	.50	.30	.70	.50	.30	.50	.30	.10
0	1.13	1.13	1.13	108	108	1.08	1.03	1.03	1.03
1	1.05	1.01	98	101	.97	94	.93	91	89
2	97	91	.85	93	.87	.82	84	.80	.77
3	90	.81	.74	86	78	73	76	.71	.67
4	83	.73	66	.80	.71	.65	69	63	59
5	.77	.66	.58	73	.64	.57	.62	.56	.51
6	.72	.60	.52	.68	58	.51	.56	.50	.45
7	.66	54	.46	.63	.53	.46	.51	.45	.40
8	.61	.49	41	.59	.47	.41	.46	40	.36
9	.57	.45	.37	.54	.43	.36	.42	.36	.31
10	.53	.41	.33	.51	39	.33	39	.32	.28

TOTAL LUMINAIRE
OPTICAL **EFFICIENCY = 92.7%**
SPACING CRITERIA: END = 1.2 DIAG. = 1.0 ACROSS = 0.9

sensorswitch

HIGH BAY SENSOR - FIXTURE MOUNT, LINE VOLTAGE, PASSIVE INFRARED (PIR)

TYPICAL APPLICATIONS

- Individual Control of Fluorescents
- T-5 or T-8 Fluorescent
- HID Bi-Level (w/ -SH option)

FEATURES

- PIR Occupancy Detection
- Up to 45 Foot Mounting
- Self-Contained Relay, no Power Pack needed
- No Minimum Load Requirements
- Push-Button Programmable
- Time Delay: 30 sec. to 20 minutes
- Green LED Activity Indicator
- 100 Hr. Lamp Burn-in Timer Mode

DAYLIGHTING OPTIONS

- Up-Looking On/Off Photocell (-P)
- Down-Looking On/Off Photocell (-PD)

SPECIFICATIONS

- Size: 3.625" x 3.625" x 1.25" Deep (9.2 cm x 9.2 cm x 3.2 cm Deep)
- Sensor Weight: 7 Ounces
- Sensor Color: White
- Mounting: 1/2 inch knockout
- Relative Humidity: 20 to 90% non-condensing
- Operating Temp: 14° to 160° F (-10° to 71° C)
- Storage Temp: -14° to 160° F (-26° to 71° C)
- Load Rating (1 Phase Only):
  120 VAC @ 800 W
  277 VAC @ 1200 W
  347 VAC @ 1500 W
- 1/4 HP Motor Load
- Frequency: 50/60 Hz (Timers are 1.2 times for 50 Hz)
- UL, CUL, and Title 24 Compliant
- 5 Year Warranty
- Made in U.S.A.

LOW TEMP/HI HUMIDITY(-LT)

- Conformally coated Circuit Board is corrosion resistant from moisture
- Operates down to -40° F (-40° C)

CMRB-6 Series

w/ Enhanced Daylighting Options!

High Bay Lighting Control is made simple with the *CMRB-6 Series* Passive Infrared (PIR) occupancy sensor! This self contained unit is line powered and can switch a large range of line voltages directly without the need for a Power Pack. The *CMRB-6* mounts directly to the end of a fluorescent fixture through an extended 1/2 inch chase nipple, and is keyed to easily mount through a half inch knockout. With mounting heights up to 45 Feet, this sensor is perfect for High Bay Lighting Controls. High humidity or cold damp environments are accommodated by the optional "-LT" version. In applications with abundant natural light, consider adding the -P or -PD daylighting control option.

START-TO-HIGH OPTION w/ HID BI-LEVEL FIXTURES (CMRB-6-SH)

HID Bi-Level fixtures must be controlled by line voltage and provide their own interposing relay for switching the capacitor in the ballast from "High" to "Low". For these applications, the CMRB-6 has a Start to High (-SH) option that must be used. This option provides a timer (factory set at 20 minutes) that acts as a warm-up period for the HID lamps. The sensor also offers a 100 hour lamp burn-in timer. Once engaged, the sensor goes to an "On" state for the 100 hours. If power is interrupted, the sensor will continue with the 100 hour countdown when power is restored. Once expired, this feature is automatically removed unless engaged again. During the Start-to-High period or the 100 Hr burn period, the LED flashes continuously indicating that the sensor is in an override "On" state. This feature allows HID lamps to "burn-in" and reach full color and light output. If a lamp is replaced, it is suggested to reengage this feature.

SENSOR OPERATIONS

The sensor detects changes in the infrared energy given off by occupants as they move within the field-of-view. When occupancy is detected, a self-contained relay switches the lighting "On". The sensor is line powered and can switch a large range of line voltages. An internal timer, factory set at 10 minutes, keeps the lights "On" during brief periods of no activity. This timer is selectable at 2.5 minute increments from 30 seconds to 20 minutes, and is reset every time occupancy is re-detected. This state-of-the-art design requires no manual field adjustments.

DAYLIGHTING CONTROL OPTIONS (-P & -PD)

For spaces with abundant natural light from windows or skylights, this series offers two On/Off Photocell options. As the daylight levels change, both options insure that an adequate light level is maintained according to a programmable set-point value. The ***Up-Looking On/Off Photocell (-P)*** option is ideal for skylight applications as the Photocell views through the back of the sensor (towards the ceiling and skylights). The -P option operates "open loop" as it can not view the lights it is controlling. Conversely, the ***Down-Looking On/Off Photocell (-PD)*** option looks down through the sensor's lens and therefore can view the lights it is controlling. This is more applicable for areas where daylight is coming in through High Bay garage doors or windows below the level of the sensor. For more detailed information on these daylighting control features, see the CMRB-PC Technical Data Sheet.

Model Numbering System: CMRB-6-[DAYLIGHTING CONTROL]-[START-TO-HIGH]-[VOLTAGE]-[TEMP/HUMIDITY]

MODEL#	DAYLIGHTING CONTROL	START-TO-HIGH	VOLTAGE	TEMP/HUMIDITY
CMRB-6	Blank = None -P = Up-Looking On/Off Photocell -PD = Down-Looking On/Off Photocell	Blank = No STH -SH = w/STH	Blank = 120-277 VAC -3 = 347 VAC	Blank = 14° to 160° F -LT = -40° to 160° F
FB-1	Mounting Bracket for Deep Fixtures			

PHOTOMETRY INFORMATION

STANDARD

Williams Catalog #GL-4-632-EBHW3/3 Test Report #12158.1, Dated 12/29/03 Ballast Factor: 1.2
Lamp Type: F32T8/835/RS Lumens: 2950 Lamp Quantity: 6

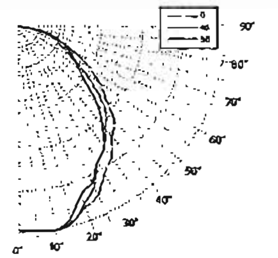
CANDLEPOWER DISTRIBUTION

VERT. ANG.	HORIZONTAL ANGLE 0	45	90	ZONAL LUMENS
0	8113	8113	8113.	
5	8146.	8183.	8201	781.3
15	8101	8137.	7937.	2298.6
25	7455.	7074.	6874	3310.0
35	6419.	5910	5910.	3818.3
45	5382.	4928.	4473.	3763 3
55	3945	3255.	2909	2959.0
65	2509.	1927	2182	2138.6
75	1181	1236	1418.	1295.4
85	144.	345	326	326.3
90	0	0.	0	

LUMEN SUMMARY

ZONE	LUMENS	% LAMP	% FIXTURE
0 - 30	6390.	30.1	30.9
0 - 40	10208	48.1	49.3
0 - 60	16930	79 7	81.8
0 - 90	20691	97.4	100.0
90 - 120	0	0.0	0.0
90 - 130	0	0.0	0.0
90 - 150	0	0.0	0.0
90 - 180	0.	0.0	0.0
0 - 180	20691.	97.4	100 0

TOTAL LUMINAIRE OPTICAL **EFFICIENCY = 97.4%***
SPACING CRITERIA: END = 1.3 DIAG. = 1.2 ACROSS = 1.2



* Tested with a 1.2 ballast factor

NARROW DISTRIBUTION

Williams Catalog #GL-4-632-ND-EB3/3 Test Report #13472.0, Dated 02/21/07 Ballast Factor: 1.0
Lamp Type: F32T8/835/RS Lumens: 2950 Lamp Quantity: 6

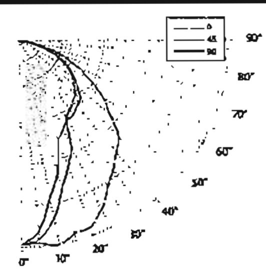
CANDLEPOWER DISTRIBUTION

VERT ANG.	HORIZONTAL ANGLE 0	45	90	ZONAL LUMENS
0	8942	8942	8942.	
5	8898	8720.	8399	829 7
15	8748	6749.	5999	2012.1
25	8198	5113.	4321	2561 4
35	6949	3706.	3971	2800 1
45	5999	3371	3663	2904.3
55	4385	2785	2907.	2627 7
65	2813.	1964	2028.	2029.2
75	1285.	1050.	921.	1096.0
85	171	135.	128	166.8
90	0	0.	0	

LUMEN SUMMARY

ZONE	LUMENS	% LAMP	% FIXTURE
0 - 30	5403	30 5	31 7
0 - 40	8203.	46.3	48 2
0 - 60	13735	77.6	80 7
0 - 90	17027	96 2	100.0
90 - 120	0.	0 0	0.0
90 - 130	0.	0.0	0 0
90 - 150	0	0 0	0 0
90 - 180	0	0 0	0.0
0 - 180	17027	96 2	100.0

TOTAL LUMINAIRE OPTICAL **EFFICIENCY = 96.2%**
SPACING CRITERIA: END = 1.2 DIAG. = 0.8 ACROSS = 0.7



WIDE DISTRIBUTION

Williams Catalog #GL-4-632-WD-EB3/3 Test Report #13517.0, Dated 03/30/07 Ballast Factor: 1.0
Lamp Type: F32T8/835/RS Lumens: 2950 Lamp Quantity: 6

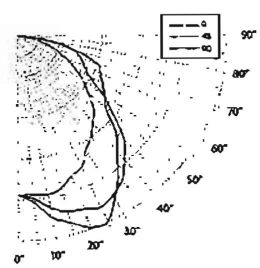
CANDLEPOWER DISTRIBUTION

VERT ANG.	HORIZONTAL ANGLE 0	45	90	ZONAL LUMENS
0	4434	4434	4434.	
5	4427.	4539	4641	432.6
15	4398	5063	5379	1409 3
25	4027	5249	5722.	2360 2
35	3447.	4934	4748.	2848 6
45	2906.	4089	3762	2971.2
55	2162.	2838.	2872	2531 1
65	1408.	1999.	2489	2050 1
75	715.	1605	1717.	1474 2
85	135.	377	360.	374.4
90	0.	0.	0.	

LUMEN SUMMARY

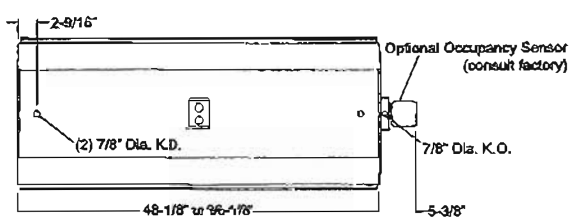
ZONE	LUMENS	% LAMP	% FIXTURE
0 - 30	4202	23.7	25.5
0 - 40	7051.	39 8	42.9
0 - 60	12553	70.9	76.3
0 - 90	16452	92.9	100 0
90 - 120	0	0 0	0.0
90 - 130	0.	0.0	0.0
90 - 150	0.	0.0	0.0
90 - 180	0.	0 0	0.0
0 - 180	16452	92 9	100.0

TOTAL LUMINAIRE OPTICAL **EFFICIENCY = 92.9%**
SPACING CRITERIA: END = 1.2 DIAG. = 1.6 ACROSS = 1.5

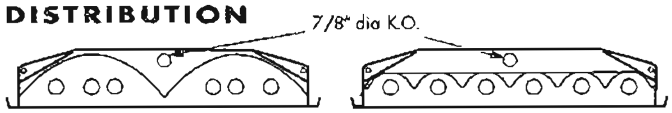


DETAILS

BACK VIEW



DISTRIBUTION



Narrow Distribution Wide Distribution

ZONAL CAVITY COEFFICIENTS (STANDARD)

EFFECTIVE FLOOR CAVITY REFL = 20

CEILING	.80			.70			.50		
WALL RCR	.70	.50	.30	.70	.50	.30	.50	.30	.10
0	1.16	1.16	1.16	1.13	1.13	1.13	1.08	1.08	1.08
1	1.07	1.03	.99	1.05	1.01	.97	.97	.94	.91
2	.99	.91	.85	.96	.90	.84	.86	.81	.77
3	.91	.81	.74	.88	.80	.73	.77	.71	.67
4	.84	.73	.65	.81	.72	.64	.69	.63	.58
5	.77	.65	.57	.75	.64	.56	.62	.55	.50
6	.71	.58	.50	.69	.57	.50	.56	.49	.44
7	.65	.53	.44	.64	.52	.44	.50	.43	.38
8	.60	.47	.39	.59	.47	.39	.45	.38	.33
9	.56	.43	.35	.54	.42	.34	.41	.34	.29
10	.52	.39	.31	.50	.38	.31	.37	.30	.26

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JP49357 12/31/07

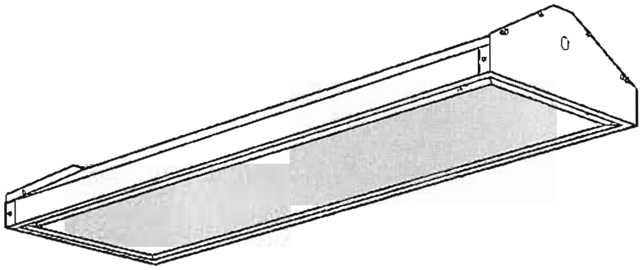
Figure B.14

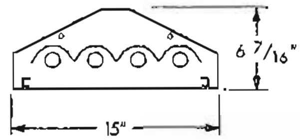
Product Data: H.E. Williams, GLS T8 (Elementary Gym Lighting)

SLOPED T8 INDUSTRIAL

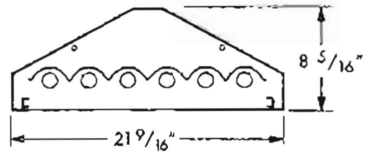
GLS
T8

SERIES
JOB ______
TYPE ______
VOLTAGE ______





4 lamp



6 lamp

SPECIFICATIONS

- HOUSING – .040" die formed aluminum housing
- REFLECTIVE SURFACES – Highly specular anodized MIRO 4" aluminum reflector standard – optional white reflector available
- FINISH – 92% minimum average reflective white powder coat with multi-stage iron/phosphate prepared metal.
- ELECTRICAL – Electronic ballast standard, instant start T8, rated Class P
- LABELS – UL listed to U.S. and Canadian safety standards as fluorescent luminaire suitable for dry or damp locations
- MOUNTING – Pendant mount with VBY hangers and chain, 3" spacer brackets or single point 3/4" conduit utilizing hub and splice box adapter

FEATURES

- Designed with a sloped top to reduce dust build-up on the fixture
- Designed without flanges to prevent dust build-up along the fixture sides
- Includes double-gasketed lens to reduce, not prevent, dust entry into the fixture*
- High performance MIRO 4" reflector system standard
- Clear acrylic lens standard, other shielding options available (Consult factory for details)
- Heavy gauge aluminum housing for maximum heat dissipation and extended ballast life
- All parts painted after fabrication to facilitate installation, increase efficiency, and inhibit rusting

*The GLS is designed to reduce the build-up of dust on the exterior of the fixture (It is not rated as a dust-tight fixture)

ORDERING INFORMATION

Submittal

	SERIES		NOM. LENGTH		TOTAL LAMPS	WATTAGE/TYPE		FRAME TYPE	SHIELDING		OPTIONS		BALLAST		VOLTAGE
EXAMPLE	GLS	-	4	-	4	32	-	F	CHA118	-	OPTIONS	-	EB4	-	UNV

SERIES

GLS	Sloped T8 Industrial

NOMINAL LENGTH

4	4'

TOTAL LAMPS

4 or 6

LAMP WATTAGE/TYPE

32	4', 32 watt T8

DOOR FRAME TYPE

F	White flat aluminum

SHIELDING

CHA118	Clear high temperature acrylic glazing (non-prismatic lens)
A12125	#12 pattern acrylic, .125" thick
PC12125	#12 pattern polycarbonate, .125" thick

OPTIONS

OCC SEN	Occupancy Sensor
S7238/B	Cord, 72" length, No. 18 AWG, 3 conductor, black
6CPI/L5-15P/TWLK	6' cord & NEMA Twistlock 15A plug, 120V
6CPI/L7-15P/TWLK	6' cord & NEMA Twistlock 15A plug, 277V
REFLWHITE	White Reflector
VBY	1 pair VBY hangers
VBY-3	1 pair VBY hangers and 2 pieces 3' chain
HUB 3/4	Cast iron hub and junction box for single pendant mount

BALLAST TYPE

EB4	4 lamp electronic ballast
EB2/2	(2) 2 lamp electronic ballasts
EB4/2	(1) 4 lamp & (1) 2 lamp electronic ballast

VOLTAGE

120	120V
277	277V
UNV	120 - 277V
347	347V

Note: For more options/accessories, ballast combinations, and product details, please consult factory

williams

GLS T8 SERIES

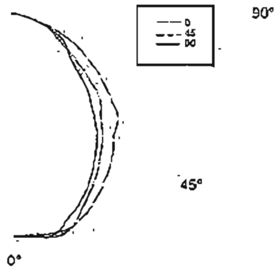
PHOTOMETRY INFORMATION

Williams Catalog #GLS-4-432-FCHA118
Test Report #13076.2, Dated 04/28/06

Lamp Type: F32T8/835/RS
Lamp Quantity: 4

CANDLEPOWER DISTRIBUTION

VERT. ANG	HORIZONTAL ANGLE 0	45	90	ZONAL LUMENS
0	4376.	4376.	4376.	
5	4356.	4360.	4396.	416.7
15	4333.	4343.	4142.	1215.5
25	3908.	3691	3558.	1729.1
35	3366.	3029.	2846	1919.7
45	2896.	2412	2016.	1865.5
55	2035.	1418.	1318.	1375.3
65	1243	859.	958	962.1
75	457.	385.	364.	398.3
85	32.	32.	35.	37.3
90	0	0.	0.	



LUMEN SUMMARY

ZONE	LUMENS	% LAMP	% FIXTURE
0 - 30	3361.	23.7	33.9
0 - 40	5281.	37.3	53.2
0 - 60	8522.	60.2	85.9
0 - 90	9920	70.1	100.0
90 - 120	0.	0	0
90 - 130	0.	0.	0
90 - 150	0.	0	0
90 - 180	0.	0	0.
0 - 180	9920	701	100.0

TOTAL LUMINAIRE
OPTICAL **EFFICIENCY** = **70.1%**
SPACING CRITERIA: END = 1.2 DIAG. = 1.1 ACROSS = 1.1

ZONAL CAVITY COEFFICIENTS

EFFECTIVE FLOOR CAVITY REFL. = .20

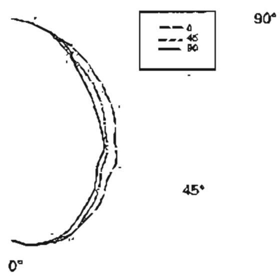
CEILING	.80			.70			.50		
WALL RCR	.70	.50	.30	.70	.50	.30	.50	.30	.10
0	.83	.83	.83	.81	.81	.81	.78	.78	.78
1	.78	.75	.73	.76	.73	.71	.71	.69	.67
2	.72	.67	.63	.70	.66	.62	.63	.60	.58
3	.67	.60	.55	.65	.59	.55	.57	.53	.50
4	.61	.54	.49	.60	.53	.48	.51	.47	.44
5	.56	.48	.43	.55	.48	.42	.46	.41	.38
6	.52	.44	.38	.51	.43	.38	.42	.37	.33
7	.48	.39	.34	.47	.39	.33	.38	.33	.29
8	.45	.36	.30	.43	.35	.30	.34	.29	.26
9	.41	.32	.26	.40	.32	.26	.31	.26	.23
10	.38	.29	.24	.37	.29	.24	.28	.23	.20

Williams Catalog #GLS-4-632-FCHA118
Test Report #13074.2, Dated 04/27/06

Lamp Type: F32T8/832/RS
Lamp Quantity: 6

CANDLEPOWER DISTRIBUTION

VERT ANG	HORIZONTAL ANGLE 0	45	90	ZONAL LUMENS
0	6856.	6856.	6856.	
5	6978.	6994.	7037	667.9
15	6856.	6884.	6695.	1935.5
25	6276.	6028.	5808.	2806.9
35	5428.	4988.	4799	3180.8
45	4360.	3818.	3320.	2952.7
55	3086.	2354.	2209	2234.1
65	1872.	1418.	1624.	1569.5
75	716.	672.	745.	715.0
85	43.	58.	43.	58.9
90	0.	0.	0.	



LUMEN SUMMARY

ZONE	LUMENS	% LAMP	% FIXTURE
0 - 30	5410	25.5	33.6
0 - 40	8591.	40.4	53.3
0 - 60	13778.	64.9	85.5
0 - 90	16121	75.9	100.0
90 - 120	0.	0	0.
90 - 130	0.	0	0.
90 - 150	0.	0	0.
90 - 180	0.	0	0.
0 - 180	16121.	75.9	100.0

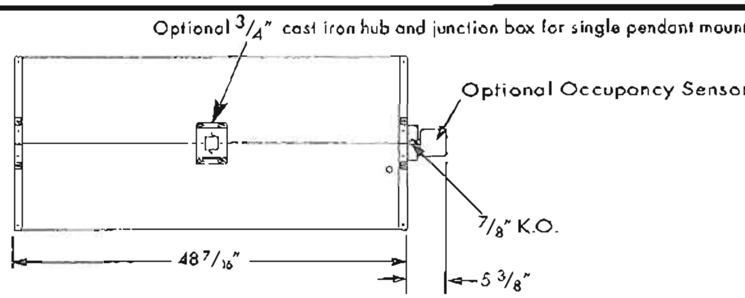
TOTAL LUMINAIRE
OPTICAL **EFFICIENCY** = **75.9%**
SPACING CRITERIA: END = 1.2 DIAG. = 1.2 ACROSS = 1.1

ZONAL CAVITY COEFFICIENTS

EFFECTIVE FLOOR CAVITY REFL = 20

CEILING	.80			.70			.50		
WALL RCR	.70	.50	.30	.70	.50	.30	.50	.30	.10
0	.90	.90	.90	.88	.88	.88	.84	.84	.84
1	.84	.81	.79	.82	.80	.77	.76	.74	.73
2	.78	.73	.68	.76	.71	.67	.69	.65	.62
3	.72	.65	.60	.70	.64	.59	.62	.58	.54
4	.66	.58	.52	.65	.57	.52	.56	.51	.47
5	.61	.52	.46	.59	.51	.45	.50	.45	.41
6	.56	.47	.41	.55	.46	.40	.45	.40	.36
7	.52	.43	.36	.51	.42	.36	.41	.36	.32
8	.48	.38	.32	.47	.38	.32	.37	.32	.28
9	.44	.35	.29	.43	.34	.28	.33	.28	.24
10	.41	.31	.26	.40	.31	.25	.30	.25	.22

BACK VIEW



williams

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Figure B.15

Product Data Sensor Switch, CM-6 (Elementary Gym Control)

sensorswitch

HIGH BAY 360° SENSOR - CEILING MOUNT
LOW VOLTAGE, PASSIVE INFRARED

TYPICAL APPLICATIONS

- Warehouse
- Gymnasiums
- Racquetball Courts

FEATURES

- PIR Occupancy Detection
- Communicates with Other Sensors
- Up to 45 Foot Mounting
- Push-Button Programmable
- Time Delay: 30 sec. to 20 minutes
- Green LED Activity Indicator
- 100 Hr. Lamp Burn-in Timer Mode

AVAILABLE OPTIONS

- Isolated Low Voltage Relay (-R)
- On/Off Photocell (-P)
- Low Temp/Hi Humidity (-LT)

SPECIFICATIONS

- Size: Circular, 4.55" Dia., 1.55" Deep (11.56 cm Dia., 3.94 cm Deep)
- Sensor Weight: 5 Ounces
- Sensor Color: White
- Mounting: Ceiling Tile Surface, Round Fixture or Junction Box
- Relative Humidity: 20 to 90% non-condensing
- Operating Temp: 14° to 160° F (-10° to 71° C)
- Storage Temp: -14° to 160° F (-26° to 71° C)
- UL, CUL, and Title 24 Compliant
- 5 Year Warranty
- Made in U.S.A.

LOW TEMP/HI HUMIDITY(-LT)

- Conformally coated Circuit Board is corrosion resistant from moisture
- Operates down to -40° F(-40° C)

CM-6 SERIES

Programmable Edition!

The *CM-6* sensor was specifically designed for High Mounting applications (15 - 45 feet). Above 15 feet, the *CM-6* provides Passive Infrared (PIR) detection in a 30 to 40 foot diameter area, making it perfect for warehouses or gymnasiums where the sensors are mounted on a 30 to 40 foot grid pattern. Multiple sensors may be used together to provide coverage as needed. If any one sensor detects occupants, all the lights will turn "On". In Raquetball Courts, it is preferred to locate the sensor near the entrance (furthest from the wall). For freezer applications, use the CM-6-LT for cold temperature and corrosion resistant characteristics. For lower mounting applications, refer to CM-9 or CM-10 Technical Data Sheets.

SENSOR OPERATIONS

The sensor detects changes in the infrared energy given off by occupants as they move within the field-of-view. When occupancy is detected, a DC output goes high and can drive up to 200 mA of connected load. The sensor is powered with 12 to 24 VAC/VDC and typically operates with a PP-20 or MP-20 Power Pack; enabling complete 20 Amp circuits to be controlled. An internal timer, factory set at 10 minutes, keeps the lights "On" during brief periods of no activity. This timer is selectable at 2.5 minute increments from 30 seconds to 20 minutes, and is reset every time occupancy is re-detected. This state-of-the-art design requires no manual field adjustments.

CONTROLLING HID BI-LEVEL LIGHTING

In Gymnasiums or Warehouses where control of HID Bi-Level Lighting is desired, the CM-6 is used with a PP-20-SH Power Pack. This Power Pack provides for a Start-to-High Timer, which brings the lamps to full "On" for up to 20 minutes upon initial power up. The Power Pack must be on the same power circuit as the fixtures to sense the initial power on condition. Some Electronic HID fixtures have this Start-to-High feature built in. In this case, the standard PP-20 or MP-20 Power Pack may be used to switch fixtures from Hi to Low. Consult fixture manufacturer in these cases.

DAYLIGHTING CONTROL OPTIONS (-P)

For spaces with abundant natural light from windows or skylights, this series offers an ***On/Off Switching Photocell (-P)*** option. In a CM-6 sensor this option is most applicable when used in areas where daylight is coming in through High Bay garage doors or windows below the level of the sensor. As the daylight levels change in the room, the sensor insures that an adequate light level is maintained according to a programmable set-point value. The -P option provides two modes of operation; one simply inhibits the lights from turning on, while the other has full On/Off control of the lights. For more detailed information on the daylighting control features, see the CM-PC Technical Data Sheet.

ORDERING INFORMATION

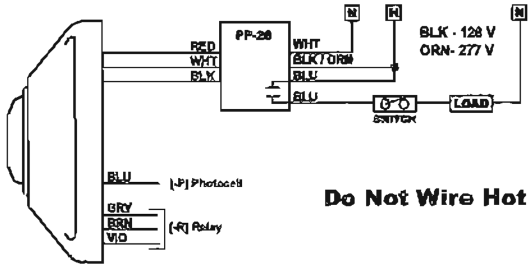
MODEL #	DESCRIPTION	TEMPERATURE	OP. VOLTAGE	CURRENT
CM-6	High Bay 360° Sensor, Low Voltage	14° to 160° F	12 to 24 VAC/VDC	4 mA
Add suffix				
-R	SPDT Relay, 1 Amp			16 mA
-P	On/Off Photocell			4 mA
-RP	Relay & On/Off Photocell			16 mA
-LT	Low Temp/High Humidity	-40° to 160° F		

WIRING INSTRUCTIONS

Wire lead connections are Class II, 18 to 22 AWG.

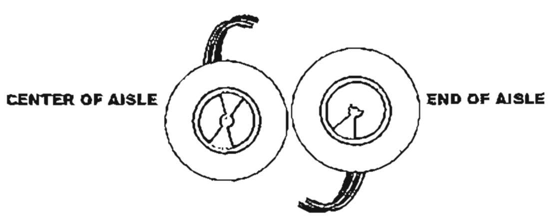
STANDARD CM-9

RED - 12 to 24 VAC/VDC
BLACK - Common
WHITE - Output (HI DC for Occupancy)



MASKING KIT

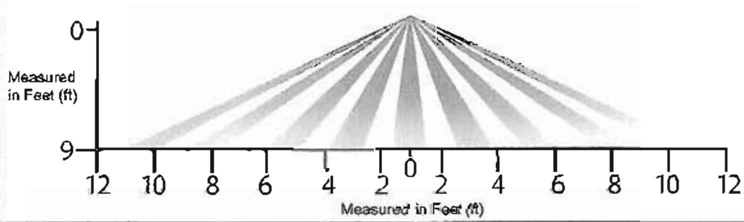
The sensor views a 360° circular pattern. The kit provided may be used to mask off half of the viewing for end of aisle, or trim the side viewing to create a rectangular pattern for center of aisle. Shown below is the masking for the center of aisle and the end of the aisle.



FIELD OF VIEW

The *CM-6* lens views in 5 separate 360° coneshaped patterns. The outermost (fifth) cone viewing at a 54° angle is only effective up to a 12-15 foot mounting height and is therefore not typically considered in High Bay applications. The fourth cone views at a 45° angle and is effective up to 20 feet. The inner three cones viewing at a maximum 30° angle continually maintain their effectiveness. The geometric effect is that the *CM-6* maintains a 15 to 20 foot radius up to a 45 foot mounting height. From 35 to 45 feet, the *CM-6* will generally only detect major motions such as a forklift truck. However, in colder environments, the *CM-6* may maintain very sensitive detection in all cones up to greater heights.

LOW VIEW



RELAY OPTION (-R)

GRAY / BROWN - Connected during Occupied state
VIOLET / BROWN - Connected during Unoccupied state
Note: Relay is energized during Unoccupied state

PHOTOCELL OPTION (-P)

BLUE - Photocell output (High: Occupied & Low Light)
Use Blue wire from sensor in place of White wire. For multi-level control, use 2 Power Packs and connect White to primary load and Blue to daylight load.

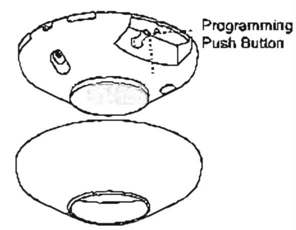
ISOLATED LOW VOLTAGE RELAY OPTION (CM-6-R)

To enable a sensor to interface with a building management system, the -R option provides dry contact closure via a SPDT, 1 Amp, 40 Volt relay. The relay coil is energized and changes state when ALL connected sensors register "Unoccupied". When using multiple sensors, only one sensor per zone needs to have a relay.

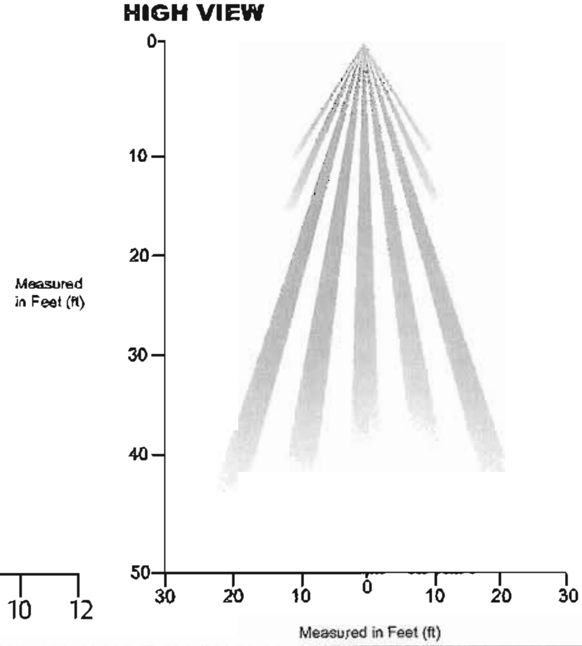
Note: Sensor must have power at all times for the relay to function .

MOUNTING CONSIDERATIONS

The sensor typically mounts directly to the ceiling tile, or to the metallic grid. However, if desired, the mounting holes are slotted to line up with a standard round, or rectangular box (screws not provided).



HIGH VIEW



sensorswitch
SENSOR SWITCH, INC.
900 Northrop Rd., Wallingford, CT 06492
(203) 265-2842 info@sensorswitch.com
www.sensorswitch.com

revised 08/31/2006

Appendix C

Task 3 – Supporting Information

Figure C.1

Construction Cost Estimate for Cooler/Freezer Condensing Unit Ventilation

BARTON & LOGUIDICE, P.C.
CONSTRUCTION COST ESTIMATE

TASK 3 - COOLER / FREEZER CONDENSING UNIT VENTILATION

PROJECT TITLE:
SANDY CREEK CENTRAL SCHOOL DISTRICT - NYSERDA FLEXTECH STUDY

LOCATION:
SANDY CREEK, NY

B&L JOB NO: 1190.001-S
DATE PREPARED: 6/3/2008
ESTIMATED BY: DCW

ITEM NO.	ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1.	WALL PENETRATION & INTAKE LOUVER	1	EA	$400.00	$400.00
2.	DUCTWORK	1	LS	$800.00	$800.00
3.	THERMOSTAT & CONTROLS	1	EA	$300.00	$300.00
	CONSTRUCTION SUBTOTAL				**$1,500**
	CONTRACTOR'S OVERHEAD & PROFIT			**15%**	**$200**
	CONTINGENCIES			**10%**	**$200**
	ESTIMATED TOTAL CONSTRUCTION COST				**$1,900**

Appendix D

Task 6 – Supporting Information

Figure D.1

Construction Cost Estimate for Implementation of DCV Control in Auditorium

BARTON & LOGUIDICE, P.C.
CONSTRUCTION COST ESTIMATE

TASK 6 - IMPLEMENTATION OF DCV CONTROL IN AUDITORIUM

PROJECT TITLE:
SANDY CREEK CENTRAL SCHOOL DISTRICT - NYSERDA FLEXTECH STUDY

B&L JOB NO: 1190.001-S

DATE PREPARED: 6/3/2008

LOCATION:
SANDY CREEK, NY

ESTIMATED BY: DCW

ITEM NO.	ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1.	TRANE CO2 SENSING KIT	2	EA	$800.00	$1,600.00
	CONSTRUCTION SUBTOTAL				$1,600
	CONTRACTOR'S OVERHEAD & PROFIT			15%	$200
	CONTINGENCIES			10%	$200
	ESTIMATED TOTAL CONSTRUCTION COST				$2,000

Appendix E

Task 7 – Supporting Information

Figure E.1

Construction Cost Estimate for Improved Vending Machine Control

BARTON & LOGUIDICE, P.C.
CONSTRUCTION COST ESTIMATE

TASK 7 - IMPROVED VENDING MACHINE CONTROL

PROJECT TITLE:
SANDY CREEK CENTRAL SCHOOL DISTRICT - NYSERDA FLEXTECH STUDY

B&L JOB NO: 1190.001-S

DATE PREPARED: 6/3/2008

LOCATION:
SANDY CREEK, NY

ESTIMATED BY: DCW

ITEM NO.	ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1.	OCCUPANCY BASED VENDING MACHINE CONTROL	8	EA	$210.00	$1,680.00
	CONSTRUCTION SUBTOTAL				**$1,680**
	CONTRACTOR'S OVERHEAD & PROFIT			15%	**$300**
	CONTINGENCIES			10%	**$200**
	ESTIMATED TOTAL CONSTRUCTION COST				**$2,180**

Figure E.2

Product Data: USA Technologies, VendingMiser

VendingMiser®

ENERGY MANAGEMENT SYSTEM
For Refrigerated Vending Machines

Improve the profitability of your existing cold drink machines. Vending Miser® puts you on a cost-effective refresher course for energy savings and conservation.

VendingMiser cuts energy costs down to size

VendingMiser incorporates its innovative energy-saving technology into a small, plug-and-play powerhouse that installs in minutes either on the wall or on the vending machine. It's that easy.

With VendingMiser there's no need to have new machines to achieve maximum energy savings resulting in a reduction in operating costs and greenhouse gas emissions. When equipped with the VendingMiser, refrigerated beverage vending machines use less energy and are comparable in daily energy performance to new ENERGY STAR® qualified machines.

Power play

Compatible with all types of cold drink vending machines, the VendingMiser uses a Passive Infrared Sensor (PIR) to power down the machine when the area surrounding it is vacant. Then it monitors the room's temperature and automatically re-powers the cooling system at one- to three-hour intervals, independent of sales, to ensure that the product stays cold.

This Miser runs the bank

For a series of up to four machines, VendingMiser can use its embedded Sensor Repeater, which allows it to be controlled from the PIR sensor of any other Miser in the bank.

Refresher course

VendingMiser's microcontroller will never power down the machine while the compressor is running, eliminating compressor short-cycling. In addition, when the machine is powered up, the cooling cycle is allowed to finish before again powering down. This reduces the wear and tear on your machines, extending the lifespan and prolonging your profitability. Maintenance savings is generated through reduced running time of vendor components - estimated at $40 - $80 per year, per machine. The VendingMiser has been tested and accepted for use by major bottlers.

Vending Miser offers...

- A quick, inexpensive solution to energy savings and conservation
- Longer machine lifespan
- Early return on investment
- Environmental benefits

VendingMiser can also control other cooled product vending machines, such as refrigerated candy machines.

VendingMiser Technical Specifications
Electrical Specifications
Input Voltage: 115 Volts
Input Frequency: 50/60 Hz
Maximum Load: 12 Amps (Steady-State)
Power Consumption: Less than 1 Watt (Standby)

Environmental Specifications
Operating Temp: -15°C to 75°C
Storage Temp: -40°C to 85°C
Relative Humidity: 95% Maximum (Non-Condensing)

Compatibility
Vending Machines: Any machine, except those containing perishable goods such as dairy products

Inactivity Timeouts
Occupancy Timeout: 15 minutes
Auto Re-power: One to three hours, dynamically adjusted, based on ambient temperature

Dimensions
Size: 4.5"W x 1.75"H x 3.25"D
Weight: 2.2 lbs. (includes power cable)

Regulatory Approvals
Safety: UL/C-UL Listed
Information Technology Equipment (ITE) 9T79

Other energy-saving products offered by USA Technologies include VM2IQ™, CoolerMiser™, SnackMiser™ and PlugMiser™.

VendingMiser reduces energy consumption an average of 46%—typically $150 per machine.

GSA Schedule Contract GS-35F-0031R

ENERGY STAR PARTNER

USA TECHNOLOGIES

For more information about VendingMiser by USA Technologies: 888.521.6982 www.usatech.com

Frequently Asked Questions

Will VendingMiser® keep my drinks cold?
Absolutely - VendingMiser® has been tested and accepted for use by both major bottlers.

Is the VendingMiser® easy to install?
Yes! VendingMiser® is a simple external plug-and-play product. The VendingMiser® can be installed on the wall with simple hand tools or it can be attached to the vending machine without tools using the new Easy-Install system. The Easy-Install System allows quick installation in 5 minutes.

Is VendingMiser® safe for all machines?
Yes! VendingMiser® is compatible with all types of cold drink vending machines. In fact, by reducing run time of the machines, VendingMiser® reduces maintenance costs.

Has VendingMiser® been field tested?
Tens of thousands of VendingMisers® are operational in the field. Typical energy savings have been independently documented to be between 35% and 45%. Measurement and verification test results as well as testimonials are available on the website.

Are there any locations not appropriate for VendingMiser®?
VendingMiser's® savings are generated as a result of location vacancy. Therefore, a machine in a location that is occupied 24-hours, 7 days a week will likely generate little savings. Our VM2IQ is more appropriate for this type of location and will typically save up to 35% energy use.

Technical Specifications

ELECTRICAL SPECIFICATIONS

Input Voltage:	115 Volts (230 Volts available)
Input Frequency:	50/60 Hz
Maximum Load:	12 Amps (Steady-State)
Power Consumption:	Less than 1 Watt (Standby)

ENVIRONMENTAL SPECIFICATIONS

Operating Temp:	-15°C to 75°C
Storage Temp:	-40°C to 85°C
Relative Humidity:	95% Maximum (Non-Condensing)

COMPATIBILITY

Vending Machines:	Any machine, except those containing perishable goods such as dairy products.

INACTIVITY TIMEOUTS

Occupancy Timeout:	15 minutes
Auto Repower:	One to three hours, dynamically adjusted, based on ambient temperature

DIMENSIONS

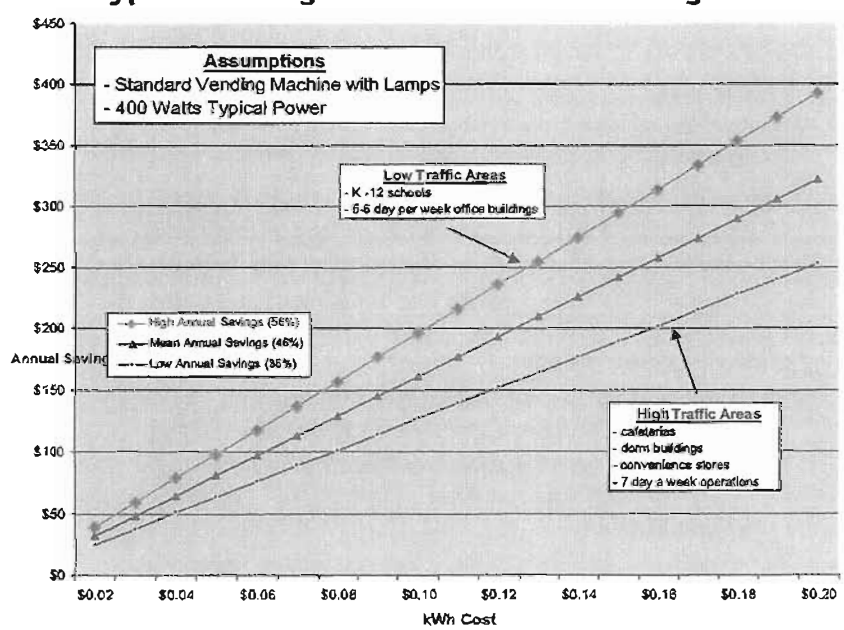
Size:	4.5"W x 1.75"H x 3.25"D
Weight:	2.2 lb. (incl. power cable)

REGULATORY APPROVALS

Safety:	UL/C-UL Listed Information Technology Equipment (ITE) 9T79

UL LISTED   c UL LISTED

Typical Saving Generated with VendingMiser®



VendingMiser® Products

VM150	VendingMiser® with PIR Sensor
VM151	VendingMiser® only
VM160	Weatherproof VendingMiser® with PIR Sensor
VM161	Weatherproof VendingMiser® only
VM170	Easy-Install VendingMiser® with PIR Sensor
VM171	Easy-Install VendingMiser® only
VM180	Weatherproof Easy-Install VendingMiser w/PIR sensor
VM181	Weatherproof Easy-Install VendingMiser only

Appendix F

Task 9 – Supporting Information

Figure F.1

Construction Cost Estimate for Improved Engine Block Heater Control

BARTON & LOGUIDICE, P.C.
CONSTRUCTION COST ESTIMATE

TASK 9 - IMPROVED ENGINE BLOCK HEATER CONTROL

PROJECT TITLE:
SANDY CREEK CENTRAL SCHOOL DISTRICT - NYSERDA FLEXTECH STUDY

B&L JOB NO: 1190.001-S

DATE PREPARED: 6/3/2008

LOCATION:
SANDY CREEK, NY

ESTIMATED BY: DCW

ITEM NO.	ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1.	8-POLE CONTACTORS, ELECTRICALLY HELD	2	EA	$600.00	$1,200.00
2.	TIMECLOCK	1	EA	$300.00	$300.00
3.	WIRING	1	LS	$500.00	$500.00
4.	ENCLOSURE, NEMA 1	1	EA	$250.00	$250.00
	CONSTRUCTION SUBTOTAL				**$2,250**
	CONTRACTOR'S OVERHEAD & PROFIT			15%	**$340**
	CONTINGENCIES			10%	**$230**
	ESTIMATED TOTAL CONSTRUCTION COST				**$2,820**

NOTICE

State of New York
David A. Paterson, Governor

New York State Energy Research and Development Authority
Vincent A. DeIorio, Esq., Chairman