

DELTA

Demonstration and Evaluation of Lighting Technologies and Applications • Lighting Research Center

DELTA Portfolio

Lighting Case Studies

Volume 2, Issue 3

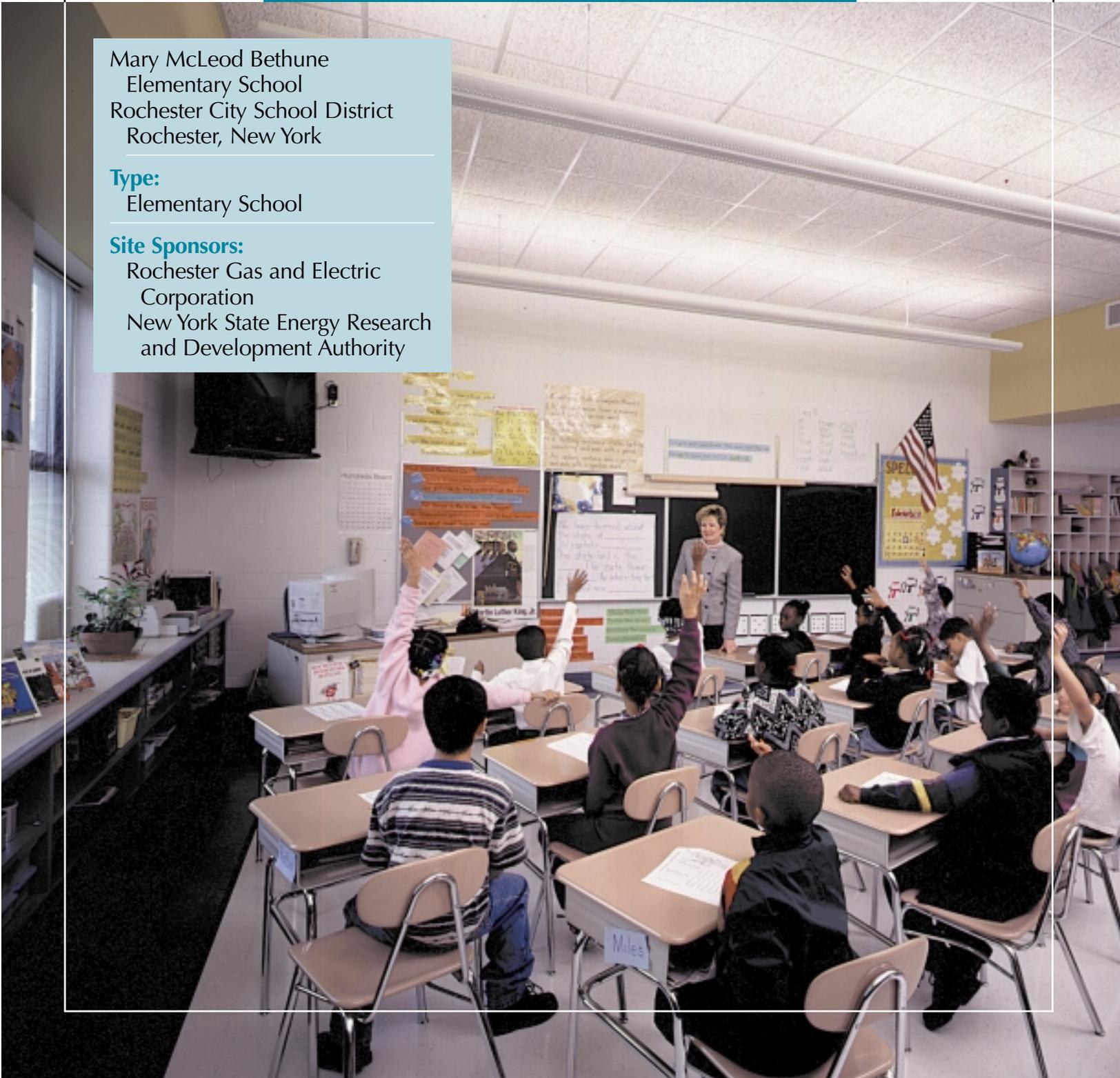
Mary McLeod Bethune
Elementary School
Rochester City School District
Rochester, New York

Type:

Elementary School

Site Sponsors:

Rochester Gas and Electric
Corporation
New York State Energy Research
and Development Authority





Project Profile

Rochester City School District recently opened the 100,000 square foot (9,295 square meter) Mary McLeod Bethune Elementary School in a residential neighborhood in northeast Rochester, New York. Neighborhood groups and agencies contributed to the design of their colorful two-story facility, which accommodates up to 800 children in preschool through fifth grade. One of the design goals was to give the large school a more intimate scale, so that the children could relate to each other in smaller groups. To accomplish this, offset corridors subdivide the large L-shaped building into “neighborhoods.”

Bethune Elementary is right in step with technological advances in education. Each classroom connects with a district-wide video learning program through computers and a television system.

Tall windows and high ceilings give the classrooms a light, airy atmosphere. Suspended

fluorescent uplights provide a low-glare ambient light for the various visual tasks performed in these rooms. The uplights also have a slight downlight component, which adds some visual interest. Some classrooms have vaulted ceilings uplighted from suspended and wall-mounted luminaires. The lighting in every classroom is controlled by occupancy sensors with manual override capability.

The library is centrally located on the second story near the atrium lobby. This area also features fluorescent uplights for comfortable general lighting, with compact fluorescent downlights and deep-cell parabolic luminaires to light work counters.

Alive with color, the cafeteria is dressed with banners suspended from its two-story ceiling. The cafeteria doubles as an auditorium, with a Disneyesque proscenium arch over the stage. Direct/indirect luminaires suspended

from the ceiling are wired to provide multiple light levels, which can be varied according to how the space is used. The stage lighting system uses simple PAR38 incandescent track lights with colored filters, controlled by a theatrical dimming system.

The two-court gymnasium is the center of athletic activities for the school and is frequently used by the community for after-school events. This space is lighted with a mix of high pressure sodium (HPS) and metal halide (MH) lamps in uplights mounted in the structure of the barrel-vaulted ceiling.

Each corridor has its own color scheme, identifying a “neighborhood” within the school. Recessed fluorescent troffers are mounted perpendicular to traffic flow; this arrangement allows wide mounting distances and makes the halls seem less long and narrow.



Mary McLeod Bethune Elementary School, Rochester, New York

● *Lighting Objectives*

- Use energy-efficient lighting products to reduce lighting energy use.
- Simplify maintenance by limiting the number of lamp types and by using lamps that the district already stocks.
- Provide low-glare ambient lighting to produce a visually comfortable environment for students and teachers.
- Increase energy savings by automatically switching off lighting when classrooms are not in use.
- Integrate windows and skylights throughout the building to give students and teachers a connection to the outdoors.

▲ *Lighting and Control Features*

- ▲ Indirect lighting. Uplights suspended from ceilings, mounted to walls, and attached to joists bounce light off ceilings, providing uniform light levels with little glare.
- ▲ Energy efficiency. Primary light sources are T8 fluorescent lamps powered by electronic ballasts in classrooms, library, cafeteria, and corridors. The gym uses a combination of HPS and MH lamps.
- ▲ Occupancy sensors. Ultrasonic occupancy sensors detect movement in classrooms and switch lights off after people have left the room.

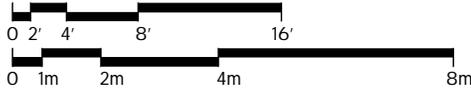
Techniques

Project Specifications

The principal light sources in the school are F32T8 4' (1220 mm) rapid-start (RS) lamps with a color rendering index (CRI) of 85 and a correlated color temperature (CCT) of 3500 K (neutral). Recessed downlights use 18- and

26-W compact fluorescent lamps (CFLs) with a CCT of 3500 K and CRI of 82. The gymnasium uplights use a combination of one 400-W clear MH lamp with a CRI of 65 and a CCT of 4000 K (cool), and one 400-W clear HPS lamp with a CRI of 22 and a CCT of 2100 K (warm).

All 4' fluorescent lamps are operated on instant start (IS) electronic ballasts. Lamps are tandem-wired to multiple-lamp ballasts whenever possible to permit two-level switching and use of higher-efficiency ballasts. High power factor (HPF) magnetic ballasts power the CFLs and high intensity discharge (HID) lamps.



A Pendant-mounted fluorescent uplight, two lamps in cross section, with two rows of slots on bottom side. Each slot contains a white perforated metal panel with openings providing a small amount of surface brightness (less than 2% downlight). Oval extruded aluminum housing, 3" x 9" (75 x 230 mm), in continuous rows. Lamps: (2) F32T8/RE835.

B Recessed 1' x 4' (0.3 x 1.2 m) fluorescent troffer with prismatic lens. Lamps: (2) F32T8/RE835.

C Fluorescent up- and downlight, three lamps in cross section (one for uplight, two for downlight). Steel housing, 8" x 6" (200 x 150 mm), with 2" (50 mm) high baffle, blades spaced 4" (100 mm) on center, in downlight section. Continuous rows suspended from ceiling or wall-mounted 12" (300 mm) from ceiling. Lamps: (3) F32T8/RE835.

D Recessed downlight with white cone and regressed fresnel lens, 7-1/2" (190 mm) diameter aperture. Lamps: (2) CFQ26W/RE835.

E Surface-mounted fluorescent 9" x 4' (0.2 x 1.2 m) luminaire with prismatic acrylic wraparound lens. Lamps: (2) F32T8/RE835.

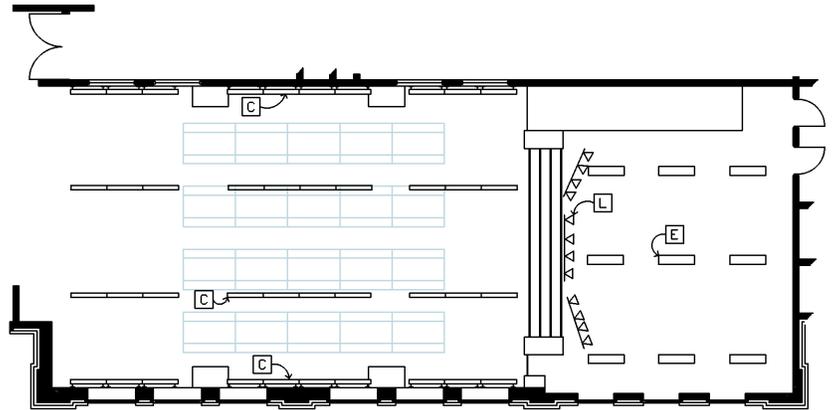
F Recessed 2' x 4' (0.6 x 1.2 m) luminaire with 18-cell, 3" (75 mm) high semi-specular parabolic louver. Lamps: (3) F32T8/RE835.

G Wall-mounted fluorescent uplight, two lamps in cross section, with asymmetric distribution. Oval extruded aluminum housing, 9" x 3" (230 x 75 mm) in a continuous run around base of vaulted ceiling. Lamps tandem-wired. Lamps: (2) F32T8/RE835.

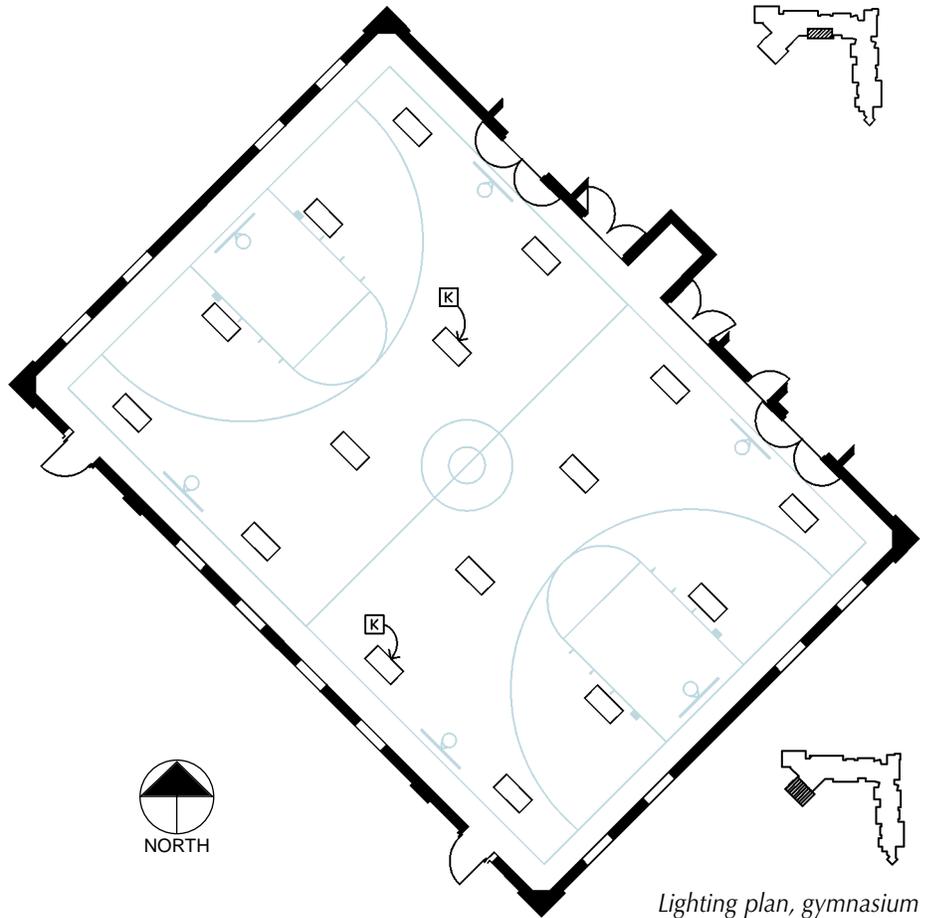
H Pendant-mounted fluorescent uplight, two lamps in cross section, with widespread distribution. Oval extruded aluminum housing, 3" x 8" x 12' (0.08 x 0.2 x 3.6 m), suspended by aircraft cable from vaulted ceiling. Lamps: (2) F32T8/RE835.

J Recessed downlight with clear cone, 6" (150 mm) diameter aperture. Lamps: (2) CFQ18W/RE835.

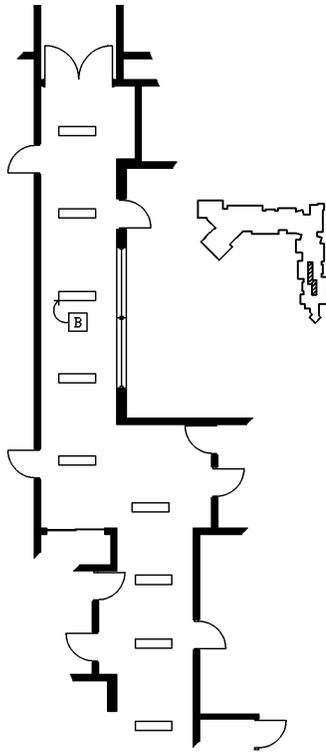
K Rectangular HID uplight mounted on bottom flange of exposed structure to uplight barrel-vaulted ceiling in gym. Steel housing, 6" x 16"



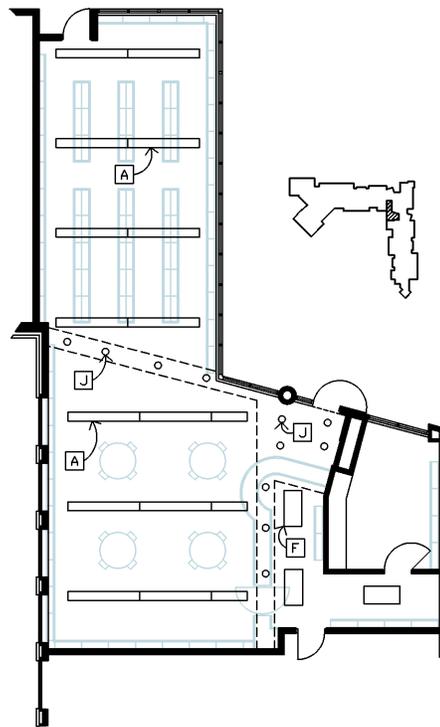
Lighting plan, cafeteria/auditorium



Lighting plan, gymnasium



Lighting plan, corridor



Lighting plan, library

Wattage

Input wattages for luminaires include ballast watts and are estimated from manufacturers' published literature. All calculations were based on the following values:

T8 fluorescent lamps (electronic ballast)

F32T8 (4'): 30 W per lamp for 2-, 3-, or 4-lamp IS ballast

Compact fluorescent lamps (magnetic ballast)

CFQ26W: 32 W per 1-lamp HPF ballast
CFQ18W: 23 W per 1-lamp HPF ballast

Metal halide lamps (magnetic ballast)

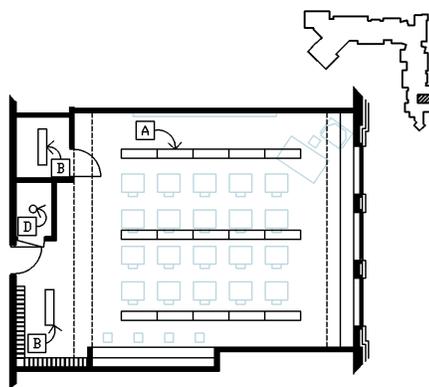
MH400W: 458 W per 1-lamp HPF ballast

High pressure sodium lamps (magnetic ballast)

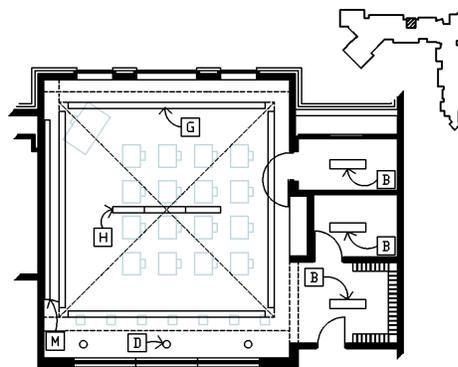
HPS400W: 465 W per 1-lamp HPF ballast

Incandescent lamps

250W PAR38/FL/krypton: 250 W



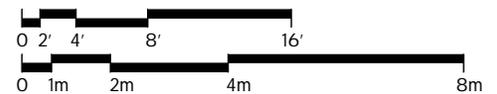
Lighting plan, classroom



Lighting plan, vaulted ceiling classroom



NORTH



x 46" (0.2 x 0.4 x 1.2 m), mounted in field-fabricated box secured to structure. Houses one 400-W MH lamp and one 400-W HPS lamp, protected by a glass lens. Symmetric distribution; those mounted near walls, asymmetric distribution. Lamps: MH400/U and HPS400.

L

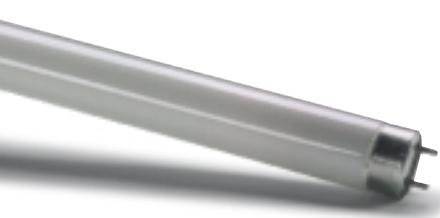


Track head with PAR38 krypton-filled lamp, colored glass filter (blue, red, green, or amber) and cube cell louver accessory, mounted to continuous 8' (2.4 m) track on stage ceiling. Lamp: 250PAR38/FL/krypton.

M



Recessed linear fluorescent luminaire, one lamp in cross section. Mounted in continuous row in soffit over chalkboard in each vaulted-ceiling classroom, 6" (150 mm) opening, with prismatic acrylic lens. Lamp: F32T8/RE835.



Details



Typical classroom



Vaulted-ceiling classroom

Typical Classrooms

The typical 1000 ft² (93 m²) classroom has a 12'-6" (3.8 m) ceiling. Uplights (type A) are suspended with aircraft cable 18" (460 mm) from the ceiling to the top of the luminaire and spaced 9' (2.7 m) apart. The soffit and soffit face are painted with bright colors such as yellow, blue, green, or orange. During the day, with horizontal blinds partially open, DELTA measured horizontal illuminances at student desks of 38 to 48 footcandles (fc) (410 to 520 lux [lx]). Nighttime desk illuminances were 30 to 49 fc (320 to 530 lx). These illuminances comply with New York State's requirements for a minimum of 30 fc maintained

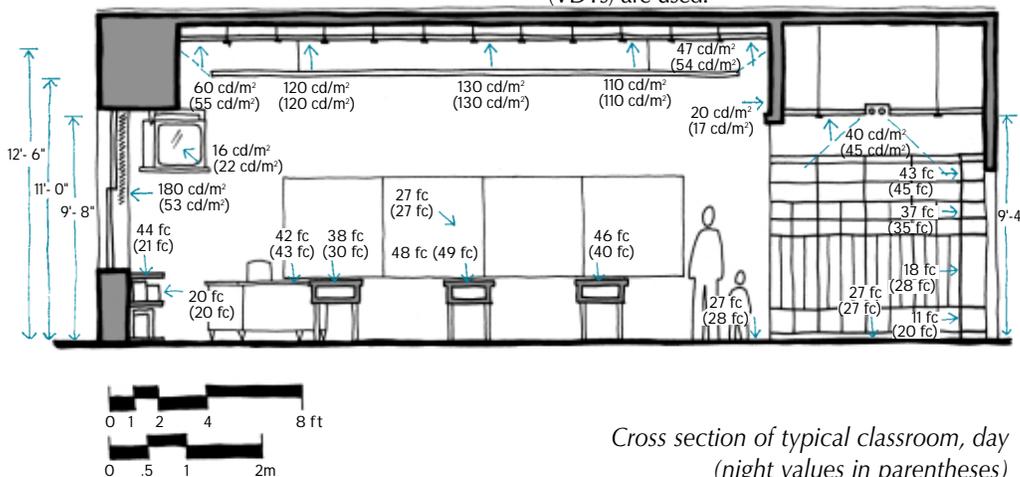
on classroom desks. The daytime and nighttime vertical illuminances in the center of the main chalkboard are about 27 fc (290 lx). This illuminance is very close to the State's requirement of 30 fc on chalk and display boards.

Students learn to use computers at a work area in the back of the classroom. Ceiling luminances in this part of the classroom range from 560 cd/m² directly above the luminaires to 110 cd/m² between luminaires. This 5:1 luminance ratio meets the Illuminating Engineering Society of North America's Recommended Practice for Office Lighting (ANSI/IESNA RP-1-1993) for spaces where video display terminals (VDTs) are used.

Suspended in one corner of each classroom is a television that the teacher controls with a hand-held infrared remote control. Some teachers responded that they must turn off the lights in order to operate the television. (See *Maintenance and Product Performance* on p. 12.)

The entry of every classroom is fitted with cubbyholes where students store their coats and lunch boxes. A fluorescent lensed troffer (type B) provides plenty of light for the children to identify their belongings. Vertical illuminances at the front edge of the cubbyholes range from 43 fc (460 lx) near the ceiling to 11 fc (120 lx) near the floor.

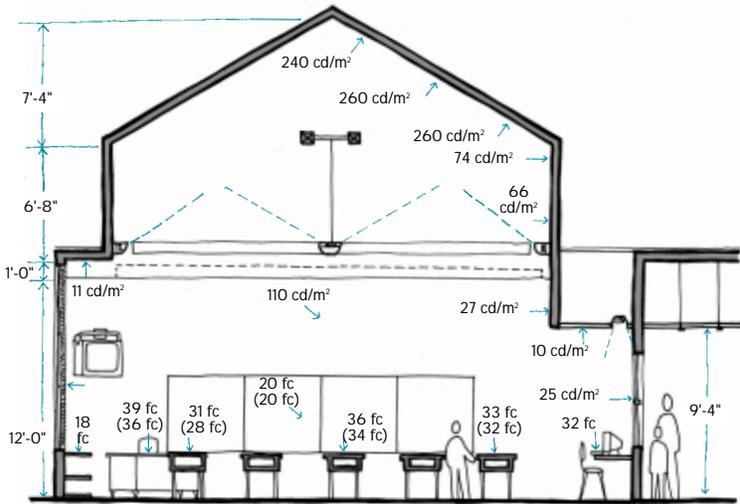
All the classroom lighting is controlled by an ultrasonic occupancy sensor mounted near the center of the main classroom area. The occupancy sensor switches lights on when it senses motion in the room, and switches the lights off after a preset time if it fails to detect movement. A manual override switch at the classroom door allows teachers to switch the lights off during the school day.



Cross section of typical classroom, day (night values in parentheses)

Vaulted-ceiling classrooms

Some of the classrooms on the second floor of the school have vaulted ceilings with a 26' (7.8 m) apex. Asymmetric uplights (type G) are



Cross section of vaulted-ceiling classroom, day (night values in parentheses)

"Compared to our previous school this lighting seems to be softer, yet seems to illuminate better!"
-Teacher

mounted around the perimeter of the room at 13'-6" (4 m) above finished floor (aff). A 12' (3.6 m) symmetric distribution uplight (type H) is suspended at the same height in the center of

the vault. As in the typical classrooms, the soffits in these rooms are painted, and the color continues up the vertical surface at the base of the vaulted ceiling. Above the chalkboard, a continuous linear luminaire (type M) is recessed in the soffit for supplemental lighting on the board. The computer work area is lit by compact fluorescent downlights (type D) recessed in the soffit.

During the day, with the horizontal blinds open and all lights on, desktop illuminances range from 26 to 39 fc (280 to 420 lx). At night the illuminances are similar, ranging from 26 fc (280 lx) to 36 fc (390 lx). The vertical illuminance in the center of the chalkboard is about 20 fc (220 lx) day and night.

The illuminances that DELTA recorded in these

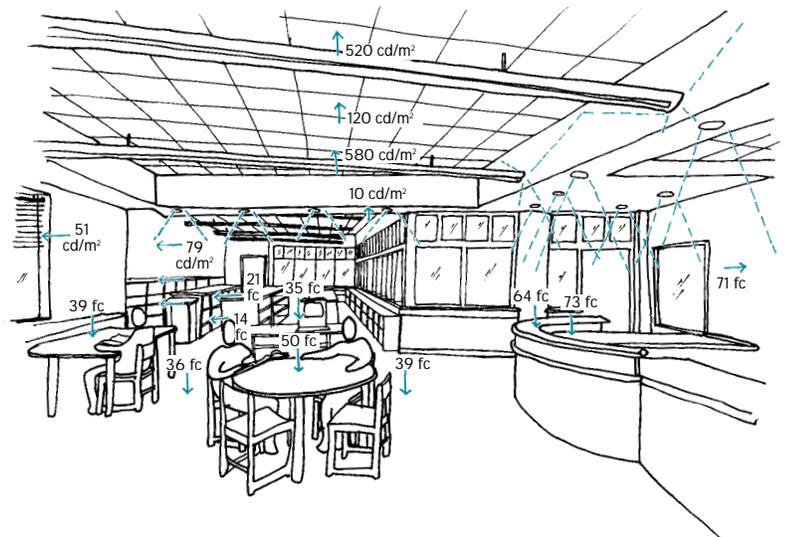
classrooms are slightly lower than in a typical classroom. This difference is probably due to the paint on the wall above the uplights, which is as low as 10% reflective, absorbing light that would otherwise be reflected back into the space. DELTA compared the illuminances in this room to those in another vaulted-ceiling classroom where all the wall and ceiling surfaces were painted white: illuminances on the desks averaged 50 fc (540 lx), about 20 fc (210 lx) higher in the white-painted room.

Library

The continuous rows of uplights (type A) in the library are mounted on an 8' to 10' spacing (2.4 to 3 m), providing an average of 45 fc (480 lx) on tabletops in the reading area. (The State of New York requires a minimum of 30 fc [320 lx] maintained at desk height in libraries.) In the stack area, vertical illuminances range from 22 fc (240 lx) at the highest shelf to 14 fc (150 lx) at the lowest shelf. Titles on book spines are easy to read on all the shelves. At the circulation desk, CFL downlights (type J), recessed in a dropped soffit, boost light levels to 64 fc (690 lx). Fluorescent luminaires with parabolic louvers (type F), mounted in the ceiling behind the soffit, provide 73 fc (790 lx) on the librarian's desk.



Library



Perspective of library



Details

Gymnasium

The gym can be divided into two small courts. The 31' (9.4 m) high barrel-vaulted ceiling runs lengthwise southeast to northwest. Sunlight falls on the southeast- and southwest-facing translucent fiberglass windows all day, providing diffused daylighting into the space. In addition to the daylighting, HID luminaires (type K) uplight the ceiling, which is made of metal decking painted white. The uplights, mounted on the bottom flange of the roof truss about 6' to 9' (1.8 to 2.7 m) from the ceiling, contain one MH lamp and one HPS lamp in the same housing. Even though the two light sources have very different color appearances (MH looks blue-white, while HPS looks yellow-white), the luminaires are far enough from the ceiling so that the two colors of light combine to produce a yellow-white light on the ceiling and the floor below. Illuminances at the floor range from 35 fc (380 lx) near the walls behind basketball hoops to 68 fc (730 lx) in the center of the gym. (The state requires a minimum of 20 fc [220 lx] maintained in gymnasiums.) Vertical illuminances at 5' above the floor (1.5 m) average 39 fc (420 lx).

"I like the indirect lighting."

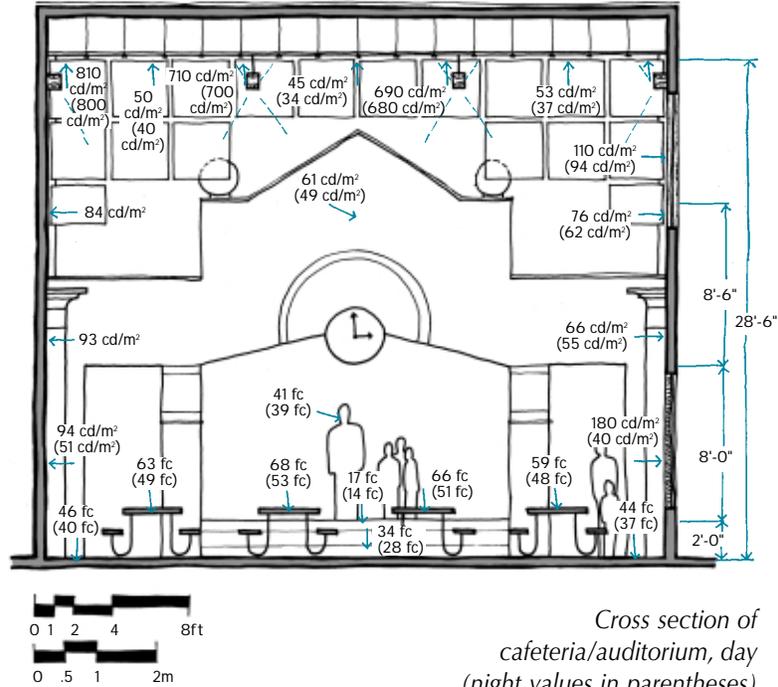
-Physical education teacher



Gymnasium

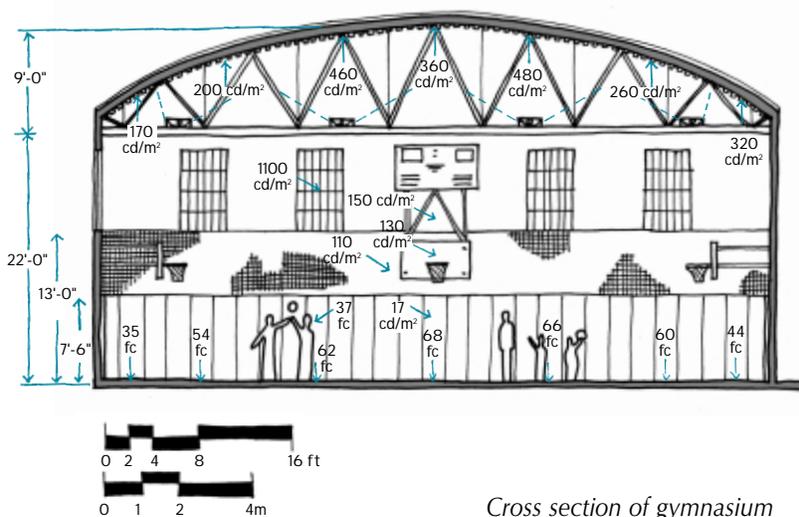
Cafeteria/Auditorium

This two-story space serves the school primarily as a lunchroom during the day. Continuous rows of fluorescent up- and downlights (type C) are pendant- and wall-mounted about 12" (0.3 m) from the ceiling. The short suspension length prevents the uplight from spreading evenly on the ceiling, so bright stripes of light are visible above each luminaire. The two-lamp downlight section provides an average of 50 fc (540 lx). Horizontal blinds, usually closed, shade windows on the south wall. During the day, with all the lights on, illuminances at the lunch tables average 64 fc (690 lx). Brightly colored banners echoing the accent colors in the classrooms are suspended from the ceiling in a staggered pattern, catching light from the linear luminaires as well as from the high windows.



Cross section of cafeteria/auditorium, day (night values in parentheses)

At the east end of the cafeteria a large and very colorful proscenium arch sets the stage for the students' talents as they rehearse and perform school plays and concerts. The stage is deep, with several rows of black curtains and track lighting controlled by a small theatrical dimming system. The track lights (type L) are fitted



Cross section of gymnasium



Cafeteria/auditorium, day



Cafeteria/auditorium, night

with louvers and colored filter accessories, which the students can use to produce a variety of stage lighting effects. Work lighting is provided by fluorescent lensed wrap-around luminaires (type E), surface mounted to the ceiling.

Typical Corridor

Different multicolored patterns in the wall

and floor tile of the corridors help students identify their school "neighborhoods." Recessed 1' x 4' lensed fluorescent luminaires (type B) are spaced 10' (3 m) apart, providing very uniform floor illuminances, averaging 32 fc (350 lx). They produce a slight scallop pattern on the walls, where student projects are displayed, but the maximum to minimum uniformity ratio is

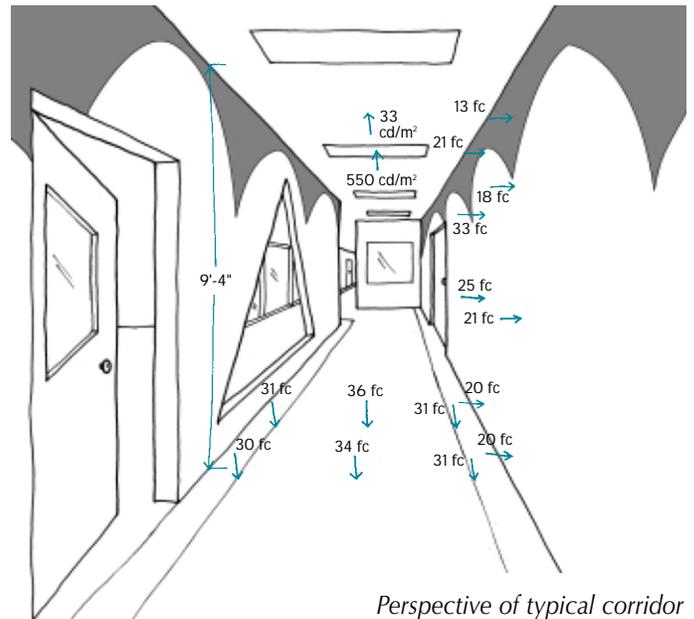
only 2.5:1. This even lighting makes the corridors seem bright and open. Students and staff can easily see where they are and where they are going.

"People coming in from outside think it's bright and beautiful!"

-Principal



Typical corridor



Perspective of typical corridor



Project Evaluation

Energy Impact

DELTA used input watts from the manufacturers' literature to calculate the lighting power density (LPD) for the school. The connected LPD for the entire building is 1.06 W/ft² (11.4 W/m²). However, the in-use LPD during core school hours (8:00 a.m. to 3:00 p.m. weekdays) drops to 0.88 W/ft² (9.5 W/m²). Much of the difference reflects DELTA's observation that the lighting in many spaces, particularly the classrooms, is switched off by occupancy sensors. (See *Controls* below.) Additionally, several spaces (storage areas, closets, lounges, copy rooms, and restrooms adjacent to each classroom) were only lighted for brief periods during the day.

The table summarizes the LPDs in the school, compared to ASHRAE/IES 90.1-1989 energy standards and the New York State Energy Conservation Construction Code.

Controls

The Rochester City School District uses automatic lighting controls as an energy-saving measure in all new and renovated school buildings. Occupancy sensors are used in classrooms, while time clocks control the lighting in public spaces.

Occupancy sensors Occupancy sensors control the lights in classrooms, storage rooms, and restrooms, as well as most offices and other large storage spaces. Ultrasonic occupancy sensors are ceiling mounted in each classroom and office. This type of sensor emits inaudible high-frequency waves and receives the reflected waves. It interprets any change in the reflected wave pattern as human movement and responds by switching on (or keeping on) the lights. Occupancy sensors are available with adjustable sensitivities and time delays. The time delay is the interval from the moment when the sensor stops detecting movement until it switches off the lights. The ultrasonic occupancy sensors in this building have built-in ranges from 30 seconds to 15 minutes, and most have settings between six and eight minutes. Each classroom has a manual override switch next to the door so that occupants can also switch lights on and off manually.

DELTA installed occupancy and light loggers in two classrooms for a two-week period to moni-

Space	Building Areas and Lighting Power Densities				
	Total Area (ft ²)	Total Connected LPD	ASHRAE/IES* Allowed LPD (prescriptive method)	NY State Conservation Construction Code	In-use LPD during core hours
Classrooms	38,573	1.03	—	—	—
Corridors and Public Spaces	20,150	0.71	—	—	—
Library	1,783	1.51	—	—	—
Gymnasium	4,480	3.30	—	—	—
Cafeteria and Kitchen	4,050	1.42	—	—	—
All Other Spaces	31,464	0.90	—	—	—
Total Building	100,500	1.06	1.57	2.20	0.88

1 W/ft² = 10.76 W/m² ASHRAE = American Society of Heating, Refrigerating and Air-Conditioning Engineers

tor the lighting use in these rooms. On typical school days, lights were switched on for an average of six hours out of the 8.5 hour day. At lunchtime, lights were switched off for an average of 32 minutes each day. Also, classroom lights occasionally switched off for several minutes between classes in the mid-morning and mid-afternoon periods. The occupancy sensors appear to be effective in saving lighting energy for about 30% of the school day. Ultrasonic technology was a good choice because it is sensitive enough to detect most of the small movements of students working at their desks. This minimizes the occurrence of "false-offs," when the lights are switched off even though the room is occupied.

The storage room and single restroom in each classroom are fitted with wall-switch passive infrared (PIR) occupancy sensors, which detect the movement of heat sources such as occupants. PIR sensors are less sensitive to slight movements than ultrasonic sensors, and teachers reported instances of lights being switched off when the restrooms were still occupied.

Switching Lighting in the public spaces (lobby, corridors, stairways, and public restrooms) is on a pre-programmed time switch that switches lights on at 6:00 a.m. and off at 10:00 p.m. each weekday during the school year. During the summer, while maintenance crews work on the building, the lights in these spaces are switched on at 7:00 a.m. and off at 6:00 p.m. During evenings

and on weekends throughout the year, 10% of the luminaires in these spaces remain on to serve as emergency lighting.

The custodial staff switches gymnasium lights on each school morning at 7:00 a.m. with a master switch and switches them off at either 5:00 p.m. or 9:00 p.m., depending on after-school and evening activities.

Environmental and Economic Analyses

Occupancy sensors and energy-efficient lighting products have enabled Bethune Elementary to achieve notable cost savings. LPDs were significantly lower than either the New York State Energy Conservation Construction Code or the ASHRAE/IES 90.1-1989 whole-building prescriptive method allows. DELTA compared the annual energy cost of the entire school compared to an ASHRAE/IES-compliant school model with an LPD of 1.57 W/ft² (16.9 W/m²). The following assumptions about operating hours were used in the development of this model ("school day" use includes nighttime hours):

- The school year has 180 weekdays and 75 weekend and holiday days. The summer break contains 80 weekday and 30 weekend and holiday days.
- Classroom lighting is on 8.65 hours/school day; during the summer it is on 8.5 hours/day

for 20 days. In the restrooms and store-rooms adjacent to the classrooms, lighting is on for 2 hours/school day and 2 hours/day for 15 days during the summer.

- Corridor, lobby, and restroom lighting is on 16 hours/school day, 11 hours/day in summer. Additionally, 10% of lighting in these areas is on for 8 hours/school day and 14 hours/day in summer.
- Lighting in the offices, library, and cafeteria is on 9, 7, and 8 hours/school day, respectively, as well as for 15 days in summer.
- Lighting in the gymnasium is on 12.4 hours/school day; during the summer, this lighting is on 15 hours/day for a total of 10 days, and 9 hours/day for 4 weeknights.
- Storage area lighting is on for 1 hour/school day and 2 hours/day for 15 days in summer.
- Lighting in conference rooms, photocopy areas, and teacher lounges is on 4 hours/school day and 4 hours/day for 15 days in summer.

The lighting system in this school saves more than 119,000 kWh annually in lighting energy use over a comparable school lighting system at 1.57 W/ft² (16.9 W/m²) operating the same hours. Taking into account the estimated impact on the school's heating, ventilation, and air-conditioning system, this reduction in lighting energy use corresponds to annual cost savings of about \$15,040. These savings are due to lower overall energy and demand costs, assuming energy costs of 8.7¢/kWh for electricity and 45¢/therm for natural gas used in the school's heating system.

Using estimates developed by the U.S. Environmental Protection Agency, the reduction in lighting energy use from this school will result in lower annual power plant emissions of nearly 89 fewer tons (81 metric tons) of CO₂, 1,550 fewer pounds (692 kg) of SO₂, and 668 fewer pounds (298 kg) of NO_x compounds. These emissions have been identified as potential contributors to environmental problems such as acid rain, global warming, and smog.

The lighting construction cost for this facility was about \$500,000 or \$5 per square foot. This is higher than the \$3 per square foot cost of lighting installations in typical schools, but Rochester City School District decided to invest in high-quality lighting for all of their recent projects.

"I don't think the lighting is good. I would give it a 70%."
-Teacher

"I like it being bright. I'm very comfortable with the lighting."
-Teacher

Staff and Student Response

DELTA interviewed teachers and other school personnel about their impressions and experiences with the lighting. They were asked about task visibility, visual comfort, problems with the lighting or window glare, and overall satisfaction with the lighting. The teachers who were interviewed generally liked the lighting and agreed that it was much better than in their previous schools. Most of them reported that the students had no trouble seeing their work or the classroom visual aids.

One teacher who taught in a vaulted-ceiling classroom said her students sometimes had to go up to the board to see what she was doing. She felt that her room was not bright enough. DELTA compared photometric measurements in this room, whose upper wall surfaces were painted green, with the same type of room where all the surfaces were painted white. DELTA discovered that the low-reflectance accent paint color lowered the illuminances at desk height by about 30%. DELTA recommended that the school district paint all surfaces above the uplights white to increase the amount of reflected light in the space.

DELTA also surveyed three classes of fifth-grade students, asking them to rate the quality of lighting in each of the evaluated areas, and then compare the lighting in these areas with the same areas in the school they attended last year. Most of the students thought the lighting in the gym, classroom, and hallway was good, and that it was better in this school than in the school they attended last year. More students rated the cafeteria lighting as fair, but still thought it was better than in their previous school. Although more students rated the library lighting as good, a relatively high percentage did not respond. Most of those who did respond thought the lighting in last year's school library was better. This apparent contradiction is probably because, when DELTA did the survey, the library's computer system was not fully operational, and many students had not been to the library, and were not allowed to check out books. Simply put, they may have responded negatively because they had not yet spent much time in the library.

Maintenance and Product Performance

The most significant problem the maintenance staff reported was that they have had to consistently replace T8 lamps that have failed prematurely. The specific reason for this has not yet been identified.

LIGHTING SURVEY
Percentages of 5th Grade Students Who Agree:

I think the lighting in this room is:	Good	Fair	Poor	No Response
	Gym	85%	14%	1%
Cafeteria	41%	47%	12%	0%
Classroom	65%	30%	4%	1%
Library	47%	31%	7%	15%
Hallway	60%	29%	11%	0%

I think the lighting in this room is better in my school this year or better in my school last year:	Better This year	Better Last Year	No Difference	No Response
	Gym	67%	26%	4%
Cafeteria	57%	40%	0%	3%
Classroom	60%	30%	4%	6%
Library	36%	49%	1%	14%
Hallway	71%	23%	3%	3%



Immediately after the school opened, a few teachers reported lights turning off in their classrooms when the rooms were still occupied. The sensitivity of the ultrasonic occupancy sensors was adjusted, and reports of false-offs in classrooms have been reduced dramatically.

Several teachers also pointed out that they had to turn the lights off in their classroom in order to operate the infrared remote controls for their classroom television. The electronic ballasts in the uplights were interfering with the infrared signal from the remote control device. High-frequency electronic ballasts operate in a frequency range of 20 to 60 kHz, while infrared remote control devices for television use signals with a carrier frequency of about 30 to 60 kHz. When an electronic ballast operates near the infrared receiver—the television—it can interfere with the carrier wave, and the television could fail to respond or malfunction. This compatibility problem cannot be easily solved. In most cases teachers told DELTA that a darkened room enhanced classroom television viewing, anyway. The National Lighting Product Information Program publication, *Lighting Answers: Electromagnetic Interference Involving Fluorescent Lighting Systems*, describes the problem and recommends the following possible solutions:

(1) Move the lamp away from the field of view of the receiver by moving it behind the receiver, for example. (2) Use low-frequency (60-Hz) ballasts in troublesome luminaires. (3) Install fresh alkaline batteries in the controller as a short-term solution.

Lessons Learned

- **Indirect lighting can provide a visually comfortable classroom environment while using a modest amount of energy.** Combining energy-efficient lamps, ballasts, and luminaires with automatic controls, high ceilings, and adequate suspension lengths produced a classroom lighting environment that is pleasing in appearance and visually comfortable

for teachers and students, at a lower lighting power density than energy codes require.

- **Ultrasonic occupancy sensors usually require field adjustments to minimize “false offs.”** Adjusting the sensitivity of ultrasonic occupancy sensors *after* the room is furnished and occupied helps keep lights from being switched off when the space is still occupied.
- **Use high-reflectance paint colors above uplights.** When relying on reflected light to illuminate a space like the vaulted-ceiling classrooms, optimize surface reflectance by painting with light colors. The best solution is to use a color with a reflectance that is at or above the 75% reflectance of most commercial ceiling systems.
- **Mixing MH and HPS in uplighting can be attractive.** The 6' to 9' distance between the uplights and the ceiling of the gym allows both colors of light to combine enough to produce a homogenous yellow-white light that reflects off the ceiling and down to the floor.
- **Electronic ballasts can interfere with television remote controllers.** When planning to use infrared devices near luminaires with high-frequency electronic ballasts, try out the system using the selected luminaires, ballasts, and infrared device. If there is interference, try changing the position of the luminaire or receiving device (the television, for example), or consider using magnetic ballasts, which operate at 60 Hz, instead.

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